ESCALATE

Germany, Saxony-Anhalt

Evidence Base for a Skills Escalator (WP4)

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List of Abbreviations

ESCALATE	Coordinated Higher Institutions Responses to Digitalisation, Erasmus+ KA2 - Cooperation for innovation and the exchange of good practices, KA203 - Strategic Partnerships for higher education
EU	European Union
WP	Work Package

Useful Definitions[1]:

Digital Skills: Competences in and / or knowledge of IT tools including computer programs and programming languages.

Digitisation / Digitalisation of Jobs: Job automation by means of computer controlled equipment.

Baseline Digital Skills: Digital literacy skills that employers ask for in the vast majority of jobs across all sectors in the UK labour market. Includes spreadsheet and word processing tools like Microsoft Excel and Microsoft Word, as well as enterprise management software like Oracle or SAP. These proficiencies are increasingly becoming a basic skill requirement for a majority of occupations.

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/807830/No_Longer_Optional_Employer_Demand_for_Digital_Skills.pdf

Executive Summary

Digital transformation is generating a fierce debate among education providers, policy-makers, economists and industry leaders about its societal impact. The transformation process of increasing digitalisation is changing Germany at various levels. As a result, knowledge and competence requirements are changing, which in the economic context leads to demands for specific skills and competencies and shows existing gaps and needs for action. The discourse on the development of digital competences is based on the assumption that digitisation will have far-reaching effects on future personnel and qualification requirements as well as on the labour and training market.

Overall, it is clear that the issue of digitisation is increasingly to be shaped at the social level and cannot be seen exclusively from the technical perspective. So, it can be understood as a social innovation (Buhr, 2015). As a cross-cutting issue, digitisation therefore requires a broad-based digital basic education in order to avoid a digital divide - in the professional world - in the education system as well as in the private sector.

This report presents the main findings of the implementation of a Digital Skills Escalator model, focused on the **medical technology sector** in **Saxony-Anhalt**, Germany. Medical technology was chosen as the smart specialisation sector because it is an industry that is one of the growth sectors internationally and nationally and there has been a particular push in recent years to create structures to promote this industry in Saxony-Anhalt. The Escalator model addresses the digital skills pipline of the region under consideration in relation to the current situation of educational opportunities in the medical technology sector.

This report was based on desk research which include secondary data analysis using datasets, studies and reports from, governmental and private providers. In addition, stakeholders from companies in the medical technology sector, for example, were included, which provided a deeper insight into the situation as well as the needs and problem aspects of the sector. The identification of gaps in qualifications and skills in the field of medical technology can help to support the country's activities to further develop the lead market of health and medicine. As cross-cutting skills, digital skills are a central part of developing this innovative industry through educational processes.

The analysis revealed multi-layered points that go far beyond the development of digital skills and address further fields of action, which ultimately affects many sectors in Saxony-Anhalt. Recommendations we make refer to

- Increasing the attractiveness of vocational training
- Vocational training must be continuously developed
- Stronger promotion of talent in STEM subjects
- Fundamental creation of the conditions for the development of digital skills in Saxony-Anhalt's schools:
- Promotion of Lifelong Learning and on the job training:
- Promoting further networking of the players in medical technology

Methodology

This report was based on desk research which include secondary data analysis using datasets, studies and reports from, governmental and private providers. This approach enabled a more concrete description and analysis of the selected smart specialisation sector **medical technology** of the federal state of Saxony-Anhalt, in order to be able to carry out the step-by-step development of the Escalator model as an example. The decision in favour of this sector is based, among other things, on the definition of 5 lead markets by the state of Saxony-Anhalt within the framework of the Regional Innovation Strategy. These represent central future fields and already existing strengths of the economic development of Saxony-Anhalt.

- Energy, mechanical and plant engineering, resource efficiency;
- Health and medicine;
- Mobility and logistics;
- Chemistry and bioeconomy;
- Food and agriculture.
- In addition, the cross-sectional areas of information and communication technologies, key enabling technologies, and media and creative industries.

Medical technology represents an innovative sub-market and a specialisation profile of the lead market "health and medicine". At the same time, there are also overlaps with the state's initiatives to shape the digital transformation and to promote the development of digital skills in addition to cooperation structures between business and science. The desk research opened up informations to identify and analyse main policies, strategies and plans regarding medical technology, digitalisation and the development of digital skills (or necessary skills) in the region of Saxony-Anhalt (e.g. *Digital Agenda*) In addition, this has enabled the identification of regional and local stakeholders who are important for the potential use and design of the Escalator model with regard to the further development of the medical technology sector.

In addition to the desk research avtivities, 6 guideline-based interviews were conducted with company representatives from the medical technology sector and medical technology industry associations (innoMed e.V.) in Saxony-Anhalt. This made it possible to gain further deeper insights from the field regarding the skilled labour situation, perceived skills gaps and the regional education sector. Topics of the interviews:

- Assessments of future developments in medical technology (Impact on the staff situation, qualifications needed in the future),
- Employee structure (occupational groups, qualifications, demand for skilled staff, competence/qualification gaps)
- Qualification/ personnel development/ further training (educational landscape, deficits, future design of educational pathways)

The creation of the Escalator has consisted of the following main steps;

- Defining the context of the healthcare economy and medical technology in Germany and Saxony-Anhalt
- Defining of national activities related to digitalisation and the medical technology sector
- Description of the Geography of the Escalator model region Saxony-Anhalt
- Defining the policy context of Saxony-Anhalt related to the smart specialisation and digitalisation

- Defining the digital skills pipeline through the mapping and the identification of training provisions regarding digital skills and skills needed in medical technology.
- Identifying aligned investments.
- Creating the Escalator model
- Identifying digital Skills Gaps and higher Level Smart Specialisation Sector skills gaps needing to be addressed.
- Proposing recommendations to tackle the identified skills gaps

Background to the ESCALATE Project

The ESCALATE project was the subject of a successful application to Key Action 2 – Cooperation for Innovation and the Exchange of Good Practices – of the Erasmus+ programme submitted by West University of Timisoara to the Romanian National Agency. The project has been developed by six partners from five EU countries, namely five universities and an independent company, which specializes on foresight and prospective - strategic studies for the public and private sector.

The official start of the ESCALATE project is 01.11.2019 and it is a 24-months project with the end date being 31.10.2021.

The aim of the project is to assist universities in implementing activities designed to increase the levels of digital competences for employability, upskilling, according with a growing range of employment generated by the digital economy, aligned with the needs of and opportunities offered by the labour market and linked to professional profiles.

The primary focus is to understand digital education disruption and to enable open-source technology and innovative solutions for both educators and students, leading to increased learning-outcomes that meet the learning needs of students whilst also being relevant to the labour market and societal needs (creating a 'better' digital future).

Our target groups are higher education institutions (HEI), education providers, teachers, learners for existing and new digital skills provision. Indirect target group consists primarily of those citizens with low levels of digital skills at risk from digitalization facing a keen need to acquire the digital knowledge and use of digital technologies, but also labour market (LM) forecasters such as labour market observatories.

The project has two linked objectives. Firstly, to help universities understand the scale and depths of the challenges they face from digitalisation - to enable them to formulate effective policy and education system governance - by developing and making freely available new methods and techniques in digital skills acquiring, foresighting and forecasting. We will explore the state-of-the-art before developing and testing the new materials across 6 major themes.

Secondly the project will trial the potential of a new innovative practice (a Digital Skills Escalator) across a selected region in each partner country to test its potential as a mechanism for both identifying where there is unmet demand and subsequent need for new digital skills provision and as a means of building a more holistic offer from education providers. This report addresses this objective for our region.

The University of Exeter has summarized existing practices and lessons learned from their work developing the Exeter Data Analytics Skills Escalator and has passed this onto partners who will then build policy and stakeholder relationships to enable testing of the model in their own region and policy landscape.

This report will be presented at Partner Meeting 3 where a methodology for utilising the findings with policymakers will be devised. This is likely to include meetings, regional reports, workshops, and events.

The Concept of a Skills Escalator

Escalators are relatively new developments that seek to achieve the following two related, but not identical, aims.

1. To ensure a region has sufficient citizens skilled in a particular field/sector critical to economic success.
2. To ensure that the skills and training needed to enter or progress in this field/sector are available locally, at all levels.

The former can be understood as a driver of economic success and the latter is more concerned with inclusive growth. As a project we are looking specifically to develop Digital Escalators where the skills at the 'lower end' of the qualifications can be quite generic but will link into a very specific key sectoral need at the higher end. Linked to a City or Region's 'smart specialisation'.

A good example of this is the existing Exeter Data Analytics Skills Escalator is relatively broadly defined. It encompasses topics such as:

- Statistical understanding
- Digital and programming skills
- Use of AI and high end algorithm development for the analysis of 'big data'
- The translation of environmental intelligence into new products and services and local growth.

Put simply the Escalator is a pipeline of skills, or perhaps more accurately a 'funnel of skills', linked to a specific smart specialisation sector. The fact that a significant proportion of individuals may apply these skills usefully outside the prioritised smart specialisation sector is not problematic. Having a relatively broad, and some might say flexible focus (in which the 'environmental' focus can be picked up or dropped, as convenient) enables engagement across a wide range of educational and other partner organisations and access to a wider range of opportunities.

The Escalator Model is not intended to be a fixed journey from school to Higher Education and CPD but instead is designed for people to enter and leave when necessary. Its purpose is to promote discussion, engagement and coordinated partnership activity.

The context of Medical technology in Germany and Saxony-Anhalt

Medical technology was chosen as the smart specialisation sector because it is an industry that is one of the growth sectors internationally and nationally and there has been a particular push in recent years to create structures to promote this industry in the state of **Saxony-Anhalt**. As subpart of the health sector, medical technology is also characterised by innovation and digitalisation dynamics.

The market for medical technology is driven by demographic developments, especially in the mature economies, as well as by high health investments in many emerging countries. Other factors include the increasing importance of health as a commodity and new or further technological developments (SPECTARIS 2020). In addition, changes and requirements in the course of digitalisation are also evident here in many ways. Overall, the German healthcare sector is lagging far behind other sectors in terms of digitalisation. In the Digitisation Index, which is surveyed annually by TNS and ZEW on behalf of the Federal Ministry for Economic Affairs and Energy, the health sector has consistently been at the bottom of the list for several years with 37 out of 100 points (BMWi, 2018).

Thus, medical technology companies and research players are central stakeholders in the environment of an increasingly digitalised health economy. As a result, the business model of medical technology manufacturers is also changing: from the classic provider of device technology to the solution provider to the provider of digital and holistic healthcare solutions in the healthcare sector (SPECTARIS 2020).

Health economy in Germany

Like other economic sectors the health sector is of course increasingly influenced by diverse digital transformation processes which has effects on many levels. For example, digitalisation is profoundly changing the possibilities and ways of working in medicine and care. The core issue is how new forms of care, structures and changing needs in the health sector can be supported by digital solutions. Dispan notes, that in the 2020s "*we will see the full impact of the digital transformation in the health sector*" (Digital Health) (Dispan 2020). As a result, digital as well as medical-technical interdisciplinary competences are increasingly becoming key qualifications.

The health economy is one of the most important growth sectors in Germany and it is of considerable economic importance. Gross value added in the core area of the health economy was just under 370 billion euros in 2018. This corresponds to more than 12 percent of the gross domestic product. With annual growth of 4.1 per cent, the sector has grown significantly faster than the gross domestic product over the last ten years (BMWI, 2018). There are currently 5.7 million people working in the health sector. This means that about one in eight people in employment today works in this sector. However, it must be stated that the health sector is extremely complex and diverse. The health economy is a cross-sectional sector within the German economy. It encompasses the production and marketing of goods and services that serve the preservation and restoration of health (BMWi 2020).

Background: The health economy can be delimited by means of a layer model which systematises the individual sub-aggregates of the health economy on the basis of the definitions of the OECD and the WHO (cf. Hessisches Statistisches Landesamt 2010). It consists of the core area of the classic health care system (above all hospitals, the rescue system, doctors' practices and outpatient care services). Around this core area, there is a first layer with the area that is necessary to supply the core area with services and products. This includes health-related wholesale and retail trade, including pharmacies. The second layer includes the capital- and technology-intensive preliminary and supplier industries such as the pharmaceutical industry, medical technology, biotechnology or the health trade. The third layer contains the private and statutory health insurance companies, long-term care insurance companies, parts of the accident insurance and the public administration in the field of health care as further institutions of the health economy (Fuchs/Fritzsche, IAB, 2019).

Medical technology

The medical technology (medtech) sector belongs to the industrial health economy. The industrial sub-sector of the health economy has a share of 21.8 per cent in the value added of the health economy. With around 1.0 million people in employment, about every 7th job in the health economy is located in industrial health economy. It is by far the most globalised sector of the health economy and accounts for more than 90 percent of the health industry's exports. The level of exports is rising sharply and was just under 120 billion euros in 2019 (BMWi 2020). In economic and employment terms, medical technology is a high-growth sector characterised by intensive innovation and quality competition. At the same time, medical technology is a very heterogeneous and multidisciplinary industry that is characterised by the use of a wide variety of technologies. And as an interdisciplinary field of technology, it combines many research areas, technology development lines and key technologies (Dispan 2020). The complexity of newly developed medical products is expected to grow in the future, especially if they increasingly involve system solutions and/or products with cross-sectoral approaches (e. g. combination of medical product and medicine).

Two economic sectors of the official statistics make up the core area of the medical technology sector: 1. Production of irradiation and electrotherapy equipment and electromedical devices, 2. Manufacture of medical and dental apparatuses and materials (Dispan 2020).

It is problematic that companies in the medical technology sector are hardly directly comparable with each other, as they are partly active in completely different markets with different products for the most diverse applications. Another problem in delineating a medical technology market arises from the constant further development of products and their linkage with other markets. The boundary between the biotechnology sector on the one hand and medical technology on the other is becoming increasingly blurred.

Forecasts for the coming years envisage an average annual increase of the world market for medical technology of around five percent. The market size is expected to reach a of around 550 billion US dollar in 2023 (Frost & Sullivan 2020). Within the EU, German medical technology manufacturers are leading the way. Of the industry turnover generated in the European Union, which amounted to around 107 billion euro in 2018. German manufacturers account for 41 percent. So the German medtech industry is very export-intensive, with export rates of around 65 percent. More information about the German medical technology sector:

- The 1,400 Medical technology manufacturer generated a total turnover of 33.4 billion euro in 2019. Domestic turnover in 2019 was 11.4 billion euro (plus nine percent), while foreign business reached a value of 21.9 billion euro (plus eleven percent).
- The industry employs a total of over 215,000 people in Germany. The overall economic employment effect is around 350,000 jobs in the medical technology value chain.
- 93 percent of medtech companies employ fewer than 250 people. There are 13,000 micro-enterprises alone with around 60,000 employees. But only 90 medtech companies in Germany have more than 250 employees. If we look at the distribution of German medical technology manufacturers by size class, we see a balanced industry consisting of global key players and a strong core of medium-sized companies. The 1,324 companies, each with fewer than 250 employees, employed more than 68,000 people in 2019 and generated sales of 8.6 billion euro.
- German medtech manufacturers generate about one third of their turnover with products that are not older than 3 years. On average, research-based medtech companies invest about 9 percent of their turnover in R&D. In addition, around 15 per cent of the workforce is

employed in R&D. This means that the manufacturers' R&D intensities are well above the German industry average.
- In 2019, medical technology ranked second after digital communication in terms of applications filed at the European Patent Office: 13,833 of the total of over 181,406 applications were in this field. With 1,278 applications, Germany ranks second behind the USA (5,470 applications) and ahead of Japan (1,004 applications).

In a 2018 study conducted by Roland Berger and SPECTARIS entitled "Health 4.0", it became clear that the opportunities and challenges of digitalisation in the medical technology industry have so far only been recognised and used to a limited extent. Among other things, the study investigated whether the companies surveyed felt well prepared for future challenges of digitalisation. This was the case for only 24 % of the medical device manufacturers. Just 36 % of the companies had a digitalisation strategy, and investments in digitalisation were also low. In most cases, less than 2.5% of turnover was invested in corresponding projects (SPECTARIS, Roland Berger 2018). A market study by the consulting firms Luther and Clarefield cognises central challenges for the German medical technology: Price pressure, the need for digitalisation and internationalisation, and the tightening of regulatory requirements. In the sector analysis on medical technology, even Dispan notes that the megatrend in medical technologies is digitalisation in conjunction with artificial intelligence (AI) and the platform economy. This cross-cutting topic will have the greatest influence on medical technology and health policy progress in the coming years and is also associated with the greatest opportunities and risks. Digital health, e-health, electronic patient records (ePA), health apps, telemedicine and applications from AI-supported big data analysis have the potential to transform the healthcare industry and thus also medical technology in the coming years (Dispan 2020).

In addition to digitalisation as a general megatrend, the medical technology sector is also affected by technological developments and trends:

- **Artificial Intelligence (AI) and Big Data**: AI and Big Data are increasingly finding their way into medicine and medical technology. In imaging diagnostics, artificial intelligence and and big data are already being used extensively to accelerate analyses and support decision-making.
- **Sensor technology**: Sensors are playing an increasingly important role in medical technology. In addition, wearables are being equipped with ever more intelligent and versatile sensors.
- **Patient-specific medical technology**: Individual therapies and medical devices are increasingly being developed therapies and medical products are increasingly being developed.
- **E-health** enables the provision of medical care via digital channels.
- **Robotics and networked operating theatres**: In addition to the increasing integration of robotic systems into the operating theatre the range of technical assistance systems is growing. Medtech providers suppliers are moving away from being pure product providers towards becoming system providers with open interface concepts to enable networked and advanced operating and advanced operating environments (Luther and Clarefield 2020).

Qualifications and skilled labour needs

One of the central challenges with regard to the digital change in Germany is the oft-stated reminder of an increasing lack of skilled workers and experts and the associated threat to the competitiveness of Germany as a business location. The penetration of computer science into almost all areas of work and life has been accompanied by an above-average increase in the number of jobs for computer specialists in recent years. For the period from 2010 to 2017, the ICT sector is even showing the highest growth rate in the industry with 250,000 new jobs (+27 percent) (BMWi, 2018a). The shaping of digitisation and thus the increasing demand for skilled workers with digital skills is becoming a challenge for the competitiveness of the 3.8 million small and medium-sized enterprises (SMEs) in particular. After all, SMEs provide the majority of jobs and generate the largest part of value added in Germany. The 2019 company survey carried out by KfW Research (2020) shows clearly that the digital change has reached the breadth of the SMEs in Germany. But 38% of SMEs surveyed see a lack of IT skills among existing employees or a lack of IT specialists on the labour market as a stumbling block. Two years earlier the figure was 29 %. Most SMEs are trying to build digital literacy through further training. It is also interesting to note that apparently the employment of university graduates favours digitization. Thus, digitisation projects have increased, especially in companies with university graduates. This share is three quarters higher than in companies without university graduates and almost twice as high in companies with their own R&D (KfW Research, 2020). A Special survey by KfW Research (2018) is dedicated to "digital literacy": Which skills are important from the point of view of the companies, which ones are lacking? To this end, a differentiation was made between basic skills and advanced skills:

- Digital basic skills: skills such as the operation of standard software and devices. More than three quarters of SMEs (78%) attach great importance to these skills, while only 8% attach no importance at all. Online skills are also important for the majority of SMEs (51%) - e.g. Internet research, handling social media or online marketing. The operation of special software or digital production machines is important for 45% of SMEs.
- Advanced digital skills: Programming skills are important for only 18%, while more than half (54%) have no need at all. The situation is very similar with complex statistical data analysis. They are of great importance for 16% of SMEs. In summary, 24% of SMEs have a strong need for advanced digital literacy.

The knowledge-intensive sectors of the economy have the greatest need of all digital skills. This applies both to the R&D-intensive manufacturing industry and to the knowledge intensive service providers. The sectors IT and financial service providers as well as mechanical engineering and health care stand out in particular. The need for more complex digital literacy is strongly concentrated in R&D-intensive industries: 54% of SMEs in this sector need programming skills and 38% need statistical data analysis. Overall, the demand for digital skills in R&D-intensive manufacturing is below average. A survey by the Stifterverband describes a demand for the area of technological skills of around 700,000 people with the relevant skills in the economy alone by 2023. In addition, over 2.4 million workers each need to be trained in key skills such as agile working, digital learning or collaboration techniques. Complex data analysis is the tech skill with by far the largest gap in demand (455,000 people). This high value indicates that in the future, companies will collect and process large amounts of data to an even greater extent than before and that artificial intelligence based on complex data analysis will become increasingly important (Stifterverband, 2017).

The result of the technological developments and trends described is that new competence profiles will become more relevant for the medtech industry in the next years (Luther and Clarefield 2020). A survey ("Digital Jobs@Medical Technology") conducted by SPECTARIS and Kienbaum Consultants International in 2020 addresses the current and future need for skilled workers in the German medical technology sector against the backdrop of the digital transformation, among other things. The BVMed Autumn Survey 2020 with 118 medical technology companies revealed that medical technicians and engineers are particularly in demand for professional qualifications (BVMed 2021).

The survey of more than 80 participants, mostly from the management and the HR-department, revealed already an obstacle to growth in companies due to the lack of "digital experts". Half of the respondents assume that their company could grow by up to ten percent if the demand for "digital experts" could be sufficiently met. The need for skilled workers and managers who can advance digitalisation in the company through their qualifications is increasingly growing and cannot currently be met by the labour market in one third of the companies surveyed. The assessed shortage of skilled

workers relates in particular to the functional areas of IT and also for R&D and production. With regard to the effects of digitalisation on the development of employment, almost half of the companies expect a net increase in employment as a result of digitalisation. From the point of view of the medtech companies, production is most affected by the change in job profiles with 46.3 %, followed by finance & controlling with 43.9 %. Controlling with 43.9 %. This is followed by Service and Supply Chain Management with 34.2 % each. Human Resources, Marketing and Sales and Purchasing are affected with 24.4 %. According to the survey, Regulatory Affairs and QM, R&D and IT are least or not at all affected. As other studies also show (Digitalisation and the Future of Work, by Arntz, Gregory and Zierahn 2017), it is also estimated here that routine tasks in the middle qualification and wage groups will be increasingly replaced by digitalisation (SPECTARIS, Kienbaum, 2020).
Overall, the companies surveyed in the study "Digital Jobs@Medical Technology" signalled a pressure to act – almost 70 % of the companies do not see themselves as well equipped for the challenges of digitalisation. In the area of **future skills**, the focus is on building up technological skills and digital key competences - skills that will be increasingly expected in the future, but which are only available to a limited extent today. Almost 80 % of the respondents assume that the ability to analyse complex data will gain a strong or very strong increase in importance. This is followed at a distance by the design of networked IT systems and smart/hardware/robotics development, which are rated as such by 69.5 % and 68.2 % respectively. In addition to technological skills, other skills are seen as important in the course of digitalisation. This category includes so-called digital key qualifications that make it easier for employees across departments, functions and hierarchies to find their way in an increasingly digitalised working environment and to actively participate in shaping it. Three quarters of the study participants rated as very strongly or strongly gaining in importance: Digital Learning, Agile Working, Digital Literacy, Ability for appropriate Digital Collaboration. In this context, more than two-thirds of the study participants attach considerable importance to continuing vocational training and "lifelong learning" in the next 5 years.
Kraft and Morgenstern point to the importance of university graduates in enabling medical technology companies to shape the digital transformation. Among other things, the focus should be on the 70 German-language degree programmes in biomedical engineering, which should accordingly equip graduates with qualifications important for digitalisation. About 40 universities, 50 universities of applied sciences and vocational academies are directly involved in biomedical engineering education. In deriving recommendations for the design of study programmes for medical technology graduates in view of the challenges of the digital transformation, two essential sub-aspects are distinguished. On the one hand, contents from the field of information and communication technology as well as from computer science belong in every degree programme. This includes basic knowledge of programming, the structure and functioning of computers, communication systems (e.g. mobile devices), measuring systems, control and regulation technology as well as the handling of important software systems typical for the industry, including the professional use of the internet (e.g. for scientifically validated literature research and evaluation via relevant databases). The second main aspect is the use of digital technologies for teaching and learning during studies (Kraft and Morgenstern, 2020).
Dispan (2020) believes that in-company education and training will continue to be of great importance in the future in order to meet the demand for skilled workers and the changing competence requirements of medical technology companies. In order to secure the next generation of skilled workers and engineers, the graduates from universities and colleges are very important as career starters in the company. Graduates in medical technology, electrical engineering, computer science, information technology, etc. are sought after. There is a high demand in the area of regulatory affairs and in the entire spectrum of hardware and software development.

"The more IT requirements there are and the more specialised the jobs are, the more we feel the skills shortage."[2]

National activities

German Digital Policy

In an international comparison, Germany only occupies a midfield position in terms of current digitalisation in European Commission's Index for the Digital Economy and Society, Germany ranks 12th among the 28 EU countries (DESI 2020). At least basic digital skills and basic software skills are well above the EU average. Germany ranks fifth for both indicators. The high proportion of students of technical and natural science subjects in Germany should be emphasised. 38% of first-year students today choose a MINT3 subject (Bildungsbericht 2020, 191). This is a very high proportion by international comparison, which is primarily due to the above-average importance of engineering sciences in Germany (OECD 2019a, 240). The share of ICT specialists in the labour force is in line with the EU average (3.9%). A major challenge for Germany in shaping the digital change is the increasing demand for ICT specialists. The share of ICT specialists in the total employment of women is 1.4%, which is also in line with the EU average. The share of ICT graduates in the total number in Germany is 4.7%, well above the EU average of 3.6% (DESI 2020).

In Germany the federal and the federal state (the ´Länder´) governments are jointly responsible for digital education. In Germany, the development of digital literacy is seen as an interdepartmental task and therefore plays an important role in all relevant strategies. It can also be noted that a wide variety of strategies, programs and funding measures exist at state and federal level to support the digitisation of universities. The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK) published a strategy on "Education in the Digital World " in 2016. The requirements formulated in this strategy for the education sector are to be implemented in a binding manner in the federal states. A competence framework with six areas is defined. This describes the competences that pupils should have at the end of their compulsory schooling in order to participate actively and self-determinedly in the digitally shaped society.

Key initiatives in the last years: In November 2018 the Implementation strategy of the Federal Government for shaping digital change entitled "*Shaping Digitisation*" was adopted. In this implementation strategy, there is a concentration on priority projects that the ministries have identified (BReg, 2020). The *AI Strategy Germany* of the Federal Government, also adopted in November 2018 (BReg, 2018), also the Ministry of Education and Research's (BMBF) Digital Strategy adopted in April 2019 entitled "*Digital Future: Learning. Research. Knowledge*" (BMBF, 2019a) and in the MINT-Action Plan of February 2019 (BMBF, 2019b). In March 2018 a new Minister of State for Digitisation was appointed, reporting directly to the Federal Chancellery. In 2014 Germany adopted its *Digital Agenda* (BReg, 2017). The Federal Government's Digital Agenda sets out the guidelines for digital policy and bundles measures in central fields of action in order to accompany and help shape digital change and is a starting point for the future digital policy of the Federal Government. The Federal Ministry of Economics and Energy, the Federal Ministry of the Interior and the Federal Ministry of Transport and Digital Infrastructure are jointly responsible for its implementation. The strategy consists of five fields of action. 1. Digital literacy, 2. Infrastructure and equipment, 3. Innovation and digital transformation, 4. Society in digital change and 5. Modern state. Each field of action is preceded by common guiding principles.

The field of action *Digital literacy* focuses on the main points *School education*, *Education, training and further education* and *Competent society*. The intended objective is, that "all people become able to take advantage of the opportunities offered by digitization. They should be able to shape digital change in a self-determined way and deal responsibly with the risks."

[2] Anke Haupt, HR-Manager at Draeger („Die Menschen vertrauen uns ihr Leben an" in: Medizin & Technik, Heft 3/2019, pg. 70)

The national “Hightech-Strategy 2025” forms the strategic umbrella of the Federal Government's research and innovation policy. The strategy focuses on the topics "Health and Care", "Sustainability, Climate Protection and Energy", "Mobility", "City and Country", "Security" and "Economy and Work 4.0". Digitization is being promoted as a central cross-cutting issue in all the fields mentioned. One of the objectives pursued: “In terms of content, it will be important in the coming years to the possibilities of digitalisation even more consistently, to more consistently, to strengthen our technological sovereignty in forward-looking technological sovereignty in forward-looking industries and key technologies and to meet the demand for highly qualified skilled workers” (BMBF, 2018).

Medical technology

As one of the most important manufacturers of medical technology, Germany is to take a leading role in the digitisation of medicine. To this end, the German government has embedded a funding programme in the "High-Tech Strategy 2025" to support the mainly small and medium-sized companies (SMEs) in the German medical technology sector. The funding programme "KMU-innovativ: Medizintechnik" (Innovative medical technology) is designed to support application-oriented research by SMEs. Access to research funding is to be made noticeably easier for SMEs and thus supply-oriented research in medical technology and related future areas is to be promoted.
In addition, the BMBF, together with the Federal Ministry of Health (BMG) and the Federal Ministry of Economics and Technology (BMWi) as well as representatives from industry, science, health care and self-administration initiated the national strategy process "Innovations in Medical Technology" in 2011. Experts from science, industry, care and politics worked together to develop a coherent innovation policy in medical technology. The research and innovation policy recommendations resulted in the medical technology programme "Improving Patient Care - Strengthening Innovation" for the supply- and industry-oriented promotion of innovation in the service of patients. The BMBF is initially providing a total of 240 million euros for the ten-year medical technology program until 2021.

With the program "Digital Media in Vocational Education and Training in the Health Professions (DigiMed)", the Federal Ministry of Education and Research (BMBF) is promoting the modernisation of vocational education and training, particularly with regard to the learning potential of digitalisation. However, according to a 2018 study by the Bertelsmann Foundation, Germany is still a long way from this position, landing in 16th place out of the 17 countries surveyed. The assessment was made on the basis of the Digital Health Index. This is based on the following criteria: Legislation and national strategy for digital health, technical readiness and suitability for everyday use, networking and data exchange within the health system. The field is led by Estonia in first place, Canada in second place and Denmark in third place (Bertelsmann Foundation).
In Germany, there are more than thirty cluster initiatives and networks specialising in medical technology, whose main goal is to achieve continuous innovation in research and development as well as in manufacturing by connecting companies, hospitals, universities, and other research institutions. Dedicated cluster management teams help obtain funding for joint R&D projects, provide shared facilities, and organize educational training programs for their members (GTAI 2019). The support of innovative technology clusters is part of the German government’s national High-Tech Strategy 2020. Winners of the “Leading-Edge Cluster Competition” receive an additional EUR 80 million in funding to accelerate their ongoing projects and bring innovative solutions to market. Many cluster initiatives have a special focus on supporting start-ups and on the topic of digital health. Important production and innovation clusters in medical technology are the greater Hamburg area (Life Science Nord), Berlin and the surrounding area (Health Capital Berlin Brandenburg), Nuremberg/Erlangen (Medical Valley EMN) and the Tuttlingen area (Medical Mountains).

Figure 1. Germanys Medical Technology Cluster Networks (GTAI 2014)

Geography of the Escalator concept: Saxony-Anhalt

Saxony-Anhalt is one of the 16 Bundeslaender (federal state) of Germany. It is located in the western part of eastern Germany. By size, it is the 8th largest state in Germany and by population, it is the 11th largest. Saxony-Anhalt has about 2.2 million inhabitants (2018). While the northern parts of the state are sparsely populated, the population density in the centre and south is over 150 inhabitants per square kilometre. The state capital is the city of Magdeburg (235,723 inhabitants). It is the second largest city in the state after Halle/Saale (236,991 inhabitants). Saxony-Anhalt is a young federal state with a long industrial tradition. Technical innovations as well as the favourable location in the heart of Europe led to the emergence of a centre of industrial progress in this region at the beginning of the 20th century. The socio-economic situation is still marked today by the effects of two phases of de-industrialisation followed after the Second World War: The almost complete destruction of the production facilities in the Second World War followed by the partial dismantling of still-functioning industrial plants as reparations. And at the beginning of the 1990s, privatisation of the economy took place in the course of reunification, which led to the collapse of large parts of the industry in the following years. This had enormous social consequences, including high unemployment and the migration of skilled workers to economically stronger federal states.

Overall, the country has managed a slow but relatively steady economic recovery since 1990. The gross domestic product of Saxony-Anhalt was around 62.65 billion euros in 2020. The GDP per capita of Saxony-Anhalt was € 28,880 in 2019, the lowest of all German states (Germany: 41,358; EU: 31,000)

(Eurostat 2019). However, major structural disadvantages still exist today that affect the country's economic performance.

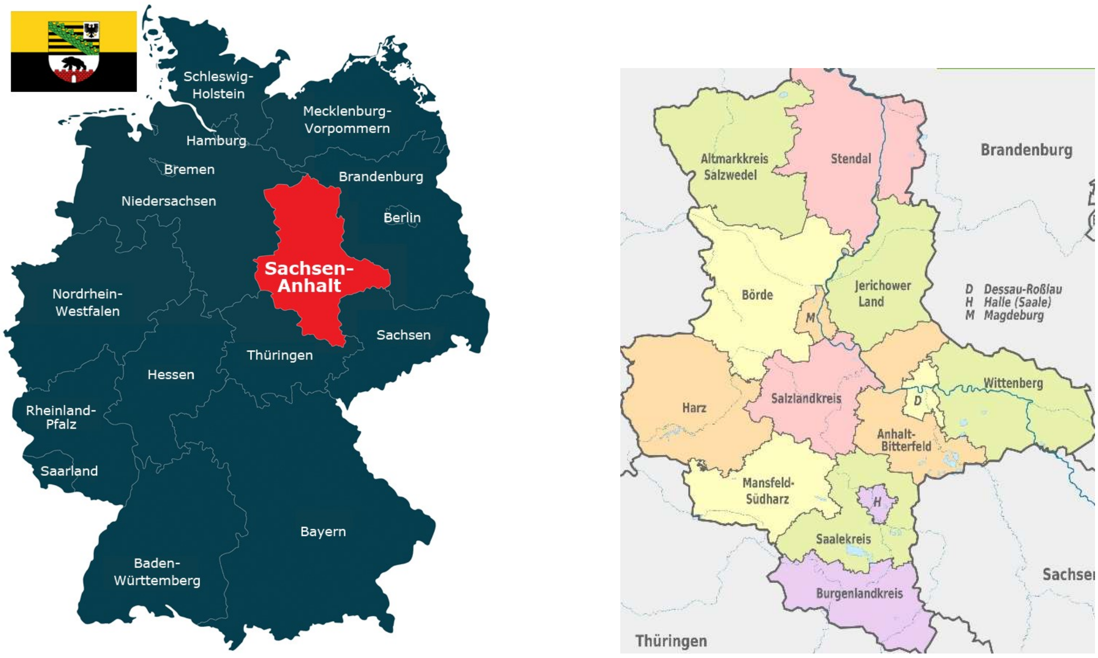


Figure 2,3. Geographical positioning of Saxony-Anhalt (www.wikipedia.org)

The economy in Saxony-Anhalt is decisively shaped by SMEs. For example, in 2019 there were only 11 companies with an annual turnover of more than 500 million euro (Statista, 2021a). The state also lags behind other federal states in the area of public and private research and development spending. In 2019, for example, internal expenditure on research and development per capita in Saxony-Anhalt was 450 euro, while in Baden-Wuertemberg, which is far stronger in terms of industry, it was 2700 euro (Statista, 2021b).

The most important economic sectors today are primarily the chemical, mineral oil and pharmaceutical industries, the automotive supply industry, mechanical engineering, the metal industry, the food industry, the health sector supported by a strong, publicly funded research landscape. The basis for the strong food industry is, among other things, the best - and sometimes most productive - soils in Germany and sometimes in Europe, which are located in the Magdeburger Boerde, and a highly automated agricultural economy. Saxony-Anhalt is thus the granary of Germany. In the meantime, a strong, highly productive pharmaceutical industry has also developed in Saxony-Anhalt. In Saxony-Anhalt, the most highly occupied occupations are in the health sector, transport and logistics occupations and manufacturing occupations.

Compared to the western German states, Saxony-Anhalt's economy faces various challenges: in productivity, innovation, export orientation and wage levels. The reasons for this are to be found in particular in the sectoral structures, the size and smallness of the companies and, last but not least, in the workforce structures (MW, 2018a). Saxony-Anhalt is in the midst of a strong demographic upheaval. In addition to the general trend of increasing life expectancy, the country is affected by further demographic challenges. With an average age of 47.9 years, Saxony-Anhalt has the oldest population in Germany (Statista 2021c). At the beginning of the 1990s, the birth rate in Saxony-Anhalt halved. This was followed in parallel by the strong migration, especially of young, well-educated people. As a result the population of Saxony-Anhalt has fallen by more than 700,000 people since

1989, a decline of one quarter. The population decline in recent years has already put considerable pressure on the availability of skilled workers in Saxony-Anhalt, which will increase in the future. Whereas in 2014 there were 1,460,610 people of working age in Saxony-Anhalt, in 2017 there were in 2017, the figure was only 1,426,949. Calculations by the Federal Statistical Office for the total period from the total period 2005 to 2020, the labour force in Saxony-Anhalt is expected to decline by a good by a good fifth.

The research and education system in Saxony-Anhalt

According to the "Grundgesetz" (Basic Law for the Federal Republic of Germany), education is a matter for the federal states, which results in different school systems within Germany. Participation in education and the types of school can differ from region to region. Hauptschulen[3] and Realschulen exist in only six states. In Saxony-Anhalt, these types of education are offered at the so-called "school types with several courses of education". In the reporting year 2020, 198,408 students attended general education schools, 45,012 attended vocational schools and there were 55,089 students in higher education institutions (Statistisches Landesamt, 2021). In 2019/20, 51,870 students in 1,701 classes attended a Gymnasium (ISCED-level 2+3A), a secondary school in the secondary education sector that leads to higher education entrance qualification (Statista, 2020). The course of education from school year 5 to 12 follows common basic guidelines. The basis is formed by a strongly equipped core area of the subjects German, Mathematics and foreign languages. Within the framework of an appropriate total number of lessons and with the aim of providing the pupils with an in-depth general education, the timetables also include a balanced number of other subjects which contribute their very specific and indispensable share. These include the individual natural sciences as well as the social sciences, the artistic and musical subjects and sport. School-specific offers are provided in the compulsory and optional areas, for example computer science. Within school years 7-9, therefore, the first foundations can be laid in the area of computer science. Within the school years 10-12 students can take computer science at the higher level if they choose to do so. In Saxony-Anhalt there are currently 3 schools which, with the approval of the Ministry of Education, are run as schools with a focus on mathematics, science and technology. In addition to the regular lessons, the students are taught in-depth and supplementary learning content in these respective focal areas.

As part of the regularly surveyed *Education Monitor* among the most efficient education systems, Saxony-Anhalt ranked 16th out of a total of 16 federal states in 2020. The study also shows that the Corona crisis has exacerbated existing problems in education especially in the area of digital equipment. Compared to the previous year, Saxony-Anhalt has fallen four places to last place. The reason for this is the above-average age of the teachers. The school dropout rate is also "alarmingly high". In 2019, the proportion of school leavers without a lower secondary school leaving certificate in the population of the same age in Saxony-Anhalt was 11.6 per cent.

The Study by the Institute of the German Economy on behalf of the New Social Market Economy Initiative evaluates the education systems of the federal states in twelve areas and on the basis of around 90 indicators. Saxony-Anhalt has strengths in school quality (4th place) and funding conditions (7th place). There is a need for action primarily in integration, input efficiency, care ratios, expenditure prioritisation, research orientation and the area of "higher education/MINT[4]". According to the authors, there is also a need to catch up in digitisation and IT training. The digital pact at schools and

[3] In Germany, "*Hauptschule*" refers to a general school form of intermediate education, i.e. level 2 according to UNESCO's ISCED classification. Primary school is the first school for all children. It is usually divided from grade 1 to grade 4. After primary school, children in Germany are divided up into the other types of school. The classic types of school are the Hauptschule (for pupils who are more skilled in crafts, 9 years), the "*Realschule*" (for children who are of average ability, 10 years) and the "*Gymnasium*" (for children who aspire to the Abitur = Higher education entrance qualification, 12 or 13 years).

[4] MINT: MINT subjects is a collective term for teaching and study subjects or professions in the fields of mathematics, information technology, natural sciences and technology.

vocational schools should be implemented quickly, teaching concepts developed and teachers trained, the study recommends (IW, 2020).

A distinctive research and science landscape has developed in Saxony-Anhalt since 1990. Saxony-Anhalt has 2 universities (Otto von Guericke University Magdeburg with about 14,000 students and the Martin Luther University of Halle-Wittenberg with 19,000 students) 8 universities of applied sciences and 29 non-university research institutions. Today, for example, there are five institutes of the Gottfried Wilhelm Leibniz Science Association, three Max Planck Institutes, one Max Planck Research Centre, two Fraunhofer facilities and sites of two major research institutions of the Helmholtz Association.

The Policy context in Saxony-Anhalt

Activities related to the health economy

To prepare for the European Union's Structural Funds period, the state government of Saxony-Anhalt summarised the framework for action in a "Saxony-Anhalt Regional Innovation Strategy 2014-2020" in 2013. This outlines the state's contribution to achieving the overarching goals of the Europe 2020 Strategy: "smart", "sustainable" and "socially inclusive" growth. Within the framework of the *Regional Innovation Strategy*, important lead and growth markets were identified for Saxony-Anhalt in 2014 on the basis of the existing core competences and specialisation advantages in the field of science and business and with a view to the future global challenges for the state: (1) Energy, Mechanical and Plant Engineering & Resource Efficiency, (2) Health and Medicine (3) Mobility and Logistics, (4) Chemistry and Bioeconomics, (5) Food and Agriculture, (6) Cross-cutting markets ICT, Key technologies & Creative industries (MW, 2014).

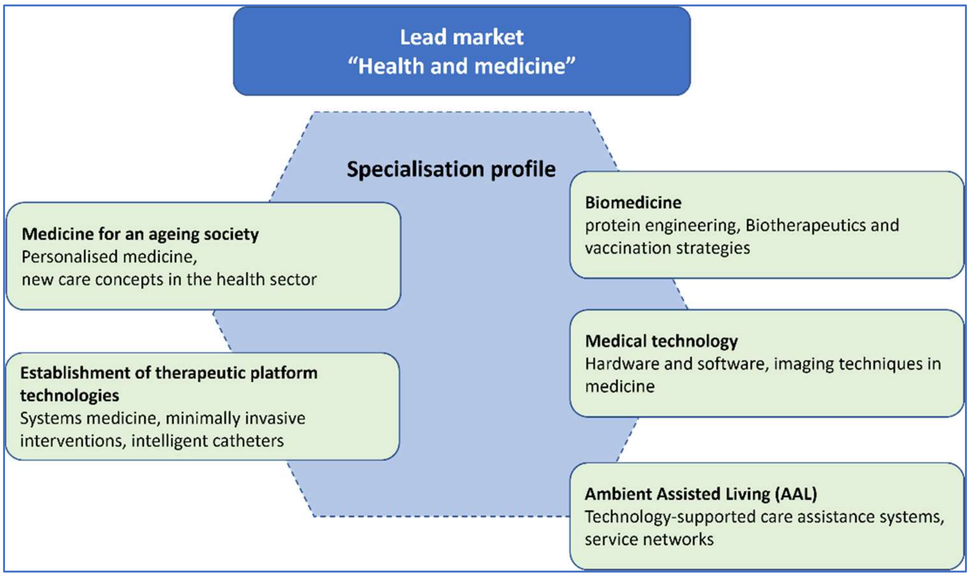


Figure 4: Lead market Health and Medicine

One of these lead markets is the field of "Health and Medicine" which is also to be strengthened in the new innovation strategy of the state of Saxony-Anhalt until 2027 through the promotion of research projects, knowledge transfer and infrastructure. Saxony-Anhalt's health sector accounts for 13.7 percent of the state's gross value added. Almost 17 percent of the state's employees subject to social insurance contributions work in health professions. Between 2010 and 2018, their number increased by 16 per cent, more than double the 7 per cent increase in overall employment. One tenth of gross value added is generated by the "industrial health industry" (pharmaceuticals, medical technology, etc.); around 16,000 people are currently employed here. Zika et al. (2017) assume that the health industry will soon be the largest industry in the eastern German states.

Saxony-Anhalt has set itself the goal of testing the age-friendly society of tomorrow with its citizens as a model. The increase in neurodegenerative (dementia) diseases, the development of suitable care structures with multi-professional and integrative approaches, as well as an overall higher level of health awareness among the population offer innovation potential that is to be effective not only regionally but also nationally and internationally. The vision for the area of "Health and Medicine" was defined as follows: *"Saxony-Anhalt's medical research and technology will become an internationally recognised centre of excellence for age-related diseases and the neurosciences".*

In Saxony-Anhalt, there is already a good basis for research into the biological mechanisms of ageing and the development of interdisciplinary possibilities for the prevention, diagnosis and therapy of age-related diseases, as well as the necessary support of care through smart AAL assistance systems[5]. In general, the health sector has an extraordinarily high socio-political importance for the country, which is based on general demographic developments and structural requirements on the one hand. Specific challenges affecting demand:

- Demographic change and ageing society with a strong increase in multimorbid and chronically ill patients
- lack of suitable care structures with multi-professional integrative structures
- Rising costs in the health care system
- Increasing health awareness and willingness of the population to privately finance pre- and after-care (VDI, GIB, 2013).

On the other hand, the health industry also represents an important economic factor for Saxony-Anhalt and is seen as an opportunity for medical-technical, bioscientific and social innovations. In individual areas such as the pharmaceutical and vaccine industry, the state can already draw on many years of experience and established structures. For example in the pharmaceutical industry, Saxony-Anhalt is the second largest production location in eastern Germany after Berlin. IDT Biologika from Dessau-Roßlau is one of three German companies currently in the process of clinically testing a corona vaccine. Saxony-Anhalt is already an established location for the development and production of innovative medical technology products. This is complemented by a high-profile research infrastructure; the range of incubation infrastructure as well as existing clusters and networks. A differentiated funding and training offer contributes to strengthening the location.

The research landscape in the health sector is framed by universities, university clinics with research focuses (neurosciences and immunology in Magdeburg and epidemiology and nursing research in Halle), renowned research institutions such as the Leibniz Institute for Neurobiology in Magdeburg and lighthouse projects with direct economic relevance such as Magdeburg's medical technology research campus STIMULATE[6], the Weinberg Campus in Halle (mainly biotechnology) or the federally funded initiative "Translational Region for Digitalised Health Care" (TDG) in the south of the state in the field of care. Like other federal states, Saxony-Anhalt has long since recognised the great potential of medical technology and has established measures to favour the settlement of new companies in this sector. Saxony-Anhalt is a globally respected R&D and economically dynamic region in the field of medical technology for image-guided minimally invasive surgery, not least through the DZNE[7] and the STIMULATE research campus. The STIMULATE is one of the ten winners in the competition organised

[5] Ambient Assisted Living includes methods, concepts, (electronic) systems, products as well as services that support the everyday life of elderly and also disabled people in a situation-dependent and unobtrusive way.
[6] Solution Centre for Image guided local Therapies
[7] At the Magdeburg site, the German Centre for Neurodegenerative Diseases e. V. concentrates on system perspectives of degenerative dementias.

by the Federal Ministry of Education and Research. Nationwide, 100 initiatives from all economic sectors applied. Over a maximum period of 14 years, up to two million euros per year will flow into this public-private partnership project from the BMBF. In addition, the partners will make their own contributions and receive substantial funding from the state. Central partners in the research campus are the OVGU, Siemens Healthcare and the STIMULATE association, which includes 20 partners from industry and non-university research. STIMULATE is thus the largest federally funded research project in Saxony-Anhalt. In the long term, the STIMULATE project is to develop into the "German Centre for Image-guided Medicine" (Sachsen-Anhalt, 2020).

The research areas in Saxony-Anhalt are characterised overall by a high level of networking between the university and non-university institutions. The educational landscape is complemented by other training institutions as well as public and private vocational training institutions with a focus on health economics.

Unique selling points of Saxony-Anhalt for the lead market "Health and Medicine"

- Good and high-profile research infrastructure with regional competence nodes and internationally visible research groups, especially in the fields of neurodegenerative diseases, protein biotechnology, biosystems technology and medical technology.
- At the Magdeburg site, the German Centre for Neurodegenerative Diseases e. V. concentrates on system perspectives. (DZNE) on systems perspectives of degenerative dementias
- Provision of incubation infrastructure in the university environment
- High degree of mobilisation and improvement of visibility, among other things through the work of clusters and networks
- Differentiated funding offer
- Training offers at all relevant levels of education that are well assessed by companies
- Globally visible and respected R&D and economically most dynamic region in the field of medical technology for image-guided minimally invasive surgery
- Very successful to partly pioneering medicine in the field of minimally invasive operations
- In Saxony-Anhalt, SMEs are developing which, through research cooperation and networks in the field of universal design and assistive technology, are gaining a leading position throughout Europe and are sustainably supporting social innovation (VDI, GIB, 2013).

Medical technology is taking an increasingly important place within the lead market of "health and medicine". Facts:

- Around 120 companies are active in the medtech market in Saxony-Anhalt - from small and medium-sized enterprises to global players. The portfolio ranges from production (e. g. plastic tubes, diagnostic detectors, ambulances, cryogenics) to hardware and software (e. g. medical imaging, telemedicine) to services (e. g. gas sterilisation, medical device propagation, distribution).
- In the Halberstadt region, the focus is on plastics. The location has cluster potential.
- The focus at the Neuromedizin-Zentrum Magdeburg is the development of state-of-the-art medical technology devices.
- Cooperation between science, research and companies is increasingly taking place via specific medical technology networks and clusters (Cluster Med-Tech, Stimulate, InnoMed) (IMG-Sachsen-Anhalt).

Cluster Medizin- und Gesundheitstechnik des Landes Sachsen-Anhalt www.medizintechnik-sachsen-anhalt.de	- Plastics technology in medicine - Surface finish for medical devices - Robotics in medicine - Medical imaging - Health care products - Rehabilitation	- Companies: 16 - University Hospitals: 1 - Universities: 1 - Research Institutes: 2	ST
Stimulate Verein e.V. www.forschungscampus-stimulate.de	- Image-guided local therapies - Medical imaging - Intelligent catheters - Medical software - MRI tools	- Companies: 16 - Universities: 1 - Research Institutes: 3	ST
InnoMed e.V. www.innomed-magdeburg.de	- Neuromedtech - Diagnostics - Ambulance vehicles - Gas sterilization - Ultrasonic measurement technologies - Medical software - Reprocessing of medical devices - Intelligent catheters - Telemedicine - Medical imaging	- Companies: 28 - University Hospitals: 1 - Universities: 2 - Research Institutes: 1	ST

Figure 5. Medical Technology Cluster Networks in Saxony-Anhalt (GTAI 2014)

Digital Policy

A particular challenge for Saxony-Anhalt is the socio-economic shaping of the digital transformation. Saxony-Anhalt is still lagging behind most other federal states in terms of digitalisation. In the *Digital Index*[8], by the *Fraunhofer Institute for Open Communication Systems*, Saxony-Anhalt ranks second to last despite significant progress (e.g. 78.3% of households are equipped with an internet connection of at least 50 Mbit/s; only 3.4 out of 100 businesses belong to the ICT sector; in terms of the IT start-up scene, Saxony-Anhalt ranks second to last; 0.4% of employees work in information technology or other ICT professions; 43.3 % of businesses report a shortage of IT specialists - the highest figure in Germany). According to the study, Saxony-Anhalt recorded the second-largest expansion performance in the provision of fast internet to private households (Hoelscher et al., 2021).

In December 2017, the state government adopted the *Digital Agenda* for Saxony-Anhalt. In this strategy paper, 157 measures of the state government were recorded that are intended to successfully shape the digital transformation in Saxony-Anhalt. The Digital Agenda for Saxony-Anhalt is divided into the following six strategic goals: "Digital Infrastructure", “Economy, Science and Work 4.0", "Education in the digital world", "Culture and Media in the Digital Transformation", "Digital services of general interest and sustainability", "Public administration as a digital service provider". The strategic goal "Economy, Science and Work 4.0" in particular addresses a series of measures to support SMEs. Examples of this are the “Mittelstand 4.0[9]” competence centre in Magdeburg and the control centre for the "Partner Network Economy 4.0". “Mittelstand 4.0” fields of activity and competence include the topics of digital business models, digital networking & standardisation, safety & security and usability & acceptance. Concrete help and orientation for the conception and targeted realisation of one's own digitalisation projects are to be shown and conveyed within the framework of workshops,

[8] Since 2017, the Competence Centre Public Information Technology (ÖFIT) at the Fraunhofer Institute FOKUS has been investigating the question: "How digital is Germany? What is the current state of digitisation in Germany at the level of the federal states?

[9] commonly refers to a group of unique businesses in German-speaking countries which are very successful and are usually capable of surviving economic turbulence. Generally small and medium-sized companies.

lectures, guidelines, learning and business games or mobile learning. The EU project "SKILLS+" (Interreg Europe) aims to improve the skills of small and medium-sized enterprises (SMEs), especially in rural areas, in the use of information and communication technologies (ICT), thus opening up the opportunities of the Digital Single Market and the digital economy to them. With the Saxony-Anhalt DIGITAL INNOVATION funding program, the state of Saxony-Anhalt supports companies in the design and implementation of investment-based digitisation projects (Sachsen-Anhalt, 2017).

In addition, the networking of business and science is an essential part of the strategic goal to develop innovative products and services from the idea to market maturity. Close cooperation between the state's universities and non-university research institutions and businesses is to be intensively supported. With the establishment of *regional digitisation centres* as control centres for digital transformation, the aim is to expand digitisation in the regions. The centres are to develop a digital strategy for the region and provide impetus for digitisation in the economy, administration and society. The *Competence Network for Applied and Transfer-oriented Research* (KAT) aims to ensure that new knowledge and innovative technologies from the universities find their way into the local economy. Transfer officers as regional contacts have the task of working with small and medium-sized enterprises to implement research and development projects for the digitalisation of their production processes and business procedures. The *ego.-INKUBATOR* and *ego.-Gründungsstransfer* (Start-up transfer) programmes enable universities to filter and further develop services and product ideas from research results. These funding programmes are particularly suitable for start-ups in the IT and creative industries as well as for the realisation of all ICT-based business models.

A central building block of the *Digital Agenda* is the area of education in the digital world. In this context, the concept of media literacy (competence) is taken as a starting point. Media literacy is seen as the "key" to the digital world. Dealing with modern media confidently and responsibly is a cultural technique like reading, writing and arithmetic. In Saxony-Anhalt, the strategy of the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK) "*Education in the Digital World*" is consistently implemented through various programmes. Agreements were made on educational and curricula, on the development of lessons, on the development of educational media and on the legal framework for the use of digital media in schools.

In this way, the use of digital media is to be increasingly promoted as part of early childhood education in day-care centres. The educational programme *Bildung:elementar* ("*Education: elementary - Education from the very beginning*") is geared, among other things, to developing media competence in children. In view of the unavoidable presence of digital media, special attention is paid to language promotion and media education. A selection of measures in the school sector:

- As of the 2018/19 school year, the state concept "*Education in the digital world through the use of digital media and tools at schools in Saxony-Anhalt*" became binding for all schools in the state.
- The subject curricula in all school types were updated until the school year 2020/21 in order to be able to develop the competences of the learners with regard to the use of digital media, technologies and tools as well as life in the digital world in a subject-integrative manner.
- Media education concepts are developed in the schools which include both school form and age-specific competence development for the pupils and school-specific further training planning for the teachers. They will be binding at every school from the school year 2021/22.
- Promoting the media competence of teachers (Further training modules on the use of digital technologies in schools on the following topics: basic knowledge and skills on school-relevant

IT applications, interdisciplinary media competences, subject didactic applications and scenarios). In-depth qualification offers, e.g. on the use and evaluation of web-based multi-media teaching and learning offers. In the first phase of teacher studies, the acquisition of digital literacy competences in teacher training courses will become mandatory in order to meet the KMK requirements for media education/digitisation. In the second phase of teacher studies, "media didactic days" on the didactic possibilities of using digital technologies in school are obligatory.

- Creation of infrastructural conditions: The state supports the school authorities in equipping the schools with ICT infrastructure and connecting them to the fibre-optic network. All schools receive specifications for minimum requirements for IT equipment and digital terminals, e.g. further expansion of the Saxony-Anhalt education server as a state-wide digital support system for teaching, establishment of a uniform web-based education management system (MW, 2018).

The digitalisation of the world of work (Work 4.0) is leading to changes in the job and qualification profiles of trainees and skilled workers. Therefore, one objective of the *Digital Agenda* is to enable trainees to learn the necessary digital competences so that they can already use the opportunities of the digital working world and networking in a forward-looking and productive way when they start their professional lives. This also includes the promotion of additional qualifications for trainees within the framework of the state's continuing education programmes. The program "*Sachsen-Anhalt WEITERBILDUNG BETRIEB*" supports SMEs in the implementation of in-company continuing education measures, also with low-threshold incentives and offers that enable companies as well as employees to acquire digital skills and knowledge. The "Sachsen-Anhalt “*WEITERBILDUNG DIREKT*" programme also promotes the career advancement and development prospects of employees. Another package of measures is dedicated to the recruitment and qualification of skilled workers. Here, too, the state provides support, e.g. within the framework of the "Skilled Workers in Focus" initiative. This is because new job profiles and forms of work will develop in the course of digitalisation (MW, 2019).

A special initiative is to promote girls and women in MINT-professions. In all phases of life, girls and women in MINT professions are supported in increasing their chances on the training and labour market. The specific programmes "Make up your MINT", "FEMININ", "Me-CoSa 4.0", "MiKA" or the updating of these programmes will contribute to career orientation, increasing the inclusion chances of single parents as well as mentoring and coaching for female students and young academics in MINT subjects at all universities and colleges in the country.

In the area of higher education, the *Digital Agenda* has defined various objectives especially related to the digitisation of higher education teaching:

- Development and use of e-journals, e-lectures, e-learning, e-assessment, SMACT technology (SocialMedia-Mobile-Analysis-Cloud-IoT),
- Broadband expansion, EDU roaming, virtual research environment, state-wide identity management (IDM) with state-wide electronic identity (eID) for students,
- Creation of e-platforms on a common basic infrastructure, state association Open Educational Resources (OER), online lecture halls, central register for qualifications.

The state supported various projects within the framework of the *Quality Pact for Teaching* (QPL) until 2020, some of them with a clear reference to digitisation in teaching (e.g. Establishment of the state-wide “Network for digital university teaching”, Founding of the Centre for Multimedia Teaching and Learning at the Martin Luther University).

The *Commission on Digitisation in Teaching of the State Rectors' Conference of Saxony-Anhalt (KDL)* notes that, in contrast to other federal states, Saxony-Anhalt has not yet had a state funding programme for digitisation in teaching. Likewise, the Teaching Obligations Ordinance (LVVO) would like to see even greater consideration for the creation and use of digital teaching offers for teachers is desirable. The universities' self-assessments showed that sustainable and competent service facilities at all universities are seen as the key to achieving the respective digitisation goals. It is clear that only the service facilities available at a higher education institution will promote the use of digital teaching and learning offerings in the desired breadth and sustainably accelerate the overall process. In addition to the lack of e-services, the higher education institutions frequently refer to the lack of digitisation strategies, in which digitisation in teaching (in addition to administrative and technical focal points) represents an important partial aspect. Other important deviations from the actual to the target are seen in relation to media competence and the consideration of digitisation in curriculum development (KDL, 2019).

In summary, Saxony-Anhalt is attempting to shape the digital transformation through initiatives at various levels. One focus is on preparing for new job profiles and forms of work in the course of digitalisation. The state's programmes are designed to provide low-threshold incentives and offers that enable companies and employees to acquire digital skills and knowledge. All these initiatives aim directly or indirectly to increase digital skills and digital literacy from school age to the workplace, including academic and vocational qualifications at all levels. In addition to schools and vocational schools, higher education institutions have a special role to play in promoting digital skills. They must increasingly offer innovative forms of teaching, learning and examination and continually adapt these to the subject-specific requirements of higher education. Therefore, in the future, university teachers will have to be even more qualified to work in virtual interactive learning environments in order to ensure high quality teaching at an international level. In the process, many digital higher education resources will be open to citizens for their individual education and training.

The digital skills pipeline

As in other sectors of the economy, the competence requirements in the medical technology sector, will continue to increase. Not only due to the digital transformation, but also due to shifts within the industry with a corresponding increase in the complexity of processes and products. Therefore, in addition to the promotion of digital skills, it is above all scientific/technical knowledge and skills as well as process thinking that must be considered and promoted in the education chain.

Further findings from the desk research and the interviews

Similar to the entire area of the health economy, it is very difficult to provide precise information on qualifications and individual occupational groups for the area of medical technology. On the one hand, this is due to the fact that there is a wide range of value creation with a high diversity of products and services and internal fields of activity within this sector (e.g. device technology provider, solution provider, digital and holistic provider of health solutions, R&D, production, service). There is no such thing as the “classic” medical technology company. In recent years also, it has become apparent that companies from outside the industry, from the automotive, software and sensor segments, are increasingly intensifying the competition (Luther and Clairfield, 2020). The sector has been subject to structural change in recent years and will continue to be so in the future, which has a corresponding effect on the structure of the workforce. In the medical technology companies generally there is a massive shift in the proportion of direct to indirect activities and thus a strong change from production to service activities. The reasons for this shift are, on the one hand, the decline in the importance of in-house production or the reduction in the scope of in-house value creation, e.g. through outsourcing of prefabrication and other functions or through relocation of production, and, on the other hand, the increase in the importance of service functions such as marketing and sales (e.g. through stronger export orientation), development (of products and software), regulatory affairs, quality management, service, etc. (Dispan 2020)

Medical technology is therefore a strongly interdisciplinary occupational field whose specialists are recruited primarily from various disciplines of engineering (medical technology, electronics, computer science, information technology) other natural sciences or economics. For example, the content of the medical technology degree programme is strongly influenced by the subject areas of mathematics, physics, electrical engineering and computer science. Meanwhile there are more than one hundred Bachelor's degree programmes and around eighty Master's degree programmes in the field of medical technology in German-speaking countries. In addition, many workers have a background of industrial-technical as well as commercial professions. These professions are usually trained in Germany within the framework of *dual vocational education and training*[10]. The system is called dual because the training takes place in two places of learning: in the company and in the vocational school. The industrial-technical training occupations offered by the companies are, for example: Surgical mechanic, tool mechanic, industrial mechanic, mechatronics technician, electronics technician, technical product designer, machine and plant operator etc. In addition, there are commercial apprenticeships such as industrial clerk, IT clerk, warehouse logistics specialist - also increasingly medical technical assistants.

Education provided and digital skills taught in the area of medical technology

With regard to the promotion of skills in the medical technology sector in Saxony-Anhalt, there are no programs specifically geared to this area. Rather, competences and skills are taught in the respective specific training occupations (VET), study programs at higher education and further education programs. Digital skills, media literacy and knowledge of mathematics, physics, biology and technology are taught more or less as part of general school education.

Referring to the promotion and teaching of digital skills as already mentioned, the guidelines for the promotion and development of digital education are being implemented by the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder of the Federal Republic of Germany (KMK) via the "*Education in the Digital World" strategy*. The recommendations and resolutions of the KMK are not binding, but are implemented individually in the Federal states (Länder). Therefore, there are also differences between the federal states with regard to the implementation of framework curricula and individual subject orientations.

Two goals are formulated for the strategy:

"1. the Länder include in their curricula and education plans as well as framework plans, starting with primary school, the competences required for active, self-determined participation in a digital world. This is not implemented via a separate curriculum for a separate subject but becomes an integrative part of the subject curricula of all subjects. Each subject contains specific approaches to competences in the digital world through its subject and action approaches […].

[10] The duration of vocational training in the dual system varies between two and three years depending on the chosen occupation. In some cases it can also be three and a half years. Formally, there are no entry requirements for access to training in the dual system; training in the dual system is basically open to all. However, the majority of trainees have a secondary school leaving certificate or even a higher education entrance qualification when they start their training.

2. In the design of teaching and learning processes, digital learning environments are systematically used in accordance with curricular requirements, following the primacy of pedagogy. The possibility of individualisation and the assumption of personal responsibility in the learning processes are strengthened by a lesson design adapted to the newly available possibilities. learning processes are strengthened" (KMK, 2016).

The term "competences in the digital world" was chosen for the competence framework that forms the basis of the KMK strategy. With regard to the concrete requirements for a school-based "education in the digital world", it goes beyond the concepts for media education developed so far and is to serve as a basis for the future revision of education, teaching and framework curricula of the subjects by the Länder. Three competence models were used for the competence framework:

- the competence model "DigComp" commissioned by the EU Commission and developed by the Institute for Prospective Technological Studies, JRC-IPTS,
- the "Competence-oriented Concept for School Media Education" of the Länder Conference on Media Education of 29.01.2015, which is widely known in Germany, and
- the model of "computer and information-related competencies" underlying the ICILS study of 2013 "Computer and information-related competencies of students in grade 8 in international comparison" underlying model of "computer and information-related competencies".

The aim is for each individual subject with its specific approaches to the digital world to make its contribution to the development of the requirements formulated in the competence framework. The "Competences in the Digital World" comprise six areas of competence:

1. **Search, process and store**
   - Search and filter (Clarify and define work and search interests; Use and develop search strategies; search in different digital environments; Identify and merge relevant sources)
   - Evaluate and assess (Analyse, interpret and critically evaluate information and data; Analyse and critically evaluate sources of information)
   - Storage and retrieval (Securely store, retrieve and access information and data from different locations; Summarise, organise and store information and data in a structured way)
2. **Communicate and cooperate**
   - Interact (Communicate using different digital means of communication; Select digital communication options in a targeted and situation-appropriate way)
   - Share (Share files, information and links; Master referencing practices (source citations)
   - Collaborate (Use digital tools for collaboration in bringing together information, data and resources; Use digital tools for collaborative development of documents)
   - Knowing and adhering to rules of conduct (netiquette) (Know and apply rules of conduct in digital interaction and cooperation; Adapt communication to the respective environment; Know and consider ethical principles in communication; Consider cultural diversity in digital environments)
   - Participate actively in society (Use public and private services; Share media experiences and engage in communicative processes; Participate actively in society as a self-determined citizen)
3. **Producing and presenting**
   - Develop and produce (Know and use several technical editing tools; Plan a production and design, present, publish or share it in different formats)
   - Further processing and integration (Edit, merge, present and publish or share content in different formats; Process information, content and existing digital products and integrate them into existing knowledge)

- Observe legal requirements (Know the meaning of copyright and intellectual property; Consider copyrights and rights of use (licences) for own and other people's works; Consider personal rights)

4. Protect and act safely

- Act safely in digital environments (Know, reflect and consider risks and dangers in digital environments; Develop and apply strategies for protection)
- Protect personal data and privacy (Consider measures for data security and data misuse; Protect privacy in digital environments through appropriate measures; Constantly update security settings; Consider youth protection and consumer protection measures)
- Protect health
- Protect nature and the environment (Consider the environmental impact of digital technologies)

5. Problem solving and acting

- Solve technical problems (Formulate requirements for digital environments; Identify technical problems; Identify needs for solutions and find solutions or develop solution strategies; Use tools according to requirements; Identify own deficits and look for solutions)
- Use digital tools and media for learning, working and problem solving (Know and creatively use a variety of digital tools; Formulate requirements for digital tools; Identify appropriate tools for solution; Adapt digital environments and tools for personal use; Identify and formulate algorithms)

6. Analysing and reflecting

- Analyse and evaluate media
- Understand and reflect on media in the digital world

Initial Education or Compulsory Education

The competence framework stipulates that students who start *primary school*[11] or enter lower secondary school in the 2018/2019 school year can acquire the competences formulated in this framework by the end of compulsory schooling (*tenth grade*)[12].

At the “Gymnasium (Grammar school)[13] , it is possible to take the subject of computer science as an optional compulsory subject. In the Gymnasium, the students acquire mathematical and scientific and technical competences in general and information technology skills in particular. The compulsory elective subject of computer science contributes to the development of study skills and thus to the general higher education entrance qualification, in that the students

- become acquainted with the concept, implementation and use of computer science systems for different areas of application deal with
- independently or in a team, identifying and analysing computer-related questions and problems, recognise, analyse, plan solutions, work out solutions, control and evaluate solutions,
- plan and realise longer-term learning processes, e. g. in the preparation of specialised theses or the implementation of projects, in a practice-oriented and plan and realise results-oriented learning processes
- document their own problem-solving processes and present the results of their work and present and interpret the results of their work according to scientific interpret them.

[11] years 1-4; students: Comprehensive, mixed abilities; outcome/qualification: Going on to secondary school

[12] years 5-10; students: For the practical-minded, preparing for vocational training; outcome/qualification: Leading to 2-3 year apprenticeship, to secondary vocational, general schools or attaining a high school diploma

[13] years 5-12; students: For above-average abilities and motivation; outcome/qualification: Leading to the exam required for studies at university/college

In the compulsory elective subject of computer science, competences at a basic level are aimed at in school years 9 to 12. In some content areas, advanced competences are also acquired. The tenth school year plays a special role in its joint function with the completion of lower secondary school and the introductory phase in preparation for the qualification phase. This is reflected, among other things, in the acquisition of competences in the content area of information and data and the corresponding focal points of school years 10 and 11 (3 hours per week possible). Starting with an iconic programming language, the skills and abilities are further developed via text-based implementation in year 10 up to object-oriented software development. In grade 12, competences acquired in the context of a software project are brought together and deepened (2 hours).

Grades	**Key areas of competence**
ninth grade	- Interpret and develop algorithms - Understand the basics of computer science systems <u>Knowledge resources</u>: Milestones in computer science; Units of measurement and coding of data; Number systems in computer science; Concept of information (information as context-related interpretation of data) ; File format as a specific description and representation of data within files; Data security as a description of all measures to secure data of any kind against loss, manipulation and other threats, manipulation and other threats; different types of data storage; logical functions and basic building blocks; basic circuits (e.g. flip-flop, half and full adder) ; EVA principle and related hardware components; computer model according to J. v. Neumann; File management ; Processes and process management ; Intranet and Internet
tenth grade (introductory phase)	- Implement and test algorithm and data structures - Understand computer science systems in the world of life and work <u>Knowledge resources:</u> Terms: class, object, instance, attribute, method ; UML diagrams: Class diagram, object diagram ; Syntax of a programming language and formal forms of description ; Basic algorithmic building blocks and their formal forms of description, and Correspondences in a programming language; Simple and structured data types; Variables and constants; assignment and comparison operators, arithmetic and logical operators; an elementary sorting procedure and an elementary encryption procedure
grade 11/12 (qualification phase)	- Course 1: Object-oriented modelling - Course 2: Acquire, structure and process data - Course 3: Software engineering and project work - Course 4: Current developments in computer science in a social context

	Knowledge resources: UML diagrams (activity or state diagram); Parameter list (value and reference parameters); Creating and removing objects (constructor: structure, function, overload and, if necessary, destructor); Validity areas, access rights and integrity; Overloading operations; Associations, inheritance; Modules and libraries; Design of graphical user interfaces; Test procedures and their application Relationship between information and data; Database system (database, database management system, frontend, backend); Relational database; Entity-relationship diagram; Entity, attributes, relation and cardinality; Normalisation of a database; Interfaces of databases; Query language for displaying and manipulating data Software engineering methods; Documentation of projects; Project planning and organization; specification of requirements; Technical design of the software; implementation and testing; quality assurance One or more topics on current developments in computer science are dealt with. The following are examples: current informatics systems and technology assessment; design of computer science systems; Virtual worlds (e.g. 3D modelling)

At the “Gymnasium”, *elective courses on key competences* are offered in preparation for school years 5-9.

"Learning methods”, year 5/6:

- Try out learning and working techniques
- Finding and processing information
- Reflect on their own use of media
- Organise and store knowledge
- Prepare and present work results in text form
- Communicate safely and responsibly on the Internet
- Use digital tools

"Work on the PC", year 7/8

- - Make good use of digital learning programmes and tools
- - Trying out complex presentations
- - Exploring tutorials as media learning aids
- - Examining and reflecting on media as a socialisation tool
- - Presenting and networking learning outcomes in multimedia form
- - actively use wikis, forums and blogs
- - Design, produce and use learning media
- - Learning by playing

"Modern Media Worlds”, year 9

- - Share digital learning environments
- - Network information and make it available for further use at the school
- - Investigate and evaluate the digitalisation of life

A subject that has proven to be additionally conducive to the development of digital and technical skills is the elective subject of *technology*. The aim is not only to give students a broad insight into various technical subject areas, but above all to use networked knowledge, e.g. knowledge from the natural sciences, in concrete applications. The competency model for the subject of technology is based on the educational standards developed and recommended by the Association of German Engineers (VDI) as objectives for general technical education and technology teaching.

Competency model for the subject technology:

- Understanding technology
- Designing and making technology
- Using technology
- Evaluating technology
- Communicating technology.

Grades	**Key areas of competence**
ninth grade	- Analyse technically shaped life situations and evaluate technical evaluate products - Justify and evaluate functionality and design in the building industry - Investigate the technical use of renewable energy resources - Evaluate safety technology, remote monitoring and remote control
tenth grade (introductory phase)	- Design and manufacture a multi-part object - Control and regulate technical systems - Develop and visualise an automation process
grade 11/12 (qualification phase)	- Course 1: Logistics - Managing Processes in Engineering - Course 2: Apply ways of thinking and working in the technical sciences - Course 3: Analysing changes in life through technical systems - Course 4: Technical internship: Developing a product prototype, planning functionality, design, cos

Due to the close connection to digital information technology, the use of digital tools and end devices is both an integral part of the learning process and an explicitly designated subject of learning in technology lessons. In general, digital tools for this are:

- web-based information retrieval and learning environments,
- the use of standard software for the presentation of results, for documentation and documentation and presentation, for structuring specialist knowledge,
- computer animations and simulations of technical processes,
- use of digital measuring equipment in experiments,
- computer-aided design and
- programming in applications of robotics and automation.

<u>Training provided at VET level</u>

At VET level, various professions can be found in the medical technology sector. A selection of typical training occupations: Medical-technical assistant for functional diagnostics; Medical-technical laboratory assistant; Electronics technician for information and systems technology; IT systems electronics technician; Telectronics technician for devices and systems; Technical assistant for medical device technology - also industrial-technical training occupations like Surgical mechanic, Tool mechanic or Industrial mechanic. These training opportunities take place at state or private sector educational institutions.

What should be emphasised is that in Saxony-Anhalt there is no possibility to take the specific training course to become a *medical technician*.

More or less, in these professions, the promotion of digital competences is already an immanent part of vocational training and should be integrated professionally within the individual learning fields.

Training provided at HEIs level:

All in all, there are various study programs at the higher education institutions that represent specialisations that are used in the medical technology sector. In addition to medical technology, these are mainly engineering and IT-focused subjects. The degree programs are networked with various non-university research and transfer institutions. See table.

The bachelor's degree program in "medical technology", which is interdisciplinary oriented can be studied at Otto von Guericke University and is explicitly geared to the industry, deserves special mention. The Otto von Guericke University Magdeburg will work together with companies in the region to secure specialists for the growing market in the field of medical technology. The Bachelor's degree program is a perfect-fit content supplement to the existing Master's degree programme in medical technology and enables consecutive, coordinated training to become a medical technology engineer at OVGU.

In order to acquire competences for later fields of application in research and business, students acquire medical and biological basics from the first semester onwards. Together with the sound technical training, these form the prerequisites for the research fields of medical imaging and physics, minimally invasive technologies, telemedicine, computer-assisted surgery or medical image processing and visualisation represented at the Magdeburg university. Occupational fields:

- Technician (support and maintenance of technical equipment in hospitals and medical practices).
- Product manager (sales, service, marketing for medical devices and equipment)
- Software developer (programming, conception of software for use on medical equipment)
- Development engineer (development of software, development tests, testing of hardware components of medical devices)
- System administrator (support of the IT infrastructure, e.g. of hospitals)
- Quality engineer (quality assurance in the development of medical devices and optimisation of development processes)
- Research (in the field of mechatronics, electrical engineering, software development with a focus on medical applications)

Currently, the programme has about 230 students and about 90 new students per year[14].

With regard to the development of digital competences, 3 compulsory modules can be identified within the curriculum that focus on this area in terms of content.

[14] https://ranking.zeit.de/che/de/studiengang/36969

Module: Computer-aided diagnosis and therapy

- Understanding of selected diagnostic and therapeutic processes.
- Ability to assess the need for computer support.
- Understanding of the criteria for the acceptance of (new) software solutions in image-based diagnostics and therapy

Module: Basics of image processing

- Ability to develop methods to solve an image processing problem.
- Basic analytical problem solving skills.
- Ability to apply a rapid prototyping language in image and signal processing.

Module: Fundamentals of Computer Science for Engineers

- Computer as a working tool, algorithms and programming, basic principles of programming in C, data structures, functions, pointers and files, object-oriented programming C++, graphics, database systems, software technology, applications.

Within the study program "Biomedical engineering", the modules "Biomedical and Scientific Computing", "Biosignal processing" and "Digital image processing" focus on digital competencies and skills.

Further training opportunities:

At the academic level, there are study and further education programs that can be assigned to the health sector and thus also indirectly relate to the field of medical technology. In addition, university and non-university research networks such as the *Stimulate* research campus also offer opportunities for demand-oriented continuing education, for example for companies.

In the area of continuing vocational education and training, there are also offers that relate to the medical technology sector and are primarily offered by private educational institutions and are mostly in the form of e-learning or blended learning formats, e.g. Basics Process Auditor Medical Devices, Medical technology and pharmaceutical industry. Overall, in the area of continuing education, there are very few offers for the medical technology sector. More extensive and differentiated offers are more likely to be found in the supra-regional context.

Actors, research and education in Medical technology Saxony-Anhalt

Universities and non-university research	• Otto-von-Guericke University Magdeburg (OvGU) (Faculty of Medicine, Faculty of Electrical Engineering and Information Technology) • Martin Luther University Halle-Wittenberg (MLU) (Faculty of Medicine, Faculty of Natural Sciences) • Harz University of Applied Sciences, Wernigerode • Magdeburg-Stendal University of Applied Sciences • Project Group Molecular Drug Biochemistry and Therapy Development (IZI-MWT) at the Fraunhofer Institute for Immunology and Cell Therapy (IZI) • Max Planck Institute for Dynamics of Complex Technical Systems Magdeburg (MPI)

	• Fraunhofer Institute for Microstructure of Materials and Systems (IMWS) • Fraunhofer Institute for Factory Operation and Automation (IFF) • Leibniz Institute for Neurobiology Magdeburg (LIN)
Transfer and research institutions	• German Centre for Neurodegenerative Diseases (DZNE) • Centre for Behavioral Brain Sciences (LIN /DZNE) • Centre for Dynamic Systems (OvGU, MPI) • Health Campus Immunology, Infectiology and Inflammation (OvGU) • Research Campus STIMULATE • Centre for Neuroscientific Innovation and Technology ZENIT GmbH • Biozentrum Halle (MLU) • Inno-Life Innovation and Start-up Centre • KAT Competence Centre Life Science (Anhalt University of Applied Sciences) • Centre for Innovation Competence "HALOmem membrane protein structure dynamics" (MLU) • Profile Centre for Health Sciences (PGZ), (MLU) • Interdisciplinary Centre for Ageing Halle (IZAH), (MLU) • Institute for Medicine & Technology e. V., (Anhalt University of Applied Science) • Ultrasound Research Centre gGmbH • Health + IT Campus
Education	Study programs: • "Biomedical engineering" (Bachelor of Engineering; Master of Science), Anhalt University of Applied Science • „Pharmaceutical engineering“ (Bachelor of Engineering), Anhalt University of Applied Science • "Medical physics" (B.SC.), Martin Luther University Halle-Wittenberg (MLU) • "Medical technology" (B.SC.), "Medical Systems Engineering" (M.SC.), "Electrical Engineering and Information Technology", (B.SC.), "Computational Visualistics" (B.SC.), "Systems Engineering and Technical Cybernetics" (B.SC.), Otto-von-Guericke University Magdeburg; • "Computer Science" (B.SC:), Otto-von-Guericke University Magdeburg, Martin Luther University Halle-Wittenberg (MLU), Harz University of Applied Sciences • "Bioinformatics" (Bachelor of Science), Martin Luther University Halle-Wittenberg (MLU) More and further education: • „Pharmaceutical and Industrial Biotechnology“ (Master of Science), „Medicine“, „Health and care sciences“ (Master of

	Science), „Medicine-Ethics-Law“ (Master of Medicin, Ethics and Law), Martin Luther University Halle-Wittenberg (MLU) • “Health promotion and management” (Bachelor of Arts), „Applied Health Sciences“, „Medical Management“ (Bachelor of Arts), Magdeburg-Stendal University of Applied Sciences • “Medicine”, Otto-von-Guericke University Magdeburg Vocational Education and Training: (Selection) • Medical-technical assistant for functional diagnostics • Medical-technical laboratory assistant • Electronics technician for information and systems technology • IT systems electronics technician • Telectronics technician for devices and systems • Technical assistant for medical device technology

Escalator partners

Stakeholders from Otto von Guericke University, 6 companies from the medical technology sector and InnoMed an association representing the interests of medical technology were involved in the preparation of the report. In addition, potential stakeholders and interested parties are named who can be involved in the future for a deeper discussion and implementation of the ideas behind the Escalator model.

Policy stakeholder:

- State capital Magdeburg
- Ministry of Economy and Ministry of Education of Saxony-Anhalt

Economy/networks:

- AWSA - Employers' and Business Associations Saxony-Anhalt e. V.
- Chamber of Commerce and Industry, IHK
- Association of German Engineers, Saxony-Anhalt Regional Office
- Association of the IT and Multimedia Industry Saxony-Anhalt e. V.
- Cluster Med-Tech, Medical Technology Cluster of the State of Saxony-Anhalt
- Stimulate, Research Campus
- InnoMed e.V.

Education: The universities in Saxony-Anhalt with the corresponding faculties can be approached here, as they teach subjects that are very strongly represented in the field of medical technology. In addition, scientific research and transfer institutions.

Aligned Investments

The health industry is also to play a strong role in the new innovation strategy of the state of Saxony-Anhalt. Since 2014, the state and the EU have invested around 100 million euros in research, transfer and infrastructure. This has a corresponding effect on the medical technology sector. In addition, there are subsidies and programmes that primarily aim to improve the framework conditions for digitisation efforts and provide financial support for innovative projects, qualification opportunities and organisational development activities.

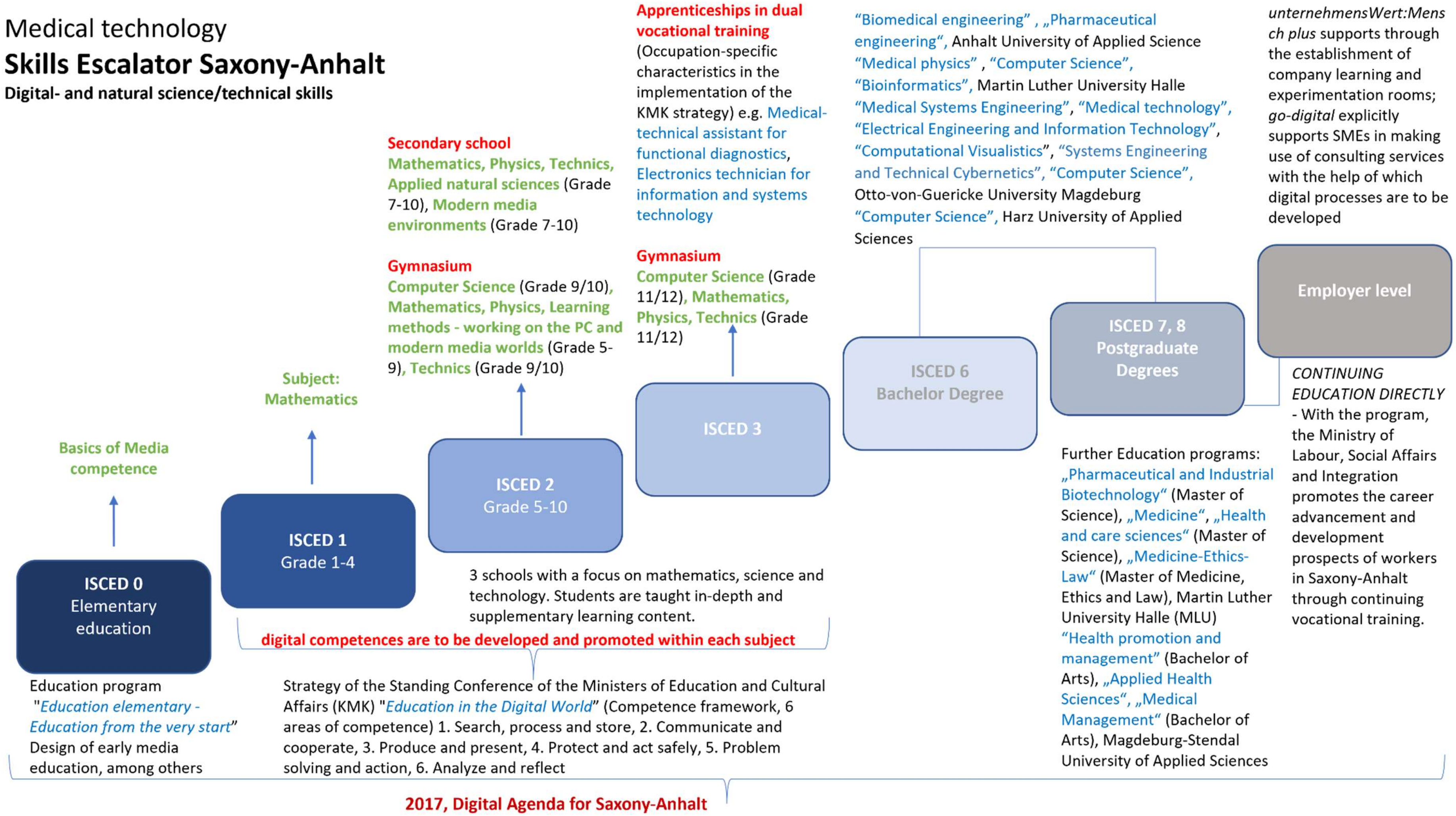
- In order to accelerate the transfer of technology from the pre-competitive field to practical application and to further strengthen the innovation potential of SMEs, the state of Saxony-Anhalt established the Medical and Health Technology Cluster (Med-Tech) on 1 July 2014. As a result, this particularly promising sector of the economy is supported by the state government as part of the innovation strategy geared to the lead market. supported by the state government.
- Future-oriented concepts of medical treatment are to be developed at the STIMULATE research campus in Magdeburg. The STIMULATE research campus is a binding public-private partnership between Otto von Guericke University Magdeburg, Siemens Healthcare GmbH and the STIMULATE Association, which brings together companies, non-university research institutions and other stakeholders. The state of Saxony-Anhalt has approved the construction of a dedicated research building for STIMULATE. In the immediate vicinity, settlement opportunities have been created for the business partners of the research campus: A medical technology campus is being created.
- Another lighthouse project is the further development of the Weinberg Campus in Halle. The technology park is the innovation location for life sciences, biomedicine and material sciences. The scientific foundation is formed by a large number of institutes and companies, such as the Fraunhofer Institute for Microstructure of Materials and Systems, the Helmholtz Centre for Environmental Research, the Leibnitz Institute for Plant Biochemistry and the Max Planck Institute for Microstructure Physics.
- Ageing research in Saxony-Anhalt: In three funding periods until 2022, interdisciplinary collaborative projects at various locations in Saxony-Anhalt are researching solutions to the challenges of demographic change under the guiding theme of "Autonomy in old age".
- Small and medium-sized enterprises (SMEs) with their registered office in Saxony-Anhalt can take advantage of a number of different funding programs in the area of digitalisation: *Digital Jetzt - Innovation Promotion for SMEs; Digital Creativity* in particular the media and creative industries sector; *unternehmensWert:Mensch plus* supports through the establishment of company learning and experimentation rooms; *go-digital* explicitly supports SMEs in making use of consulting services with the help of which digital processes are to be developed.
- Saxony-Anhalt *CONTINUING EDUCATION DIRECTLY (WEITERBILDUNG DIREKT)* - With the program, the Ministry of Labour, Social Affairs and Integration promotes the career advancement and development prospects of workers in Saxony-Anhalt through continuing vocational training. Special attention is given to supporting older people, low-income earners, single parents and people with disabilities. The costs of individual vocational training and qualification projects lasting up to 4 years are financially subsidised by up to 90 percent from the European Social Fund.
- Integration of Saxony-Anhalt into the national initiative "MINT Zukunft schaffen! (Promotion of STEM careers). The initiative focuses on getting students excited about STEM and on motivating, promoting and awarding schools in the field of STEM. To this end, the STEM

profiles of schools in general and the computer science and digitalisation profile in particular are being focused on through the "STEM-friendly school" and "digital school" programs. The other goals of the "MINT Zukunft schaffen!" initiative are to increase the number of first-year students in STEM courses at universities in Germany, and in particular to increase the proportion of women, and to ensure and increase the quality of graduates from STEM courses and professions.[15]

- DigitalPact School 2019 – 2024: For the creation or optimisation of efficient digital infrastructures conducive to learning for schools, the further development of their educational mission with a view to the requirements in the digital world and for the needs-based qualification of teaching staff, the Federal Government will provide 5 billion euros from the special fund "Digital Infrastructure" as financial assistance for all Länder in the period 2019-2024. With the support of the federal government, 137,582,000 euros in funding will be invested in school education infrastructure and teacher training in the state of Saxony-Anhalt.
- The creation of infrastructure for the further digital development of Saxony-Anhalt is a fundamental necessity. Here, the state has a lot of catching up to do in comparison to other German and international states. By 2025, ultra-fast internet connections with download speeds of at least one gigabit per second are to be available to all businesses and households. Saxony-Anhalt's gigabit strategy was developed in a broad dialogue with leading municipal associations, parliamentary groups, industry associations and other important partners. It replaces the previous broadband strategy from 2015 and for the first time also includes other areas such as mobile communications (5G) and WLAN.

[15] https://mintzukunftschaffen.de/die-initiative/

Model creation



Resultant Skills Priorities and Recommendations

Digital Skills Gaps in Saxony-Anhalt needing to be addressed

Germany and Saxony-Anhalt experienced a strong digitalisation dynamic in many fields in the pandemic year from 2020 to 2021. Nevertheless, there are still many backlogs in the international arena. Germany has fallen behind many other OECD countries in the expansion of its digital infrastructure as well as in the use of digital technologies and services. This is also evident in Saxony-Anhalt, which is at the back of the pack in terms of digital development within Germany. With regard to the development of digital skills for broad sections of the population and the creation of the necessary infrastructural and political framework conditions, there is still a considerable need for action in Saxony-Anhalt. This necessity also points to needs among digital skilled workers. This is particularly evident in the IT sector. Companies in Saxony-Anhalt with ten or more employees are clearly feeling the IT skills shortage. 79 percent of the companies that tried to recruit IT specialists reported difficulties. In no other federal state did so many companies have problems in 2020 (for comparison: Germany 66 percent). The desk research as well as the interviews and discussions on the Escalator report showed current fields of action that are perceived as important for a better development of digital competences in the broad population:

- **Problem area digitisation of schools**: Corona pandemic has shown how important the digitalisation of schools is but also in which areas the country is still lagging behind. There is a clear digital divide between the schools. Digital potentials are developed to different degrees, between digital pioneers and laggards. Primary, secondary and intermediate schools, in particular, are digitally cut off. These disadvantages are consequences of differently developed digital school strategies and infrastructures. A fundamental problem is the poor connection of Saxony-Anhalt's schools to stable internet access. At the end of 2020, for example, only 100 of the 840 school locations were connected to ultra-fast fibre-optic connections with transmission rates of up to one gigabit per second. There are also significant needs in the corresponding technical equipment of schools, for example, to develop digital competences within lessons or to be able to implement distance learning. The widespread use of digital teaching technology is not yet possible. In Germany in lower secondary general education, less than half of students attend institutions that have learning management systems (45%), Wi-Fi (26%) or internet-based collaborative work applications (17%) (National Education Report 2020). An example of the lack of equipment is that teachers in Saxony-Anhalt do not have access to service laptops, which means that they have to carry out many distance learning activities with private devices. Staff are needed to maintain the new technology in schools. But network supervisors are currently in short supply at Saxony-Anhalt's schools. The federal government and the state want to provide 15 million euros to hire specialists or train teachers accordingly. Schools receive support in terms of software, infrastructure and cloud services and can build a reliable and efficient educational infrastructure with a partner at their side. On this basis, teachers will be able to fulfil their teaching mission with the help of digital technology and also on the topic of digitalisation, as well as to develop new pedagogical and didactic concepts.
  Schools need to develop strategies for developing digital learning concepts and building digital infrastructures. Such a strategy development should be designed as a participatory process

of all stakeholder groups involved in the school (school management, teachers, students, parents).

- **Lack of promotion of STEM education**: The results of the “MINT Young talent barometer 2021” show developments that affect Germany as a whole, but which naturally also require action for Saxony-Anhalt.
    - The mathematical and scientific competencies of primary school children are below the EU and OECD average. Around a quarter of them performance is weak - in science, this group has grown group has grown significantly since 2015.
    - In an international comparison, teachers in German primary schools attend in-service training on digital media in the classroom less frequently.
    - The gender-specific choice of subjects has hardly changed for years: Boys dominate in physics or technology. Only 25 per cent of girls take physics as an advanced course, only 11 per cent of young women take up STEM education, and only 25 per cent of female students start an engineering degree.
    - More than every fifth STEM apprenticeship is broken off.
    - Due to demographically induced declining numbers of first-year students and at the same time growing numbers of pupils, this shortage of STEM teachers will intensify in the next ten years.
- **Lack of preparation of content for the requirements of a digitally oriented working world:** To seriously prepare young people for the "digital world", more computer science is needed in the classroom. A look at the labour market shows the growing need for graduates to be able to use computer programmes and the internet. Applicants who can programme software are already in high demand. However, the preparation by schools for these requirements must be significantly improved. The need for action is particularly evident in the fact that in Germany, computer science is a compulsory subject at secondary level in only 3 of the Federal States. The subject is not compulsory in Saxony-Anhalt either. Furthermore, most schools have too few qualified subject teachers.
- **Lack of IT-skills of teachers**: The success and quality of the development of digital competences depends on the extent to which teachers are also able to align teaching and learning concepts to this and also recognise the potential of using digital media. One reason for this is that digital skills have hardly played a role in teacher training to date. The penetration of a functioning digital education concept in schools is also influenced by the structural situation in schools. Saxony-Anhalt in particular is characterised by a shortage of teachers and a relatively high average age of teachers. Overall, the digital competences of teachers at all levels of education, from general education and vocational schools to higher education and adult education, need to be further developed. In addition, there is also a lack of target-oriented concepts for dovetailing face-to-face and distance learning and of support for pedagogical teachers in the professional use of digital media (National Academy of Sciences Leopoldina 2020). In the educational institutions themselves, however, digital media have so far often only been used in a limited spectrum - for example as a tool for the reception of information and less for the individual support of learners or for the support of cooperative learning settings. There is a need to establish a state-wide IT infrastructure that promotes learning and involves the actors at the state level, the municipalities and the individual schools. Digital competences must be an integral part of teacher education (teachers at schools, universities and further education institutions) – in teacher training and study seminars. This includes for example the targeted promotion of teaching innovations and the strengthening of continuing education opportunities for teachers.

- **The topic of digitisation had a subordinate role in the strategic planning of most universities:** The management structures of higher education institutions, some of which are not very professional, and the lack of leadership can also be cited as barriers to effective digitisation (EFI 2019, Gilch et al. 2019). Despite much progress due to the Covid 19 pandemic, digitalisation and also the development of digital competences are still not sufficiently located and shaped as a strategic issue. The digitization strategy must rather manifest itself in fundamental cultural and social changes. The conception and implementation of this strategy may therefore not simply be delegated to e-learning representatives, to heads of computer centres and CIOs. The university management must push ahead with the development and implementation of an adequate and stringent strategy and ensure it in cooperation with all university members.
- **Lack of Monitoring the demand for skilled labour**: The state of knowledge about which competences will be important for skilled workers in the future depends on appropriate assessment tools, which look at the developments on the labour market. there is no comprehensive regular monitoring of the future demand for skilled labour, the continuous demographic regional, sectoral and skills developments in a regularly adjusted forecast.
- **Lack of framework conditions for lifelong learning:** Overall, many structures for guidance and support of lifelong learning are not yet optimally coordinated. Need for action:
    - Creation of comparable and quality-assured offers (e.g. certificates, degrees, recognition by companies)
    - Content and requirements must be more closely coordinated between education providers, such as universities and private providers, as well as the economy and companies (communication arenas need to be improved for this; Monitoring instruments needed)
    - Hardly any offers that can be flexibly integrated into the working day (just-in-time)
    - Little overview for interested parties as to what can be occupied in which form
    - Career transitions are hardly systematically promoted to accompany advancement from the middle qualification level.
    - Workers are often not shown ways to develop new career options through lifelong learning.
    - Universities do not offer enough continuing education with a focus on digital transformation.

Higher Level Smart Specialisation Sector skills gaps needing to be addressed

The future development of the medical technology sector in Saxony-Anhalt is generally dependent on the availability and quality of the corresponding professionals in the highly qualified field, as well as the skilled workers. The focus here is on the STEM professions (in the fields of mathematics, computer science, natural science and technology) and technical professions of vocation education.

Therefore, activities should be focused on getting more pupils and students interested in and prepared for technology-oriented professions. Here, the country has strengths and weaknesses. Saxony-Anhalt, for example, is the only federal state to offer an independent subject of technology for all grades. Due to the good results in the latest IQB school achievement tests from 2018 in mathematics and science as well as in reading for ninth graders, Saxony-Anhalt reaches 4th place in school quality behind Saxony, Bavaria and Thuringia. Saxony-Anhalt ranks second to last in the number of dual study entrants measured against the total population. At 4.9 per cent, the proportion of engineering graduates to employed engineers subject to social insurance contributions was again below average (national average: 6 per cent). In addition, the STEM share of the scientific and artistic staff at the universities, at 29.6 per cent, was lower than the national average (34.3 per cent) (INSM Education Monitor 2021).

Although the statements from the companies and actors interviewed do not provide a comprehensive picture, they confirm general developments and also point to specific problems and situations in Saxony-Anhalt.

With regard to the estimates of future trends in the field of medical technology in general and also specifically for the company, a further digitalisation of business models and processes is expected, also through the stronger networking of different technologies. Production and innovation cycles are becoming faster and faster due to digitalisation. The need for specialists who have a deep understanding of instruments, their function and composition also for digital processes is increasing. Further needs are seen accordingly in engineering and business management knowledge.

Currently, gaps are seen in social skills in addition to technical skills, e.g. independent work/organisation, self-assessment). In addition, a lack of digital skills and programming knowledge was named for individual fields of activity.

A regional need for skilled workers is recognised. The lack of highly qualified specialists is explained on the one hand by the fact that many graduates of the relevant disciplines leave the country after graduation, and on the other hand there is sometimes too little cooperation between universities and companies. Often, no attention is paid to the real needs of the companies. In addition, there is criticism that there are too few training occupations in the field of medical technology, which means that there is a lack of skilled workers at middle and lower levels (production, assembly line).

Various solutions for meeting the long-term demand for skilled workers have been proposed or are already being pursued. For example, companies offer internships (sometimes with subsequent employment) and a company's own dual study programme as well as supervision of student research projects. Furthermore, it is emphasised that in addition to enabling further training, the training of own skilled workers via the dual system is becoming more important. It is almost impossible to find skilled workers for many activities through pure recruitment. In addition, the further intensified cooperation between economy and academic education is encouraged.

With regard to the regional education and qualification situation, the picture was quite mixed. Overall, the general conditions for the field of medical technology in Saxony-Anhalt are assessed as good. Most companies employ people from the region who have also completed their training and studies here. The companies also benefit from the regional educational structures, especially at the universities and universities of applied sciences, and some of them have settled here deliberately for this reason. Regional continuing education opportunities and offers are viewed very critically. There are only a few offers from the higher education institutions - the universities and private education providers should create more demand-oriented offers for companies. This also includes digital offerings that enable more individualised learning for the workforce. This must continue to be supported by the state. Furthermore, medical technology with corresponding professions should also be increasingly reflected in vocational training.

Recommendations to tackle the above Skills Gaps

Increasing the attractiveness of vocational training: The statements of the interviewees see above all a necessity in ensuring the availability of qualified skilled workers. It is becoming increasingly difficult to find suitable young people for industrial-technical apprenticeships. Fundamentally, companies and schools must find ways to generate more interest in industrial-technical training (arouse interest in technical contexts, for example through subjects such as "technology" or practical projects; many industrial-technical professions are simply unknown and need to be made known to young people; employers have to show the future prospects of these occupations and make it clear that trained professionals will still be in demand; more transparency in training remuneration and salary prospects).

Vocational training must be continuously developed and made more dynamic in view of ever new occupational requirements. In vocational education and training in particular, training regulations as well as learning field concepts and curricula must be adapted to the requirements of digitisation. To this end, an intensive exchange with the needs and practical requirements of businesses and industry must be ensured. The existing principle of dual vocational training already offers very good conditions for this. The dual system therefore needs to be strengthened by the state and must remain as an attractive career and qualification path. This can be promoted by more permeability and the link between vocational and academic education.

One recommendation for improving the skilled labour situation and better adapting to the specific needs of companies would be the introduction of a medical technology vocational training programme. This exists in part in other federal states, but not in Saxony-Anhalt. Companies should also become more involved in vocational training within the dual system in view of their own need for skilled workers, in order to recruit their own junior staff.

Stronger promotion of talent in STEM subjects: The aim must be to arouse interest in STEM among pupils at an early stage, to discover gifted pupils and to support them in an appropriate way. Here, cooperation between the schools and the economy must be strengthened in coordination with a strategic profile sharpening by the schools (pedagogy and learning cultures, qualification of the teaching staff, regional networking, stabilisation, technology and equipment). Existing initiatives must be expanded in order to increasingly address and promote girls and young women for these subjects.

Fundamental creation of the conditions for the development of digital skills in Saxony-Anhalt's schools: However, in order to teach digital competences in general education schools, there must also be personnel and technical as well as formal prerequisites. It would be necessary to equip them with a sufficient number of computers that also have the corresponding up-to-date programmes. In addition, a curriculum would have to be developed that would set transparent and binding standards for learning content. Above all, however, staff would be needed who not only have the ability to teach, but also the digital skills to teach. digital competences that they are supposed to teach. Teachers would have to be trained for this be trained. However, the half-life of computer-related knowledge seems to be shorter than that of most other subjects. It would therefore be necessary to continuously train teachers and motivate them to continuously deal with digital content and competences.

Promotion of Lifelong Learning and on the job training: The development of the digital strategy should also take more account of the education policy component, which can be achieved by adapting educational content and digital training to prepare employees well for the medical technology sector and supporting long-term labour market success. Companies must establish strategies for a continuous education process to support the development of digital- and further skills of the workforce. At the same time, in order to maintain the employability and employment prospects of today's employees, more flexible and individualized paths of digital training must be created (new practice-oriented Blended Learning Concepts for On-the-job-Training). For the acquisition and development of digital skills, relevant support programs must include tax incentives for both companies as well as for employed persons. Especially SMEs need more financial support for further education and training advice. At the same time, the bureaucratic processes for companies and individuals to apply for financial support must be simplified.

Promoting further networking of the players in medical technology: More further training opportunities and more flexible structures need to be established for the medical technology sector in Saxony-Anhalt. Here, the medical technology clusters and networks that already exist should also place a stronger focus on developing demand-oriented and adapted qualification opportunities together with the education and research partners.

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