

Fields of Application of Artificial Intelligence—Health Care, Education and Human Resource Management

6

Abstract

In this chapter you will learn a lot about the different fields of application for AI in the healthcare sector. It starts with a comprehensive evaluation of health data to increase the quality of diagnosis. The use of Artificial Intelligence can also lead to a relief of routine tasks in health care—so that doctors and nursing staff can spend more time with patients. Artificial Intelligence can also make a significant contribution to closing the strategic qualification gap in training and further education. In addition to the technical infrastructure, this requires in particular the education of the lecturers themselves; because their knowledge is also becoming outdated faster and faster. A larger field of AI applications is already available in companies through applications of virtual reality and augmented reality. Artificial Intelligence can also provide support in HR management—e.g. in the acquisition of new employees. Online platforms can help to bring together supply and demand here.

6.1 Health Care Applications to Improve Standard Processes

It is to be expected and hoped that the use of Artificial Intelligence in healthcare will improve the attainable quality of life through new medical achievements. A large number of AI applications are already available today. Large AI players in the medical field are currently *Google, IBM, Isabel Healthcare, NEC, Nuance, Microsoft, Ipsoft, Rocket Fuel* and *Fingenius*.

Digitalization will initially make it possible to prepare a wide range of **medical data for AI application**. The spectrum here ranges from **patient files** to the—in part already digitally available—**results of examinations** to the **personal health data** generated by wearables and apps (cf. Pinker, 2017; Stanford University, 2016,

p. 25). Artificial Intelligence can play off many of its advantages in the medical sector:

- Simultaneous access to hundreds of thousands or millions of relevant historical image and text documents (including reviews) for diagnostic purposes
- Real-time access to new insights gained by researchers and/or colleagues in their daily work (including clinical trials)
- Evaluation of the complete medical file of the respective patient, so that the corresponding data is available in a linked form
- AI-supported questioning of the patient to supplement any missing information and/or to test hypotheses
- Derivation of therapy recommendations which are based on a large number of therapy recommendations from third parties and the achieved results.

The **medical fields of application of Artificial Intelligence** can be grouped as follows:

- Diagnostic-supporting applications
- Diagnostic-replacing applications
- Therapy-supporting applications
- Therapy-replacing applications.

There are still many challenges to overcome on the way there. There are problems with the **interpretation of medical notes** by doctors and with the **interdisciplinary transfer of results** (also for reasons of data protection). As long as in countries like Germany a decentralized health care system is dominant and an integrated patient file (with a complete documentation of diagnoses, therapies and therapy successes) is only available as a concept, the evaluation possibilities remain very limited. In addition, as with all AI systems, a **comprehensive and intensive training phase** is required to equip AI applications such as *Watson* with the necessary data (cf. Waters, 2016; Bloomberg, 2017). A consolidated data basis that brings together anonymous medical records from a wide variety of sources is still missing in many countries.

Individual AI applications already exist. *Watson for Oncology*—an AI program for cancer detection—is used today in 230 hospitals to help physicians diagnose and treat cancer. The experience gained with *Watson Health* is incorporated into the AI algorithms for further training (cf. Rossi, 2018, p. 21). The limits of Artificial Intelligence are still evident here. As already mentioned, each AI system must be calibrated for the respective field of application. In the case of health care, it must first learn all the relevant terms and also the type of formulations in doctor's letters and examination findings. How can the statement "... could not be excluded" be evaluated? Is there something or not? In addition, the AI systems must learn the common medical abbreviations. Also, a variety of relevant guidelines and common therapies must be covered. Sometimes *Watson* already fails because of speech recognition! Again, the following applies: The system must still be fed

comprehensively with relevant data and the results need to intensively analyse the data streams until the system approaches or even surpasses that of good doctors in terms of its ability (cf. Müller, 2018a, p. 106f.; Burgess, 2018, p. 32). There is still a long way to go from a diagnostic-supporting to a diagnostic-replacing application.

The so-called *Camelyon Grand Challenge 2016* delivered interesting results in this area. This showed that the combination of machines and people lead to the best results. A team of *Harvard* and *MIT* researchers developed a deep learning algorithm for medicine to detect metastatic breast cancer. The pathologist was in direct comparison superior with a correct prediction in 96.6% of the cases of the machine with 92.5%. In a second test, the predictions of pathologists and machines were combined—with a result of 99.5% accuracy (cf. Wang, Khosla, Gargeya, Irshad, & Beck, 2016). This corresponds to an 85% reduction in the error rate if the machine supports it!

The division of labor based on this began in the area where the opposite side was bad. The pathologist can better estimate that someone has breast cancer while the machine was better at saying that someone does not have breast cancer. As in other teams, the weaknesses of an individual are thus addressed, and better solutions are achieved. For machines it is much harder to make the right decisions in unknown situations with data poverty. In contrast, it is generally more difficult for people to quickly recognize the correct patterns on the basis of a large volume of data. This insight can be applied to cognitive work through two different approaches. Either the machine makes a suggestion and the person builds on this decision or the decision of a person is judged afterwards by the machine (cf. Agrawal, Gans, & Goldfarb, 2018, pp. 65–67). In any case it is again a **diagnostic-supporting application**.

The Danish AI software company *FastCompany* tested its *Corti* AI system by letting a computer listen when people in the **call center** answer emergency calls. When someone outside a hospital suffers cardiac arrest, time is crucial: the chance of survival decreases by about 10% every minute. Therefore, the first step in recognizing that a cardiac arrest is involved is a particular challenge for call center agents—after all, it is important to correctly understand the symptoms often transmitted by panicked friends or relatives (cf. Peters, 2018).

In Copenhagen, call center agents are therefore supported by the **Corti AI system**. When an ambulance is called, the AI Assistant *Corti* is also on the phone. NLP evaluates the conversation in context and provides the agent with real-time notifications based on this information. *Corti* not only analyses what and how a person said something (e.g. tone of voice), but also takes into account the background noise. This made it possible to detect heart attacks with a success rate of 93% compared to 73% in human assessments (cf. Peters, 2018).

6.2 Digital Twins and Human Brain Projects

Another AI research field in the healthcare sector is concerned with the **development of digital twins**. Section 2.5 already described the creation of such twins for machines and plants. The medical sector deals with the virtual (digital) representation of human organs (e.g. heart, kidney, liver) or the complete human being itself. The digital mirror images created in this way can be used to simulate the state of health and the effects of a therapy. The aim is to try out the right treatment methods—without turning the real person into a guinea pig.

Institutions and companies such as the *Fraunhofer Institute*, the *Helmholtz Association of German Research Centers* as well as *Siemens Healthineers* and *Philips* are working on the **artificial birth of digital twins**. Today, it is not yet possible to predict when the corresponding breakthroughs will be achieved. The vision is not only to carry out an **integrated evaluation of all relevant patient data** (such as laboratory values and data from CT and MRI examinations) using this digital twin. The target is to simulate the entire process from prevention to diagnosis, therapy and aftercare—and on this basis to establish optimal patient care (cf. n.a., 2018a, p. 18). This is a **diagnostic and therapy supporting application**.

The following development has been observed in this field. In the past, scientists gained their knowledge “in vivo”, i.e. by observing or experimenting with living organisms. Later, such experiments can be carried out “in vitro”, i.e. in a test tube. Now the step to “in silico” is preferred because such experiments now take place in the computer—and their chips are based on the chemical element silicon.

Another AI application field tries to encode the secrets of the human brain. The new findings will make it possible to develop alternative treatment methods for neural diseases. The **Human Brain Project** (HBP) is one such an initiative. Here, an interdisciplinary team of experts consisting of scientists is striving to pass on their results through a “Medical Informatics Platform”. These relevant findings result from the combination of patient data, the knowledge of neuroscience and the results of clinical research (cf. HBP, 2017).

At the European level, these developments are being driven forward by a major **EU funding project**. The aim is to penetrate the processes in the brain even more precisely in order to use the findings there for AI systems. Originally, the human brain was to be simulated by a computer within ten years. This objective has long since been abandoned. A reproduction of the “general” intelligence of humans still represents an insurmountable obstacle for researchers (cf. Wolfangel, 2018, p. 33).

The **Human Genome Project** is already delivering tangible results. In 2003, the human genome was decoded after thirteen years at a total cost of US-\$ 2.3 billion. Today, the same analysis often costs less than US-\$ 100—and takes only a fraction of the time (cf. NHGRI, 2016). Depending on the respective data protection situation, the information generated in this way could be supplemented by further personal data. These can be obtained through wearables, apps or access to social media content. In this way, an **individual health status** could be created that also includes all genetic predispositions. Based on this, an **individual nutrition plan**

could be developed that exactly corresponds to the genetic profile of the user. In addition, it would be possible to derive an **individualized medication** (keyword **individualized medicine**) that optimally weighs effects and side effects on the individual organism with its particular characteristics (cf. McKinsey, 2013, pp. 90–92; Taverniti & Guglielmetti, 2012, pp. 3–5).

In this context, the so-called **Angelina Jolie effect** is spoken of. What happened? In May 2013, *Angelina Jolie* announced that she had both breasts amputated to protect herself against breast cancer. Her personal risk of developing breast cancer had been particularly high due to a particular genetic trait. This characteristic was recognized by a gene analysis. Since then, more and more breast cancer genetic tests have been carried out because women want to know their personal cancer risk. With certain genetic characteristics, the risk of developing breast cancer increases to up to 80% (cf. n.a., 2016b).

In 2018, the following case was reported from China: For the first time, a researcher had manipulated human embryos by using the so-called **gene scissors** (officially *Crispr/Cas9*) in such a way that they could no longer contract AIDS. These gene scissors were used in the course of in vitro fertilization. The “experiment” carried out on people was discussed very critically worldwide (cf. Kastilan, 2018, p. 64).

Food for Thought

Do we want such **transparency** about every single individual (including our own genome)—including ourselves—in order to be able to live “optimally”? Should such an analysis be carried out prenatally—with various possible decisions?

Or do we want to give life something of its **uncertainty**, its **unpredictability**, its **imponderability** and its **surprises**—good as well as bad? Because this field of tension may make life worth living—because we do not know and cannot know everything. Can we still live a real life if we know early on what will cause our death and when? Would we be blinded by all these precautions for the positive things in life just because we have a 94% chance of dying of kidney failure at the age of 62?

It becomes clear that both over-information and under-information will have negative effects. Therefore, these questions should be raised and answered early—without, however, missing the starting signal for AI deployment, which in our opinion is necessary.

Memory Box

If you want to know what developments *Amazon* can expect in health care, you should google the keyword *Amazon 1492*. Not for nothing did *Amazon* use the year of America’s discovery for this project!

Simpler **forms of self-optimization** are supported by skills from *Alexa* (cf. Fritsche, 2018). The German health insurance company *Techniker Krankenkasse* (TK) has developed the *Alexa Skill TK Smart Relax* to help *Alexa* users relax through smart meditation exercises. This should make it possible to integrate

mindfulness and relaxation techniques into everyday life. With the command “Alexa, start smart relax” the user is invited to different relaxation and mediation units. Alternatively, different playlists can be called up to support concentration.

The connected shoes offered by the company Digitsole (2019) can also make a contribution to self-optimization. The **smartphone-controlled shoes** have an adjustable heating, shock absorption and tightening. To this end, electronics are integrated into the shoes in order to provide consumers with more comfort and well-being. AI algorithms detect fatigue symptoms and injury risks at an early stage. In addition, **personalized training recommendations** can be made, and **audio coaching** can be carried out. An integrated **activity tracker** continuously records speed, distance travelled, and the number of calories consumed. In combination with a fitness or health app, this leads to exciting business models.

Another example of this is the cooperation between the sports equipment manufacturer *Under Armour* and *IBM Watson*. In a common development—called **HealthBox**—the AI system learns from physical activities, weight (incl. body mass index) and nutritional patterns something about the fitness state of the user and can derive recommendations for optimizing the training. The application consists of a *Fitbit*-like band, a digital scale and a heart rate monitor. A smartphone app called *UA Record* brings everything together to evaluate the data collected by the fitness tracker and a weighing scale. By working together with *IBM*, these data streams can be intelligently evaluated. Criteria such as age, sex and activity level are taken into account in order to give individual training and recovery recommendations. To market the *HealthBox*, *Under Armour* accesses three online fitness communities it has built up in recent years: *Endomondo*, *MapMyFitness* and *MyFitnessPal*. With this, the company is accessing the largest **wellness online ecosystem** with 165 million users today (cf. *Under Armour*, 2019).

Further developments are the chatbots and expert systems already in use today, which present themselves as **personal health managers**. Apps provide digital medical advice on common disease symptoms and often also offer a function to schedule further medical treatment. Apps can also remind patients to take the prescribed medication regularly to promote compliance. Compliance here means the willingness of a patient to actively participate in therapeutic measures, e.g. the regular taking of prescribed medicine. This is also an example of a therapy-supporting application.

Fictional Reading Tip

A very good fictional novel by *Marc Elsberg* “*Zero—They know everything you do*” shows where such attempts of self-optimization can lead.

6.3 AI-Based Medical Use Cases

Small companies also have the opportunity to enter the healthcare market with innovative solutions. The **Doctor App Ada** is a self-service application—an example of a therapy-supporting application. This startup company from Berlin started in 2011 with the development of a digital medical knowledge database. The company’s goal was to provide everyone in the world with access to high-quality, personalized health information. The app was introduced in 2016 to achieve the goal of easy access to medical information. In 2017, the app became the No. 1 medical app in over 130 countries—both in the *Apple* app store and the *Google* play store. The number of users exceeded three million in 2018—and over five million symptom analyses were completed with Ada (cf. Ada, 2019). This app also links two AI applications to achieve a convincing solution for the user: an expert system with an NLP interface. The chatbot offers its help to the user and asks if he/she feels good. If the person has a complaint, the app provides an evaluation of the symptoms, whereupon a decision can be made about the next measures (cf. Fig. 6.1).

At the end of an extensive questioning process, which resembles a doctor’s consultation, a diagnosis is made. This one cannot be called a diagnosis in many countries, because only doctors are allowed to make diagnoses. The result is much more a decision tree that assigns different probabilities to possible diagnoses. In this way, the software makes it transparent to the user how that assumption came to a certain conclusion (cf. Müller, 2018b, p. 114). This is a nice example of the Explainable AI mentioned in Sect. 1.1.

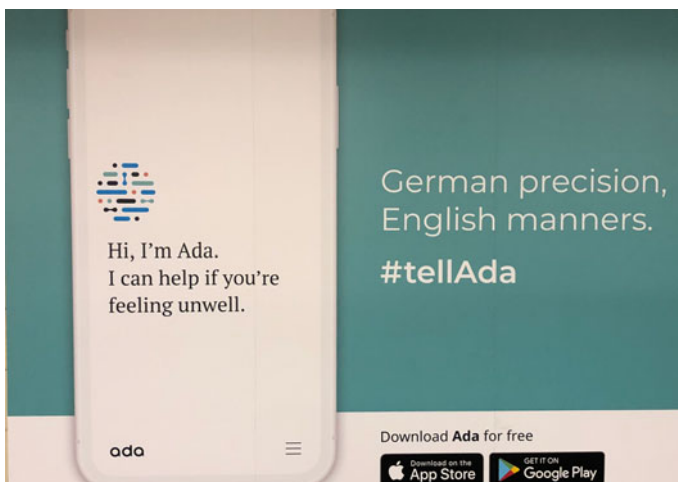


Fig. 6.1 *Ada*—Your health guide. *Source* Authors’ own picture

In the future, *Ada* may also be able to evaluate photos or videos of the skin, sensor data, recordings of other apps (e.g. from fitness trackers) or gene data. Again, the challenge lies in the connection with other companies—possibly on an ***Ada health platform***. Diagnoses and therapies may not be made on this basis, because in Germany the so-called **remote treatment prohibition** applies still. At the 121st German Medical Congress in 2018, the German medical profession voted by a large majority in favor of relaxing the ban on remote treatment. It is being worked towards the goal that physicians “in individual cases” may also provide exclusive advice or treatment via communication media to patients still unknown to them, if this a “medically justifiable and the necessary medical care” is maintained (cf. Höhl, 2018).

Cardiogram is an app that detects **irregularities of the heartbeat** with the help of an *Apple Watch*. The combination of data and prediction makes it possible to react immediately to deviations before a heart attack occurs. An accuracy of 97% is currently achieved. The precision of the results can be improved by collecting and comparing the heartbeat data of additional people. For each additional percentage point of accuracy, a disproportionately large amount of additional participant data is required (cf. Agrawal et al., 2018, pp. 45–49).

The company ***DeepMind Health***, founded in Great Britain in 2010, is pursuing a larger approach. This company has set itself the goal of making the most advanced (AI) technologies available to patients, nursing staff and physicians. The company was taken over by *Alphabet* in 2014 (cf. DeepMind Health, 2019a). The use of state-of-the-art technology is intended to prevent people from becoming seriously ill or even dying because they do not receive the right treatment in time. Many healthcare systems still lack the necessary tools to immediately analyse test results, determine the necessary treatment and ensure that every single patient requiring complex or urgent treatment is sent directly to the right specialist. To achieve this, *DeepMind Health* works with hospitals on mobile devices using AI solutions to get patients from testing to treatment as quickly and accurately as possible.

Streams is a corresponding app currently in use at the *Royal Free London NHS Foundation Trust*. It uses mobile technologies to notify doctors immediately if a patient’s condition deteriorates significantly. An example is shown below, which refers to changes in kidney functions and especially to acute kidney injury (AKI) and indicates immediate need for action. Therefore, one day in the life of *Streams* at the *Royal Free* measured in February 2017 (cf. Deepmind Health, 2019b) is shown here:

- 2,211 blood tests analysed
- 66 changes in kidney function identified
- 23 AKI alerts issued
- 11 cases required action.

Additionally, the 11 cases which required action included potentially fatal sepsis and rise in potassium, 60% could be reviewed in less than one minute and two critical cases were reviewed remotely. This application is a combination of **diagnostic and therapy supporting applications**.

An example of a therapy-supporting application is **AI-assisted surgery**. Their use, e.g. in microsurgical procedures, can ideally prevent performance fluctuations that are peculiar to human surgeons. A study with 379 orthopedic patients showed that AI-assisted surgery led to five times less serious complications than those experienced by surgeons operating alone. Robots are also already being used for eye operations. The most advanced surgical robot currently available, *Da Vinci*, enables physicians to perform complex procedures with more control than conventional approaches (cf. Marr, 2018). During operations, the doctor is no longer standing at the operating table, but at a console near the patient. From there he or she controls the robot on the basis of a three-dimensional image of the operating area. This supports the eyes and hands of the operator. Today, the fields of application of surgical robots concentrate on urology, lung and abdominal surgery. In the future, robots will be used on long space missions—to Mars, for example—to assist in operations such as appendectomy or dental treatment. Such missions are to be carried out remotely by doctors on earth.

It is to be expected that Artificial Intelligence will be able to combine its advantages of being able to evaluate large amounts of data with the use of robots. Robots can analyse data from medical pre-examinations in order to subsequently guide a surgeon's instruments during surgery. Forecasts assume that this will lead to a 21% reduction in a patient's hospital stay (cf. Marr, 2018). Using Artificial Intelligence, robots can also evaluate data from previous operations in order to develop new surgical techniques. Corresponding studies have already turned out to be very promising.

These options will help to reduce surgical inefficiencies and thus the poor results of surgery. In addition, insights gained here can be linked to the postoperative and long-term health outcomes of a patient. This again requires a **closed patient data cycle**.

The hospital processes can also be supported by **virtual nurses**. From interacting with patients to briefing patients in the required departments, virtual health care assistants can help. Since virtual nurses are available 24/7, they can continuously monitor the condition of patients and answer questions. Today, applications of virtual nursing assistants often concentrate on the regular communication between patients and service providers. A connection to the already discussed health apps offers the possibility to connect the phases of the disease with the—hopefully dominating—phases of health in a closed cycle. Thus, the virtual nurse becomes a **virtual health agent** who points out necessary wellness checks, monitors weight and sports activities and, if necessary, suggests meals and gives impulses when it is time to go to sleep.

The **EDAN** system represents an important development step towards a **virtual care robot**. **EDAN** is supposed to support people with severe motor impairments. A lightweight robot arm with five-finger hand provides a high level of safety for the

user and supports a variety of interactions with the environment. No joysticks are used for control; rather, muscle signals on the skin surface (electromyography, EMG) are measured and then processed to generate motion commands for the robot. In order to make the use of the robot as easy as possible, so-called shared control techniques are used. The robot uses its extensive knowledge to predict the user's intentions and assist in the execution of the task accordingly. If the robot detects that a glass can be drunk, the motion commands decoded from the EMG signals are adapted and the hand is guided safely to the glass (cf. DLR, 2019).

Memory Box

Already today, **robots** can be used in the **domestic environment**, for example to keep elderly single people company. As a 77-year-old test user of a robot put it so nicely: "... I thought that such a robot could be a nice change. The first night, I felt really queasy. I know computers can crash. So, what if the robot crashes and goes crazy, too? ... But even for me the robot means a better quality of life. Within a very short time, I felt responsible. And it already has something for itself if someone takes you back with 'Welcome, Dietlind. It's nice to have you back' when you come into the apartment door." (Backes, 2018, p. 119).

In addition, AI systems can also support the further **management of administrative tasks** in the healthcare sector. Intelligent language assistants can simplify communication between service providers—and produce written documentation about them if required. Therapy plans, orders of medication etc. can also be supported via AI systems. An example of the use of Artificial Intelligence to support administrative tasks is a partnership between *Cleveland Clinic* and *IBM Watson*. The AI application supports the evaluation of large amounts of data and helps doctors to develop more personalized and efficient treatments (cf. Marr, 2018).

Food for Thought

Perhaps by relieving routine tasks in the health sector, doctors and nursing staff will be able to concentrate again on those tasks in which they are (still?) indispensable—in the appreciative and compassionate conversation with the patient.

Robots in hospital logistics represent a further developed field of application in healthcare. *Panasonic* has developed a robot called **HOSPI**, which can bring sensitive drugs, bulk packs, patient files and laboratory samples to the wards and patients. This should save time for the medical personnel, which can ideally be used for the care and nursing of the patients. A total of four **HOSPI** robots are in use at *Changi General Hospital* in Singapore. They can deliver shipments autonomously to all stations within the site—24/7! The only interruptions are the scheduled charging phases and maintenance intervals. The robot uses a large number of sensors to independently avoid obstacles such as patient beds, wheelchairs, visitors and personnel. A **HOSPI** weighs 170 kg and can currently transport 20 kg (cf. Panasonic, 2019).

All in all, **AI-supported developments in healthcare** can be summarized as follows (cf. McKinsey, 2017, p. 63; Hahn & Schreiber, 2018, p. 342):

- AI systems enable **remote diagnosis of the health status of patients** via a mobile device. For this purpose, the recorded information is compared with databases in order to make nutritional and exercise recommendations or to point out possible illnesses.
- AI tools support the **analysis of the patient’s medical history** and also bind a large number of environmental factors of the patients. This enables **people with specific health risks to be identified** and transferred to prevention programs.
- **Virtual agents** can refer registered patients to appropriate physicians in interactive **health/prevention kiosks** to avoid referrals errors and waiting times.
- **Autonomous AI-based diagnostic devices** perform simple medical tests without human assistance. In this way, doctors and nursing staff can be relieved of routine tasks.
- Instead of diagnostics after patient admission, **decentralized early detection and diagnostics** through wearables etc. are possible. This supports a development from a primarily reactive medicine to a **proactive preventive medicine**.
- **AI-powered diagnostic tools** can ideally identify diseases faster and with greater accuracy because a large amount of historical medical data and patient records can be accessed in real-time.
- **Individualized treatment plans** can be developed using AI tools. The aim is to improve the efficiency of therapies by tailoring treatment more comprehensively to the needs of specific patients.
- Medical care can develop from a one-size-fits-all medicine to an **individualized medicine**, if necessary, with individually composed medications.
- The **use of digital twins** reduces the need for trial-and-error therapy through **“objectified” planning and prediction of therapy combinations**.
- AI algorithms support the **management of hospital operations**. In this way, staff deployment plans and the medicines available can be aligned with medical and environmental factors. This includes the behavior of the patients, the expected course of disease or recovery as well as regional and seasonal factors (e.g. expected influenza waves).
- Results obtained through Artificial Intelligence on the **development of health in the population as a whole** provide health payers with the opportunity to develop preventive measures. This could reduce the cost of hospitalization and treatment in general.

The extent to which the desired developments in health care can actually be exploited in a country depends on the **availability and evaluability of the necessary data**. As long as the health data is distributed over a large number of practices, hospitals, pharmacies and health insurance companies, there will be no holistic picture per patient. This holistic picture is missing not only for the analysis per patient, but also for the training of the AI algorithms.

A look at the **status quo in Germany** shows that in many cases the above-mentioned **potential in the health care system** has not yet been exhausted (cf. Bertelsmann Stiftung, 2016, pp. 1–8):

- Many **digital health applications** have the potential for patient empowerment and can contribute to improving medical care.
- The range of corresponding services is developing dynamically. There are already over 100,000 **health apps** today. 29% of Germans have already installed health apps on their smartphones.
- Over 50% of online users in Germany search the Internet at least once a year for **health-related information**.
- This development takes place primarily in the **second health market**—i.e. outside the classical health system. In addition to many startups, the Internet giants who are penetrating the healthcare market with new ideas also dominate here.
- Many **solutions are driven by supply**; they are less geared to the actual need for prevention and health care.
- The market remains largely **non-transparent** because there is a lack of procedures for identifying and evaluating innovations.
- **Healthcare providers** are called upon to actively seize the opportunities offered by digital technologies and translate them into customer-oriented solutions.

Food for Thought

Despite all the euphoria about the possibilities offered by AI applications in the healthcare sector, **the relevance of the doctor-patient discussion** should not be neglected. What great success has already been achieved by the administration of placebo preparations, because the compassionate words of the doctor and/or the simple belief in healing brought success?

With the advance of Artificial Intelligence, pure expert knowledge will lose its significance. The “good” doctor of tomorrow is more characterized by empathy and a high degree of communication skills. “Doctors who cannot do this or who do not attach importance to it will become superfluous at some point in the future” (Bittner, 2018, p. 19).

There is also the **danger of overuse through over therapy**, because with all the possible symptoms that would have been successfully “treated” by sleeping through the night in the past, the AI doctor, who is always available on the move, is now consulted—with shocking information about what it could all be!

It should not be concealed at this point that the **use of Artificial Intelligence also takes place in the porn industry**. Examples of this are the abuse of Artificial Intelligence by copying the VIP faces of *Scarlett Johansson* and *Taylor Swift* onto the faces of “classic” porn actresses. This is the phenomenon of the so-called **deep fake** (cf. Kühl, 2018).

The human-like appearance of humanoid robots also opens up new fields of application in this field. The *Abyss Creations* produces **RealDoll**, a sex doll with adjustable stimulation and additional features to conduct conversations and tell jokes. How are these new toys discussed (Chris, 2017)?

Dawn of the Sexbots

The step from ‘Westworld’ into your arms: an AI-equipped artificial lover with customizable look, voice, personality and sex drive. Could it be your perfect companion?

In 2017, the first brothels with sex robots were advertised in Ireland and Germany (cf. Maher, 2017; Petter, 2017). This shows how Artificial Intelligence can also intervene in the most intimate areas of human beings. In addition to all ethical reservations, it offers legal sex alternatives (cf. Krex, 2017).

6.4 AI-Supported Education

For decades, people have been discussing how to revolutionize education through technology. **AI-supported analyses and forecasts** can support those responsible for education systems in an important task: balancing people’s needs (in terms of skills and job aspirations) with the requirements of future employers. In theory, this will make it possible for curricula to be adapted to the demands of future working life at an early stage, so as to provide qualifications that will not be required yesterday or today, but tomorrow. Unfortunately, in most countries this will remain fiction.

Current trends focus more strongly on digital learning platforms, blended learning, MOOCs (massive open online courses) as well as paid online learning platforms. It can be seen that the way content is presented is changing more and more from text to visual information—we could also say from *Google* to *YouTube*. **Digital learning platforms** are already used in academic teaching (e.g. *Moodle*). There, lecturers can make learning content available online, communicate dates, inform courses about changes and create glossaries. Learners can download this information, view timetables, course participants and messages, and upload their own contributions if necessary. The university thus becomes mobile and can be called up anywhere (cf. Igel, 2018).

In school education in Germany, a **school cloud** is already being used in some cases. This is being developed and tested by the *Hasso Plattner Institute* together with 300 schools in the *MINT-EC school network*. The project is funded by the *Federal Ministry of Education and Research*. However, these systems are not yet truly “intelligent”. Initially, they only allow to network teachers, students and learning material—but they offer a springboard for more!

It is important that **school and university education** does not focus on rigid rote learning in fixed structures but promotes independent learning in unstructured learning environments—in order to develop **creativity** and **initiative**. It makes little sense to teach students in a digital world how to memorize information that can be retrieved at any time using a mobile device. Nevertheless, it is indispensable to build up one’s own knowledge—this provides the basis for the development of one’s own values and offers the prerequisite for well-founded decisions and one’s own creativity.

Memory Box

Somebody Who Knows Nothing Must Believe Everything!

Beyond factual knowledge, it is above all important to build up one's **own media competence** in order to be able to work competently with various sources. People who want to justify complex interrelations monocausally have to be met critically. Motto: X is all Y's fault. That's how populists "explain" the world! It is necessary to get to the bottom of the **complexity of facts** independently in order to frequently recognize that there are large differences between correlations and causalities (cf. Kreutzer, 2019, pp. 1–33).

Memory Box

To **prepare for the future world of work**, forms of knowledge transfer and competence acquisition are needed that promote creativity, problem-solving skills, self-organization, initiative, appreciative and problem-solving communication and thinking in context.

Blended learning can make a contribution to this. This is a mixture of different learning concepts, such as online courses and face-to-face events. The use of AI can help to ensure that the online learning materials are more closely geared to the individual learning level of the participant in order to help them to overcome individual learning hurdles. **Intelligent tutoring systems (ITS)**, which are used in combination with online learning, contribute to this. Natural language processing is a key technology for language learning systems such as *Carnegie Speech* or *Duolingo*. Intelligent tutoring systems such as *Carnegie Cognitive Tutor for Mathematics* are already in use in US high schools. Such systems are also used for advanced training in medical diagnostics, genetics or chemistry. Based on the respective user-machine interactions, **personal advice for the improvement of learning outcomes** is presented, which cannot usually be provided by teachers of large classes (cf. Stanford University, 2016, pp. 31–33). Cloud programs like *Bettermarks* help students to improve their skills in mathematics through the use of new digital media. In a comprehensive meta-study on the effectiveness of adaptive learning systems with a focus on languages and mathematics, **positive learning effects were confirmed in the majority of the studies** (cf. Escueta et al., 2017).

Massive Open Online Courses (MOOCs) represent another important learning and analysis environment for Artificial Intelligence. MOOCs are online courses in higher education and adult education that often reach high numbers of participants due to the lack of access and admission restrictions. The interactions recorded online provide insights into how participants learn, where they "fight" or make good progress, when they break off, etc. The interactions are recorded online and can be used for a variety of purposes. In this way, conclusions can be drawn as to where additional assistance is necessary to ensure learning success (cf. Stanford University, 2016, pp. 31–33). Overall, it can be said that AI technologies are very well suited to support the **achievement of individual educational goals**.

Food for Thought

Could a **MOOC-based education push in African countries** succeed in slowing down the population explosion that is looming there? In many countries it has been observed that the increasing education of the population leads to a higher standard of living, which results in a slowdown in population growth. Then such investments would be an important contribution to the survival of our planet.

In addition to the MOOCs, **paid online training courses** using AI technologies are becoming established. One example of this is the education website *Lynda.com*, taken over by *LinkedIn* in 2015. This platform supports the development of managers and executives through a variety of online courses (cf. Lynda, 2019).

Automated image recognition can be supported by the use of webcams to detect signs of boredom, commitment, mental under- or overload and/or a possible interruption of the learning process in gestures and facial expressions. Such *Class Care Systems* are already applied in China (cf. Böge, 2019, p. 4). In Great Britain, for example, image and speech recognition were used to **identify learning difficulties and learning preferences of students**. For this purpose, previously unusual data and data sources were also used, e.g. the activities of learners in social networks. Based on such insights, Artificial Intelligence can improve learning and teaching through greater individualization. For each participant, **indicators of learning success** can be identified that were previously unknown. In addition, the **individual learning process can be continuously monitored**. This refers not only to the number of pauses a learner takes during a lesson, but also to the time it takes to answer a question. The number of attempts to answer a question before it has been answered correctly can also be evaluated. Image recognition, eye tracking, analysis of mouse movements and an emotional analysis of the learner can provide deeper insights into performance, thinking and cognitive abilities—if the provider has received a permission in each case. A more **individual support of the learning process** becomes possible (cf. McKinsey, 2017, p. 66f.).

The question is whether we can or want to achieve this on a broader basis. On the one hand, it is about the **ethical question of the comprehensive monitoring of learners**, whose privacy would be deeply invaded. On the other hand, there is the question of the **necessary investments** that would accompany such a comprehensive approach. It is likely that such comprehensive concepts will soon only be used in particularly critical areas (e.g. in the case of massive learning disorders). In addition, they can be used where there are large financial resources, e.g. in privately financed educational institutions and in the military sector (cf. Sect. 9.2). As mentioned before the necessary systems are already implemented in China where the installation of cameras in schools and the permission of the parents is no issue to talk about (cf. Böge, 2019, p. 4).

In our opinion, an interesting use of AI is to enable learners to carry out **self-control over the learning process**, based on an in-depth analysis of this process. With such a—permission-based—evaluation the individual would be promoted purposefully. At the same time, anonymous training data could be obtained for the further development of the AI algorithms.

Here, the use of the **knowledge gained about optimal learning support** does not have to stop at the school or university boundary. The **individual learning profile**, which can change over time, would accompany the learner throughout life. He or she could be repeatedly referred to additional relevant learning content in order to prevent the increasingly rapid obsolescence of knowledge. At the same time, the relevant learning content could be prepared in a form that corresponds to the respective learning preferences.

The need for this is derived from the **challenge for all** to ensure **lifelong learning**. Because education and training in every country and in every company requires a strategic reorientation and further development in order to meet the challenges of the labor market. Figure 6.2 shows the **strategic qualification gap** to be closed. Today's (public) educational efforts focus on early childhood education, school education, vocational training at the start of working life and higher education (keyword: **qualifying**). This largely ignores the fact that people devote their longest time—often more than 40 years—to professional activities, where the demands are changing ever more rapidly and to an ever-greater extent. Here, the necessity of a **re-qualifying** arises. Not only the generation of baby boomers who will leave the labor market in the next few years will have to prove themselves in a working environment for which neither schools nor universities have been able to adequately prepare. The possibilities of the Internet, the challenges of digitalization and Artificial Intelligence were not part of the content of the study at the time, because these developments were not yet apparent. Also, typewriters rather than computers were standard equipment for a student who also had to get by without a smartphone, *Facebook* and *Amazon*—and still survived!

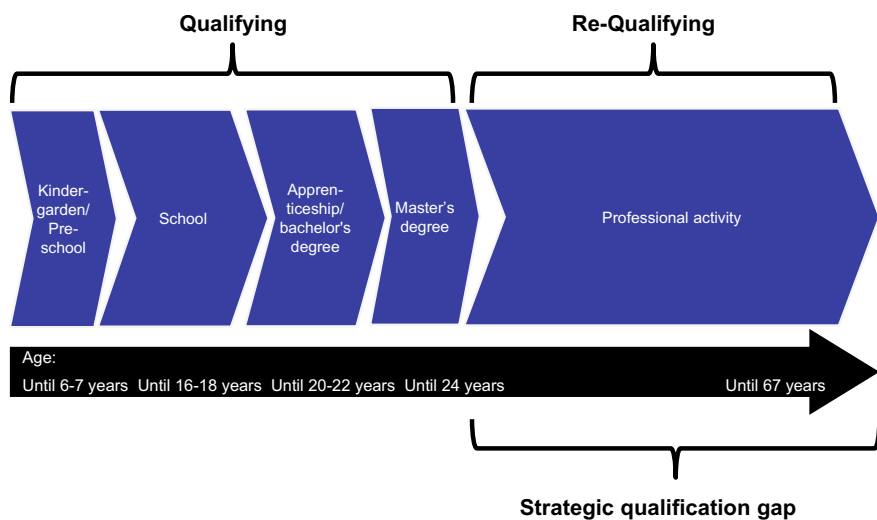


Fig. 6.2 Strategic qualification gap. *Source* Authors' own figure

The **dynamics of changes in professional life** continue to accelerate in subsequent generations. The following developments illustrate this:

- Today, hundreds of thousands of employees perform functions that did not even exist 20 years ago: App developers, community managers, UX designers (UX stands for user experience), SEO specialists (SEO means search engine optimization), social media managers, big data analysts, cloud service managers, CDOs (Chief Digital Officers), AI developers, machine learning specialists, etc.
- Accordingly, 70% of today's pupils are expected to work in jobs that do not yet exist.
- In ten years, employees will be working with technologies that are not yet operational today; quantum computing and smart dust should be considered here (cf. the *Gartner hype cycle* in Fig. 2.6).
- The future employees will have to solve problems that are not yet known today.

In order to successfully shape this change as a company and as a society, the strategic qualification gap must be systematically closed by **re-qualifying**. It is important that no employee waits for the company to do something for him or her. Here, rather a high measure of **self-initiative is demanded for closing the strategic qualification gap**, if the own employer did not recognize the indications of the time or did not act appropriately.

Food for Thought

The **elaboration of individual learning and teaching profiles** as well as the **educational offers** based on them represent an exciting field for schools and universities as well as for governments. This could make a significant contribution to closing the strategic qualification gap at national level.

What role would the lecturers play in such an **AI-controlled world**? First of all, time-consuming administrative tasks such as monitoring and answering routine questions could be eliminated. This gave the lecturers more time to train themselves continuously. This is because the strategic qualification gap also occurs with lecturers who do not actively work towards closing it. Overall, the lecturers would be more closely involved in the **qualification process as mentors and coaches**. This requires specific skills such as emotional intelligence, creativity and appreciative communication. Machines will probably not be able to learn this skill so quickly in the next few years.

In some areas of classical learning, AI systems can also replace the lecturer. This applies for the evaluation of simple written elaborations as well as for the answering of routine questions of students. In the **evaluation of written performances**, AI-controlled machines make progress. Companies such as GradeScope (2019) already support lecturers in correcting written papers and promise time savings of 50%. Here, the company relies on image recognition to decrypt the handwriting—which even a lecturer today still has to fail many times over. Based on defined learning contents, an automatic evaluation of the exam performance can take place.

Today's technology focuses only on elaborations with objectively correct answers, e.g. for mathematical tasks. Artificial Intelligence can also assist in rule-based learning, for example in checking spelling or recapitulating historical events. An evaluative interpretation of such historical events eludes automated evaluation—and this will probably always remain so. After all, history, as we all know, is written by the winners; most losers have a completely different view of things!

In addition, a **virtual supervisor** could monitor and support the work and conduct of the lecturers, as briefly described above. These virtual supervisors could send **alert messages** to the instructor if many students fail on certain tasks or tend to cancel a course. Even in the case of poor or best performance, proactive information can be sent to the responsible manager. In this way, important feedback discussions and motivating words can be used to support learning success in the long term.

UNESCO estimates that 24.4 million **primary school teachers** worldwide must be recruited and trained to ensure universal primary education by 2030. A further 44.4 million teachers are needed to fill **vacancies in secondary schools**. Many of these new hires (more than 85% in primary schools) are needed to compensate for fluctuation (cf. McKinsey, 2017, p. 68). Is it still a dream or is it a real possibility to satisfy this enormous need for teachers—at least in part—through Artificial Intelligence systems? The need for this is particularly great in Third World countries, where many people often have limited or no access to education. AI systems could contribute to the **democratization of education** via the Internet—depending on to the respective governments and the existing infrastructure.

Learning robots can be used more as a supplement than as a replacement for (missing) teachers to enrich teaching. Due to their haptic properties and attractive design, learning robots are particularly inviting for children and awaken their spirit of discovery. With regard to technical topics, the little helpers are particularly motivating. Robots such as *Dash & Dot* even provide children with their first programming experience by allowing them to develop creative applications on the tablet. A pedagogical concept that must stand behind the playful applications is a trailblazer for successful use. They serve the teacher in school as a didactic aid and should neither replace him or her nor serve as a pure pastime.

Once again, it shows that AI approaches are an exciting extension and less a substitute for current training concepts. The challenge is called **blended learning**—a mixture of different learning concepts, e.g. online courses and face-to-face events, virtual supervisors, etc.

In China supervisors can evaluate the behavior of pupils—even in school far away—based on **face recognition** in real-time. This can give the teacher immediate feedback about his lessons (cf. Böge, 2019, p. 4):

- Are pupils interested or bored?
- Are pupils asleep?
- Are pupils intimidated?
- Are pupils active in class?
- Do pupils talk to their peers?

This information is immediately transmitted to a control center and can be provided to the teacher, too, so that he or she can react to it. The parents in China are also interested in these findings. They want to check whether the pupils are as ambitious as expected.

Adapted learning materials can provide a bored child with playful content in order to motivate him or her to deal with the current material. As soon as the interest is awakened again, the complexity of the task can be increased bit by bit—individually for each child. This enables the highest possible **individualization of teaching in the classroom**. This is the future—also in China!

In Switzerland they even go the next step. Here, not only the **facial expressions of the students** are evaluated, but also their **motoric activities** during the lesson by means of IoT sensors. Does the child sit quiet or does it slide back and forth in excitement? What was the trigger for the sudden restlessness (cf. Igel, 2018)?

A technology mix that also integrates AI systems is currently increasingly being used in the **professional training sector**. Through the use of **virtual reality (VR)** glasses, educational content can be reproduced more realistically. Oriented towards the gaming industry, virtual worlds are created in which the learner is trained in situations relevant to practice:

- A prospective **steward** simulates the behavior in case of an emergency landing.
- The **midwife** must decide in a training unit which special challenges are connected with a twin birth and how these can be mastered.
- The **machine builder** recognizes the consequences the incorrectly installed valve would have on the production process.

Based on AI algorithms, weak points of the learner can be detected and reacted to accordingly. At the same time, the consequences of wrong decisions can be simulated without harming anyone.

There are already various approaches to **augmented reality (AR)** for everyday professional life, which can be used to support employees in their work in a targeted and individual way. Special data glasses (smart glasses) or tablets are linked with the data from running processes of plants and/or machines. Instructions for the next working steps are thus displayed directly to the wearer of the spectacles.

ThyssenKrupp relies on mixed reality for the **maintenance of its elevators**. The **HoloLens technology** from *Microsoft* is used for this purpose. These glasses generate a mixed reality to support a safer and faster work of the 24,000 service employees of the elevator company. These special glasses show the service technician the specific characteristics of an elevator even before he or she starts work. On site, the *HoloLens* enables access to all technical information of the elevator via augmented reality. If necessary, expert support can be requested immediately via image transmission. Since the information about the glasses can be requested and read, the hands remain free to work. First experiments have shown that the work can be done up to four times faster with the support of *HoloLens* (cf. Virtuel-Reality-Magazin, 2016).

Augmented reality glasses of this kind can also support apprentices, career starters and unskilled personnel in training programs. Also courses of action and work processes, which rarely occur, can be supported by AR glasses. In the event of incorrect operation, a red signal may appear in the AR glasses or on a tablet to prompt the operator for immediate correction. Specialists and skilled workers can be informed about the current progress of the process at any time via the corresponding devices. The information and instructions transmitted are based on real-time measurements incorporated into IoT technology.

Large training companies such as *Airbus*, *Boing*, *Daimler*, *General Electric*, *General Motors*, *Siemens* and *Volkswagen* use such **digital assistance systems** to optimize learning processes in professional training. The more qualified the learners already are, the more important it is to give them **control over their own education**. This is called **owning learning**.

Food for Thought

The predicate “Digital Natives” (from 1980 onwards) incorrectly assumes that these persons already possess comprehensive **digital competence**. However, this is often not the case. The digital competence of these persons often does not extend beyond the mere **operating competence of applications**. In addition, the majority of them are not able to distinguish between credible and untrustworthy content on the Internet.

In education, the use of new technologies will not lead to digital automatism. The **management of education** is still about a mix of teaching and learning. An AI system should therefore be understood as a meaningful didactic addition—but not as a substitution for the lecturer (cf. Igel, 2018). In addition, we should keep in mind that an educator is not only to be understood as a pure knowledge mediator but can also contribute to the development of the personality of each individual learner.

6.5 AI-Supported Human Resource Management

AI systems can also support **personnel planning**, taking into account complex rules of engagement. In addition, knowledge **gaps within a company can be identified across departments and divisions**, which are then transferred to a **training agenda** (cf. May, 2016, p. 6). AI-supported pattern recognition in the evaluation of data on potential employees could improve recruitment results. Here, the prerequisite is that the data necessary for in-depth analyses are available for the development of the AI algorithms as well as for the application in the selection process itself. The protection of the privacy of individuals practiced in individual countries will determine the extent to which Artificial Intelligence can contribute to overcoming the strategic skills gap.

In addition, in many countries there is still a **great imbalance between the existing and the necessary qualifications of the population**. This can be caused by **inefficiencies in the education system** and by **labor market regulations** that do not balance supply and demand. This means that the existing potential of individual people and countries as a whole cannot be optimally exploited. Artificial Intelligence has a key role to play in achieving better **connectivity between education systems and the labor market**. Digital technologies are already making an important contribution to connect talents and tasks via online platforms. McKinsey (2017, p. 65) estimates that **online talent platforms** will make it possible by 2025 for up to 60 million people to find jobs that better match their skills or preferences. This can also reduce the costs of personnel management.

The following example shows how a **chatbot can already support a job search** today. The world of *Jobo* still looks natural and powerful here (Bobot, 2019):

Add Jobo on messenger

Get Started

Andre, welcome! Nice to see you here. I'm Jobo and I will help you to find your next job. Let's start with the basics. You can start a new job search from the menu or just by sending me a "search" command.

Search for jobs and setup your own job alarm

What are you looking for? Note: It is better to use more general keywords like: teacher, driver, sales manager or some skills like java, wordpress, html5 etc.

Developer

I've founded 5601 jobs for "Developer" in San Francisco.

(App shows results.)

Apply for jobs via messenger or directly. Good luck!

Options: More results | Save Search | Done

Do you want to apply for the following job?

Application Architect (Entry Level) at Varite USA in San Francisco, CA 94105

Options: Yes, please | No, forget it

Which difficulties a text-based chatbot like *Jobo* actually still has today becomes visible below. This is the slightly shortened **transcript of a conversation with Jobo** (Bös, 2018, p. C1):

“Hi, Jobo

Hi!

Can you find me a job?

Oops, I didn't get your message. Should I search for jobs by using "Can you find one for me" as a keyword?

No, forget it!

What do you want me to do now?

I'd like to know if you can look for jobs in Germany.

Thanks for using me.

You're welcome.

You have good manners.

I hope the good manners will help me find a job.

I'm happy to help. What can I do for you?

Like I said, find me a job!

Oops, I didn't get your message. Should I search for jobs by using "Find one for me" as my keyword?

No, forget it!

What do you want me to do now?

Can you just look for a teaching position?

All right!

Cool! In Germany!

Thanks for using me!

It's okay. But what about the jobs? Have you found any yet?

Oops, I didn't get your message. Should I look for jobs by saying, "It's okay. But what about them now? Have you found any yet?" as a keyword?

No, forget it!

What do you want me to do now?

Find jobs!

Okay, where would you like to find a job?

Frankfurt.

Okay, I'll look for jobs in Frankfurt, Germany. Right?

That's right!

What are you looking for?

Teacher. I already told you!

Oh, sorry, I couldn't get jobs for "Teacher. I already told you!" Try changing your search criteria, use simple keywords, or select a larger city in your area.

Okay, I'm changing my keyword.

You want to keep this place: Frankfurt?

That's right!

What are you looking for?

Teacher.

I found 21 jobs for “Teacher” in Frankfurt. Would you like to save this search and be informed about new job offers?

Thank you. I had enough of this.

Bye. Bye. I hope I was able to help a little. See you soon!”

Actually, many chatbots try to compensate still existing difficulties in speech recognition by a pure text communication—often with given input possibilities. The example above makes it clear that this does not always succeed convincingly.

Much more convincing are the results of the job search platform **MoBerries** based on the *Facebook Messenger*, which this example shows (cf. MoBerries, 2019):

“Hello Marie. I’m Mo from MoBerries. Nice to meet you. I’ll help you to find your next job.

Search For Jobs!

Ok, tell me, where do you want to look for a job? Send me your current location, select one or just type a city name.

Berlin

Fine, now tell me, which job role are you looking for? Select a suggestion below or type your own job title.

Content Marketing

Look, I’ve found 1453 results for Content Marketing in Berlin.”

Using predefined decision trees, *MoBerries* develops a dialog with the user that corresponds to a natural chat. As soon as the chatbot has received enough information, he compiles a list of relevant results.

In addition, AI algorithms can help to create texts with higher impact (e.g. for job advertisements). For this, *Textio* (cf. 2019) offers an interesting application with the name **augmented writing**. *Textio* evaluates large amounts of data provided worldwide by companies from all industries. A **predictive engine** uses this data to uncover meaningful patterns in the language that lead to more powerful communication and therefore better business results. The results obtained in each case generate further data in order to further advance the learning process through a learning loop.

How can augmented writing be used in the **application process**? To learn, millions of job offers and recruiting e-mails are evaluated. The knowledge gained in this way goes into augmented writing. In the application process, **augmented job posts** can soon be used to trigger particularly qualified applications. **Augmented recruiting e-mails** can then be used to address the most interesting candidates. For example, *Johnson & Johnson* increased the response rate of its applicants by 25% through e-mails with high *Textio* scores (cf. *Textio*, 2019).

Food for Thought

One thing should be emphasized about **HR support through Artificial Intelligence**: The final decision as to whether or not to hire a candidate should remain in the hands of the managers involved. Since Artificial General Intelligence is still lacking, the human being is a much better decision maker when assessing the coherence of a candidate for a job. After all, our intelligence is much more generic and can bring together words, gestures, facial expressions, pauses in the flow of speech, etc. with the sympathy or affinity that is decisive for successful cooperation. No AI system can do that right now!

Therefore, a pure **data-driven recruiting** or a **robot-recruiting** remains (still) a dream of the future, if you don't want to hire human robots yourself. Nevertheless, the search for potential candidates should not be done without Artificial Intelligence!

In the already cited study by McKinsey (2018, p. 21), the following additional value creation potentials were determined for **human resource management** over the next few years:

- **Employee productivity and efficiency**: US-\$ 100–200 billion
- **Automation of tasks**: US-\$ 100–200 billion
- **Analysis-driven human resource management**: US-\$ 100 billion

These figures should motivate companies to go for an individual AI journey (cf. Sect. 10.3).

6.6 Summary

- There are many **fields of application for AI** in the healthcare sector.
- The **comprehensive evaluation of health data** is of particular importance.
- The evaluations can be based on anonymous data records in order, for example, to **increase the quality of diagnosis**.
- The **connection of personal health data** is indispensable for personal diagnosis and therapy.
- This opens up important fields of action in terms of **data protection law**.
- AI systems can also support **operations**.
- The use of Artificial Intelligence can lead to a **relief of routine tasks in health care**—so that doctors and nursing staff can spend more time with patients.
- Artificial Intelligence can make a significant contribution **to closing the strategic qualification gap in training and further education**.
- In addition to the **technical infrastructure**, this requires in particular the **education of the lecturers** themselves; because their knowledge is also becoming outdated faster and faster.

- The **development of learning support systems** is associated with great effort, which will only be provided by a few countries.
- A larger field of AI applications is already available in companies through applications of **virtual reality** and **augmented reality**.
- Artificial Intelligence can also provide support in **HR management**—e.g. in the acquisition of new employees.
- **Online platforms** can help to bring together supply and demand in the labour market.
- The use of **chatbots in recruiting** search still has a lot of room to grow!

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