Technology trends, Education 4.0 and beyond

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Abstract

The real-time communication and collaboration of the internet of things, the internet of services and cyber-physical systems with each other and with people have started a new era in industrial production. This era called Industry 4.0, brought about revolutionary changes in many areas of life, including education. To fully exploit the potential of smart products, services and business opportunities that are expected to be widely used in all sectors in the near future, education systems need to be overhauled to meet the qualified workforce required by this dynamic process. The ability of companies and institutions with strong information and technology infrastructure to reflect advanced digital technologies to innovation and production processes requires some certain skills, described as 21st-century skills. Education 4.0, a reflection of the era of Industry 4.0, refers to a period in which education paradigms, approaches and technologies have been changed. In this study, major technology trends and their reflections on learning and teaching processes are examined within the framework of changing educational paradigms and teaching approaches.

Keywords: Education 4.0; industry 4.0; ICT in education; technology trends

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1. Introduction

The technological evolution that has been going on for years have led to paradigm shifts called 'industrial revolution' (Lasi, Fettke, Kemper, Feld & Hoffmann, 2014). The use of steam engines in industrial production in the late 18th century marked a milestone and this era named as Industry 1.0. The invention and application of electric power as a new energy source that made mass production available in industrial production marked the second industrial revolution known as Industry 2.0. In the early 1970s, automation systems radically changed production processes in line with the industrial use of computers. This revolutionary change was considered the beginning of a new era called Industry 3.0. Today, the use of internet in industrial production with a triple structure consisting of cyber-physical systems (CPS), internet of things (IoT) and the internet of services, in other words digital transformation of industries, has initiated a new era called Industry 4.0 (Baurer et al., 2014; Maria, Shahbodin & Pee, 2018; Özlü, 2017; TÜBİTAK, 2016). Industry 4.0 is the latest natural extension of the technological revolution that has been going for 1800s.

The term 'Industry 4.0' was initially coined at the Hanover industry fair in 2011, in the context of the German Government's project on equipping traditional manufacturing technology with high technology (Deloitte, 2014). Industry 4.0 defined by McKinsey Digital (2015) as digitisation of the manufacturing sector with embedded sensors in virtually all product components and manufacturing equipment, ubiquitous CPS and analysis of all relevant data. Industry 4.0, a new production model in which virtual and physical systems communicate and interact with each other over the Internet, consists of four basic levels. The physical space (machines, robots mobile devices, etc.), the networks that provide communication (wired, wireless and cellular), the big data and server systems embedded in the cloud system and finally the smart factories, smart services, smart cities and users (Alçın, 2016). Digital economy and society, sustainable economy and energy, innovative work environment, healthy living, smart mobility and civil security are among the priority areas that characterize Industry 4.0 (Granrath, 2017).
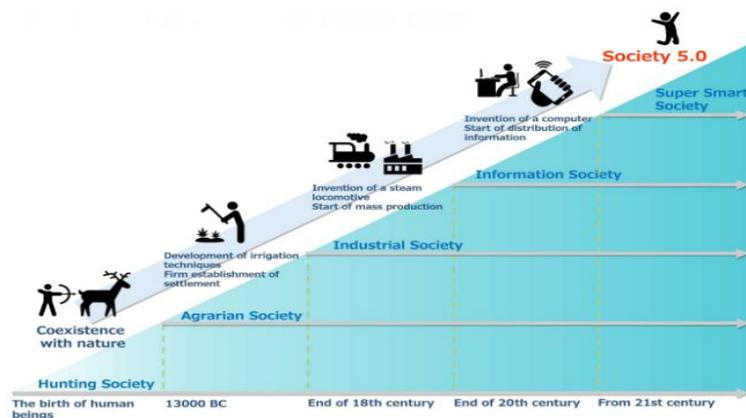

Figure 1. Evolution of Societies up to Society 5.0 (Keidanren, 2016)

Based on the Industry 4.0's, inevitable effects on the social structure Japanese Government initiated a new transformation movement as 'Society 5.0- Toward Super Intelligent Society.' Society 5.0 is an information society mainly aiming for a prosperous human-centred society. Accordingly, technology for the society in which changes in production processes concern not only the industrial production area but also the entire society in all aspects (Keidanren, 2016). Society 5.0 is widely used to refer to a super-smart society capable of managing technological power correctly. Unlike the past information society, where the information was collected through the network and have it analysed by humans, in Society 5.0 the creation of knowledge will be done by machines. Thus, it is possible to obtain optimal results that bring new value to industry and society in ways not previously possible (Granrath, 2017; Önday, 2019).

2. Technology in Education Timeline

The timeline regarding the use of technology in education reveals that different technologies have always been used to increase the effectiveness of learning and teaching. The tools, techniques and supplies used in education are naturally affected by technological advancements. In fact, as stated by Alkan (1996), it is necessary to know the effects of industrial, social, cultural, political, economic and demographic factors that affect education processes to make realistic diagnoses and to take the necessary measures.

As illustrated in Figure 2, early technology uses in education commenced with one-way correspondence education through different uses of postal communications, radio and television programs between 1840 and 1850. Use of teaching machines and programmed instruction applications followed by computer-assisted teaching applications between 1960 and 1990. Web-based technologies have been recognised as pioneering ground breaking innovations in education in mid-1990s.
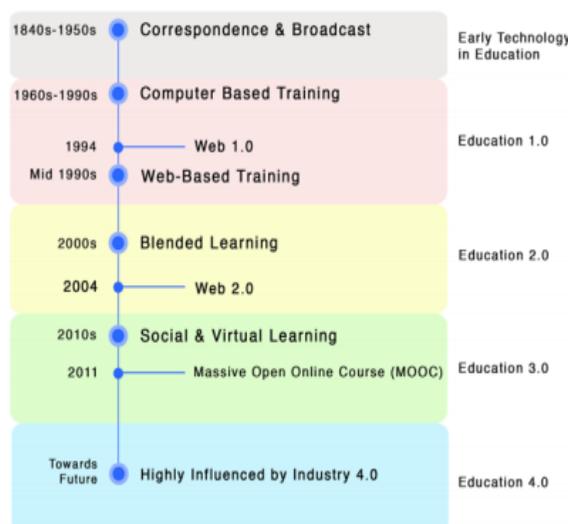

Figure 2. Technology in education timeline (Jeschke, 2014)

In Education 1.0 period, the web tools were used just to provide one-way information. It was not possible to make any corrections or additions by third parties to the content provided. Since there was no direct interaction in this process, the learners' roles were passive (Semerci, Yavuz & Semerci, 2018). In Education 1.0 period, predominantly traditional teaching approaches were adopted, the teacher became a mere information transmitter, while the students were consumers of knowledge. With the introduction of Web 2.0 technology in 2004, the Education 2.0 period has begun. This era brought some profound changes in students and teachers roles. In addition, digital learning platforms brought substantial changes in education. In 2010, social and virtual learning environments and mass learning applications came to the forefront and this era has been called Education 3.0. Unlike traditional learning methods, learner-practices have been used widely. In line with the emergence of Industry 4.0, a new period called Education 4.0 was started concurrently. According to Öztemel (2018), Education 4.0 refers to a period in which digital transformation and innovation started to dominate in education as in many other fields.

3. Technology Trends and Education 4.0

Recently, smart technologies have become increasingly used in many areas of our lives. Technology trends indicate that the future will be characterised by smart devices called smart digital networks. Gartner defines the people, devices, content, and services spiral as an 'intelligent digital network' and considers the 'Smart,' 'Digital' and 'Network' trio as key components that will shape the future (Panetta, 2018). Some of these technologies that bring massive changes in every aspect of life from production to working life, from learning to social development are listed below (Baheti & Gill, 2011; Brown, 2015; Bulut and Akçacı, 2017; Panetta, 2018).

- IoT
- Big data analysis
- Cloud computing
- Intelligent sensor (data to digital conversion)
- Smart robots and machines
- Artificial intelligence
- Three-dimensional (3D) printing technologies,
- Augmented reality (AR)
- Mixed reality (MR)
- Virtual reality (VR)
- Data analytics
- CPS
- Digital twins
- Quantum computing
- Radio frequency identification technologies
- Smart spaces.

In recent years, we are gradually moving toward an ecosystem where physical and virtual dimensions are increasingly intertwined. This emerging ecosystem is expected to have greater interaction between people, machines and digital technologies to better serve the needs of society in providing diverse benefits for both local and global economies (Jurčić et al., 2018). Although Industry 4.0 is based on high technology, the human factor will remain at the forefront. This fact is strictly emphasised in high tech strategy of the German government, as the philosophy of industry 4.0 is not based on a human-free industry, but a human-oriented change based on the principle that technology should serve people (High Tech Strategy of the German Government, 2019). Undoubtedly technology trends will continue to bring radical changes to every stage of education as in other areas of life. Therefore, it is crucial to anticipate the impact of these technologies at every stage of education and take the necessary steps.

The closed relationship between industrial and educational periods leads to the emergence of new professions that require some specific skills. For instance, cybersecurity specialist, machine learning specialist, information systems administrator, application developer, cloud computing manager, IoT architect, blockchain engineer, artificial intelligence specialist, data analyst, health practitioner and instructional designer are among these leading light occupations. With bearing this fact in mind, it is inevitable that educational institutions should be structured to meet the demands of highly qualified manpower of this dynamic transformation process (Akkoyunlu, 2018; Lizut, Marzano & Grewinski, 2018).

Despite the fact that technology constitutes the driving force of industrial revolutions, the focus of all revolution periods including Industry 4.0 is human. Therefore, education has two main responsibilities in this change process. First, educational institutions have the responsibility to train individuals capable of adapting and using new developments and meeting the expectations of contemporary society. Second, they have to train highly qualified individuals to meet the requirements of technology intensive labour market. At this stage, all stakeholders are to focus on the answer of the following question: Is our current education system is convenient to train individuals with the skills and the qualifications required by the new industrial revolution process?

As indicated in Basic Law of National Education article 2 and sub-article 3, the fundamental goal of Turkish National Education System is 'To prepare individuals for life by giving them the necessary knowledge, skills, behaviours and the habit of working together to ensure that they have a profession that will make them happy and contribute to the happiness of society.' In addition, the aim of the national education system is also stated as, 'To promote and accelerate economic, social and cultural development while increasing the prosperity and happiness of Turkish citizens and Turkish society and to make the Turkish Nation a constructive, creative and distinguished partner of contemporary civilisation' (Basic Law of National Education, 1739).

To realize the above-mentioned objectives Article 13 of mentioned law states that 'With all degrees and types of programs and educational methods, training tools and materials are continuously developed according to scientific and technological principles and innovations subject to the environmental and national needs. Improving productivity in education and ensuring continuous development and innovation are based on scientific research and evaluation. Educational institutions responsible for producing information and technology and developing our culture are equipped and strengthened; such studies are encouraged and supported financially and morally' (Basic Law of National Education, 1739). In this context, modernisation in education, science, technology and

innovation has become priority issue in national development plans, national education policy and strategy documents.

The historical development process regarding the use of technology in education in Turkey reveals that technological advancements mostly affected the industrial sector until 1950s. In this period, education technology was lagged behind a period of 100 years from industrial technology. However, with the introduction of radio, television and teaching machines in education an important period of development was experienced in mass education and individual education in educational technology as of 1960s (Alkan, 1996). As illustrated in Figure 2, web-based education applications, online learning, mixed learning and mass learning (MOOC) applications started to use in education in line with the emergence of Web 1.0 technology. The later periods reveal that education is directly affected by technological advancements and constitutes the dynamics of development processes.

The most comprehensive technology integration project in Turkey was taken into effect as of the year 2010. In this year, the Movement of Enhancing Opportunities and Improving Technology (FATIH) Project has been initiated by Ministry of National Education (MoNE). This Project considered as the most comprehensive technology integration project in education. The project has consisted of five major dimensions as hardware that includes interactive boards, tablet computers, printers, broadband and secure internet connection to all classrooms, e-content through Educational Informatics Network (EBA) platform, assistance services and teacher training. The fundamental goal of the project was to provide every student with the best education, the highest quality educational content and equal opportunities (MoNE, 2018).

As pointed out by Goldstein and Chesky (2011), education policies, strategies and programs should be handled in a way that enables individuals to acquire competencies that can compete at national and international level, taking into consideration the speed of development of technology and future predictions. The FATİH Project is a technology integration project initiated in the direction of making the necessary steps toward training students as a constructive, creative and distinguished partner of contemporary civilisation as stated in the relevant law (Basic Law of National Education, 1739).

Education 4.0, as a sub-step of Society 5 is represented by different paradigms such as sense-making, growth mind-set, creative thinking, STEAM (Science, Technology, Engineering, Art and Math) learning, classroom in the clouds, coding, flipped learning and maker learning (Semerci, 2018). Thereof, the development effort toward Industry 4.0 requires the updating of infrastructure, technology, teacher competencies and programs to take advantage of the full potential of smart products, services and business opportunities in the future. In the following section selected technology trends and their reflections to education were examined.

3.1. Big data and artificial intelligence

The prominent Industry 4.0-period technologies as big data, artificial intelligence, augmented reality, MR, VR and smart fields have an important position in education besides other areas. The big data analysis is one of the innovative technology trends in Education 4.0 era. Big data are consisted of data obtained from the traces of different varieties of digital environments and gives opportunity to analyse in according to the requirements. To evaluate a data as big data, it is expected that it will consist of five components known as 5V model; variety, velocity, volume, accuracy and value (Bozkurt, 2016; Terzi, Demirezen & Sagiroglu, 2016). Big data analysis has created new challenges and opportunities in education as well as many other fields.

In learning processes, it is possible to use big data with the opportunities offered through learning analytics. Learning analytics is defined as collecting, measuring, analysing and reporting information about learners to understand and improve learning environments (Bozkurt, 2016). The basis of the innovative and productive education approach of education 4.0 is based on personalised learning (Öztemel, 2018). In personalised learning, content is presented using the most appropriate learning methods and strategies to optimize learning experiences based on the analysis of students' educational activities. Among other miraculous technology trends and innovative applications, the data analytics will be of particular importance for the training of students with personal learning difficulties.

The synergy created by learning analytics and artificial intelligence enables the analysis of student performance, identifying the relationship between materials, teachers and programs, identifying their capacity and needs and developing educational content at different levels of difficulty. It is of great importance to develop a learning program in line with the individual learning needs of this technology

and to highlight problematic issues. Student performance reports obtained through learning analytics will also help teachers to better understand their students. In this manner, determination of students' strong and weak points, knowledge and skill levels will make it possible to design student tailored learning programs.

In the near future, the combination of artificial intelligence and intelligent tutoring systems is expected to allow computer programs to predict student responses and help teachers design their own customised, adaptive tutoring systems (Cohen, Beal & Adams, 2008). The more computers become familiar with learner behaviours, the more automated individual assignment, grading and creation of new content is expected in the near future (CDTM, 2015).

One of the areas that have the potential to use big data analysis in education is mobile learning (m-learning) and MOOC training. An increasing amount of data is considered to be important in terms of analysing learner behaviours in online learning environments and creating learning environments appropriate to the user profile. The use of big data analysis and artificial intelligence in educational processes is expected to be automated in the future by structuring courses, announcing and planning educational resources and using dynamic algorithms in accordance with student levels (CDTM, 2015).

3.2. AR

AR refers to the technology used to close the gap between real and virtual space by improving and increasing human perception. In augmented reality, physical and virtual objects are combined in a mixed space in which the user can move without restrictions. In this area, the virtual elements are positioned to appear to be part of the real world according to the users' view. AR is being used effectively in the fields of medicine, maintenance and repair, entertainment, sports and marketing, tourism, architecture and construction, cultural heritage and museum visits, military applications as well as learning and teaching (Manuri & Sanna, 2016).

AR provides excellent opportunities for trainers to provide an enriched learning experience for the students. AR has the potential for radically changing the way students and machines interactions, thus allows student to proactively interact with course materials (Manuri & Sanna, 2016). Education 4.0 era education concept requires the use of different tools and techniques in line with learners' needs (Semerci et al., 2018). In this context, AR is considered as one of the best practices for the individualised learning model. AR applications adapted for educational purposes contribute to the common working culture and encourage cooperative learning. In this process, teacher-student, student-educational material and student-student communication/interaction increase naturally.

As with virtual reality, AR allows visualisation of microscopic or macroscopic systems. This is a unique development in terms of transferring the events that cannot be transferred to the learning environments otherwise (Manuri & Sanna, 2016; Nasır, 2018). AR also contributes to the preparation of interactive course materials and reduces the gap between real and virtual due to 3D visualisation opportunities. Applications that enable students to interact with book content, also called magic books or smart book, are the examples prominent use of AR in education.

The fact that mobile devices such as tablet computers and smartphones have the necessary hardware for AR makes these tools attractive for use in educational processes. There are promising developments (Adhani & Rambli, 2012) and numerous research findings reveal the positive results of the use of these applications in education. Even though there are some limitations as to change or update the contents (Manuri & Sanna, 2016) it is possible to say that such limitations might be handled and AR continue to be used increasingly in the field of education due to its invaluable contributions.

3.3. 3D printing technologies

3D printing technologies have been used for more than 25 years, but mainly in the industrial field due to their high prices and inability to complete their serial production process. These tools have become popular for education, as prices have recently reached reasonable levels. 3D printing technologies, which are used in almost all sectors such as aviation, defence, space, medicine, architecture, construction, food, automotive, pharmacy and art, have brought revolutionary innovations to today's classes (3D Printing Systems, 2019; CB Insights, 2019).

In education, this technology enables students to develop creative ideas and transform their ideas into real models (Özsoy & Duman, 2017). The transformation of students' creative ideas into tangible, visible concrete objects provides students with unique learning experiences in the learning process.

The use of 3D printers in education is of great importance for the development of new generation individuals who learn by producing, not solely consuming (Brown, 2015; Kuzu-Demir et al., 2016).

In education, 3D printing technologies are used in the teaching of many fields of science. The introduction of these tools with improved pre-made lesson plans as in STEAM training (CB Insights, 2019) has greatly facilitated use in training purposes. As emphasised by McCue (2015), this technology has a special ability to capture people's imagination and in the near future, there will be a 3D printer on teachers 'and students' tables (or they want to have) to help them learn the basic principles of science, technology, engineering and mathematics.

Today, the formation of information communities is important for students to be active in the process of creating, structuring, evaluating and developing new information (Hong & Chiu, 2016). In this context, several learning communities are formed for different purposes (Johnson et al., 2016). One of the most popular of these communities is the 'Maker' movement. In this movement, individuals coming from different fields work together, design and perform learning activities.

Members of the maker movement are known as 'Do It Yourself-DIY' enthusiasts interested in engineering, electronics, robotics and manufacturing. Members of this movement actively encourage students of all ages to do electronic do-it-yourself activities (Brown, 2015). Project-based and problem-based cooperative learning environments contribute to the development of 21st century skills such as creative and critical thinking, problem-solving, taking responsibility, using information and communication technologies effectively, developing cooperation and communication skills and analytical thinking skills (Özsoy & Duman, 2017; Trilling & Fadel, 2009). For this reason, the use of 3D printers in educational purposes, relevant projects and cooperation activities carried out within this scope has utmost importance.

3.4. Digital learning platforms

With the effective use of Web 2.0 technologies since the early 2000s, fundamental changes have emerged in the generation, access, sharing and storage of information. In this period, users became more active and participatory. The learning and teaching environments, teaching methods and techniques were changed dramatically. In line with these radical changes in learning environments, methods and techniques different learning approaches have emerged as e-learning, mixed learning, mobile learning and ubiquitous learning (Semerci & Keser, 2013). In this period, students have become active individuals who produce information, inquiry the source of information and take responsibility for their own learning from the position of individuals who were solely the consumer of information.

Digital learning environments such as learning management systems (LMS), learning content management systems (LCMS), learning portals provide countless benefits for learners, teachers, school administrators, families and all other relevant counterparts. These environments, which arise with different names, but learning is carried out through mobile networks, internet, intranet networks and online systems, are all called digital learning environments. These platforms have become extremely important for the new generation learners for whom mobile technologies are considered as an integral part of their life.

Oblinger (2003) defines the basic characteristics of today's digitally literate students as mobile experience oriented. The role of digital learning platforms, including smartphones, is increasing day by day in the upbringing of new generations with high-level skills required by the age (Akkoyunlu, 2018). In literature, there are many research findings showing that collaborative online environments are effective in acquiring students with new educational skills (Lizut et al., 2018). Thus, considering the intense interest of especially children and youngsters in mobile technologies, it is crucial to take into account the learning potential of these tools.

On the other hand, in the dynamic life process, we are in learners are expected not to acquire unrelated, memorised information, but to synthesize the information and use it in solving real-life problems. This necessitates the use of strategies, methods and techniques in the field of education, which facilitates the access of individuals to information during the active learning process (Maden, 2013). In this context, digital learning platforms offer students active learning opportunities, provide access as much as possible anytime and anywhere and provide interactivity for students where possible to enhance learning (McIntyre, Wegener & McGrath, 2018).

To ensure the motivation of the students in the learning process, the students should be able to establish the connection between the theoretical knowledge and its applications in the real world, in other words, they need to know how to use them in real life. Methods such as project-based learning, challenge-based learning (Johnson et al., 2016) and self-directed digital learning are crucial

requirements for lifelong learning and active learning for employees' professional future. Digital learning platforms provide active learning environments for students (Johnson et al., 2016). Such applications positively affect students' interest and motivation by providing learner-centred learning opportunities (Kamacı & Durukan, 2012).

Yet another trend in the use of technology in education is Bring-Your-Own-Device (BYOD). In this practice, educational institutions allow students to bring their own mobile devices when it is not possible for the institutions to provide mobile devices to everyone (Safar, 2018). This practice is convenient with the current century's education concept and learner-centred constructive learning approaches provides many advantages especially for increasing the communication, cooperation and motivation of the learners (Mahesh, Jayahari & Bijlani, 2016; Parsons & Adhikari, 2016; Peasgood, 2014; Safar, 2018). The BYOD provides teachers with the opportunity to directly monitor students' progress and provides direct feedback to students (CDTM, 2015). This practice also allows students to access corporate information and information resources anywhere and anytime they wish to.

In practice, there are a number of research findings reveals the negative consequences of digital platforms and mobile technologies that are used in educational processes (Semerci, 2018; Çetinkaya & Keser, 2014; Yıldırım, Yaşar & Duru, 2016). However, it is not acceptable to prohibit these tools for them since they consider irreplaceable tools. As emphasised by Akkoyunlu (2018), we live in a 'mobile dependent' society, where people cannot do without their mobile devices. Therefore, we need to focus on finding logical and applicable solutions for the effective use of these tools as digital learning platforms.

In line with the increasing use of mobile devices, several applications developed that allows teachers to control these devices from a single centre. Researches reveal that such programs increase positive learning outcomes and minimize negative effects by providing access to only the allowed training platforms in the classroom (Mahesh et al., 2016). While mobile tools give the opportunity to connect to different digital learning platforms at the desired place and time, they provide teachers with real-time analysis and timely feedback on the performance of each student (Ivanchuk & Kulchyncky, 2019; Peasgood, 2015). As a consequence, digital learning platforms play an important role for learners of all ages. In the near future, it is envisaged that the synergy of artificial intelligence and big data analysis will take learning to a completely new dimension that has never been witnessed before and digital learning platforms will become irreplaceable mediums.

4. Conclusion

Historical progress reveals a close relationship between education and industrial revolutions (Yazıcı & Düzkaya, 2016). Recently, we are experiencing a period of intensive use of smart technologies in almost every field of our life. For this reason, it is important to foresee the potentials of this period to take necessary actions timely and wisely. Moreover, educational institutions have responsibility of raising qualified manpower at all levels required by this dynamic development process. Thus, educational institutions have the chance to turn technology trends into opportunities.

A number of initiatives launched to ensure the transformation from Industry 3.0 to Industry 4.0.; however, Scientific and Technological Research Council of Turkey (TÜBİTAK) points out that the digital maturity level of Turkish industry is unfortunately between Industry 2.0 and Industry 3.0 level (TÜBİTAK, 2016). Similar to the digital industries' maturity level, the level of education in Turkey located somewhere between Education 2.0 and Education 3.0. Therefore, the current education system needs to be restructured in accordance with the developments to meet the needs arising with education 4.0 (Semerci et al., 2018). These regulations should be focus on arrangements to raise individuals equipped with 21st century skills.

In this revolutionary process, teachers also have important roles and responsibilities besides other stakeholders of the educational system. Therefore, universities where future teachers trained should reconsider their programs in such a way as to enable prospective teachers to acquire critical thinking, creativity, communication and cooperation competencies, research competencies, digital workforce competencies and future strategy for globalisation competencies (Nasir, 2018). Besides, students are expected to have some certain skills and competencies in this new era. According to Aoun (2017), data literacy skills to access, analyse and use of in the digital world, technology literacy skills to understand mechanical systems, coding and artificial intelligence skills and competencies and finally human literacy skills are quite important in this smart revolution era.

In this study, first, technology trends in education have been examined in line with the industrial

revolutions. Then, the reflections of technology trends on education were examined within the framework of changing educational paradigms. As a consequence, past experiences reveals that use of technology in education is inevitable. However, comprehensive strategic planning and extensive pilot studies are crucial to ensure that technology integration processes in education do not result in high economic losses, failures and frustrations.

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