Paradigm Shift in Human-Machine Interaction: A New Learning Framework for Required Competencies in the Age of Artificial Intelligence?

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Abstract: Smart machines (e.g., chatbots, social robots) are increasingly able to perform cognitive tasks and become more compatible with us. What are the implications of this new situation for the competency requirements in the 21st century? This paper evaluates the underlying paradigm shift with relation to smart machines in education. It discusses the potentials and current limitations of smart machines in education in order to eliminate prejudices and to contribute to a more comprehensive picture of the technological advances. In light of human augmentation, the paper further proposes a possible learning framework that includes the human-smart machine relationship as a normative orientation for new competency requirements.

1 INTRODUCTION

The 21st century confronts us with a variety of challenges. Globalization, increasing digitalization and a longer life expectancy in industrialized countries are changing our work and our lives. The conventional three-stage model of education, work and retirement is increasingly changing into a multistage life (Gratton & Scott, 2016).

A technology that has made particularly great progress in recent years is artificial intelligence (AI). AI includes different elements such as the ability to solve domain-independent problems and the ability to interact and learn from its environment (Dellermann, Ebel, Söllner & Leimeister, 2019, p. 638). In form of *smart machines*, AI can, to a certain extent, make decisions and solve problems without the help of a human being (Pereira, 2019). Chatbots (e.g., Amazon´s Alexa) or social robots (e.g., SoftBank Robotics´ Model Pepper) can be considered as manifestations of such smart machines. Today, smart machines support us in everyday life, but have also the potential to replace us (Wike & Stokes, 2018). For example, in the field of natural language processing, GPT-3, an autoregressive language model with 175 billion parameters, is capable of generating news articles that human reviewers can hardly distinguish from articles written by humans (Brown et al., 2020). A number of critical voices are being raised, indicating that we may need to redefine our role as humans in relation to smart machines (e.g., Davenport & Kirby, 2016; Floridi, 2016; Aoun, 2017; Jarrahi, 2018; Baldwin & Forslid, 2020).

With respect to education, this may imply that we have to question our competencies and strengths and redefine them in relation to smart machines. There are tasks that smart machines can do better than we can. Aoun (2017, p. 53) requests "a new model of learning that enables learners to understand the highly technological world around them" and calls his model *humanics*, with the goal of providing a "robot-proof" education (Aoun, 2017, pp. 53-61). In addition to a "robot-proof" knowledge, competencies that help us to collaborate with smart machines in everyday life could be valuable. Suto (2013, p. 139) introduces the concept of *robot literacy*, a media literacy focusing on forming appropriate relationships with smart machines. Since our image of smart machines is often influenced by Hollywood movies such as *I,Robot* or *Ex machina*, it is sometimes difficult to keep an unbiased, neutral picture of the technology. Digital natives are not always familiar with new technologies and may need to be actively made aware of and informed about these technologies (Ng, 2012). Even though certain students may be able to acquire digital skills automatically by growing up as digital natives

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in the internet age, it may be fruitful to actively foster the digital competencies of students in the sense of a skill-based perspective (List, 2019).

Jarrahi (2018, pp. 578-579) argues that the discussion about AI is often characterized by two positions: one side claiming that smart machines "will soon outthink humans and replace them in the workplace", the other side assumes that the concern around AI is just "another overhyped proposition" (Jarrahi, 2018, p. 578). According to Jarrahi (2018), it would be better to think about ways, how humans and smart machines could combine their individual strengths in a synergetic way. The augmentation of human skills is central (Davenport & Kirby, 2016). In the future, those people who work at the interface with smart machines and are able to blend their skills, might be in high demand (Quick, 2019).

Existing learning frameworks, such as *the OECD learning framework 2030*, recognize the challenges associated with AI and call for new solutions in a rapidly changing world (Organisation for Economic Co-operation and Development [OECD], 2018, p. 3). To prepare for 2030, students as the decision makers of tomorrow should have a broad set of *competencies*, consisting of knowledge, skills, attitudes and values (OECD, 2018, p. 5). Further, students should be competent in *creating new value, reconciling tensions and dilemmas* and *taking responsibility* (OECD, 2018, p. 5). While we agree that students need such competencies, we believe that it may be useful to evaluate the role and competencies of the student in relation to smart machines.

As smart machines can act autonomously and take over tasks for the students, smart machines may become more than just an advanced tool. We argue that smart machines increasingly take over a co-roll towards us, which has implications on our competency requirements. Smart machines may become cooperation and learning partners. In light of the identified research desideratum, the following research question should be addressed:

How do smart machines influence the competency requirements for the 21st century?

The objectives of the paper at hand are therefore twofold:

- Evaluating the underlying paradigm shift of smart machines with regard to education, in order to better understand current developments, obtain a more unbiased picture and evaluate underlying assumptions;
- Explaining the implications and raising awareness for smart machines with regard to competency requirements, with the goal to contribute to a normative foundation for the use of the technology.

Our paper can serve as a starting point for future research, as it highlights important concepts and variables related to competency requirements with regard to smart machines and provides a normative orientation. In the light of human augmentation, we want to contribute to a more comprehensive picture of the technology in order to eliminate prejudices and to lay the foundation for better decisions on the use of smart machines.

To this end, we lay the foundation for the emerging competency requirements in section 2. We take a closer look at the driving forces of change, which result in the merging of smart machines with our everyday lives and discuss the potentials and current limitations of smart machines. Section 3 explains the potential paradigm shift in education with regard to smart machines and makes a proposition towards an extended learning framework. Section 4 concludes with some final remarks.

2 CHANGING LEARNING AND WORKING CONDITIONS

2.1 Driving Forces of Change

The competency requirements in the 21st century depend on various developments. Among other things, our society is challenged by demographic change, increasing digitalization, and globalization.

Life expectancy in most countries has risen sharply during the last century. At some point in time a 100-year life could be possible (Gratton & Scott, 2016). The life phase of work is increasingly characterized by a large number of stages combined with reorientation. The conventional three-stage model of education, work and retirement is increasingly changing into a multistage life (Gratton & Scott, 2016). Therefore, the ability to engage in life-long learning is becoming increasingly important.

At the same time, the increasing digitization also presents us with new challenges. Connecting a wide range of devices to the internet enables us to generate more data than ever before (Floridi, 2013, p. 5). Dealing with data and the associated problem solving is becoming increasingly important and is regarded as an important 21st century skill (Aoun, 2017; Rios et al., 2020). Due to the "half-life of facts" (Arbesman, 2013), it is difficult to stay up to date. Advances in AI

are leading to increasingly smart machines that help us recognizing patterns in data and deal with the information overload. However, AI technology also carries the risk of partially replacing us, as smart machines are able to perform and automate cognitive tasks.

In the wake of globalization, this tendency is further intensified. Baldwin and Forslid (2020) speak of a twin trend of globalization and robotics (globotics). Successful business models are spreading around the world and arbitrage opportunities provide financial incentives to drive globalization further (Baldwin, 2019, p. 63). Regulatory attempts by individual countries have only a limited effect. It is the tech companies like Google who are creating new realities (e.g., in the field of autonomous driving) (https://waymo.com/journey).

2.2 Smart Machines Merge with Our Everyday Life

According to Floridi (2013, pp. 3-5) we are in transition to a new era of *hyperhistory* in which we will become increasingly dependent on our own technological achievements. Information and communication technologies (ICT) are not only used to record and transmit data, but also to process it increasingly autonomously. Information as a fundamental resource is becoming increasingly important and life offline is hard to imagine. Unlike the era of history, people become dependent on ICT in the era of *hyperhistory*. Although most people today still live historically, there is a shift to a hyperhistorical life (Floridi, 2016).

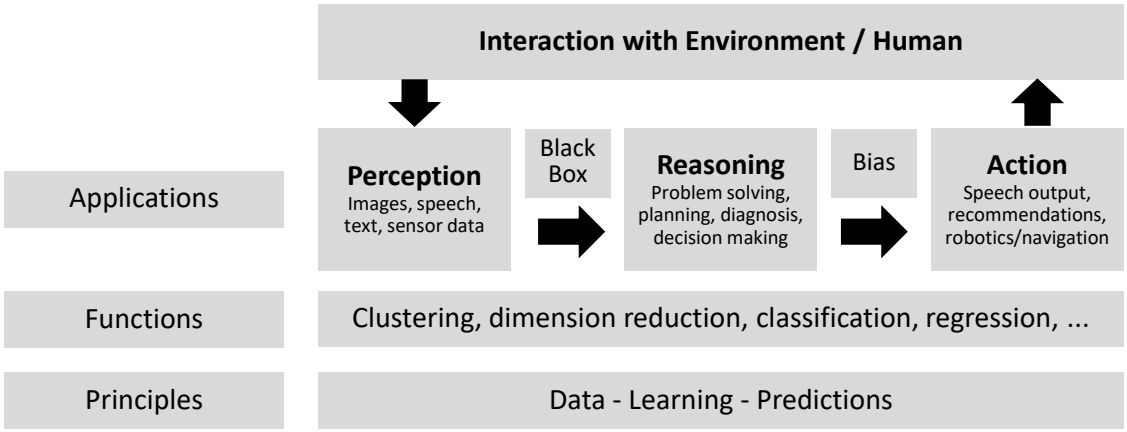
We are in the process of creating an *infosphere*, an informational environment comparable to, but different from, cyber space (Floridi, 2013, p. 6). The creation of an *infosphere* shared by human and digital agents is facilitated by the fact that machines are becoming increasingly smart. To a certain extent, they are becoming more compatible with us humans and can take over more areas of our expertise.

Smart machines are able to perceive and interact with their environment because they have the ability to process large unstructured amounts of data due to the underlying technology of AI. As Figure 1 shows, this process of perception, reasoning and action is currently facing the two obstacles of *black box* and *data bias*.

First, smart machines are currently often a *black box* who are difficult or impossible to interpret (Zornoza, 2020). New "explainable AI"-approaches would be important to understand the reasoning of the smart machine (Zornoza, 2020). As long as smart machines are not explainable, they cannot be fully trusted, which restricts the current use of the technology.

Second, since every smart machine is only as good as the data on which it was trained, biased training data (e.g., with regard to gender, race, religion, etc.) can lead to stereotyped or prejudiced content generated by smart machines (Brown et al., 2020, p. 36). As some of the best smart machines today, are mostly trained with data from the internet (Brown et al., 2020, p. 9), these fears are justified and addressed by researchers (Brown et. al., 2020, pp. 36-39).

Smart machine may currently be restricted in their use due to technological limitations. However, already today, smart machines can improve organizational decision making (Jarrahi, 2018). Raisamo et al. (2019) argues that smart machines can help humans to augment their capabilities. Similar to eyeglasses, smart machines could act as *a tool* to compensate for possible weaknesses and enhance strengths (Raisamo et al., 2019, p. 131). Different researchers are also exploring how smart machines can support us not only



Source: Adapted from SBFI (2019, p. 30).

Figure 1: Capabilities of Smart Machines to interact with the Environment.

as *a tool*, but as *a partner*. For example, Dellermann et al. (2019) introduce the concept of *hybrid intelligence*, which combines the complementary intelligence of humans and smart machines. Together, the human and the smart machine "create a socio-technological ensemble that is able to overcome the current limitations of (artificial) intelligence" (Dellermann et al., 2019, p. 640). As Dellermann et al. (2019, p. 640) point out, smart machines and humans learn from each other through experience and improve over time. Wesche and Sonderegger (2019) go even one step further and argue that smart machines could in the future increasingly act as *a leader*, as smart machines have begun to take over leadership functions by guiding and commanding human workers. Figure 2 illustrates the potential evolution of smart machines and its transformative effect on society.

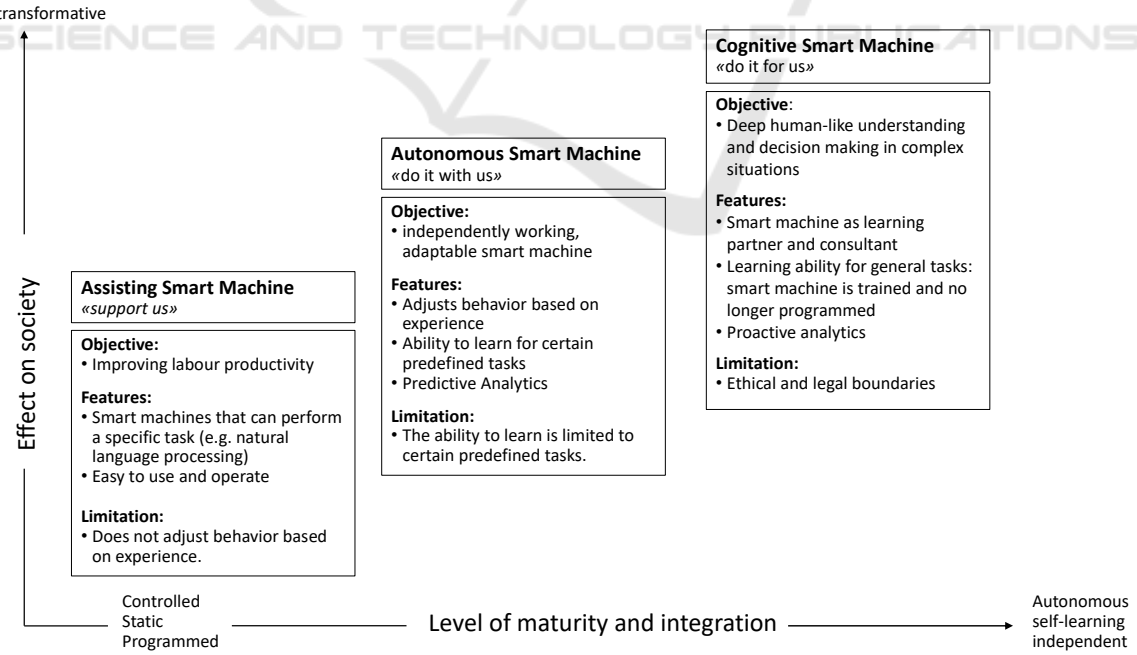
For now, many smart machines often serve as tool to support us in a controlled, static and programmed environment as for example the free translation tool DeepL (https://www.deepl.com). Even though these smart machines are already very useful, the transformative effect on society is comparatively small. However, smarter machines step into a co-role with us, becoming increasingly autonomous, self-learning and independent, the greater are the transformative effects and the associated challenges for society.

Whether we as society live in a world where smart machines evolve into a co-role to us is also a normative question that needs to be discussed. In certain areas (e.g., autonomous driving), many people may be willing to let smart machines take the lead. In other areas (e.g., in law enforcement), it will probably still be of critical importance that humans have the last word. No matter which path we will choose as society, it may be valuable to anticipate the current developments and search for solutions, how humans and smart machines can act in a complementary and mutually reinforcing way.

3 SMART MACHINES AS LEARNING PARTNERS?

3.1 Paradigm Shift of Mutual Dependency

For education, the upcoming of smart machines means that we have to question our own strengths and competencies and redefine them in relation to smart machines. The internet provides us with a large amount of current data and information that can be accessed by students at any time. The threshold between offline and online is becoming blurred. Today, we live an "onlife" life in a global *infosphere* (Floridi 2013, p. 8). Students have the knowledge of the world in their pockets (Döbeli, Hielscher & Hartmann, 2018, p.23).



Source: AIMDek Technologies (2018), Gould (2018), Robinson (2018) and own contributions.

Figure 2: Potential Evolution of Smart Machines.

Smart machines help us to access and understand the flood of data on the internet. Through them, new tools are available for learning and working (Döbeli et al., 2018, p. 17). For example, free translation tools like DeepL (https://www.deepl.com) can be a great help when translating a text. Although we still have to learn languages in school, technology can influence the way we learn languages in the future. Students can use smart machines to compensate for deficits and improve their strengths. Just as glasses are a support for someone who cannot see well, smart machines could be a support for someone who cannot write well.

Similarly, in the field of computer science, smart machines could help us to create computer code more easily. OpenAI's language generator GPT-3 is able to create computer code for web-page layouts using prompts like "Give me a button that looks like a watermelon" or "I want a blue button that says subscribe" (Heaven, 2020). This still means that a computer engineer has to understand the basic principles of programming. However, the smart machine can make his work processes much more efficient.

Living in an *infosphere* together with smart machines also has social and ethical implications. Smart machines are able to imitate us better and can take on new appearances. Computationally created virtual beings like Samsung´s NEON (https://www.neon.life) are no longer visually distinguishable from real people. Google´s algorithm Duplex can call local businesses (e.g., to make haircut appointments) (Google Developers, 2018). The persons called often do not notice that they are talking to a computer. In our view, this raises ethical concerns, especially if people are not aware that smart machines are already capable of such things. Smart machines, who mimic and manipulate human users of social networks, raise concerns about the manipulation of elections (Schmuck & von Sikorski, 2020).

Smart machines are changing the information and communication habits of the society (Döbeli et al., 2018, p. 16). Among other things, concerns about privacy, accessibility (only for those who can afford?), social manipulation and autonomy (Raisamo et al., 2019, pp. 138-139) should be taken seriously. Dellermann et al. (2019, p. 641) point out, that the goal should not be to maximize trust in smart machines, but rather to "find a balance between trust and distrust that makes it possible to leverage the potentials of AI and at the same time avoids negative effects stemming from overreliance on AI".

In the future, we may be dependent on smart machines to a certain extent (e.g., to oversee large amounts of data). On the other hand, smart machines will rely on us, because they need instructions to fulfill their purpose. We may have to acquire new competencies on how to interact and collaborate with smart machines, that go beyond ICT- or data-literacy.

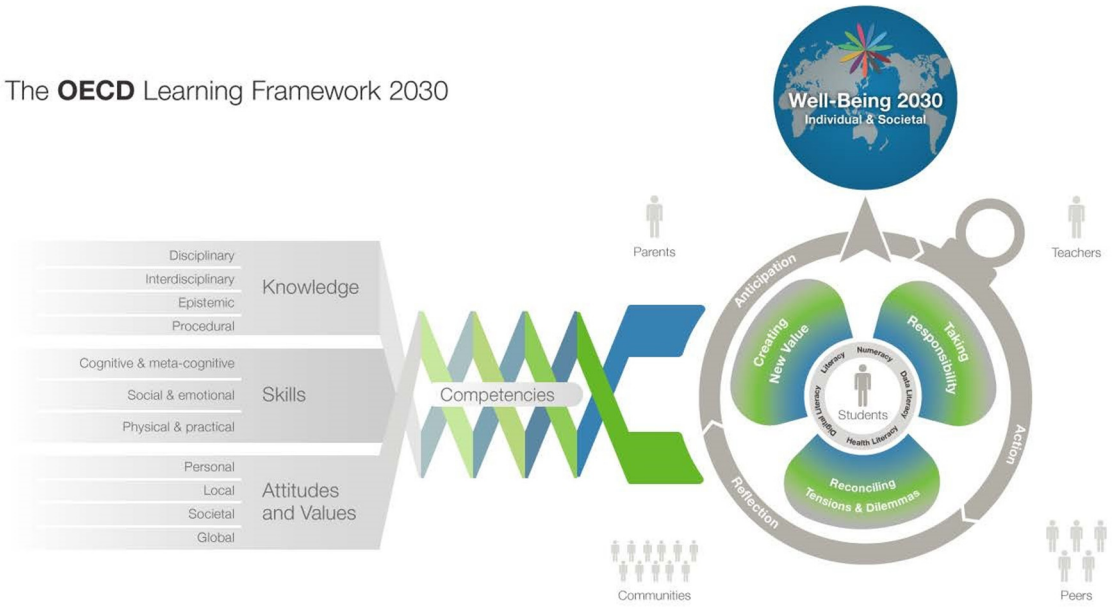
3.2 Towards an Extended Learning Framework

With the goal to navigate through a complex and uncertain world, the OECD (2018, p. 4) has developed a "learning-compass" depicted in Figure 3. At the center of the framework lies the student who faces the challenges of the 21st century, tries to transform our society and shape the future with the goal of individual and societal well-being. Not only students but also teachers, school managers, parents, and communities should be considered as learners in this context (OECD, 2018, pp. 3-5). As can be seen from Figure 3, the student should be competent in *creating new value, reconciling tensions and dilemmas* and *taking responsibility* (OECD, 2018, p. 5). The OECD (2018, p. 5) defines competencies as a combination of *knowledge, skills, attitudes and values*.

First, the student should be competent in *creating new value*, to provide innovative solutions at affordable costs to economic, social, and cultural dilemmas. To do that, the student should be able to think creatively, develop new ways of thinking and living as well as invent new business models and new social models (OECD, 2018, p. 5).

Second, the student should be competent in *reconciling tensions and dilemmas*. In a world characterized by equivocality, different standpoints must be weighed against each other. Such trade-offs could involve balancing autonomy and community, innovation and continuity, or efficiency and the democratic process. To achieve that, the student must become a system thinker, who thinks and acts in a more integrated way, taking short- and long-term perspectives into account (OECD, 2018, p. 5).

Third, the student must *take responsibility* for their actions. The attempt to actively shape the future is a process of weighing up possible risks and rewards. Only when we accept accountability for the products of our work, we can shape the future by evaluating the future consequences of our actions (OECD, 2018, p. 6).



Source: OECD (2018, p. 4).

Figure 3: The OECD Learning Framework 2030.

In the context of smart machines, the OECD learning framework remains still helpful and valid. However, as we argued in the previous sections, we think that smart machines increasingly take over a co-roll towards us. Through that, smart machines could support us in different ways in navigating through a complex and uncertain world with the goal of actively shaping the future.

First, smart machines could *perform automatable tasks* for us, as we have seen in the example of Google Duplex, who can call local businesses (e.g., to make haircut appointments) (Google Developers, 2018). Baldwin and Forslid (2020, p. 9) argue that smart machines can perform many mental tasks like photo recognition, handwriting recognition, or language translation as well as humans. Especially repetitive, standardizable tasks can be automated more easily (Latham & Humberd, 2018, p. 12).

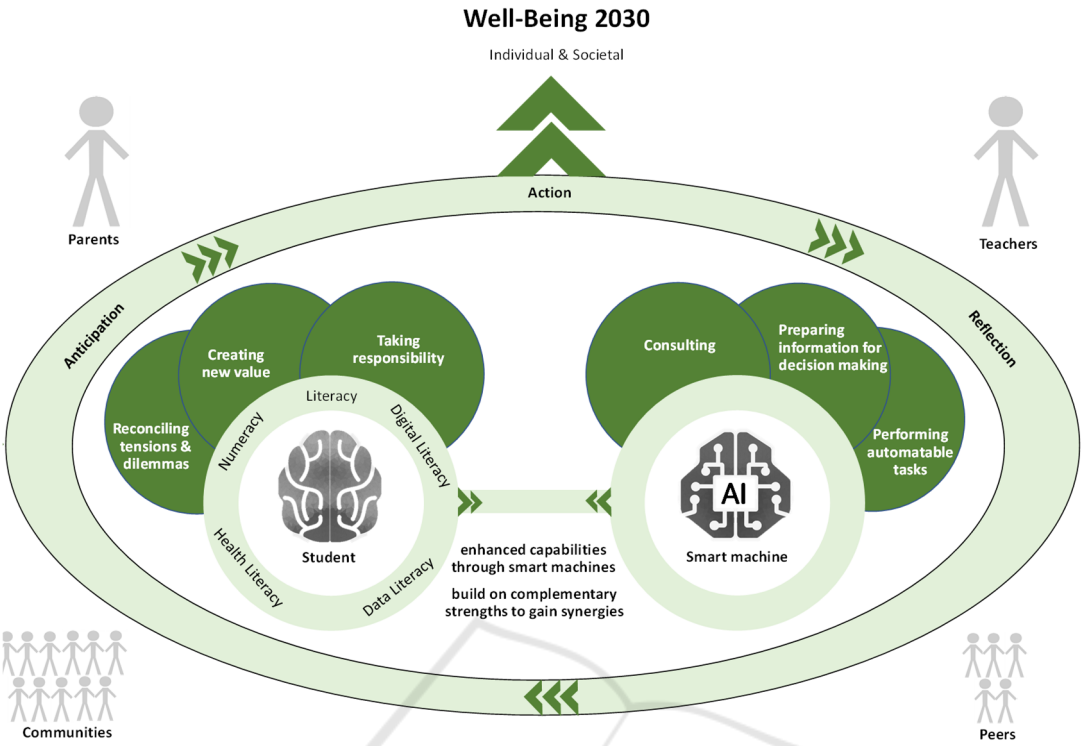
Second, smart machines could *prepare information for decision making*. According to Jarrahi (2018, pp. 581-584), smart machines have a relative advantage in handling complex situations with large amounts of data. While the student still has to decide where to seek and gather data, the smart machine could support the learner by collecting, curating, processing and analysing data (Jarrahi, 2018, p. 583). Ideally, the student would be able to make better decisions, as the smart machine creates a more solid basis for decision making.

Third, smart machines could *consult us* in our process of *creating new values* and *reconciling tensions and dilemmas*. While the responsibility for action remains in the hands of the student, the smart machine can suggest different approaches and methods, and weigh up possible risks and rewards as objectively as possible. In the light of *hybrid intelligence* (Dellermann et al., 2019), the student and the smart machine could form a team that makes them both more efficient and at the same time – to a certain degree - mutually dependent on each other. Figure 4 depicts this relationship.

To a certain degree, the student is depending on smart machines because the student needs the smart machine to make meaningful decisions based on large amounts of data. Further, smart machines can relieve the student from repetitive, *automatable tasks* and improve the decision making through *consulting*.

To a certain degree, a smart machine is depending on the student, because the student is the one, who needs the vision to *create new values, reconcile tensions and dilemmas* along this way, and *take responsibility* for his chosen actions. Even though the smart machine can enhance the capabilities of the student, the smart machine needs to be guided and checked for potential data biases.

In our view, the paradigm shift of mutual dependency means that there will be a shift in the competencies required. Certain tasks and competencies are already today being outsourced to smart machines and will probably become less important in the future (e.g., repetitive desk research). Other competencies, such as the capability to collaborate with smart



Source: OECD (2018, p. 4) and own contributions.

Figure 4: Paradigm Shift of Mutual Dependency.

machines to use them efficiently as a working tool, will probably become more important. In the future, people may need to acquire a "robot-proof" education in order to stay relevant on the job market (Aoun, 2017).

This may include new *knowledge* in the form technical literacies (e.g., Aoun, 2017, pp. 55-58; Carretero, Vuorikari & Punie, 2017, p. 11; OECD, 2018, p. 4) but also new knowledge about ourselves as Aoun (2017, pp. 58-61) argues for a new concept he calls *human literacy*. Wilson and Daugherty (2018, p. 11) further propose *fusion skills*, which are the skills that enable "to work effectively at the human-machine interface". This may involve the ability to delegate tasks to smart machines, train them, or formulating the questions in a way, such that the smart machine can deliver the answers (Wilson & Daugherty, 2018, p. 11).

To collaborate with smart machines, we might also need new *attitudes and values*. In order to use smart machines, we have to accept them (see e.g., De Graaf & Allouch, 2013), which implies a certain level of collaboration readiness. Further, we need to develop an awareness of the different situations where we can encounter smart machines. We need to develop a sense for their limitations and be cautious about their potential data biases. This may also involve thinking about explanations for the smart machine´s outcome (Wilson & Daugherty, 2018, pp. 5-6).

We may have to rethink our attitude towards digital devices if smart machines like Amazon's Alexa are able to listen to our conversations. "To speak freely" could take on a different meaning in the future. In a broader sense, as smart machines become more similar and more compatible to us, we may have to treat them more like equals, learn how to form appropriate relationships (e.g., see Suto, 2013), and think about augmentation strategies (Davenport & Kirby, 2016) to position ourselves in relation to the smart machine. Similar as the Copernican, Darwinian or Freudian revolution, smart machines may challenge us in what it means to be human (Floridi, 2016).

4 CONCLUSIONS

Based on the OECD learning framework 2030 (OECD, 2018, p. 4), we have discussed the potential influence of smart machines on the competency requirements for the 21st century. We shed light on the underlying factors that may lead to a paradigm shift of mutual dependency of human and smart machine

and outlined competencies, that may be needed in order to collaborate with smart machines.

In our view, it is still an open question how to best foster collaboration competencies with smart machines. Aoun (2017, pp. 77-110) proposes an "experimental learning" approach, which integrates classroom and real-world experiences (Aoun, 2017, p. 81). Although we think that this is already a promising approach, more research in this area is needed.

With this paper, we want to contribute to a better understanding of the changing human-smart machine relationship in the age of artificial intelligence, in order to eliminate prejudices and to lay the foundation for better decisions on the use of smart machines. In the light of human augmentation, young people - as the citizens and decision makers of tomorrow – should be equipped with the necessary knowledge, skills, attitudes and values to recognize the opportunities as well as the dangers in the use of smart machines. In this way, they could increase their ability to actively shape the future.

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