Artificial Intelligence and Education

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Abstract **- Artificial Intelligence (AI) is one of the emerging technologies of today. It provides applications in addition to the traditional computing environments, and is also in affordable smart devices, making AI available everywhere. These affordable devices have built-in capabilities to handle complex computing tasks (edge computing), flexible access to fast network resources, access to cloud-based services to solve complex problems on a collaborative basis, and access to an enormous amount of open and closed data resources. In education, AI contributes in at least two ways: (1) the scope and content of education - what kind of education is needed; and (2) the process of education – support and changes to education and the teacher's work. In the scope of education, we must consider that AI (and related technologies) will replace some jobs (education will no longer be needed), some jobs will change dramatically (education content must be modified), and a lot of new jobs will be generated (new education must be established). In the process of education – the work itself - AI will have and has the role of reformer and enabler, which also changes the characteristics and division of duties. In this paper we analyze the opportunities and challenges caused by AI in education. Although the focus is on the role of AI, it is difficult to separate it from other technology-driven changes, especially in the discussion about work life.**

Keywords - Artificial Intelligence, Learning, Teaching, Machine Learning, Intelligent Systems, Computers in Education, Expert Systems

I. INTRODUCTION

A. Artificial Intelligence

Artificial Intelligence (AI) has grown in importance in the field of Information and Communication Technology (ICT) over recent decades. It is one of the "solid" application areas that has lasted from the 1950s until today, albeit manifested in varying forms. Our paper [6] separates *four sequential waves* in the progress of AI: AI in program code from the middle of the 1950s, AI in (rule based) Expert Systems from the late 1970s, AI based computer architectures from the mid-1980s, and *AI based on Machine Learning (ML)* from the middle of the 2000s. As is typical for new *radical technologies*, at the beginning they take the role of *change driver* but are slowly adopted widely by potential users and become part of "*the new normal*". Which is why the waves above have a start but no end – all of them still exist as part of everyday ICT. The programming languages Lisp and Prolog are used in special purpose applications and expert systems support decision-making in a wide variety of application areas (e.g., IBM's Watson in medicine), while specialized application-oriented computer architectures are now part of computing infrastructure.

AI (*fourth wave)* is undoubtedly one of the emerging technologies today. *Emerging technologies* can be described by the following properties: radical novelty, opportunities still largely unrealized, capable of changing the status quo, relatively fast growth in use. The *emergence phase* is somewhat uncertain and ambiguous from the user point of view. The first users of an innovation are *innovators* – users that are eager to test new ideas - *and early adopters*[1] - users that make their own decisions without waiting for the experiences of other users. These user groups are ready to carry and accept the risks of uncertainty so as to gain early benefits of the innovation. Technical progress finally convinces most of the potential users (followers: early majority, late majority, laggards), who accept new technologies in a more mature phase of their life cycle, based on the experiences of others (imitation).

In a way AI is already widespread in many application areas. In the *education* sector, we seem to be in the embryonic phase - a variety of trials exist, simple "commercial" applications are available, but it is not yet widely in general use. AI is somehow hidden and embedded in the more general trend, that of *computers and ICT in education*. The spread of AI to new application areas – also in the education sector - is slower than the progress of the technology (AI) itself, because the focus of the research and development (R&D) is on AI technologies, rather than its applications.

Traditionally, the term "AI" relates to *expert systems*, which are *rule based* applications that manage knowledge. AI based on ML handles and manages (properties of the) data using *learning algorithms*. In *supervised learning* it is *trained* to understand the basics of the problem area. During use it learns from mistakes and corrects its future behavior (*self-learning*). In supervised learning the results of the analysis are known in advance (by the trainer) and the learner (trainee, machine) makes the right or wrong decisions. What is critical for the learning results is the size of the *training data set*. Massive amounts of data are

[1] See E. Rogers, Diffusion of Innovations, 5th Edition, New York: Free Press, 2003.

needed to guarantee good learning results – e.g., masses of photos to train a system to find content elements in photos, a lot of live video material to identify people from the faces in it, etc. AI applying ML is based on learned content (handled by the algorithms of linear statistics), whereas a traditional expert system handles the data based on rules. A good example of the transfer from rule-based intelligence (expert system) to ML is the progress of Google Translator: the coded rule base of 0.5 MLOC (Million Lines of Code) was replaced by a learning algorithm of 500 LOC; the learning capability has improved the quality of translations dramatically, because the training data set is growing all the time along with use.

Learning can also be *unsupervised (autonomous)* [2], wherein no data set is available, and learning is fully based on algorithmic reasoning. The current AI is called *narrow / weak AI*, which means its applicability is in a *narrow specific application area.* The transition toward *general / strong AI* and unsupervised learning has started. The system understands facts and their relationships without the restrictions of a specific application area.

Although AI itself is not the topic of our paper, we wanted to provide this general overview of the progress and its basics to give the necessary background to understand the opportunities and challenges of AI, especially its limitations. More background is available in our last MIPRO paper [6], of which this paper is a continuation.

B. Artificial intelligence in the society of today

Thanks to the growing intelligence of ICT-based systems, the role of human work is changing. Automatization itself already has a long tradition: factories are partially robotized, computers do the boring routine work. Robotics is also being transferred to office work in the form of software robots (*Robotic Process Automation – RPA*)[3]. Although intelligent tools and applications support human activities in many ways, most of these are based on mechanical automation of (parts of) processes or replace human work in the mechanical stages with programmable machines and computer applications.

Advanced AI brings new opportunities for the use of ICT. Instead of mechanical automation it provides means for embedding *"human like" intelligence*, both in existing systems and in totally new application areas. The role of human work is changing: some tasks and jobs are *disappearing*, some are *changing* dramatically, and a lot of *new ones are being born*. Productivity is expected to rise with less pressure on humans. This will give rise to challenges in society – the education sector included.

C. AI-supported education

AI will change the education sector in two ways:

- First, *changes in work and the demand for it*: the education sector must be prepared for the accelerating changes in work life, concerning expertise in different professions and the demand for new work. Some jobs are disappearing, most will change, and a lot of new jobs will be generated.
- Second, changes *in education practices*: AI affects education itself. AI not only has the role of reformer and enabler but also a supportive role. It provides a means of re-dividing the workload. Examples of such activities in education are automation in the grading of examinations, analyzing (changing) students' needs in real-time, and pointing out places where courses need to be improved (based on student behavior).

AI can also support the transition to new learning paradigms – *flipped* learning, *time- and place-independent* learning and *blended (multiform)* learning. *Intelligent assistants* and *chatbots* are ready to help students independently of the time and this relieves the teacher from routine mentoring. Students' learning activities can be also supported by AI tutors, AI based feedback, etc.

The topic of *AI in education* is new. Rather than providing remarkable innovations in education practices, it is more a question of empirical trials and prototypes in *learning analytics*, *visualization* of data collected, and *statistical reasoning* based on it (Sedrakyan et al., [12]). Some learning platforms utilize machine learning but to a limited extent. The use of the term AI has become quite prevalent in the marketing speak of digital educational platforms, even though actual AI-based applications range from non-existent to very rare.

However, a lot of *ethical issues* must be considered in this context: the reliability of results, the validity of data to forecast the real progress of students, the ownership of the data collected and the right to use it, the context dependency of the algorithms used in the analysis, etc. Plenty of data is collected in the various systems that are integrated into daily teaching. One important question is what is the *teacher's ability (and will)* to utilize this data and to interpret it in the right way. Cultural differences play an important role – the difference of the goals and needs in the "culture of development" and the "culture of usage" might cause conflicts.

The use of AI at schools is a kind of by-product of general computerization and adoption of ICT-based applications / course materials / platforms. Its manifestation can be seen in the use of digital materials, which support learning-based adaptability in the students' progress. Data is collected, but teachers are not educated / trained to use this knowledge to improve their work. Whether or not they should be is another question. Of course, it should be the starting point of all efforts in this area.

D. Research question and the structure of the paper

The aim of this paper is to analyze the changes caused by AI in the current society, especially from the educational point of view. Above, we have introduced the topic and its background. We have a preconceived notion about the situation. The motivation to write this paper was to learn

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[2] Good article to study on the role of ML in AI is: B. Marr, "Supervised -v- Unsupervised Machine Learning -- What's The Difference?". Retrieved from https://www.forbes.com/sites/bernardmarr/2017/03/16/supervised-v-unsupervised-machine-learning-whats-the-difference/#7e933555485d in February 12th, 2020.

[3] See e.g. https://en.wikipedia.org/wiki/Robotic_process_automation

more about AI and to assess the *state of the art*. We have set the following *research problem* for our paper:

What is the role of Artificial Intelligence in education now, and in the near future?

Two *sub-questions* can be derived from it:

1. What will the technology-driven changes mean for future jobs?
2. How does AI support and change teaching?

These questions also provide a structure to the paper. We return to the findings of our previous paper [6], which handled the progress of AI in the sequence of waves; the current paper is a continuum of it. The paper is structured in the following way. The findings discussed are based on a simple *literature review* conducted as a mapping study[4]. In *Section 2* we focus on the *technology driven changes* in *work*. *Section 3* handles *AI-driven changes in teaching*. *Section 4* concludes the paper and binds the different viewpoints together.

II. TECHNOLOGY-DRIVEN CHANGES IN WORK

In his books[5], *Yuval Noah Harari* has analyzed the changes of humankind from the historical, current, and future perspective. He separates the *physical* and *cognitive* side of a human being. The physical part can mainly be automatized and replaced by cognitive activities. Currently, cognitive tasks can also be automatized: humans solve problems by perceiving and reasoning; AI does the same faster by *handling big amounts of data* with statistical operations. Harari handles the changing role of the human being and the birth of societies. The latest book reviews the future (challenges) and the role of AI, robotics, and automatization.

The *World Economic Forum* published in 2018 contains an analysis of changes in work [21]. The report handles a wide set of viewpoints and aims to recognize changes, to be *proactive*, and to recognize the *driving forces* in the background (to be prepared). The report has a short-term focus on the changes – the floating five years, current (2018-2022) - but it also debates the *far-term* perspective until 2050. The report lists the *technologies* that companies have planned to adopt (and that will have an effect on job profiles): big data analytics, app- and web-enabled market, the Internet of Things, ML, cloud computing, digital trade, augmented and virtual reality, encryption, new materials, wearable electronics, distributed ledger (blockchain), 3D printing, autonomous transport, robots (stationary, non-humanoid land, humanoid, aerial and underwater), quantum computing, and biotechnology [21, p.7]. All these represent remarkable *opportunities to change* the characteristics of work. The list also provides a (narrow) vision of the *required technical skills* for planning education. In addition to the technology drivers behind the changes, the report lists "*soft skills*" for which there is a growing demand in work: analytical thinking and innovation, active learning, creativity, technology design and programming, critical thinking and analysis, complex problem-solving, leadership and social influence, emotional intelligence, reasoning, problem-solving and ideation, and systems analysis and evaluation. The report points out the changes in the job profile (over a period of five years): roles remain stable 48%, new roles 27%, redundant 21%, other 4% [21, p. 9]. These figures mean a lot of challenges to be solved in education: how to keep workers relevant in the changing job market. NB – the timespan is less than *five years*. There is a need not only to take into account the *needs of the change drivers* (of the time), but also to provide *permanent and reformable* skills, which are applicable in new contexts and situations (along with the changes in the drivers). These skills are often referred to as 21st century skills: these can be elaborated to be the most essential general skills needed in 21st century work life (Griffin & Care, [4]).

McKinsey & Company (Manyika et al.) report on the changes in the job market [8]: Close to 50% of current work activities can be automated by adopting currently demonstrated technologies; 60% of occupations have more than one third of activities that are automatable; only 5% of occupations consist of activities that can be fully automated. The results differ significantly by country and occupation, and also by demographic figures: developing countries have the highest demand for new workers and in highly developed countries the tendency is to automate. Professions in the "danger zone" (decrease / no growth) cover predictable and unpredictable physical work, office support work, and customer interaction. "Growth zone" professions are highly educated, for instance, care providers, managers and executives, teachers, and technology professionals. The report estimates that up to 800 million people could be displaced by automation worldwide and will need to find new jobs by 2030; 75 - 375 million of these workers may need to *switch occupational categories* and learn new skills. Despite the changes, the report is optimistic about the future: there will be enough work even in the future: the labor market will be able to adjust to the changes, as it has done throughout history. Automatization will decrease the amount of routine work, which means higher education of professionals. More time will be spent on activities that machines are less capable of doing, such as managing people, mentoring, applying expertise, and communicating with others. These tasks require more social and emotional skills and advanced cognitive capabilities, such as logical reasoning and creativity.

The Fast Future report [16] analyzed future jobs from 2010 to 2030. The "forecast" is based on an analysis of economic, political, socio-demographic, environmental, science and technology related changes in the period. Based on the *futurists'* analysis, it mentions twenty future professions, some of which are listed here: body part maker, old age wellness manager, memory augmentation surgeon, new science ethicist, vertical farmers, weather modification police, virtual lawyer, avatar manager, virtual teachers, waste data handler, social 'networking' worker,

[4] See e.g., K. Petersen, S. Vakkalanka, and L. Kuzniarz. "Guidelines for conducting systematic mapping studies in software engineering: An update". Information and Software Technology 64 (August 2015), 1–18. DOI:https://doi.org/10.1016/j.infsof.2015.03.007.

[5] Author: Y.N. Harari. Three books: Sapiens – A Brief History of Humankind; Homo Deus – A Brief History of Tomorrow; 21 Lessons for the 21st Century.

personal branders. In this context we will content ourselves with the list above; details can be found in the original report. Reality or not – we leave the conclusions up to the reader; at least some of these seem to exist already.

III. AI IN EDUCATION

A. Work Profile of Teachers

The study of McKinsey & Co (Bryant et al., [2]) takes a look at the teacher's work profile (in primary and secondary level) and analyzes the opportunities of AI to support teaching work. The demand for education professionals is growing (in the USA by 5-24% till 2030; in emergent societies the growth would be 100%). To fill the demand gap, the amount of teacher training should be increased and / or the productivity of existing training should be raised by automatization and focusing human work on essential activities instead of routines.

According to the study, 20 - 40 percent of teacher hours are spent on activities that could be automated. Teachers' weekly workload is approximated at 50 hours; less than half (49%; 24.5 h) of it is allocated to direct *interaction with students*. The rest is used for preparation (10.5 h), evaluation and feedback (6.5 h), professional development (3.0 h), and administration (5.0 h). The study concludes, based on the evaluation of existing technology and expert interviews, that technology could provide the potential to *reallocate 20-30% of the teacher's time* to activities that support students' learning. Further, the hours not related to direct student interaction could be halved.

B. AI-Driven Changes in Education

We started this study by making a simple mapping study using the keywords "*artificial intelligence in education*". The publication intensity proved to be high: Scobus over 3,000, Science Direct over 6,800 and Google Scholar over 123,000 references. A general Google Search provides 615,000 hits. We limited the search to the last 3+ years (2017-2020). Our aim was not to implement a systematic literature search, but to find enough well-focused texts (based on the expert analysis) to create a general overview about the state of the art in this topic. The sources for the following were selected on a *purpose basis* (as is typical for a mapping study).

Teachthought lists [18] ten roles of AI in education. The use of *AI in grading* is found to be a tool to decrease the amount of basic activities in education: traditional mechanical automated grading support (multiple choice, fill-in-the-blank) was not counted. Promising results are available in the use of *AI in text analysis*, although essay grading software is still seen to be in its infancy phase.

The current educational software provides a means to *adapt learning* to student needs. In *individualized learning*, the learning platform responds to the students' needs, puts focus on the topics needed by the student, repeats topics that are not yet mastered etc. Essentially the software differentiates the material at hand to meet the students' changing needs for increased challenges or need for support. Doing this with software requires a deep understanding of how and why learning happens. It presents a challenge for *technologically oriented* developers to bring *pedagogical expertise* to the development process. As a simple technical solution, learning platforms collect data. Using it needs a pedagogical approach – i.e., to recognize places where *courses must be improved* – places where masses of users fail. Do these two aspects (data collection, and its use) match each other easily or not?

Smart data collection (and analysis) – when done and utilized "in-large" – can be used in *development* and *evaluation* (comparison to others) by a school, and in *marketing* it to potential students. Collected data is also useful in planning study programs and allocating resources to activities.

Human tutoring work can be replaced by *AI tutors*. Some trials exist and good experience is available in the context of the fundamentals. AI-driven programs can give students and educators *feedback* – by combining students' and teachers' views of learning, based on the monitoring data collected from a longer period of the course or study program. The data also supports the improvement of the *user experience* of the system – how the users interact with it. This is similar to the use of many current commercial systems, which make recommendations based on the users' behavior and adapt it in their interaction process.

Teachthought sees AI as an opportunity for the teacher to focus on more essential work in teaching – AI (learning platform) provides the means for routines, and teachers will supplement lessons by providing students with hands-on support for students. AI is also seen as a "neutral" tool for *trial-and-error learning*. Students do not like to fail in front of human teachers, but in the use of a learning platform, the situation is quite different.

The survey of Acer Education technology [1] quotes the findings reported by the *Stanford University* study panel related to the future of AI [15]. The report covers the progress of AI widely and lists some key findings of the report. The transfer toward *online education* is becoming a reality in all levels of education and allows the facilitation of more *customizable* approaches to consider students' individual needs in learning. The innovations cover learning analytics, personalized education, and identification of the educational needs of the students; IoT and cloud technologies support peer-based and AI-tutor mentoring. Textbooks and course material can be customized and learning resources are accessible from multiple devices (cloud).

As the students learn, so will the online education systems. Learning analytics will accelerate the development of new tools for personalized education and provide teachers with better insight of their students' performance. Robot teachers (physical, software) are not alternatives to a human teacher, but would have an assisting role to give humans the opportunity to focus on the most essential tasks. Teaching and the work of a teacher will remain; social interaction still requires authentic human skills.

The Stanford report [15] mentioned above handles the topic on a more concrete level. It refers to the history of robots as educational devices (Lego Mindstorm Kit from the 1980s). The spread of AI technologies has been slow

due to the lack of resources (funding, skilled teachers), but also because of the missing evidence of their benefits in learning. *Intelligent Tutoring Systems (ITS)* are transitioning from laboratory experiments to real use. The report mentions *Carnegie Speech* (spoken language assessment and training software to improve voice and accent training) and *Duolingo* (foreign language training) using *Automatic Speech Recognition*. Other ITS products cover *Carnegie Cognitive Tutor* (used in teaching mathematics), *SHERLOCK82* (to be used to teach Air Force technicians to diagnose problems with electrical systems) and some avatar tools (training people to deal with people from different cultural backgrounds).

The fast-growing role of Massive Open Online Courses (MOOCs) provide a means for synchronous and asynchronous education and a platform to apply adaptive learning tools. New opportunities are provided especially in professional and life-long learning, with lesser importance placed on face-to-face interaction. *Learning analytics* plays an important role in adapting these platforms for the needs of students, teachers, and schools. It applies deep learning, natural language processing, and other AI techniques to analyze the student's engagement, behavior, and outcomes. MOOCs when used by masses of students provide enough monitoring data to make the analysis reliable.

The Stanford report lists some additional future opportunities: human teachers will be assisted by AI technologies; the use of Virtual Reality (VR) in teaching, MOOCs and other forms of online education will become part of learning at all levels; the transition from hard copy books to digital and audio media and texts will continue; digital reading devices will become 'smarter' and provide easy access to additional information about the subject matter; and Machine Translation (MT) technology will make it easier to translate educational material into different languages.

The Forbes article by Marr [10] highlights the future changes in the work of teachers: "Even though most experts believe the critical presence of teachers is irreplaceable, there will be many changes to a teacher's job and to educational best practices." Educational solutions of AI are starting to mature and are ready to support teachers' work even in practice. The same factors as discussed above are pointed out: personalization, adaptability, automatization of admin. tasks, personalization, the use of digital platforms (AI-supported learning, testing, and feedback to students). New tools may support learning for the (seeing, hearing) impaired and people speaking foreign languages. Universal access to the classroom supports remote participation in the classes.

The article by Schmelzer [13] (Forbes) deals with AI applications in education. It introduces a new term "*AI-Enabled Hyperpersonalization*" to emphasize the power of AI and ML to tailor and personalize the learning environment and opportunities. In the middle of the 2020s, close to half of the learning management tools will have embedded AI capabilities. Instead of creating a single curriculum for a group of students, educators will have intelligent assistance to provide a wide range of materials for the same core curriculum to meet individual needs. The business volume of such tools is expected to reach over $6 (US) billion by the middle of the 2020s. Studies will become paperless and the learning platform will provide a means for direct interactive feedback and follow-up. Augmented tutoring provided by autonomous agents will support learning and mentoring. Intelligent assistants will enhance adaptive learning so that each of the students can learn at their own pace or time frame.

In comparison to another field, *medicine*, there the expected business volume is expected to rise to 36.15 (US) billion, with a CAGR of 52% (Compound Annual Growth Rate) in the forecast period of 2018-2025 (MarketsandMarkets, [9]). The most important AI technologies are ML, natural language processing, context-aware computing, computer vision, and querying methods. The driving force for adopting AI in healthcare is the rising need for services due to the imbalance between the health care professionals and patients; the same – a lack of skilled teachers – applies to education, too. These frontier applications are the same as in the AI market[6] in general, in which the annual CAGR is calculated to be 36.6%. In the education sector, the expected CAGR is 44.2%[7].

The paper by Kulkarni [7] brings a couple of interesting viewpoints to the discussion. It introduces the terms *AI-Led* and *AI-Assisted* (*AI-Powered*) education and concludes – as do many others – that the future lies in *AI-Assisted education*. The main responsibility still falls on a human teacher. The paper discusses the current state and lists some successful implementations: Duolingo[8] (referring to the claim that "34 hours on Duolingo's app are equivalent to a full university semester of language education") and McGraw Hill's ALEKS[9] as a web-based, AI-powered assessment and learning system. In spite of the main development effort being in the USA, *China* is catching up (and overtaking). China's current investments in AI are already slightly higher than the USA's. China, having a population of 1.4 billion, fast growth of education needs, and a lack of skilled teachers, will be in the vanguard of the serious use of AI in education. The importance of education in Chinese culture has deep roots; Chinese families spend 20-26% of their income on their children's education. Companies like Squirrel AI (collaborating with CMU) and ALO7[10] are mentioned as the leading organizations.

The paper by Shroer [14] lists twelve American companies that have AI-based *products* for use in education. The application areas cover speech recognition and transcription for students having a limited writing ability (*Nuance*), adaptive learning technology (*Knewton*), virtual learning assistant based on conversational interaction (*Cognii*), customizable STEM (Science, Technology, Engineering, Mathematics) tutoring lessons (*Querium*), personalized learning plans and reduced

[6] https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-market-74851580.html

[7] https://marketersmedia.com/new-report-2019-artificial-intelligence-ai-in-education-market-to-grow-at-a-tremendous-cagr-of-44-2/511172

[8] https://www.duolingo.com/

[9] McGraw Hill, Assessment and LEarning in Knowledge Spaces, based on the Knowledge Space Theory: https://www.aleks.com/about_aleks

[10] http://squirrelai.com/; https://www.alo7.com/en/

workloads for instructors utilizing cognitive neuroscience and data analytics (*Century Tech*), a speech-to-text tool designed for small children (*Kidsense*), AI and machine learning to help students to develop a deeper conceptual understanding of math (*Carnegie Learning*), an adaptive learning platform to help educational institutions to collect data and to increase learner's engagement (*Kidaptive*), combined computer vision intelligence and augmented reality to enhance the way students learn in the classroom (*Blippar*), a customized tutoring program that tracks the work step-by-step (*Thinkster Math*), Knowledge Engine to synthesize course and quiz results and briefings to find knowledge gaps among employees in enterprises (*Volley*), and adaptive studying and learning tools (*Quizlet*). These confirm our earlier findings in the mainstream of the current AI technologies used in education – mainly for monitoring and adaptation purposes.

At the end of this review we make three references [11; 19; 20] to reports by UNESCO, without going into details. UNESCO has handled the *role of AI in education* from two different points of view. The first report deals with the role of AI in education from three perspectives: *AI for* education, *AI as* education, and *AI in* education and examines activities to implement the principles of inclusive and equitable participation in "AI and education". The two other reports focus on the role of AI in sustainable development.

To end this sub-section, we will give a brief overview of an ambitious Finnish project - *DigiTala*[11], as an example of a practical effort to use AI in education. *DigiTala* is an interdisciplinary (pedagogical, phonetics, behavioral, signal processing) project with the goal of developing a tool for computer-aided language tests. It will be used to grade the skills of spoken foreign language at the end of general upper secondary education. Most of these (written) tests are already computerized. Currently, the oral language part is not yet included in the set of tests. In other contexts, these are based on the evaluation of human assessors. The goal is to include a computerized spoken language test in the final examination and to provide an objective (human-assessor independent) spoken language evaluation.

IV. CONCLUSIONS

In this paper we have reviewed factors related to the role of AI in education. Partially we had to extend the approach to cover other technical innovations – "*technology driven changes"* in education, because AI cannot be separated from it. Two aspects were considered: the role of technology-driven changes in *work life*, and the role of AI (and related technologies) in *education*.

Work is undergoing the pressure of rapid changes. Demand for higher productivity and the opportunities provided by new technologies are driving industry and society towards automatization. This means radical changes in human work: some tasks will disappear; most are changing, and some new ones will be born. From a historical perspective, it is easy to see that society has always been able to adapt to change and (close to) full employment in society has been the status quo. What will happen in the future? Re-education, continuing education, and life-long learning are needed to adapt to the changes. The socio-economic structure is changing fast: high-welfare societies are aging and fewer people of working age have to take care of a larger number of the older generation, who are also living longer than earlier. Automatization and robotics as replacement and support of human work would be more than welcome in this structural change. In contrast, in lower welfare societies, which suffer low employment, the birth rate is high, and people tend to have a lower level of education. If these people are to be used to replace aging workers, a new kind of education is needed.

In education AI has a growing role, too. The mapping study of publications indicates that the topic is an important one, and a lot of work is going on in this area. However, research work on AI itself is being done in different silos than its applications. This means that the results are not being fully exploited in a variety of application areas – especially not in the education sector. AI application related research is concentrated in "*money-rich*" areas – education sector is not one, but medicine for instance seems to be. Our survey, covering some relevant articles, shows that future opportunities are envisioned, but real breakthrough applications are still waiting for their time to come. The article by Bryant et al. [2] reported the difficulties in adopting new technologies in teaching: the benefits of technology-rich, personalized, blended learning pilots are not realized on full scale; students who use tablets, laptops, and e-readers in the classroom are performing worse than those who do not. The explanation for this is that adoption of new technology transfers the focus *from the subject to learning to use the technology* itself and the teachers' time is spent acting as a facilitator and coach in using the new technology rather than on the learning interaction.

Are teachers ready to use these new technologies? Some are, but the majority not at all. According to the Deloitte study [7], teachers in European schools are still using ICT in classrooms to a diverse extent. On EU level, the range of ICT intensity in lessons by teachers is polarized. Roughly half of the teachers reported using ICT in classrooms in more than 50 % of the lessons. At the same time, nearly half of the teachers reported using ICT in the classroom rarely, in less than 50 % of the lessons. Teachers' perceptions of pedagogy-related obstacles to using ICT in teaching relate to insufficient pedagogical support and to a lack of pedagogical models on how to use ICT for learning, not to a lack of learning platforms or devices. One example of this complex situation can be given from the Finnish school system, which is known for its highly educated teachers. According to the report by Tanhua-Piiroinen et al. [17], over 50 % of Finnish teachers reported to have only "basic skills in ICT" and 10 % reported deficiencies in their ICT skills. The challenges in applying AI to education is not only about the algorithms and platforms but about the *capabilities possessed by the teachers*. Time and money for teachers' continuing education is required.

The reported AI-based tools mainly cover algorithmic intelligence, rather than the current AI with ML on a wide scale. Key applications seem to be based on algorithmic reasoning (like expert systems), data mining, big data type

[11] https://blogs.helsinki.fi/digitala-projekti/about-digitala/

analysis and visualization, not on a wide scale in system intelligence and its learning capability. The support provided to teachers mainly includes decision support, not automatic decision making. Grading, adaptation to the students' needs (often only adaptive user experience[12]), the use of electronic study materials, bidirectional feedback collection and analysis, and assistance "robots" are the main applications. The real use of ML is still minor: natural language processing (speech recognition, speech synthesis, natural language processing and analysis) has found its way into real applications but these are culture- and language-sensitive, not global; minority languages will still have to wait for a long time to convert these opportunities into practice. Progress in machine translation will help the situation (in the future) but does not solve the problem that education itself is culture-sensitive, having *different values and goals in different cultures.* The transition towards the use of cloud-based systems and universal learning platforms, MOOCs, especially in professional and continuing education as well as in regular education, seems to be clear. Because these systems are used by masses of people, even the follow-up data (because of the large amount) is useful on an ML basis to really make the platform AI-based.

What does the future look like through the eyes of experts in the field? We will close this paper by quoting (albeit loosely) the opinions of 17 experts, based on the interviews of Disruptor in [3]. These *expert opinions* reconfirm our findings: AI will assist instructors in performing tasks that are mostly mechanical (grading with helpful feedback, or by identifying students having difficulties). Students will receive increasingly complex support for their study problems. AI can help students to personalize their learning experience and it tracks the student's performance, enabling the students' needs to be addressed. AI will play the role of a teaching assistant (chatbots to address student questions between lectures). AI will be implemented to improve online and remote education. AI is a component in larger systems - combinations of AI with other technologies such as augmented reality. AI will make education accessible to all sectors of the population – especially students with disabilities. Education will be redefined as continuous learning instead of discrete curricula-based courses. All learning in basic areas will be managed by AI, with "teachers" replaced by facilitators and behavior managers. With the integration of IoT and 5G, classrooms will be replaced by virtual classrooms. Most students complete AI-supported flipped classroom and blended learning based programs virtually, and more in-depth studies on-site. AI is an aid for teachers in repetitive and data-driven tasks. Education is going to be AI-enhanced, but AI will not replace teachers completely, nor will all student learning become remote.

In an interview (Tekniikka&Talous 21.2.2020) *Professor Yutaka Matsuo* from Tokyo University pointed out that AI is not a threat to humans. Soon – within 5-10 years – AI will understand the semantics of words and moving robots will learn to manage their own movements. Simple tasks based on image processing (machine vision), speech recognition and natural language understanding will become possible. The current "intelligent assistants" – Siri, Alexa, Google assistant – just imitate something they have learned, without understanding it. Human thinking is based on two layers: a symbolic system and a system, which collaborate without our ability to explain it. Because we are not able to explain human behavior, it is difficult to transfer it to AI.

AI as a technology is already available and it is being adopted as its maturity reaches the expectations of the users. The future is already here to a certain extent, but there is more to come!

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