ALGORITHMS AND ARISTOTLE

IN PURSUIT OF THE BEST EDUCATION FOR THE DIGITAL AGE

Published by the Vodafone Foundation Germany

ALGORITHMS AND ARISTOTLE

IN PURSUIT OF THE BEST EDUCATION FOR THE DIGITAL AGE

Published by the Vodafone Foundation Germany

GLOSSARY

A glossary of key terms on digitalization and its effect on the labour market and education can be found in alphabetical order throughout the book.

Sources: bertelsmann-stiftung.de, bmbf.de, businessdictionary.com, chip.de, computerwoche.de, content.net, criticalthinking.org, Dorsch-Lexikon der Psychologie, edglossary.org, elearningindustry.com, empathielernen.de, e-teaching.org, faz.net, finanzen.net, fraunhofer.de, Gabler Wirtschaftslexikon, goodplace.org, handelsblatt.com, heise.de, idw-online.de, it-wissen.de, n-tv.de, planzone.de, plattform-maerkte.de, spektrum.de, spiegel.de, sueddeutsche.de, vrnerds.com, welt.de, wikipedia.com, zeit.de

Publisher
Vodafone Stiftung Deutschland gGmbH
Ferdinand-Braun-Platz 1, 40549 Düsseldorf
Telephone +49 211 533-5579
www.vodafone-stiftung.de

Content Editor (V.i.S.d.P)
Dr. Mark Speich

Overall Project Management
Dr. Johanna Börsch-Supan,
Sebastian Gallander, Alice Steinbrück

Publishing Company
TEMPUS CORPORATE GmbH –
Ein Unternehmen des ZEIT Verlags
Askanischer Platz 3, 10963 Berlin
www.tempuscorporate.zeitverlag.de

Management Board
Ulrike Teschke, Jan Hawerkamp

Project Manager
Andreas Lorek, Yvonne Baumgärtel

Art Direction
Christopher Jung, Judith Hehl

Editorial Staff
Fenja Mens, Andreas Schäfer,
Bettina Schneuer

Translation
Ashleigh Rose, Dr. Sylva-Michèle Sternkopf

Copy-Editing
Katrin Weiden, Lisa Wicklund

Production
Dirk Woschei

Printing
Kösel GmbH & Co. KG

Vodafone Stiftung Deutschland (eds.)
TEMPUS CORPORATE | Edition Speersort
October 2016
ISBN 978-3-945627-13-6 (Publication)
ISBN 978-3-945627-14-3 (Online PDF)

CONTENTS

ALGORITHMS AND ARISTOTLE — IN PURSUIT OF THE BEST EDUCATION FOR THE DIGITAL AGE

BY
MARK SPEICH
AND
SEBASTIAN GALLANDER

Dr. Mark Speich is Managing Director
of the Vodafone Foundation Germany.

Sebastian Gallander heads the Think Tank
of the Vodafone Foundation Germany.

Technology is changing the economy almost as much as climate change is changing nature. This might be a bit of an overstatement, but it illustrates how deeply current technological developments – for example artificial intelligence, robotics, and machine-to-machine communication – could influence economic processes in the future. All this will generate far-reaching consequences for the labour market and jobs. Hence it is for good reason that an intense debate has arisen in politics and government regarding how the Germans should prepare for this challenge, so that digitalization does not entail increased social divisions. The Vodafone Foundation would like to contribute to the search for answers to this question. To that end, we brought together German and international experts from a variety of sectors. Their findings are presented in this book in order to support the efforts of decision-makers in federal and regional governments.

To begin, the renowned robotics and automation expert *Ken Goldberg* of Berkeley University gives an overview of the technological upheavals that are already underway and how they are likely to develop in the future. The consequences that these changes could have in terms of employment are then illustrated by Oxford economist *Carl Benedikt Frey*, who worked on one of the most internationally recognized studies on the subject.

By contrast, a closer look at the situation in Germany is offered by *Joachim Möller*, Director of the Institute for Employment Research of the Federal Employment Agency, who has analysed the most recent German figures on this topic. But what do all these changes in the economy of tomorrow mean for the education of today? How should young people prepare for future employment?

Stephen Spurr is looking for an all-encompassing answer to that question. For years, he offered his students at the best schools in England a comprehensive education; today, he advises a worldwide school network. His concepts are complemented from two completely different directions: *Fiona Brunk's* and *Pantelis Pavlakidis'* look at the day-to-day social reality of an inner city school in a deprived area of Berlin demonstrates how digitalization is already affecting students, and how teachers are doing everything in their power to prepare them for further education, using also simple means. Beyond classical education, there is also the path of creating one's own business, on which innovation expert *Stephan Gutzeit* is concentrating – as well as calling for more support for creative entrepreneurs.

The various findings that are gathered in this book seem to have an important commonality, upon which the CEO of the Vodafone Foundation Germany *Mark Speich* further elaborates: technological competence,

A L G O R I T H M

The magic word that conjures up the growing influence of computer programs on our daily lives, yet one that is often met with a shrug. Few people are able to explain algorithms, although in principle they are easy to understand. An algorithm is a unique, executable sequence of instructions of finite length for solving a problem. According to these conditions, algorithms can set out both the rules for multiplying and the assembly instructions of a furniture manufacturer. There are thousands of mysterious algorithms that determine our everyday life in software programs and are active in almost every technical device. They calculate the shortest route through a city, predict who will fall in love with whom, influence the global economy, and may, if necessary to complete their given task, even independently develop new algorithms.

from the adept use of all digital media to the basic understanding of algorithms, is becoming undeniably evermore important. At the same time, education must provide people with those kind of skills that computers can never take away – open-mindedness, orientational knowledge, critical thinking, self-discipline, creativity, and empathy.

»Technology alone is not enough. […] It's technology married with liberal arts, married with the humanities that yields us the results that make our hearts sing«, which Steve Jobs once said it is in Apple's DNA. It seems that we will need to look even harder for ways to use this recipe for success for the education system of the digital age.

MULTIPLICITY — BRINGING OUT THE BEST IN PEOPLE AND ROBOTS

BY
KEN GOLDBERG*

Professor Ken Goldberg is an artist and professor of robotics, automation, art, and social media at the University of California, Berkeley. As Director of the People and Robots Initiative, a multicampus multidisciplinary research program, and UC Berkeley's Automation Sciences Research Lab, he is an internationally renowned expert in the area of artificial intelligence, robotics, and cloud computing. He has published over 200 peer-reviewed technical papers on algorithms for robotics, automation, and social information filtering. His inventions have been awarded eight US patents.

Stories of robots taking over our lives are popular in the news and films. The term »Singularity« claims we will soon reach a point when robots and computers will surpass humans and make us obsolete. This fear of robots isn't new. It goes back to the Pygmalion myth in Greek history through to Frankenstein and the Luddites and takes many forms, including the new film »Ex Machina«.

Our worries are fueled by perceptions of accelerating advances in technology, which are changing the world around us. It seems to us that we are within the greatest period of technology that the world has ever seen. But if we go back 100 years to the beginning of the 20th century, there were far more significant advances: x-rays, automobiles, air conditioners, the theory of relativity (not to mention the zipper!). These were fundamental advances that had an enormous effect on humans, on society, on jobs, on our daily life. In some sense they dwarf the technologies that we have seen in the last 20 years.

I'm an optimist. My perspective of the future is that humans – together with robots – have many good years left.

One of the genuinely new and very exciting frontiers in technology is Cloud Robotics. The paradigm most robotics has had to observe for the past decades is that we always assumed that robots had to carry all of their computing and memory on board. With the emergence of Cloud Robotics a new generation of robots can use wireless networking, Big Data, open source, and deep learning to improve how they assist (but not replace) humans in tasks from driving to housekeeping to surgery.

There are over five million service robots like the Roomba Robbie vacuuming homes and offices and over 3000 robots assisting surgeons in operating rooms around the world. But robots are not yet folding our laundry or loading our dishes into the dishwasher. These mundane chores are fiendishly difficult for robots. The essential problem is uncertainty. There is uncertainty in the sensors, in the actuators, in the environment, in the physics itself. Put yourself in the position of being

ALPHAGO

Software by Google subsidiary DeepMind, which defeated the Go world champion Lee Sedol in March 2016. The Chinese board game is considered the most complex game in the world. Although there are only four basic rules, there are more possible moves than atoms in the universe. Since it is impossible to examine all search trees to find the best move, programmers developed artificial neural networks for AlphaGo that enable the software to anticipate moves rather than precalculate them and to continuously improve through self-training. The method thus resembles human intuition, which is why AlphaGo is considered a milestone in the development of artificial intelligence.

a robot: everything around you is blurry and unsteady, low-resolution and jittery, you can't really tell what things are, where they are, and how they are moving. You can't perfectly control your own hands, it is like you're wearing huge oven mitts and goggles smeared with Vaseline.

The key to a new generation of robots is the Cloud. The Cloud is not just a new name for the Internet. It is a new paradigm that uses the Internet in new ways. Everything can be stored in the Cloud using remote server farms with shared memory and processors. The Cloud also provides economies of scale and makes sharing data across applications, devices, and users easier than ever. (while of course raising huge privacy and security concerns). Here is what I see as the four advances of Cloud Robotics:

The first advance of Cloud Robotics is Big Data. Consider designing a robot to declutter your house. This is very important for anyone who has kids and especially for those of us who are getting older. When a senior citizen drops something on the floor, they may not notice it because of poor eyesight. Even if they see it, it is not easy to reach down and pick all these things up. But the consequence of tripping over an object on the floor and falling can be catastrophic in old age. What if a robot could work quietly while you are sleeping or at work, picking things up off the floor and putting them where they belong?

The problem is that no matter how well you program the robot there will always be something that it hasn't seen before. Ideally, any robot that's working in your house should be connected to a Wi-Fi network so it has access to a vast library of information on the Internet, where there's information on almost every object imaginable. It is an enormous amount of information, and it is constantly growing.

The second advance of Cloud Robotics is Cloud Computing. The Cloud not only holds vast amounts of information on demand but also provides access to remote clusters of computers and their computing power on demand. Robots can carry at most a few computers, but there are many problems that require far more computation than those can provide. One exciting approach is to model the environment, sensors, and actions using probability distributions. To solve them requires taking the convolution of several distributions. This quickly becomes infeasible with onboard computing power as the probability distributions become more complex, multi-modal, and nonparametric. Cloud Computing, the use of clusters of computers through the Cloud, now makes these computations possible. Such computing power also facilitates statistical optimization, machine learning, and planning motions in high dimensions with many simultaneously moving robots.

The third advance of Cloud Robotics is Open Source. It uses the fact that humans are increasingly connected over the web, exchanging information and ideas. Here's an example. I was born in Nigeria, and I went back there a few years ago. I was surprised to find that there was an enormous interest among students in robotics. In Africa, like all countries, robots are the »gateway drug« for getting students interested in science, technology, engineering, and math (STEM). But existing educational robots are still relatively expensive. Together with Professor Ayorkor Korsah at Ashesi University College we started the African Robotics Network (AFRON) and we announced a worldwide challenge to design an ultra-affordable robot for education. We set the target price for this at US $10. Just as a way to get attention, we didn't

think anybody could possibly achieve this. We received 28 submissions from people all around the world with very interesting designs. But they all cost about 50 to 100 dollars. Except one: an inventor from Thailand took an old SONY game controller and modified it by attaching two bottle caps as wheels to make a mobile robot. He also added lights, but he wanted something that would detect when it bumped into something. He realized that he could use the two thumb switches on the top. The problem was that when he tested it, the thumb switches wouldn't react; they needed more leverage. He thought about what might work as counterweights for the thumb switches and came up with a brilliant idea: lollipops. And so the lollibot was born. What kid could resist a robot with two lollipops on top of it? The amazing part of this is that the entire costs for the lollibot are US $8.96. That includes the two lollipops. This is an example of the power of the Cloud harnessing the vast amount of human ingenuity that is out there in the world.

The fourth advance of Cloud Robotics is Deep Learning. What we are considering now is what if robots have an unlimited memory and computing power. What would that enable? I want to give a few examples from work in my lab:

Computers and robots are very good at playing chess and inverting large matrices but they are actually very, very bad at doing things that even a one-year-old child is good at. Like picking things up and putting them into a place. This kind of dexterity is very important though, if we want robots to assist us in our homes, in handling warehousing or performing surgical tasks. One of the challenges is what we call robust grasping. By robust we mean reliable.

Here is the idea. Imagine that a robot looks down and sees something on the table. It then takes an image of that object, sends that up into the Cloud. In the cloud, there is a lot of information stored on that object to assess its properties, its centre of mass, its materials, its friction, etc. All the information that is available in the Cloud comes

Researchers in Artificial Intelligence are trying to emulate human perception and action through machines. Computers shall be enabled to independently solve problems. However, to date they have not yet been capable to simulate the human capacity for understanding in all its complexity. Therefore, research is focused on sub-regions in order to further facilitate work, for example through artificial intelligence. At what point is a machine considered intelligent? To answer this question, the mathematician Alan Turing in 1950 developed the Turing test: a man and a machine try to convince a test person of their humanity without visual contact (e.g. via a chat). If the tester cannot definitely determine who is the human and who is the machine, the machine is considered intelligent.

back down to the robot and then the robot is able to pick the object up. The ultimate challenge is to do this in real time, that the whole roundtrip process from sensing to processing to actuation can happen in milliseconds.

This is where Deep Learning as one of the new enabling technologies in this field comes in. Deep Learning has been extremely effective, for example, in image processing. The key there has been to have access to vast libraries of images, many millions of images. The scaling effects have allowed deep learning to do things that couldn't be done before.

In my lab we are doing something analogous for grasping, for dexterity. What we are using is the growing amount of data on three-dimensional objects that are being put online because of 3D-printing and other new technologies. With this we're building what we call the Dexterity Network, or Dex-Net. With 10 000 three-dimensional models stored in the system we are now processing those models to compute robust grasps.

Deep Learning plays a key role to match objects that are similar in the data set. We found that Deep Networks are much more effective than any methods we knew before at matching a new object to the set of objects that we have pre-stored. So we are essentially building on the library of precomputed grasps that we have for previous objects.

By using Google Compute Engine and Cloud Storage we can distribute the computing between different nodes. Currently we're using 1500 nodes across the network to do the computation. What we are starting to see are scaling effects, in other words, the benefit is accruing when we start to have a critical number of objects in the data set.

Building on this, our newest steps are physical experiments. We are setting up robots to self-learn over time. We place objects in front of a robot arm. Along with a wire set up as a reset mechanism the robot can reposition an object and re-grasp it over and over again. And the idea is to leave this running in a lab overnight, over a weekend or a matter of weeks, so that over time the robot will become better and better and more and more dexterous.

The other field we are working on is robot assisted surgery. What we are trying to do is provide something similar to driver assistance systems in cars for human surgeons. Surgeons will have assist tools that are able to support them with tedious subtasks, while still being very much at the wheel, as you will. For example, injecting fluids in a very uniform matrix across the particular origin of interest is something that robots can already do very well now. Reliably cutting a pattern from gauze is already more tricky for a robot. Even more complicated tasks we are working on with newly developed pieces of hardware, include scanning and probing the surface of objects to detect underlying irregularities. Such as finding a subcutaneous tumour. And then of course making exact incisions and removing such a tumour.

Again, Deep Learning plays a crucial role in developing these robot assist tools in surgery. We analyse recordings of human surgical experts as they perform surgeries and use Deep Learning to process them by segmenting out the motions to learn a subtask and the sequence of motions from the vast amount of pre-stored trajectories of videos stored online.

This is a snapshot of several of the areas of where we are seeing the Cloud have a major impact on the field of robotics.

How are Cloud Robotics going to matter to us as humans in this exciting present and future? Many are worried that this will mean the end of human jobs. It is important to emphasize that progress with robots is slow: humans are safe for quite a long time. There is no doubt that there will be a reduction in employment but we have to also realize that a huge amount of that is because of changing demographics and globalization. Those are much bigger influences than the changes in robotics.

The other factor is the term »Singularity« that I feel is causing a great deal of alarmist fear that I feel is unwarranted. Let's counter that term with something more important: »Multiplicity«. Rather than a singular, monolithic Artificial Intelligence (AI) that is suddenly going to take over and replace humans, what is much more exciting is the idea that we need to work together as humans and with groups of machines. And the key here is diversity.

It is known that computers and machines work better when there is a diversity of algorithms. Something known as random forests is the most effective technique for machine learning and it involves not just one random tree but a forest of random trees, all different and sufficiently diverse. There is numerous research on something called collective IQ, not the IQ of an individual but the IQ of a group. When trying to study what makes a group more efficient and more effective, one thing that we have already found out to be crucial to the effectiveness of a group of humans, just like for a group of machines, is diversity. Having a multitude of different perspectives is crucial to innovation and problem solving. So what is important in the next decades, is to change our way of thinking to a growth mindset where we emphasize how new combinations of people and machines can enhance curiosity, creativity, initiative, empathy, and multidisciplinary thinking.

* I would like to thank Johanna Börsch-Supan for her assistance in preparing this article.

PROGRAMMER OR PERSONAL TRAINER

AN INTERVIEW WITH CARL BENEDIKT FREY

A discussion with economist
Carl Benedikt Frey of the
Oxford Martin School at the
University of Oxford on the impact of
digitalization on jobs of the future

Dr. Carl Benedikt Frey is Oxford Martin Citi Fellow and Co-Director of the Oxford Martin Programme on Technology and Employment at the Oxford Martin School, and Economics Associate of Nuffield College, both at the University of Oxford. He is also a Senior Fellow of the Programme on Employment, Equity, and Growth at the Institute for New Economic Thinking in Oxford, and the Department of Economic History at Lund University.
www.carlbenediktfrey.com

Mr Frey, you published a highly acclaimed study in 2013 along with your colleague Michael A. Osborne. In it you studied the automation of professions and jobs in the US labour market. You came to the conclusion that almost half of all jobs are in danger of being replaced by machines, computers, or algorithms within the next twenty years. Which professions will no longer exist?

C B F : We cannot predict which occupations will actually disappear. We only examine to what extent a job is automatable from a technological capabilities point of view, given the type of task it involves. Neverthless, once an occupation becomes automatable, the demand for workers in such jobs tends to fall over time.

Which areas are most at risk?

C B F : Manufacturing jobs will be affected, as has been the case for quite some time now. What is new is that service jobs are now also becoming increasingly automatable. In the future, jobs in transportation – think of self-driving cars – as well as the logistics, and even in service or sales will be affected.

How did you conduct your study?

C B F : We initially sought to determine in which activities people will continue to have a competitive advantage over machines. Together with a group of computer scientists and robotics experts, we defined three areas, which we called »engineering bottlenecks«. First of all, all activities that have to do with creativity, for example the ability to develop new ideas, works, or theories. Machines are very good at finding solutions for clearly defined tasks, but they are not yet in a position to ask the right questions. Second: social competence. These are activities where human exchange, negotiation skills, or the appropriate response to emotions matter

Out of the development of Artificial Intelligence, a number of ethical questions arise that have not yet been adequately discussed, even according to numerous computer experts. In 2015, in an open letter from the Future of Life Institute, a total of 1000 scientists, Internet entrepreneurs, and computer specialists from the United States assembled a catalogue of topics and questions which highlights the risks of independently acting computer systems and algorithms: What does positive, beneficial Artificial Intelligence even mean? How do you teach a machine about ethics, such as the balance between personal and material damage? Would an artificially intelligent machine violate data protection when it observes people? Can autonomous lethal weapons be brought into conformity with humanitarian international law? The group has called for a ban on autonomous weapons that operate without human intervention.

a great deal and will be hard to replace. And last, fields involving perception and the manipulation of objects. For machines and robots, it is difficult to navigate in complex environments.

But if I understood your findings correctly, you also believe that automation could affect future doctors or lawyers. How?

CBF: No. Doctors or lawyers are not yet automatable, although some of the tasks they do are. The review of documents and case histories is increasingly being performed by algorithms, and diagnostic procedures too can be automated. There are also early experiments in which surgical robots assist surgeons. But we are far from seeing these jobs become fully automatable.

Let us return to the endangered areas. When people in these sectors lose their jobs: what will they do instead? In which direction will the labour market shift?

CBF: There is not a straightforward answer to this. Some workers become unemployed or even drop out of the labour force. But at least up until now most workers have found new jobs. Taking the case of manufacturing jobs being automated away, these workers have either shifted into more cognitive work in professional services

by means of upskilling, or they have taken on manual service jobs that are non-automatable, sometimes at lower pay. The consequence has been a highly polarized labour market, in which traditional middle-income jobs have disappeared, but employment in high and low-income jobs has surged.

With automation, production costs decrease and productivity increases. What kind of an impact does this have on wages?

C B F: Productivity growth happens when technology is either implemented to substitute workers or when it complements workers skills. In the first case, automation will put downward pressure on wages, in the latter case, wages will grow in tandem with productivity.

How is the situation in emerging and developing countries going to change?

C B F: According to a study recently published by the World Bank, which applied our method to developing and emerging countries, shows that low-income countries are even more affected by automation. In India 66 per cent of jobs are at risk, in China 77 per cent, and in Ethiopia as much as 85 per cent. This underscores what we have long known: agricultural workers are very easily replaced by machines. These jobs might not be automated anytime soon because many people in these countries work on small farms or in family businesses that have not yet undertaken automation. But it is only a matter of time.

You describe extensive changes in the labour market. The challenges are enormous, even and especially for the education systems of the future. What skills or competencies should be encouraged?

C B F: Workers will have to reallocate to jobs and tasks that are non-automatable, involving creativity and/or social intelligence. In addition, some will have

Automation is the transfer of functions in the production process from humans to artificial systems and equipment, made possible by technological progress. The history of automation dates back to antiquity. Heron of Alexandria described a door control in his book on machines (Automata), in which a temple door was opened with the help of fire. With the invention of the steam engine and the advent of industrialization, more and more processes have been automated. Meanwhile, goods are mostly made by machines, which has shifted the tasks for people towards administration, planning, and service. In the future, automation - at least in part – will affect almost all professional fields and threaten millions of jobs.

to acquire technical skills to operate newly introduced technology. The education system must therefore promote creative, social, and technical skills.

Many people, especially those who work in optimistic Silicon Valley, say that after a troubled period of transition in which jobs mostly disappear, we will end up with more work in the digitized world than there was before – as with all system changes in the past. You seem sceptical about this.

CBF: They might be right, but it is important to remember that transitions of the past did not take place without friction. In cities like Detroit or Liverpool massive job losses have occurred, and many have seen their living standards stagnate or even decline. Now we are transitioning to a digital industry, but even if an older worker continues to study and acquire the requisite skills, the question still remains as to whether a company will hire that person at all or whether they will prefer a 22-year-old fresh from university. We will certainly not experience an unemployment rate in double-digits, but we will have to prepare for dramatic changes.

BIG DATA

The term Big Data refers to large amounts of structured or unstructured data as well as to their analysis and evaluation. The global data volume has increased so much, due mainly to electronic communications, that this information from social networks, search engines, and large companies, for example from the financial industry, the energy industry, or healthcare, can be used to obtain economic benefits. As these data sets are too large to be analysed with manual methods, they must be processed using specially developed methods, which only specialists are able to do. For the average person, Big Data has become a common term that generally refers to digital technologies and the social upheaval associated with them. Since in many cases the people affected have not agreed to the use of their data, Big Data is a challenge for data protection.

On the other hand, many have lamented that technical assistance and simplifications, with an app for almost every area of life, are leading to a collective infantilization and a loss of self-responsibility. Many motorists who have become accustomed to navigation devices now become almost disoriented if their device stops working.

CBF: If that's the case, then it is certainly not the fault of technology. For example, you see these families in restaurants where the children stare rigidly at their smartphones rather than talking to each other. Of course it's the parents' duty to ensure that their children put down the phones. It's up to us to use technology in line with our values. If we don't pay enough attention to that, it may have undesired consequences.

Interview by Andreas Schäfer

NEW DIGITAL TECHNOLOGY AND THE FUTURE OF EMPLOYMENT

COMMENTS ON C.B. FREY

BY
JOACHIM MÖLLER

Professor Joachim Möller is Director of the Institute for Employment Research (IAB), the research institute of the Federal Employment Agency in Nuremberg. After studying Philosophy, Political Science and Economics at the universities of Tübingen, Strasbourg, and Constance he completed his doctorate in the Social Sciences in 1981. In 1990 he qualified as a professor at the University of Konstanz. Joachim Möller has been a professor of Economics at the University of Regensburg since 1991.

The study by Frey, Osborne (2013) on the consequences of digitization – cyber-physical systems, soft and mobile robotics, artificial intelligence and the like – has triggered an intensive international discussion on the future of employment. Of course, the debate on the substitution of jobs by machinery or technology is anything but new and the authors of this path-breaking contribution are well aware of this. At the beginning of the industrialization era the invention of the automatic weaving loom made thousands of specialized craftsmen jobless. The triumphant advances of assembly line production after the turn from the 19th to the 20th century meant an enormous rise in the efficiency of production, increasing the productivity of relatively low-skilled workers at the same time. By contrast, computerization of work processes, the advances in information and communication technology, programmable machine tools, and other automatization means that became dominating since the 1980s favored the highly qualified workforce and were thus a driving force behind the so-called skill-biased technical change. All these developments in the past meant enormous ground shifts in the quantity and the quality of labour required. The same holds for the profound changes in the international division of labour. Forty or fifty years ago, industries like textile production, coal mining, or steel mills were providing sizable shares of workplaces in the advanced countries and have now been reduced to sparse remainders. That is to say that rapid structural change is not a phenomenon that only occurred in recent days.

What we can learn from the past is:

- there is no such thing as secular aggregate mass unemployment due to technology;
- there are always winners and losers (employees of different qualifications and professions, firms, regions, industries);
- adjustment processes are typically painful and costly for the persons and firms involved.

BLENDED LEARNING

Blended Learning describes an educational form, in which so-called e-learning methods are used in addition to the traditional classroom setting. By combining face-to-face learning and online phases, the advantages of both methods are amplified. The aim is to acquire knowledge more quickly, to comprehend relationships more deeply, and to be able to apply what has been learned more effectively. Therefore, blended learning as a method is considered diametrically opposed to classic memorization. While this method is already widely used in English-speaking countries, many teachers are still sceptical about it in Germany.

To John Maynard Keynes who coined the term technological unemployment in the early 1930s we owe two basic insights: first, technological unemployment occurs when »our discovery of means of economizing the use of labour [is] outrunning the pace at which we can find new uses for labour«, and second, those firms, regions and countries » … are suffering relatively which are not in the vanguard of progress«. The point is simply that the technology leaders will obtain a bigger share of the market. The higher product demand can well overcompensate the fact that less labour is needed for producing a single unit. Hence, although technologically advanced firms might substitute labour by capital or technology, they could even increase their employment at the same time. This fits to the fact that typically firms that are pioneers of cyber-physical production systems are not known for mass-layoffs but for expanding their workforce. Moreover, recent studies seem to show that emerging countries might be affected much more than advanced countries. Automatization of all sorts could reduce the share of labour in total costs and lead to re-shoring phenomena because the advantage of proximity to the main markets and fast response to market impulses might then outweigh the advantage of low costs per working hour.

Hence, are digitization, robotics, and artificial intelligence from a labour market point of view »nothing new under the sun«? No, that

would be a severe misunderstanding. There are some indications that the pace with which the changes occur in some exposed and vulnerable fields of the economy – manufacturing and perhaps in the future even more in disembodied services – is accelerating. Disruptive changes and the winner-take-all dynamics should be of great concern.

The German situation

What is special with the German situation is the relatively high share of manufacturing (automotive, machine tools, electrical engineering, and chemicals). Medium-sized companies play an important role not only as component suppliers but also as internationally active producers dominating a specific niche in the world market (»hidden champions«). On the one hand, recent developments of cyber-physical systems like remote maintenance concepts, individualized mass production, high-performance logistics, and intensified production/service networks have a huge potential for these industries and mean a further enhancement of their competitiveness. On the other hand, the related requirements of agility in a quickly changing market environment, flexible work organization, and the adjustment of skill requirements pose enormous challenges. An asset of the German system of labour relations in this respect can be seen in its strong ties of social partnership. The organization of within-firm flexibility, for instance with respect to working hours, is a model example and had its baptism of fire in the Great Recession 2008/2009 (see Möller 2010). Insofar many German firms are well prepared for the requirements of the era of digitization. However, if the new era implies more disruptive processes, i.e. the rapid rise and decline of firms, then the system shows its weakness because between-firm flexibility is less developed in the German system. Moreover, it can be asked whether the existing German training system in its present form can meet the challenges of the new era or if it has to be extended and complemented. This calls for a differentiated view. Without any doubt the German system of dual training, an apprenticeship within a firm in combination with theoretical

learning at a public school, is on the whole a key institution with significant merits for the initial skill formation of young workers. It provides a combination of firm-specific and general knowledge, and young workers are generally up-to-date regarding professional knowledge after having completed the training period. Broad evidence shows that a sound training at labour market entrance is crucial for the worker's labour market career. Dual training is exemplary in this respect and hence this cornerstone should be strengthened – if need be, partly modernized – rather than weakened. The German educational system, however, has some weaknesses when it comes to continuous professional development and the permeability between practical vocational training and academic education. More recently, concepts of a dual course of study offer a combination of these two spheres and can be seen as a useful complement to the traditional system that meets the requirements of the digitization era. Of course, leading firms in manufacturing and services have established excellent in-house training. Yet continuous professional development in the breadth is capable of expansion.

Studies for Germany

There are several follow-up studies of Frey, Osborne (2013) for countries outside the US. Typically these contributions simply take over the substitutability risk indicators for the various professions calculated by Frey and Osborne for the US. When applied to Germany, the outcome even exceeds the substitutability figures for the US. This is simply a reflection of the relatively high share of employment of manufacturing in the German economy, because the risk of substitution of certain tasks through technology is comparably high in manufacturing occupations.

The transfer of US data to other countries can be criticized as inadequate because the task content of different professions differs between countries or even within-country. Studies that are based on country-specific substitutability risk indicators are more reliable

CLOUD ROBOTICS

The term Cloud Robotics was coined in 2010 by James Kuffner and constitutes a development of Network Robotics. While robots or individual systems in Network Robotics still need to access the stored knowledge of a network, here they draw all information from the Internet. The information base is much more voluminous. Using the cloud, a robot can upload and compare pictures, maps, or data and is thus able to perform the tasks assigned to it quickly and accurately. This way, robots are also able to adapt to new situations by querying the appropriate comparative data and independently drawing conclusions – they are capable of learning. Since large parts of these processes take place in the cloud, i.e. they are outsourced, the functionality of the machine increases without it being necessarily larger or more expensive.

(Bonin et al. 2015; Dengler, Matthes 2015 a, b). Another important point of departure is the underlying time horizon for the substitution process. The pioneer study by Frey and Osborne looks at substitution processes which according to experts are likely to occur in the coming years. By contrast, Dengler, Matthes (2015 a, b) and Buch et al. (2016) in their studies for Germany consider tasks within a certain profession that already can be substituted by digital technology today. Of course, this has consequences for the results. According to the criterion used by these authors, the share of employees working in professions where more than 70 per cent of the task content is under a high risk of substitution is with 15 per cent markedly lower compared to approaches using the Frey and Osborne indicators.

Dengler, Matthes (2015 a,b) and Buch et al. (2016) stress two further important points. First, the task content of professions is not constant over time. It adjusts to different needs and technology developments. Take the example of a chimney sweeper. In former times, his or her main task was actually sweeping the chimney. Today this task is secondary. In the first place, a chimney sweeper is an environmental technician who measures emission values, makes security checks and, gives advice for more efficient energy use. This example shows that if the main task within a profession becomes obsolete because of the evolution of needs, technology, or other reasons, the task compo-

According to the advocates of collaborative work, e-mail is dying a slow death, at least in working contexts. Because for the rapid exchange, management of collaboratively drafted documents, or uncomplicated distribution of workflows, e-mail is proving to be too cumbersome; in addition, e-mails are sometimes lost. These processes are more effective with tools for collaborative work. These tools allow for centralized management of individual projects, a quick exchange via chat and video features, as well as the involvement of all employees in all operations. The result: better teamwork and increased quality – at least according to the proponents of collaborative work.

sition within the profession responds to new requirements. If this is so then we should only in rare cases observe that professions (and the corresponding jobs) disappear. Much more often, the professions survive by adapting to new conditions.

Second, we observe that workers in the same industry can be exposed to different risks of substitution. Not only the task composition within the same profession, but also the composition of professions within manufacturing industries varies across regions. The comparison between the federal states of Saarland and Bavaria is a striking example. Both have roughly the same share of manufacturing workers in total employment although the share of employees exposed to high risk of substitution in Bavaria is five percentage points lower (about 15 vs 20 per cent, see Buch et al. 2016, p.3). A possible explanation is that the state of progress in structural change varies from one region to another.

Final remarks

All in all, we should be careful not to fuel unjustified fears of job losses on a large scale. I am well aware that this is not the intention of Frey and Osborne. However, the reception of the »47 per cent of jobs at risk« in the media with headlines like »Robots – the arrival of the job-destroyers« tends to scandalize and misses the main point. The merits of the Frey and Osborne study lie in the fact that we can iden-

tify certain tasks within a profession, a firm or an industry that are exposed to a higher risk of substitution. Moreover, it is rather likely that the tasks at risk are not only those manual and cognitive routine jobs requiring low and intermediate skills but also those performed by high skilled workers.

To what extent job losses materialize in all fields where technology is able to substitute human labour remains an open question. Engineers typically tend to overestimate the technical possibilities, and there might be legal and economic hurdles or even preferences standing against it.

It is rather likely, however, that need for adjustment is increasing in the future. This is the case not only within professions and firms but also between professions, firms, industries, and regions. This poses a challenge for labour market policy as well as for the education, training and re-training system.

References:
- Bonin, Holger; Gregory, Terry; Zierahn, Ulrich (2015): Übertragung der Studie von Frey/Osborne (2013) auf Deutschland, Mannheim.
- Dengler, Katharina; Matthes, Britta (2015 a): Folgen der Digitalisierung für die Arbeitswelt: Substituierbarkeitspotenziale von Berufen in Deutschland. IAB-Forschungsbericht No. 11, Nuremberg.
- Dengler, Katharina; Matthes, Britta (2015 b): Folgen der Digitalisierung für die Arbeitswelt: In kaum einem Beruf ist der Mensch vollständig ersetzbar. IAB-Kurzbericht No. 24, Nuremberg.
- Buch, Tanja; Dengler, Katharina; Matthes, Britta (2016): Relevanz der Digitalisierung für die Bundesländer: Saarland, Thüringen und Baden-Württemberg haben den größten Anpassungsbedarf. IAB-Kurzbericht No. 16, Nuremberg.
- Frey, Carl Benedikt; Osborne, Michael A. (2013): The future of employment. How susceptible are jobs to computerisation? Oxford.
- Möller, Joachim (2010): The German labor market response in the world recession – De-mystifying a miracle. In: Zeitschrift für Arbeitsmarktforschung, Vol. 42, issue. 4, pp. 325–336.
- Möller, Joachim (2015): Verheißung oder Bedrohung? Die Arbeitsmarktwirkungen einer vierten industriellen Revolution. IAB-Discussion Paper No. 18, Nuremberg.

ARTIFICIAL INTELLIGENCE AND AUTOMATION: THE CHALLENGES FOR EDUCATION

A SCHOOL PERSPECTIVE

BY
STEPHEN SPURR

Dr. Stephen Spurr is the Group Education Director of Inspired, a new and quickly growing international network of premium schools on four continents and with 15 000 students. He started his career in academia as a university lecturer, having gained a first-class degree in Classics at the University of Sydney, the award of a postgraduate Fellowship at Harvard, a Rome Scholarship, and a Doctorate in Philosophy from Oxford University. In 1984 he was appointed to teach at Eton College, becoming Head of Classics and House Master, and was Headmaster of Clifton College from 2000–2005. From 2005–2014 he was the Head Master of Westminster School, the leading academic British public school.

Education is far too often left out of the debate on artificial intelligence (AI) and automation, so educationalists must regain the initiative before it is too late.

Take, for example, the article in Wikipedia on the application of AI. Education does not appear. Finance, transport, medicine, commerce, military use, industry, games, yet not education. That is symptomatic of the situation. But the debate could not be more important. It is about how well education prepares young people to flourish in a society pervaded by intelligent technology.

In the past industrialization, technology and automation have increased productivity and, arguably, the quality of life. But with this new wave – some say tsunami – of technological innovation and automation, the future could be very different indeed. Thus educationalists, whose task it is to plan for the future as they teach the young in the present, cannot bury their heads in the sand as the waves approach. They need to think ahead and, in doing so, take control of the agenda.

This article, which concentrates on education in schools, and aims to provide practical suggestions based on a lifetime's professional experience, believes that school teachers have a very significant role to play and that governments and school leaders must provide the professional development and resources to assist them to live up to their vocation and responsibilities.

Teachers and their concerns

There is much to do. Technology is changing very quickly, so we cannot simply wait until the next generation of teachers is ready. Current teachers need to be supported, trained, and continually retrained. To do so properly we need to understand their concerns and challenges. In effect these fall into three broad categories.

Firstly they fear that their traditional authority, knowledge, and wisdom will be replaced by super-intelligent machines which will make them redundant, alter our economy and even engulf us as a species. And when they hear from eminent academics such as Stephen Hawking that AI could spell the end of the human race, their fears seem fully justified.

Other teachers are simply apprehensive. They are immigrants in the world of digital technology, while their pupils are natives. They worry that the teacher-pupil role is in danger of being reversed, and the best that teachers can hope to become are assistants or child-minders, no longer the authoritative transmitters of knowledge to the next generation.

And thirdly there are those who, through scholarly disdain for technology, insist on the superiority of traditional teaching methods, looking only to the past and selling the future of their pupils short.

And yet recent studies by the OECD and from Australia might seem to give some credence to this third group. In affluent schools too many classrooms have become technologically rich but ineffectively so, these studies argue. iPads and other devices have been handed out, and teachers demoted to the role of »facilitators«. When they have tried to teach, their pupils are texting, playing games, or plagiarizing from the Internet. In these circumstances educational technology has become a distraction, pupils have become lazy – while believing they are mastering the skill of multi-tasking – and their learning has diminished together with their powers of concentration.

Worse still, in wealthy societies at large, gadgets have become a fashionable distraction. Take for example the artificially intelligent clothes peg that warns you not to hang out the washing because it is likely to rain, or the toothbrush that scores your attempts to clean your teeth and tells you to do better next time. These are gimmicky solutions to non-problems, which risk infantilizing the citizen body rather than educating it, making us gadget-dependent rather than independent thinkers.

Then there is the ethical dimension. On the one hand the anxiety of teachers, shared by parents, of the harmful effects of the misuse of the Internet, enhanced by evermore powerful search engines, and on the other what it is to be human in an increasingly machine driven age.

All the above is completely understandable and must be taken seriously. However, the greatest danger is surely non-engagement by educators. The argument of this article is that teachers must embrace

CONTENT SHARING

A form of e-learning, in which learning content is exchanged, e.g. through commercial or free sites such as the "Centre for Teaching Media on the Internet" (ZUM), in order to improve the quality of transcripts or educational content and to make course material freely accessible. Particularly in connection with the sharing economy as an increasingly strong form of the future economy, sharing should play a greater role in schools, according to some educational researchers. Not only as a way to spread knowledge effectively, but as a cultural technique that "leaves the pure competitive spirit behind," as described by futurologist Willi Schroll.

change and the opportunities AI offers, use it to empower their teaching and to help their pupils excel – in their learning, in becoming informed citizens, and responsible human beings.

Teaching styles

So how can they do this and what form must education take? At the end of the fifth century BC, Socrates tried to break the mould through question and answer, encouraging higher-order thinking in his pupils, getting them critically to examine traditions and preconceptions and to consider the proper purpose of life.

But we all know what happened to Socrates. He was put to death for being too revolutionary and upsetting the established order at a time when Athenian democracy was under threat, and the lecture mode where teachers transmitted their knowledge through instruction and rote learning became the general norm in Western universities and schools for the next 2500 years.

In another culture 100 years before Socrates, Confucius reasserted hierarchical values in society with the teacher as the authoritative figure, whose knowledge and views were unquestioned by pupils. These values are still ingrained in the Eastern educational tradition.

This is of course a generalization. Many Western teachers use the dialectic method effectively to engage their pupils; and there are Chinese educators who emphasize the Confucian saying »I hear and I for-

The term creativity refers to the ability of an individual to create something new. It goes back to the Latin word "creare" meaning to create, and is commonly associated with activities of creatively gifted artists or artistically active people. However, every person shapes from an early age on, by a creative exchange with their environment, their world in some way. Therefore, every person has everyday creativity. This includes fluid thought, association joy, and the ability to change perspective and to push limits in a controlled way. Although an exceptional giftedness in this area seems to be a natural predisposition, a creative approach to problems and questions can be trained.

get, I see and I remember, I do and I understand«. And we should all remember that both Confucius and Socrates placed moral integrity and the common good at the heart of their teaching.

Equally, when pupils of both cultures learn together, Western children are often impressed by the powers of concentration and memory of their Chinese counterparts, while the latter, in remarking on the questioning by their Western fellow pupils, often also complain that such interjections slow up learning in lectures given by truly inspirational teachers. Yet by taking the best of both cultural traditions, a winning learning fusion can be created: with pupils preparing thoroughly in advance for each lesson and then asking focused questions during it from an informed point of view.

I mention such traditional norms and cultural differences, since in our modern interconnected world the aim of teaching must be to transform the pupils of today, wherever they are taught and from whatever background, into the morally responsible global citizens of tomorrow, willing to think for themselves and to collaborate with each other for both national and international public good and prosperity.

To succeed, teachers must now rethink education, combining the best of the past methods of instruction with the best of the new, while also understanding the learning styles of various cultures and backgrounds and, indeed, of each of their pupils on a one-to-one basis. And

they must be convinced that by embracing AI-powered educational technology this great task and responsibility will be made easier not more difficult.

AI is already here

In fact there is nothing new about AI – a term invented some 60 years ago – and it has incrementally filtered through into modern life over this period almost without our noticing. This is true of education as well, despite the Wikipedia article mentioned before.

Some ways in which AI is already embedded in educational technology include:

- adaptive assessment tests where a pupil's level of knowledge and understanding is quickly recognized and then questions are adapted to test his or her skills of thinking and application;
- objective and rapid marking and grading of exams; »intelligent e-textbooks« with interactive annotations and quizzes to test understanding, where the teacher can see what has been read and monitor the progress of each pupil;
- personalized learning, again with adaptive computer programs that allow the pupil to learn by trial and error (which is often less intimidating than in a classroom situation) and build confidence through automated feedback and repetition until the task is learned;
- and such »computer tutors« can then provide information for the teacher about each pupil's learning to enable really effective personalized teaching and follow-up in the classroom;
- accumulated data is increasingly available on how different pupils learn (girls and boys, children from diverse backgrounds and cultures);
- and the potential of children with learning difficulties can be immeasurably advanced by assistive technology.

The list above is indicative rather than exhaustive. Teachers will already be aware of some points or even take them for granted, and there is always great merit in considering ever more carefully how best they can be used.

Looking ahead, some teachers are now experimenting with 3D holographic computer programs. These are likely to be the next big development, and it will be important to harness their use for educational purposes rather than simply for entertainment in theme parks. These devices can transport pupils interactively to any part of the world, on to the slopes of Everest or even onto the surface of Mars, enhancing their engagement – »I see and I remember, I do and I understand« – and extending their understanding and experience. Even more amazing is the technology that can transport holograms from one location to another, which could enable subject experts, inspirational speakers, or teacher-trainers to appear in any classroom or staffroom anywhere in the world.

Blended Learning

The new educational approach, which I believe is most fit for purpose for the modern age and which will serve teachers best, is that known as »blended learning«. It has many advantages, which I shall explain further below, for example:

- The best traditional pedagogical methods are combined with the best use of educational technology, maximizing the value of both and thus engaging rather than alienating educators.
- Teacher-pupil face-time in the classroom to be devoted to the development of higher-order learning and critical analysis, for both collaborative and personalized learning.
- Homework (the bugbear of pupils and parents) becomes engaging and purposeful, building self-confidence and the skills of independent thought and problem-solving.
- Classrooms do not need to be »technologically rich« but rather »technologically effective«, both keeping IT costs down and pupils concentrated on their learning tasks.
- Some curriculum time is freed up for the encouragement of character building, such as empathy, resilience, perseverance, and for pastoral and social welfare

Since the Enlightenment, critical thinking has been the essence of education and study. In addition to knowledge and skills, the learner should practice a critical approach to them. With the beginning of globalization this assumption no longer seems to apply – instead criteria such as professional relevance, efficiency, and capability optimization have come to the fore. With the challenges of digitization and the increase in available knowledge, however, awareness of the necessity for critical thinking has made a comeback. "Critical thinking must be part of the class schedule!", says New York philosophy professor Massimo Pigliucci. It is necessary to enable learners to be able to find "the golden nuggets" in the flood of information, to process it, and to draw meaning from it.

The best book on the subject is that of the developers of this form of learning (Michael B. Horn and Heather Staker, »Blended. Using disruptive innovation to improve schools«, 2014 San Francisco). Various models of blended learning are outlined and discussed, which schools are encouraged to select or modify to suit their own needs.

I still continue to observe lessons where a teacher claims to make good use of IT, but instead a power point is displayed with the teacher reading through it line by line. This is no improvement on the former classroom practice where the teacher writes everything on the board and asks the pupils to copy it all down in their exercise books. There is perhaps ten minutes of discussion at the end of the lesson and then the homework is to learn everything off by heart for a test next time. It is perhaps slightly better than the traditional lecture from the teacher at the front of the class with five minutes for questions at the end – but not much. Knowledge is transmitted, which is important, but very little actual learning occurs in the lesson, and pupils do not develop the skills of critical analysis or understand how to apply their knowledge to new situations.

The blended approach includes the notion of the »flipped classroom«. In this sense pupils prepare, in their own time at home or during time set aside for private study in school, for the next face-to-face lesson with the teacher. At Westminster as in many other traditional

DISRUPTIVE TECHNOLOGY

A Disruptive Technology is like a needle in a haystack that entrepreneurs and start-uppers are frantically looking for. It usually arises in a niche area, unnoticed by established providers, because at first glance new technology has mostly disadvantages compared with an established product. But when additional criteria are included, it has so many advantages that the disadvantages soon stop being an issue and the new technology partially or completely replaces existing products or services on the market. Example: digital photography. At the outset, its poor resolution seemed to offer only disadvantages compared to small-format photography. But the low cost of image formation and the possibility of immediate processing triggered a boom in digital photography, and analogue photography today is only for enthusiasts.

English schools homework has always been called »prep« (i.e. preparation), the concept being that pupils arrive at the next class having researched new material and syllabus content so as to make the most of class discussion. In the flipped classroom of blended learning this prior research is often enhanced and made even more effective by the use of interactive educational technology. So this is a clear example of using the best of the traditional with the best of the new.

To give one example, a teacher might ask their pupils to read a new section of an AI-powered e-text book, to which is added a video-clip, some annotated comments by the teacher together with an engaging quiz to test comprehension. The teacher is able to see just how many pages each pupil has read (or how many times the pupil has read them), and the quiz will show what was straightforward or difficult. All this is seen by the teacher electronically before the next lesson so that they are prepared to make the very most of the face-to-face time of the following lesson in order to advance the learning of each child.

Other examples are adaptive computer programs that enable pupils to master the basic content, for example of certain language rules of grammar and syntax, and then to enrich understanding with ever more interesting and complex material appropriate to a pupil's individual experience and ability. This is done in the flipped classroom at

each child's own speed, the program adapting and reinforcing the learning and building confidence. Again the teacher can see what has been easy or more complex. The same general process can be used for the mastery and extension of mathematical or scientific content.

Parents, using the parent portal of the school learning system, are also able to see what their children are learning and with what success.

This is not the world of Big Brother and 1984! The trusting teacher-pupil relationship and the bond between parent and child have always been essential to the encouragement of learning, of aspiration and ambition; and the flipped classroom, assisted by educational technology, can make this ever more effective. The child is able to work at their own rate, building self-confidence as subject content is mastered and gaining the skills of independent research as new subjects are explored in advance of the next lesson. And that exploration must be encouraged. The flipped classroom, while in part to assist both pupil and teacher develop a really effective form of personalized learning, opens up a liberating world of independent research possibilities as both knowledge and learning power increase.

The valuable face-to-face classroom time is not then wasted with repetition, copying notes from the board, or listening to a lecture with only five minutes at the end for questions. Instead the pupil arrives prepared for each lesson and is immediately engaged in discussion or written exercises, both on an individual and collaborative basis, designed for the advancement of learning. Again teachers need to think very carefully about how to enable such deeper learning. It requires a great deal of planning. It is not just a question of pace of teaching. It is a question of pace and quality of learning, the development of analytical, creative higher-order thinking skills. AI and blended learning do not make the teacher's work any easier, but they do make it more effective and rewarding.

In this building of a child's self-confidence and liberation of their potential, assisted by educational technology, it is important, as

throughout history, that the teacher authoritatively guides the learning. If pupils are texting and playing computer games in class unseen by the teacher, then the technology becomes a distraction and learning retreats. Worse still, pupils become dependent on their devices and gimmicky applications, with the risk of turning into a dumbed-down citizen body in the future. Fortunately the software now exists which allows the teacher to turn on and off pupil devices and to start up the research programs appropriate to the task in hand at the right moment. This is an example of the sort of AI-assisted technology that educators, once they have begun to take control of the agenda, have been able to demand of programmers. And there must be and will be more.

Costs

School budgets are tight, so the cost of technology is always an issue. Too much money has been wasted by schools keen to be at the cutting edge of technology without a coherent educational approach of how best to employ it; and devices end up being little used or even discarded. A benefit of the blended learning approach is its cost effectiveness. Classrooms need to be wireless and equipped but not overly »technologically rich«, since the face-to-face time with the teacher concentrates strongly on interpersonal interaction.

Moreover, as the cost of mobile devices decreases, the use of educational technology as described in this paper has another potentially enormous benefit – namely the educational empowerment and increased social mobility of pupils from all backgrounds in both developed and emerging economies. Take Kenya as an example of the latter. In Nairobi pre-industrial labouring jobs are everywhere to be seen, but so is the rapid adoption of technology. With more and more of the population owning smartphones and turning to entrepreneurial e-commerce, Nairobi has earned itself the title of »Silicon Savannah«, enabling it to vault into the third machine age in one go; and this growing digital literacy can now be harnessed also for Kenyan education as a whole.

EMPATHY

Empathy refers to the ability to perceive and understand the experiences of others. This also includes the response to the feelings of others through compassion, sadness, or pain and sorrow. Empathy is a basic human characteristic, a prerequisite for moral behaviour and social interaction, and is already observable in infants. So-called mirror neurons are responsible for the development of empathy. The significance of mirror neurons is that they have the same excitation pattern upon observation of an action as during implementation of that action, resulting in an intuitive emotional attachment to what is observed.

While the new wave of AI will surely have a profound impact on society and many tasks carried out by women and men will become automated in the future, teachers will not be replaced by robots. More of the teaching and learning tasks will doubtless be automated by increasingly intelligent machines, but by no means all. But this will be for the benefit of both learner and teacher. Pupils will become ever more self-reliant and confident, using AI to assist them whatever their learning needs, backgrounds, or cultures, while teachers will have more time to concentrate their knowledge and wisdom on cultivating thought in their charges and developing character. Put simply they will teach their pupils to excel as human beings.

Character development

The greater time available for the learning process through the use of blended learning and AI can create space for the character mentoring and development central to both the Confucian and Socratic educational approaches. Such life-coaching can cultivate the personal qualities of empathy, courage, optimism, grit, and resilience, both for private and public fulfillment, which are as much in need today as they were then – perhaps more so. We read much today about concern for the mental health of young people, so this kind of life-skills teaching is no longer an add-on, but should be embedded – under the blended approach – in the curriculum (see further below). Nor should char-

FLIPPED CLASSROOM

A method of Blended Learning. The traditional division of information sharing and homework is reversed: students master the learning content at home before class. In school, the material they have prepared is then applied and elaborated on. Preparation of the material is done mainly at home using video sequences made available by teachers. In case of difficulties or questions, students can communicate with teachers via chat or other online channels. The advantage of Flipped Classrooms is that students control their own pace and teachers can better coach their students in the classroom. Drawbacks include, inter alia, the high effort for the teachers.

acter development be considered separate from intellectual development but rather essential to it, since it provides robust scaffolding for both thinking skills and knowledge, combining to build the confidence and well-being to help each child flourish.

Parents are to be loved by their children, as Aristotle said, because they give them life, but teachers are to be praised more since they teach them the good life. What that good life entails is beyond the subject of this paper, but I do sense that young people across the world are turning again to community, national, and global issues and away from the self-centred, indulgent, lifestyles with which they are often associated. They are deserting the narcissism of Generation Y for the aspirations of Generation Zero – the generation with the knowledge, skills, and motivation to reduce to zero the threats from pandemic illnesses, poverty, climate change, and conflict.

Solutions to these and other issues do not come with instructions. Teachers need to equip their pupils to become problem-solvers, what might be called »knowing what to do when you don't know what to do«. No longer can we get away with teaching pupils how to give the right answers to closed questions. Instead they must learn to think beyond the obvious questions and to come up with new approaches.

This demands a new way of teaching and learning – not (as so often throughout human history) directed towards maintaining the tra-

ditions of the past, the hierarchies of the status of quo, and the current balances of power but to enable people continually throughout life to update their knowledge and thinking skills to become leaders themselves or, at least, to become informed members of a globally aware democratic society and to hold their leaders accountable.

This will require confident, knowledgeable teachers who continuously keep abreast of developments in their own subjects and alive to the needs of young people – the development of their intellect, character and moral outlook. To do this they will need to be digitally and technologically literate. That is no longer an option; and I believe that blended learning techniques offer a welcome way forward. So this is the time for teachers to rediscover their vocation and reignite their passion for education. It is also the time for governments and school leaders to value them, resource them and provide the necessary time and commitment to their professional development.

Curriculum

What then should the 21st century curriculum look like? What of its content and what knowledge and skills should it seek to impart? It is beyond the scope of this paper to provide any extended discussion, so I shall limit myself to some indicative suggestions.

Traditionally schools have taught core competencies such as reading, writing, and arithmetic. Artificially intelligent machines have already surpassed humans in reading and arithmetic and are quickly catching up with writing. If machines can already defeat World Masters of Chess and Go, many have begun to argue that what we now need to teach in schools is EQ instead of IQ.

This is a false dichotomy. We need to teach both skills, and the blended approach allows time in the curriculum. Teaching them together is the recipe for developing higher-order thinking skills, as mentioned above. This is where a carefully devised life-skills programme is essential, but all subjects need to be taught in a way that enhances both individual learning and thinking of others.

INDUSTRY 4.0

Term from a project by the same name of the Research Union of the German Federal Republic's government on its high-tech strategy. "Driven by the Internet, the real and virtual world are growing together into an Internet of things," it says on the website of the Federal Ministry of Education and Research. The project aims at promoting the interconnection of industrial production and "state of the art information and communication technology". In brief: Industry 4.0 refers to the digitization of industry, which encompasses the development of new business models and the optimization of production and logistics.

Likewise with self-confidence. While the personalized teaching increasingly enabled by educational technology should help each pupil to build his or her own confidence in all subjects, time for the discussion of life skills with their teachers who understand the issues facing young people will help to create the self-aware, resilient, and optimistic generations of the future. Another practical suggestion is a public speaking course for every child from a young age. This assists immeasurably with confidence and also emphasizes that face-to-face communication must still remain an essential human skill in a world that must work together.

Traditionally also pupils have tended to study by themselves. This is still important in the sense that all need to learn personal self-reliance and resilience, but it is not enough. In an interconnected world, where issues are complicated and multi-faceted, collaborators with diverse skills working in teams, complementing each other, provide the best solutions. Likewise within the taught curriculum, subject specialist teachers need to share their awareness with their pupils of how and where areas of expertise overlap with that of other colleagues. For it is often at the vertices where disciplines meet that discoveries and breakthroughs are made. So the skills of collaboration need to be cultivated and taught: they do not just happen. Both independent and interdependent thinking must be encouraged.

Next I would add creativity. This is not a skill to be limited to the performing and expressive arts. It can be learned there but then has to be transferred to other areas of the curriculum. There should be just as much creativity applied to mathematics as to music. And I would add that digital technologies offer great potential for the development of creativity and imagination.

In terms of curriculum content, there are those who argue that, since knowledge is constantly being updated on the one hand and, on the other, is easily available via a voiced question to our iPhone's AI-powered Siri or its equivalent, there is little point in learning anything.

Thus we recently went through a period in the UK where the Department for Education was renamed the Department for Skills. The reason given was that, in the age of the Internet, where all knowledge was only a click away, pupils did not need knowledge. They only needed to know where to find it. Teachers were called facilitators. And this was known as progressive education.

The new argument is now that, since artificially intelligent machines will know everything, humans will again require only skills – the sort of skills that differentiate us from robots.

This needs to be resisted. Critical thinking skills cannot be developed in a knowledge-vacuum. We must still absorb information (e.g. through the flipped classroom) and, with the guidance of authoritative teachers, turn that into knowledge. As pupils gain the foundations of knowledge they can then be taught skills of analysis and how to solve higher-order problems. Educated in this way, they will be able to discern what information is relevant and what is not, building layers of knowledge throughout life and the ability to make sound judgments.

And even if we do arrive at a point where much routine work is performed by computers, knowledge acquisition by humans will still matter – less, perhaps, for the economy, but certainly for the proper

functioning of a democratic society where discussion by an educated and informed electorate will be evermore important.

We have rightly concentrated on STEM subjects in recent years. Sir Tim Berners-Lee, best known as the inventor of the World Wide Web and now professor at MIT's Computer Science and Artificial Intelligence Laboratory argues that children should not just use computers to enhance their learning power but should also be taught how they work. Digital literacy for the future should include an understanding of not only what is on the screen but what is behind it. A future functioning democratic society must be digitally enabled not digitally dependent. Thus Computer Science must be included in the core curriculum.

That said, we must equally ensure that STEAM not STEM lies at the heart of the curriculum. The A (for Art) is short-hand for both creative subjects and the Humanities in general. We must not return to C.P. Snow's separate »two cultures«. Both must be embedded within the core curriculum and intertwined, for the development of creativity across the spectrum of subjects, as mentioned above, and also for the creation of a balanced and civilized society.

INFANTILIZATION

In November 2012, the journalist Edo Reents published an article in the Frankfurter Allgemeine Zeitung on "the infantile society" under the headline "People Becoming Children". He accuses digitization of a deep-rooted "general infantilism". "The Google logo speaks volumes in its colourfulness and signals a childlike innocence (…) that distracts us from the business interests of the company. Devices make us too disjointed and often rude to people. Even conservative people who are called on their mobile phone while sitting at the dining table often no longer find it necessary to step away for the duration of the call (...). Playing while eating has become completely normal, and the idea that everything has its time and place no longer seems to apply. There are literally no discrete areas of life anymore."

IT DOESN'T WORK WITHOUT PEOPLE — A REFLECTION FROM THE QUINOA SCHOOL

BY FIONA BRUNK
AND PANTELIS PAVLAKIDIS

Dr. Fiona Brunk is co-founder and managing principal of the Quinoa School founded in Berlin-Wedding in 2014. Brunk studied Mathematics at St Andrews University in Scotland and completed her doctorate in Combinatorics. After graduating she worked as a Fellow at Teach First Germany. Subsequently she worked as an expert in the Innovation Management Department of the Deutsche Post DHL.

Pantelis Pavlakidis is a teacher of the third year at the Quinoa School. Pavlakidis studied Social and Cultural Anthropology, Scandinavian studies, and European Ethnology at the Universities of Münster, Lund/Sweden, and Humboldt University of Berlin. After completing his studies in 2012 he initially worked as a Fellow at Teach First Germany before joining the Quinoa School in 2014.

Digital equipment in schools has its appeal. And all the more so when the school is in an underprivileged area. Where in other schools plaster is crumbling from the walls, where rain may be leaking through the roof, gyms have been left to decay since their construction, and a restroom sign is more a fanciful alibi than reality. But the Quinoa School is different: of course, after a year of operation with 52 seventh and eighth grade students our classrooms no longer look as if they are straight out of a magazine, but compared to most other Berlin schools we have it pretty good. The building had been renovated extensively by our landlord before we moved in, and the classrooms are equipped with modern facilities. Most students know intuitively how to use the smart boards on the walls. Does the device need to be calibrated? This message brings anxious beads of sweat to teachers' foreheads, but Marc and Samira are immediately on it and save the lesson with a few skilful clicks. Next door in the computer room, a group of students volunteer to spend their break brushing up on their English skills using their smartphones and learning apps – with the old textbook and vocabulary list method, the level of interest probably would not have been half as high.

Nevertheless – the experience of our school in working with disadvantaged adolescents and their families in Berlin's Wedding quarter has shown us that digitization of the classroom is not a sufficient response to the fact that a family's socioeconomic background continues to have a greater influence on educational success in Germany than in almost any other country in the OECD. But we do not want to get lost in an education-policy debate, rather our goal is to describe what we are facing here in Berlin-Wedding every day: we see socioeconomically weak families with partially neglected and overburdened children. Some of them act like young adults: they get up independently in the morning; if there is something in the fridge, they make themselves a sandwich. If not, we offer them cereal and fruit before class because you cannot learn on an empty stomach. By contrast, others

MASSIVE OPEN ONLINE COURSES

Massive open online courses (MOOC) refers to free online courses, offered by universities, that anyone can log onto with unrestricted access. The term was used for the first time in 2008, when George Siemens and Stephen Downes offered a course at the University of Manitoba on the Internet – 2300 participants took part. The phenomenon received more hype when Sebastian Thrun offered a course on Artificial Intelligence at the University of Stanford in 2011. Around 160 000 people signed up, of which 23 000 completed the online offering successfully. In Germany, MOOCs are offered for example by the Hasso Plattner Institute on the platform openHPI. It was first assumed that MOOCs would be used by people who had no other access to education. This assumption has not been confirmed: most participants already have a degree and participate in an MOOC as additional training.

are used to having their way at home like little princes and respond with incomprehension when they get serious feedback at school. Many of them have to act as translators and interpreters for their parents at the social services departments or at the doctor; the traditional roles within the family are reversed and turned upside down.

Such young people find it difficult to enter into relationships with other people. They are initially suspicious of strangers, whether they meet them at school or in another context. They are accustomed to consuming media during the day and have shifted their social life into the digital world. I like? Thumbs up! Dislike? Simply »close«, and the airwaves are interposed as a digital barrier. But they also act and react this way in the analogue reality. In addition, they have very short attention and concentration spans, often no longer than a seven-minute tutorial on YouTube.

So what is our approach to make a difference here? In our school we are convinced that pupils will only be successful if they learn that there is an adult offering them support and orientation. For this reason, our educational approach is based on, amongst other things, building deep and lasting relationships. So for example, once a week each student meets with a teacher for tutoring. Before they can discuss curricular objectives and the necessary steps to reach them, in many cases it is necessary to first do some »tidying up« of private

matters. Because if chaos reigns in the mind, there is usually no space for a polite »please« and »thank you«, let alone for Mathematics or German.

In addition to the tutoring, we offer our young people a friendly support structure on which they can rely entirely. Many of them have been accustomed since elementary school to the devastating phrase, »You'll never amount to anything!« When you connect this impudence with the grim statistic that one in three young people drop out of high school in Berlin-Wedding every year, one might be inclined to blame students for their own failure. As the saying goes, constant dripping wears away a stone, and so young people begin to believe this devastating sentence. It is a mammoth task to break down the retracted and distorted self-images that students have. This can only be achieved by reminding them time and again of the high expectations we have of them, that it is not enough to just regurgitate the basics. Yes, the way to a self-determined future is not the easiest, but they can and will succeed. Ali is not dumber than Anton, and Flora is not smarter than Fadime. The point is that you have to show young people that they can do it, just like Anton and Flora. They need to know that there is someone who believes in them and their talents. They have to experience honest appreciation that recognizes their personal and sometimes difficult living conditions, but does not confuse that with pity. They need to know that they all make a valuable contribution to a democratic society and thus are an essential part of our community.

It would be naive to argue that this simply works and we never encounter setbacks. But we are on the right track, and that motivates us going forward. We are encouraged when the refugee Nabil, who has been in Germany for only three years, proudly announces in his speech to the Future Congress of the Federal Ministry of the Interior: »I am Nabil. I'm 13 years old. I come from the Quinoa School in Wedding. And I'm going to be a doctor.«

We cannot afford to write off a whole generation of young people. That app can not just be erased, or the whole system will break down. No robot or artificial intelligence can give us that. We need educators who are thoroughly human.

The Quinoa School was founded in 2014. It is named after a South American grain that is energy-rich and nutritious, but often underestimated – as are educationally disadvantaged young people. A total of 78 students are learning at the private secondary school (grades 7 to 10) in Berlin-Wedding. About 80 per cent speak German in addition to another language at home.
Very few families pay school fees, which are oriented to the low fees for public kindergardens in Berlin. Most families are exempt from school fees. The school is funded by public money as well as grants and student sponsorships from foundations, businesses, and individuals. From the beginning, the Vodafone Foundation Germany has been one of the school's main sponsors. With a teaching style that focuses on appreciation, reliability, and faith in the talents of the students, Quinoa hopes to help disadvantaged young people obtain a successful education.

MOORE'S LAW

Rule of thumb and self-fulfilling prophecy, which dates back to the Intel engineer Gordon Moore. In the sixties, Moore predicted that the number of transistors on an integrated circuit would double every two years. The rule, according to which the performance of computer chips would also double every two years, has been correct for nearly a half a century: from large-scale mainframes, computers have shrunk from refrigerator to PC-size, down to the dimensions of a smartphone. Strictly speaking, the law will not apply much longer, as chip manufacturers will eventually encounter physical limits in terms of miniaturization. By 2020 transistors will already consist only of just a few atoms. Nevertheless, the computer industry is trying to maintain the same conventional rhythm by equipping devices with more and more functions.

ARTISTS OUTSIDE OF ART

AN INTERVIEW WITH STEPHAN GUTZEIT

How does something new
come into the world?
A discussion with knowledge
entrepreneur Stephan Gutzeit
on incremental innovations, radical
breakthroughs and the question
whether creativity can be taught

Stephan Gutzeit is a serial innovator who builds organizations around new ideas, working with creative entrepreneurs as well as philanthropists and foundations. He completed his studies in Chemistry and Philosophy at Stanford and Harvard. Gutzeit was the lead founder of the first liberal arts college in Europe, among other ground-breaking organizations he has founded. His next project will be a philanthropic foundation modelled on the Bauhaus and devoted to helping creative change-makers achieve what he calls deep »innovation«. He is currently on academic sabbatical at the University of Oxford, where he is writing a mid-career dissertation on deep innovation and teaches philosophy of Social Science, Philosophy of Economics, and other subjects.

After studying philosophy and chemistry you worked as a management consultant and helped establish the first European liberal arts college. For decades, you've been active at the interface of academia and entrepreneurship and you describe yourself as a knowledge entrepreneur. What does that mean exactly?

S G : A knowledge entrepreneur is someone who advances innovation in or around academia, and I mean innovation in the narrow sense. It is not about incremental improvements, which is the responsibility of managers, but an attempt to start something completely new. Innovation is much more than a good idea. It's the combination of a new idea and its implementation. One might say that coming up with ideas is hard enough. But the real art is pushing them through.

Why do we need innovation?

S G : Every society needs innovation to evolve. Of course you also need tradition and gradual accumulation. A society in which everyone were an innovator would be unstable. Conversely, a social system would stagnate without innovation. There's an interplay: one must preserve what is valuable in existing things and improve those by fine-tuning them. On the other hand you also need breakthroughs and radical renewal. The paradox is that the circumstances which foster the refining are a hindrance when it comes to fresh thinking. In the German innovation system, the focus since the Second World War has been to improve what already exists. The push for radical renewal, however, was less pronounced, and so a certain imbalance arose. This affects not only universities, but also businesses and research-based institutions such as the Fraunhofer-Gesellschaft and the Helmholtz Association.

POLARIZATION OF THE LABOUR MARKET

Many economists are predicting that digitization will increase polarization of the labour market. The automation of routine activities will cause substantial job losses in the middle class – such as skilled workers and assistants. Since computerization is resulting in higher employee requirements, e.g. in the IT industry, this will cause an increase in the employment of highly qualified workers. Employees without a university degree in particular will be slipping from the middle class, but as there will be a higher demand in the services market, new jobs will be created, even if they are in the low-wage sector. Polarization can be attenuated through education and training systems that offer people higher levels of qualification, so that more of them can engage in challenging activities.

Can you give an example?

SG: Take Thomas Südhof at Stanford, the 2013 Nobel Laureate in Physiology or Medicine. The Max Planck Society had scared him away, but once he had received the Nobel Prize, German science functionaries scrambled to get him back. In a grandiose press statement they declared success, and Südhof felt compelled to clarify in an interview that he »returns« only as a visitor for a few days a year. With his »iconoclastic temperament«, as he put it, he's better off at Stanford. But the attitude of an iconoclast is exactly what you need for breakthroughs. Or think of something seemingly mundane like household appliances: Miele advertises with the claim »Forever Better«, and indeed the best conventional vacuum cleaners and washing machines in the world come out of Gütersloh. But the first bagless vacuum cleaner was built in England, by Dyson, and the first dry washing machine too, made by Xeros. I could spend hours enumerating further examples.

In principle the Germans are able to do radical innovation, too; or at least they were in the 19th century.

In 1810 the Prussian state was nearly broken, so a creative thinker by the name of Humboldt was given free reign by the king to reorganize the grammar schools and higher education. He broke with scholastic rigidities at German universities by restoring basic educational principles from Greek and Roman antiquity. He renewed a system that had become entirely self-referential by renewing something old.

Something similar happened at the end of the »long« 19th century when the Bauhaus was founded in Weimar in 1919. The war had dissolved the old structures. Walter Gropius was charged with merging two institutions, and he had an unusual amount of freedom because the social structures that might have slowed him down were broken. He built the Bauhaus on a humanistic basis, just like Humboldt had done with the university and the grammar school. His watchword was this: the machine age may seem daunting, but we can humanize and subjugate machines. We should neither reject them nor capitulate to them, but design them to serve our needs. Of course, the Bauhaus was always a minority affair. But Germany today has nothing like that at all. That strikes me particularly when I look to Germany from the creative academic culture that flourishes in Oxford.

But there is research and development taking place in Germany. Berlin is currently the world capital of start-ups. So what's the problem?

S G : Of course. They're trying, but not succeeding. The problem is the bureaucratic and politicking mentality of the people in charge and also the wrong methods. In Germany people try to achieve new things through public relations or standardized processes. The

Germans are in love with processes! But processes are only useful if you don't need to change anything essential. In academia, the best example of this combination of administrative processes and PR is the so-called »Excellence Initiative«. In business, you can take as examples the Samwer brothers and Rocket Internet in Berlin: they have highly efficient, standardized processes for copying business ideas from the United States. Plus self-marketing at its finest. But for the other kind of innovation it is all about finding the right people and building real substance ...

... let's focus on processes a bit more. You say processes don't bring anything new to light. Why not?

S G : I have to go back a bit. There is widespread dissatisfaction today with the fact that although a lot is happening that is superficially new, fundamental human problems are hardly addressed any more. In the fifties, sixties, and seventies we had more technological innovation than today, where most novelties serve only entertainment purposes. The goal today is to invent new gadgets that people will buy, regardless of whether these gadgets significantly improve people's lives. Against this tendency, there are several countermovements, social entrepreneurship for example. In principle, this is commendable, of course. How can we promote entrepreneurs who are working for society? Some fight malnutrition and disease, others help drug addicts. But equally well you might help people with technology! Another trend is so-called Design Thinking. This is an attempt to bring more creativity to businesses, and it goes back to Alex Osborn's book »Applied Imagina-

tion« from the 50s: group thinking and brainstorming. At first I thought this was worthwhile, because the basic intention was good. But this movement mistakenly assumes that processes help everyone become creative and innovative. But that does not work. Discontinuities are produced by productively nonconformist individuals!

What kind of method could produce new things?

S G : It's not about any method. It's about finding the people who are able to do new things. And then you offer those people customized help to realize their ideas. Success depends crucially on the right people. But such people are rare, and functionaries or corporate types find them hard to deal with, because a creative is the opposite of a politician.

In this workshop the central question is how education systems should respond to the challenge of digitization. You don't consider group work and processes effective. Is creativity not productive for everyone? Can't a person's curiosity and the impulse to develop something new be stimulated and promoted?

S G : I've always admired the Oxford tutorial system and now teach like that myself. It's about promoting the creativity of students in a Socratic way. But that is a habit of mind, not a process. Of course we're all creative, to a certain degree. But I don't think much of creativity techniques that supposedly enable breakthroughs. In the spirit of this workshop, it's much more important to promote personal creativity wherever it manifests itself. In elementary or high school. One shouldn't take formal career paths too seriously. Many of the most creative entrepreneurs – Steve Jobs or Bill Gates – have been college dropouts. Especially in a

country like Germany, where people share a religious belief in certificates, you should be more open to creativity, with or without a diploma.

So innovation and creativity can't be encouraged?

S G : I think it's a fantasy to believe that everyone can become super creative. Exceptional creativity is a matter of predisposition. Of course, people need help and support at all levels. In addition, I think if we encourage those who are particularly creative, they will do more for society in return. It's a kind of social contract. We don't expect music academies to open their doors to everyone. If they did, sooner or later they would wither. You can't teach creativity, the Bauhaus rightly held. But you can and should make a toolbox available that is useful and helpful for creative minds.

You've spoken of radical novelties and discontinuities. But what would such a technical innovation look like today? What do you mean by technical progress that truly serves man?

S G : Compare an app that counts calories with the transition from propeller aircraft to jet planes, and you'll realize that innovation has a completely different dimension than what we now consider innovative. If you want a more concrete explanation, I can only paraphrase Karl Popper: If one could foresee an innovation, it wouldn't be innovative any more. Now, what could such a radical breakthrough be? Perhaps an invention that makes travelling both more energy efficient and significantly faster as well as more comfortable through some new functional mechanism that I can't yet necessarily identify.

Even in ancient times, clever minds were thinking about machines; in the early 13th century an Arab engineer designed sophisticated hand-washing machines and humanoids. The first functioning machine was a flute-playing machine, which Jacques de Vaucanson constructed in 1737/38. The term robot was introduced in 1920 by the writer Karal Capek for humanoid machines. Since the industrial robot was introduced in 1960, development has gone ahead rapidly. Today, robots land on Mars, move around (as play figures) in childrens' rooms, can mow the lawn and have taken over many tasks previously carried out through human activities. They are the subject of divergent points of view: while some set great hope in robots, others see them as a terrifying spectre of the future.

Your hopes for innovation lie entirely with the creative entrepreneur working as and like a designer. What exactly do you mean?

S G : Designers simultaneously look at economic, aesthetic, and cultural dimensions of a problem and arbitrate among them. They must consider all aspects of a design problem, and their mutual connections and relationships. That has a lot to do with vision. The most important thing is to look at things afresh, beyond conventional schemas. Few people are capable of this because it requires special endowments. It also requires a strong character: you have to go against your entire environment! And creative entrepreneurs are people who found new institutions around fresh ideas.

You are currently preparing a new organization in the spirit of the Bauhaus. How will this institution or establishment distinguish itself from conventional universities? Will it have to be located virtually on the Internet? Will there be such a thing as conventional teaching?

S G : No, not virtually. It must of course have a common space, a house where people meet and live together. The key factor is that you start by formulating a problem, rather than with openended basic research.

The vision of many car manufacturers and companies in the IT industry who want to bring completely self-driving cars on the market within the next five years. Currently, self-driving cars exist only as prototypes, but Allianz Insurance announced in 2015 that they will soon offer insurance for autonomous vehicles. In Germany, reservations are still considerable, especially after a partially self-driving electric car from the company Tesla caused a fatal accident in July 2016. If self-driving cars prevail in the coming decades, experts estimate that up to 10 million jobs in transport will be in danger.

Take Edwin Land for example, the inventor of the Polaroid camera. He wanted to revolutionize photography by radically reinventing the development process. First, the challenge was designed by artistic people, often art history graduates. Once the technical problems had emerged as well-defined, he borrowed professors from Harvard and MIT, who worked alongside his permanent staff to fill the gaps in the requisite basic and applied research. And Land had an organizational approach that he called »sun and satellite«: for each problem, one person took the lead and the others assisted them. As the question changed, the roles changed. The sun became a satellite and vice versa. I would call it a framework culture: flexible, passionate, and always focused on the problem at hand, not on politics. One must be allowed to upset received ideas and conventional minds.

And how big would this institution have to be? How many employees would it have?

S G : There would be perhaps 30 full-time employees. But beyond them there would be a network of about 300 people to draw on ad hoc.

Sounds like an ideal art school, extended to other fields beyond art.

S G : Exactly! An experimental studio for artists outside of art!

Interview by Andreas Schäfer

BACK TO THE FUTURE — INTO THE DIGITAL WORLD OF TOMORROW WITH ARISTOTLE

BY
MARK SPEICH

Dr. Mark Speich is Managing Director
of the Vodafone Foundation Germany.

In Florian Illies' book »1913«, neurasthenia, a pathological, nervous restlessness becomes the mood of the time. This restlessness is fuelled, among other things, by the still inexact sense of slight trembling that heralds an approaching earthquake. Today, on the other hand, a feverishly nervous excitement builds up around anything that makes reference to the concept of digital transformation. This can mean phantasies of technological salvation in which »digital« represents the infinite expansion of human possibility. But it can also mean gloomy dystopias of unstoppable machine domination in which humans are robbed, first of their jobs and then of their self-determination. Many oscillate ambivalently, undecided between these two poles. And then there are the few – equally nervous – who think they can hide from the digital reality and the alleged dangers of digital dementedness by burying their heads in the sand.

What they all have in common is the ability to sense the impending earthquake, a change that is more powerful than the mere linear unfolding of technological progress. In this volume, Carl Benedikt Frey's contribution refers to the force of potential changes on the labour market of the future. And even if we do not assume those predictions are perfectly accurate, they have had a political impact. Until just a few years ago, the subject of a digital agenda had only a marginal existence in the political focus of the parliament and administration. Meanwhile it has become an issue for heads of government, opposition leaders, and political columnists. For political leaders, digital abstinence is not a sustainable approach for either their communications or planning for the future.

The number of platforms, discussion forums, and summits dedicated to these organizational perspectives cannot be ignored. For some time, conferences, green papers, and foresight processes have been joining the discussion on »work 4.0« and the consequences of the digital transformation for employment opportunities and participation in society. And these in turn are the basis for conclusions regarding

the adaptation of education and training needed in light of future scenarios. Such conclusions are inevitably faced with a dilemma: on the one hand, the need for rapid adaptation is proclaimed in view of the rate of anticipated change; on the other hand is the change itself that remains as yet unclear, since a scenario is ultimately just one possible future. Some of the uncertainties that are significant for the present discussion are clarified below.

Uncertainty 1: The digital transformation will wipe out whole jobs

If one is dealing with the use of machine learning, cloud robotics, and other technology in the workplace, there is in the beginning a great promise. It is the promise of relieving people of all tasks that are heavy, routine, and monotonously repetitive – be it physical labour or cognitive routines. Machines share their experiences with other machines and thus continuously improve what they do, as outlined by Ken Goldberg. At the same time, recognition of patterns in the vast amounts of data they collect makes it possible to respond anticipatory to events before they occur. These methods are relevant for industrial production, the analysis of texts and judgments, as well as for assistance in travel bookings or surgical interventions.

However, there are many activities in which complicated and demanding routines make up the very core of the work. Here, digital automation does not act as a liberating promise, but rather as a threat to the workplace. And even if it proves to be true that the economic transformation process associated with digitization ultimately creates more jobs than it destroys, that macroeconomic knowledge is of little comfort to the industrial worker who is replaced by a cloud connected robot, or the paralegal whose role is taken over by analysis software. In their cases, the new jobs will either be academically challenging or in fields that are far removed from their previous activity.

However, very few activities consist exclusively of routines: most job profiles therefore won't be completely replaced by algorithms or robots. Far more often we will see activities in which certain aspects

SHARING ECONOMY

In the Sharing Economy, which has spread in recent years mainly due to the possibilities of the Internet, it is no longer ownership, but the possible use of a product that is in the foreground. So platforms like Airbnb, Uber as well as car-sharing platforms are making living spaces and mobility available. In addition to commercial offerings, there are also exchange or freecycle networks for the Sharing Economy. Since in principle everyone can participate in this form of economy and for the most part it saves resources, some consider the Sharing Economy the economic system of the future, as revolutionary as the steam engine or the computer. Critics also point to negative side effects: Renting private rooms to tourists through Airbnb in densely populated areas drives up rents.

are automated while other parts are still carried out by people. Robot assistants for surgeons, software that analyses contracts or court judgments for lawyers, booking systems that compile travel patterns for sales agents, connected exoskeletons for nurses, or automated analysis tools for accountants that generate warnings prior to payment risks: all this is already no longer science fiction. Pilots, for example, have long known what it is like when parts of their activities are performed by a machine. Let there be no doubt about it: the change described here is fundamental and a lot of activities will be impacted. But also linked to this change are conclusions regarding the education and training system – beyond the loss of a significant number of existing activities.

Uncertainty 2: The digital transformation devalues knowledge and strengthens skills

In its simplest form, the breakdown of the relationship between knowledge and skills is described with the repeatedly cited idea that it is no longer about »knowing something«, but rather about being able to »find knowledge about a topic on the Internet« and ideally being able »to put it into perspective« through refined media literacy. The processes of finding and of classification, however, are essentially influenced by »knowledge«. Which of the search engine results you focus on depends on the context of understanding in which you classify the

sparsely supplied lines of text, and the extent of that context of understanding is a dimension of knowledge, not of competence. Whether you then trust the text behind the search result or are even able to compare it in turn to other texts on the same subject also depends largely on knowledge, and not on skills in using digital applications. Knowledge and competence form an unbreakable connection that is in no way changed by the digital disruption.

Uncertainty 3: The effective use of digital technologies in trades also requires a basic understanding of their functioning

It is often said that the operation of complex technical systems presupposes a basic understanding of their functioning. This assertion is contradicted by any three-year-old who effortlessly navigates the user interface of an iPad. Digital assistance systems are distinguished precisely by the fact that they make things easier for users, without their intervention and even before they think of it and without creating complexities that can only be controlled with technological knowledge. This is important, because from this lack of clarity conclusions can be drawn regarding vocational education and training. But what good is a rudimentary mastery of programming language or a rough understanding of algorithmic logic to an automotive electrician? He should not be allowed to deal with the highly complex software experts developed for the vehicle's analysis system. But with his dexterity, his ability to execute electronically selected repairs in rather inaccessible parts of a car, he will at least for a while be superior to learning robots. And should a robot outperform him one day, a basic knowledge of coding and digitally networked production will also not provide him with employment opportunities. Even vocational training optimists acknowledge that retraining a tradesman to program the machines that replaced him is rarely successful. That only leaves retraining in distant fields, which though less demanding, are not existentially threatened by digital technology. In that case, he will have the prospect of work if he performs a task that cannot be done by machines or algorithms.

SILICON VALLEY

Silicon Valley is the southern part of the San Francisco Bay Area and the most important place in the IT and high-tech industry, the abode of innovation, intelligence, and creativity, and a magnet for large amounts of venture capital. According to the observations of sociologist Andreas Boes, Silicon Valley is a "digital interactive society", in which one and a half million people deal continuously with the question of how new business models have to be developed. The estimated average age of the mostly highly motivated employees: 29. The estimated number of hours they sleep each night: 4. Because of its innovative strength, the region is seen by many as an entrepreneurial paradise, to which delegations of managers from Europe travel to learn about American work culture.

Uncertainty 4: The ultimate educational response to the digital transformation is more STEM and coding – as early as possible

Certainly we must be grateful for every professional that STEM or coding training initiatives have set on the path to a successful career as an engineer, computer scientist, or data analyst. The world of digital transformation will be marked by a significantly greater need for appropriate experts. This opens up broad employment and earnings prospects, so the numerous STEM programs are justified. But the demand for these professionals is also so high because they should program the world as intelligently as possible with the least possible access barriers for users. A world programmed by a growing number of experts is connected to a big promise: freed from routine and other stress, people can finally concentrate on what makes them human: the productive creativity inherent in disruptive entrepreneurs as well as in great artists, the caring, compassionate, motivational, and sometimes inspiring human interaction that machines can only simulate (thereby depriving them of their value), or the critical spirit that continuously questions routines and patterns.

But the focus on the »essence« of the activity can also be stressful because habitual routines create moments of active recreation, in which high-concentration, permanent creativity, or the compassionate focus on others are not required. Even university teachers complain,

SINGULARITY

Singularity is used by futurologists to describe that point in time at which machines will become smarter than humans. With the progressive development of self-learning computer systems, they predict the emergence of a super-intelligence. Since such a super machine improves on its own, it would generate an intelligence explosion that man could no longer control. Proponents of this development predict singularity for the year 2045 and forecast as a result of this a higher life expectancy or even "biological immortality". Critics consider such visions to be naive and fear that a super-intelligence could be directed against people. They argue that machines should be equipped with ethics programs to protect humanity from the incalculable consequences.

often rightly, about bureaucratic burdens. But if intelligent systems relieved these burdens completely, they would have no haven to which to escape guilt-free from the horror vacui of the empty page, which even the most productive scientists occasionally face. So, to be freed by technology to focus on one's real work can be very stressful.

As with the trades, people are also not necessarily better prepared for this »essence« in the wider educational context by acquiring a media literacy licence at a young age or learning »coding« as their first foreign language. No legal analysis software can be developed without the help of good lawyers. When a software-using lawyer concentrates on the essence of his activity, legal knowledge is more helpful than code. And while the pilot flying with autopilot should of course have a mastery of the buttons and display controls, above all he should have an ability not to trust the system blindly and be able to fly independently in case of system failure. Much more disturbing than the notion of an automotive electrician tampering with a vehicle's analysis software is that of a pilot trying to optimize autopilot algorithms with only basic coding skills.

Uncertainty 5: Unequal access to digital technology is the main cause of the risk of a digital divide in society

This claim has become uncertain even with regard to the countries of the global South, and it is certainly incorrect for the developed

countries of the West, where even households that are dependant on welfare have access to smartphones and computers.

The digital divide in society is thus not a question of access to technology, but of interaction with technology.

The vibrant wealth of data in the Snapchat world, in which e-mails are already relics of a past form of communication, conveys a breathlessness and restlessness that undermines concentration. This is at least the case where there are no structures for leisure time and a break from the digital world. The real divide is between those who are helpless in the face of digital possibilities and temptations and those who – mostly through parenting – are encouraged to take breaks and focus on the analogue, whether that means doing homework, playing the piano, or reading a printed book. And there is a divide between those who, thanks to their knowledge, can deal productively with the wealth of information on the Internet – as explained above – and those who drown in this deluge because they lack the ability to sort through it. More than schools, parents are the ones who are the formative power of this social dividing line.

The consequences for an education program that is open to the future

If it is true that the precise contours of change for many activities are still unclear and if furthermore, it seems likely that the great majority will entail partial or complementary digitization as opposed to total replacement (and for these activities, non-digitizable elements will gain in importance), the question arises as to the consequences for a suitable training program. It is clear from the foregoing discussion that STEM and coding initiatives are definitely not enough to fulfil the promise of digitization.

It is not without reason that Aristotle appears in the title of this piece. His reflections on education come from a world of human action characterized by freedom and opportune moments (kairos) and therefore never exactly predictable. It is a world of »non-necessities« and

UNCANNY VALLEY

A paradoxical, unproven phenomenon according to which hyper-realistic imitations of the human form are perceived as scary and disturbing. Instead of people, these imitations look more like bodies that move – like zombies. Only when facial expressions and body language match one hundred per cent are androids percieved as being natural. The discomfort associated with the Uncanny Valley poses a constant challenge for robot designers and regularly results in animated films becoming a box office flop because viewers cannot identify with the characters.

»mere possibilities«. For Aristotle education is therefore never aimed at an external goal. Rather, it serves an internal goal, self-realization. His »Lyceum« offered a programme with a broad scope, which is why he is still considered the intellectual pioneer of the liberal arts concept of North American colleges and the educational concept of liberating people so that they can think for themselves and act responsibly. For Aristotle, the breadth of the generalist approach to education was not limited to the humanities, but of course also included the then-known natural sciences. In his conception of education, the desire to investigate the causes of things is especially encouraged. Today we call this critical thinking, which cannot be satisfied with how things appear superfically.

Free from the idea of external goals, the educational approach that is dedicated to development of the individual later came to incorporate the neo-humanistic educational reforms, the strongest proponent of which was Wilhelm von Humboldt. Humboldt conceived education not in terms of future employment, but as inner growth through confrontation with the intellectual premises of an external world. This »general human education« was to precede any vocational training and was not designed to be elitist. Humboldt envisioned an educational programme for everyone. In the social context of his time and the reality of his own education policy, this anti-elitist claim was realized

beyond elementary school but only in exceptional cases. The challenges in offering individual development opportunities not only to a widening elite, but also to all strata of society, remain to this day.

The punchline of digitization in educational policy has been elaborated elsewhere by Jörg Dräger and Ralph Müller-Eiselt and is described in this volume by Stephen Spurr: if digitization is recognized as a tool, the goal of »universal education for everyone« can be better and more quickly achieved despite increasing heterogeneity. That means bringing the best educators, most engaging teachers, and motivating pedagogues together with data analysts, virtual reality experts, and programmers to develop digital education for all grades and should be oriented to the educational goals of the German Standing Conference of the Ministers of Education and Cultural Affairs, accessible to all students and that all teachers can use. Ideally, individual teachers thus relieved of the task of mediating the core curriculum will have much more time for individual work with students. They, too, would then be free to focus on the »essence« of their vocation and activities – for the benefit of each and every student whose individual development they could better foster. In other words, digitization opens the analogue core of the teaching profession up to new possibilities and supports a program of universal education that is not restricted to the elite. This in turn offers the best conditions for a digital future, whose effects on work and employment can not be predicted to date.

However, the success of such a vision is crucially dependent on two factors that are already essential for successful educational pathways today: the involvement of parents and the training of teachers. And it is not enough to limit this vision to the field of general education.

The decisive role that parents play in determining their children's attitudes towards and interaction with digital technology has been discussed above. And if the use of digital technology in the school context should lead to additional areas of opportunity, then the school has to rely on the support of the parents. Replacement of parents

through public infrastructure, as envisioned in an active paternalistic state apparatus, does not help here. What is really necessary is serious extracurricular work with parents, including parents without higher education, as partners in fostering stability, structure, and creativity among children. But professionalized work with parents must be a methodical part of students' teacher training programmes and not be left to the vagaries of everyday school life.

The use of digital instruments can only free teachers to devote themselves to the core of their profession when that core is developed within them. Teachers who have lost this core of their vocation (or never possessed it) cannot be liberated by the use of powerful learning analytics. Despite the euphoria about digital possibilities, we are faced with the simple realization that the core of good education is not affected by the anxiously awaited digital transformation. The urgent need for good and accessible pedagogy remains. The success of this endeavour does not rise and fall with technology. It rises and falls with the quality of teachers. And the quality question begins with the decision of suitable candidates to study to become a teacher, followed by teacher training as well as further skill enhancement, and also includes innovative teaching models, of which digitalization is only a part.

Finally, it is important not to formulate the scope of application of general education in too narrow a way.

The strength of the vocational training system in Germany lies precisely in the fact that it does not focus on preparation for a specific job. For a dynamic labour market, such a narrowing of the educational concept of education would be problematic. Especially given the impacts that digitization seems to be having on the labour market, it would be useful to broaden this concept of education in the spirit of Wilhelm von Humboldt. Terms such as attitude, character, and education of the heart have no place in mechatronics training, but they should be the basic principles of a vocational school curriculum de-

VIRTUAL REALITY

Virtual Reality is defined as the representation of a computer-generated virtual world, in which the viewers or players are immersed as though they were a part of it. To make the sense of presence as realistic as possible, sensations such as smelling or touching are triggered. Although video games constitute a virtual reality, the term is closely associated with VR goggles. These allow the wearers to turn their heads and move forward, thus reinforcing the impression of a boundless virtual world. They also give the wearer the feeling of being present in and even able to influence the virtual reality.

signed to be open to the future. So the challenge in curriculum design is to translate the core of humanistic education into a vocational school-compatible definition. This, too, is easier with an excellent digital core curriculum that relieves vocational teachers and gives them more time for individual work with trainees. Algorithms that recognize mathematical errors are one thing, but educators who inspire students to be critical of the certainties presented to them and to use their own thinking in the place of predetermined assumptions are quite another.

Every level of the education system thus provides opportunities to develop individual potential, but only if digital instruments are rationally embedded in a very traditional education program, one that is not feverishly oriented to the uncertainties of a digital discussion and ambiguous changes in the labour market, but to the core of Western educational beliefs: the best possible development of human capabilities. How to best achieve this goal, even under the conditions of digitization, remains a major challenge. And this alone should be the basis of our ongoing concern.