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# Education in Industry 4.0

Phan Kieu Linh[1]
[1]*MA in TESOL, Foreign Languages Department, College of Foreign Economic Relations, Viet Nam*

***Abstract:*** *Right now, a fourth industrial revolution is taking shape, known through the term "Industry 4.0". This term has been publicly known since 2011 when an initiative named "Industrie 4.0" promoted the idea as an approach to strengthening the competitiveness of the German manufacturing industry (Hermann et al, 2016). In this paper, author systematically examines industry 4.0 and its implications, answering for the research question 1: "What is Industry 4.0? What are its implications of Industry 4.0 in general?". Then, a review of literature on requirements on necessary skills and education under industry 4.0 is presented.*
***Keywords -****.Industry 4.0, fourth industrial revolution, education, innovation, digital.*

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## I. INTRODUCTION

In the history of humankind, three industrial revolutions have taken place. The first industrial revolution of mechanization started in the second half of the 18th century and intensified throughout the entire 19th century, led by the invention of the steam engine. Nearly a century later at the end of the 19th century, the second industrial revolution was initiated with the introduction of electricity. The third industrial revolution, or digital revolution, started in the 1970s, when telecommunication and computers emerged. All these industrial revolutions affected not only on the production, but also the labor market and the education system as well. (Benešová & Tupa, 2017).

Right now, a fourth industrial revolution is taking shape, known through the term "Industry 4.0". This term has been publicly known since 2011 when an initiative named "Industrie 4.0" promoted the idea as an approach to strengthening the competitiveness of the German manufacturing industry (Hermann et al, 2016). This fourth industrial revolution is characterized by "a much more ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper, and by artificial intelligence and machine learning" (Schwab, 2016, p.12). It is forecasted to have profound impacts on societies, and all economies (UNIDO, 2017).

## II. Research Data

### 2.1. Industry 4.0

While some literature use the term "Industry 4.0", some others use "the fourth industrial revolution". In the paper of United Nations Industrial Development Organization (UNIDO), they state that, "Industry 4.0 is one of the major drivers of the Fourth Industrial Revolution" (UNIDO, 2017, p.3). The word "Revolution" implies "a profound change in economic systems and social structures", according to Schwab (2016, p.11). However, there is no literature that distinguish these two terms in detail. In this dissertation, "Industry 4.0", and "the fourth industrial revolution" (4IR) are used interchangeably without difference in meaning.

Although Industry 4.0 is taking place at the present, "a generally accepted definition of the term does not exist" (Hermann et al, 2016, p.1). According to Hermann et al. (2016, p.11), industry 4.0 is "a collective term for technologies and concepts of value chain organization".

Based on the findings of Hermann et al. (2016), technologies or components that are commonly mentioned as part of Industry 4.0 include smart factories, cyber-physical systems (CPS), the internet of things (IoT), and internet of services (IoS). However, also important and related to industry 4.0 are concepts such as big data, human machines interface, cyber-security, advanced (autonomous) robotics, cloud computing, smart sensors, virtual and augmented reality, artificial intelligence (AI), blockchain, digital twin, etc.

Schwab (2016) share the similar idea when he underlines that industry 4.0 is not only about the "ubiquitous and mobile internet", or smart factories. It is the fusion of emerging technologies (ie. AI, robotics, IoT, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, etc.)and their interaction across the physical, digital and biological domains.

Digital technologies are not new, but they are becoming "more sophisticated and integrated" in industry 4.0 and as a result, are transforming societies and the global economy. Digital technologies will manifest themselves with "full force" through automation and the making of "unprecedented things". (Schwab, 2016, p.12)

In summary, it is not possible to define industry 4.0 with specific technological innovations as the previous three revolutions. Industry 4.0 is still happening with high probability of more innovations in the future - and is denoted by a complex combination of a variety of technologies, building on the digital power and will arguably impact our world in a way that the humankind has never experienced before.

**2.2. Implications of Industry 4.0**

Industry 4.0 is "leading to unprecedented paradigm shifts in the economy, business, society, and individually. It is not only changing the "what" and the "how" of doing things but also "who" we are." (Schwab, 2016, p.8)

Regarding economy, while industry 4.0's impacts on economy are vast and multifaceted, almost all people are concerned about employment. There are many concerns that Industry 4.0 and increased automation can lead to increased unemployment. However, the matter of labour market or employment does not solely depends on the technological feasibility but also affected by economic, legal, regulatory and socio-political factors (UN, 2017). Bughi, Manyika, and Woetzel (2017) shared the same ideas as illustrated in the Fig. 1.


**Figure1**.Five factors affecting pace and extent of automation adoption
Source: Bughi, Manyika, & Woetzel, 2017

Besides, the innovation will lead not only to the destruction, transformation, but also to the creation of jobs (UN, 2017; Bughi, Manyika, & Woetzel, 2017). Look back throughout the history, for example, when ATMs were introduced in the 1970s, the demand for bank tellers declined. However, by saving money, the banks opened more branches and created more jobs (Berlin, 2017). In the mechanization revolution, the demand for manual work in factories declined yet it created the labour demand for operating and maintaining the machines. Under the 4IR, a similar scenario is expected. According to the study of Frey and Osborne (2013), through the impact of technological innovation, employment will grow in high-income cognitive and creative jobs and low-income manual occupations, but it will greatly diminish for middle-income routine and repetitive jobs. WEF (2016, p.1) also forecasted that disruptive changes could lead to "a total loss of 7.1 million jobs, two thirds of which are concentrated in routine white collar office functions… and a total gain of 2 million jobs, in Computer and Mathematical and Architecture and Engineering related fields" worldwide over the period 2015-2020. Nevertheless, there is also an extreme scenario for the future labour market where even writing, one of the most creative professions, is threatened by the advent of automated narrative generation (Podolny, 2015).

To foster positive outcomes of the 4IR, it is the urgent need for all stakeholders to anticipate future employment trends and required knowledge and skills of the workforce (Schwab, 2016, p.44). One thing can be predetermined is that the future economy will require highly educated and well-trained people (Baygin et al., 2016).

Regarding business, Schwab (2016) mentions four main major effects of 4IR including changing on customer expectations; promoting data-enhanced products; forming new partnerships; and transforming in operating models.

For customer expectations, they are redefined into experiences. Buying an Apple product is not only because of its usage, but also because of its branding, packaging, customer services, etc. In the era of accessing and using data, more power is shifted to consumers when they can access to more data on supply chains and make peer-to-peer comparisons on the performance of products. Especially, they expect a "now world" regarding on the real time that companies respond to their demand.

For products, emerging technologies as smart sensors enable businesses to measure and monitor their asset performance over time through data and analytics. This not only helps businesses to maximize their utilization but also offers opportunities to make new price services. For example, long-distance haulers are interested in paying tire manufacturers by the 1,000 kilometres of road use rather than periodically buying new tires.
For collaboration, the 4IR forces companies to think about how offline and online worlds work together in practice. This leads to new collaborations between the established and young businesses or between traditional industry and innovative technology companies to find a good solution for enhancing value based on technologies.

For business models, we have seen the establishment and staggering development of companies with technology platform in the 21st century. Ribaudo (2016, p.5) provided the perception of "technology creators", who use capital to develop and sell intellectual property and "Network Orchestrators", who use digital networks of businesses or consumers to create, market, and sell goods, services, or information, with the company acting as organizer. He underlined that by creating a "digital divide", those business can yield significantly different revenue multiplier results as demonstrated in the Fig. 2.

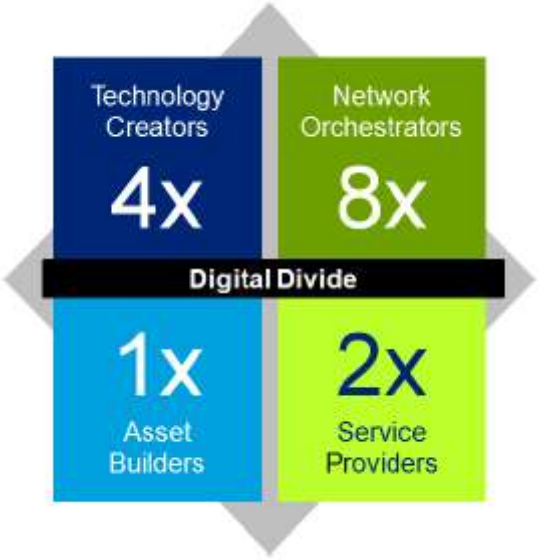


**Figure 2.** Revenue Multipliers above and beyond the digital divide
Source: Ribaudo (2016, p.6)

UNIDO (2017) also shared this idea when emphasizing that digital technologies initiate new business models and value-producing opportunities. Taking Uber for example, although this name was unknown some years ago, it has become one of the popular providers for mobility services. In August 2018, Uber has 75 million riders with 3 million drivers despite of owning no cars (Craig, 2018). Facebook took only six years and Google just five years to reach revenue of $1 billion a year. "There is no doubt that emerging technologies… are increasing the speed and scale of change for businesses" (Schwab, 2016, p.52). UNIDO (2017) believe that opportunities offered by Industry 4.0 are attainable for most developing countries. However, those countries that would like to take full advantages of the new wave must possess the required skills, energy infrastructure, broadband and transport networks (UN, 2017). In another aspect, emerging operating models underline the importance of cyber and data security to avoid direct disruption, according to Schwab (2016).

**Regarding society**, the two most important impact of 4IR are the potential for rising inequality and changing how communities form and relate to one another (Schwab, 2016, p.86). The discussion on implications of 4IR on economy and business above also allude to the potential for rising inequality between those who are able to participate fully in innovation-driven ecosystems by providing new ideas, business models, products and services, and those who can offer only low-skilled labour orordinary capital. And rising inequality, according to Wilkinson and Pickett (2011) can lead to various issues for societies as security, health, welfare, and education to name some. Regarding community, "one of the greatest effects of digitization is the emergence of the "me-centred" society (Schwab, 2016, p.88) - a process of individuation and emergence of new forms of belonging and community, developed based on individual values and interests. New forms of digital media are affecting how a community is framed when people can connect each other in entirely new ways, across boundaries. Via social media, IR4 empower citizens when offering them opportunities to participate in civil debate or decision making yet it can also be used as new forms of surveillance and other means of control that run counter to healthy, open societies (Global Risks Report 2016, WEF). Besides, there is the fact that our political and civic decisions are shaped by what we read, share and see in the context of social media.

**Regarding the individual**, 4IR have manifold impacts on human, not only changing our behaviour and expectation as discussed in the impacts of 4IR on business and society. Nowadays, we are spending most of the time with technologies and the internet and there are growing concerns that it may negatively affect our social skills, cognitive skills, and ability to empathize (Konrath, O'Brien & Hsing, 2010; Carr, 2010; Kuper, 2015). The problem of privacy and losing control over personal data will also be intensified in the years ahead. And at the high phase of development of AI and biotechnology, 4IR is pushing to question what it means to be human when issues as life extension, designer babies, memory extraction and many more can be made via AI and biotechnologies if the principles of moral and ethics are not put at the heart of innovations (Schwab, 2016).
In brief, the implications of 4IR is profound in all aspects and unprecedented. However, "in an age of constant movement, nothing is so urgent as sitting still" (Iyer, 2014). When everything is still under our choices, it is necessary to think comprehensively how we would like to navigate this revolution.

## III.Education In Industry 4.0

There are scenarios in which AI and machine learning replace human in the labor market. But in the majority of cases, technologies will serve to enhance human labour and cognition. In such world, there is a need to prepare workers skills that enable them to work alongside and engage more comprehensively with increasingly capable, connected and intelligent machines (Schwab, 2016; Bughi et al., 2017).

There is an increasing list of researches dealing with education in the 21st century, education in a technological society, education in the era of the 4IR. Those literatures provide us ideas about education in coming future.
First, it is the focus on building "intrinsically human capabilities that machines cannot yet match" (Bughi et al., 2017, p.18). These are creativity, as well as critical and systems thinking, logical thinking and problem solving, and so on. The importance of skills has been highlighted since the late of the 20th century (Pandya, & Basavaraj, 2018) but it has become even more important if one person wish to succeed in this century of increasing technological innovation. Going through literature in this field as the study of Brynjolfsson and McAfee (2014), Schwab (2016), the future of jobs report of WEF (2016), Bughi et al. (2017), Butler (2018), Short and Keller-Bell (2019) to name some, provides a list of essential skills need to be equipped in Industry 4.0 as illustrated in the Fig.3.


**Figure 3. Word cloud showing necessary skills in Industry 4.0**

However, the hard or technical skills still keep a certain role. "The key to success in the twenty-first century..is to combine hard and soft skills into a comprehensive package tailored to specific needs" (Short and Keller-Bell, 2019, p.134). The future of jobs report (2016) of WEF also mentioned "In essence, technical skills will need to be supplemented with strong social and collaboration skills." (p.3).

Nevertheless, "simply reforming current education systems to better equip today's students to meet future skills requirements is not going to be enough to remain competitive" (WEF, 2016b, p.8) because the future is uncertain with increasingly intelligent machines. Therefore, lifelong learning must be promoted (UN, 2017; WEF, 2016b, Gleason, 2018). Lifelong learning can be defined as "all learning activity undertaken

throughout life, with the aim of improving knowledge, skills and competence, within a personal, civic, social and/or employment-related perspective"

(European Commission, 2001, p. 9). And "learning how to learn" is one of the eight key skills identified by the European Union that all citizens should have for lifelong learning (EU, 2006).

Education has a crucial role in shaping societal transitions. It have to change, in collaboration with government and industry to respond to the 4IR. An important note here is the emphasis on "specific needs" or particular sectors. It is essential to understand "a country's or industry's skills base" (WEF, 2016b, p.7) or "to understand the industry and country-specific outcomes of the 4IR" (Schwab, 2016, p.44) because expected knowledge and skills will vary by industry and geography or region. This change should also be considered in a comprehensive context, including the implications of 4IR on individuals as mentioned above and emerging technologies that can be applied into educational activities (Gleason, 2018).

## IV. Conclusion

In this paper, fundamental understanding about industry 4.0 and its implications in various aspects as economy, business, society, individual, and education in particular, were presented. All industries are being pushed up a curve of transformation by 4IR yet not all industries are at the same point of disruption, according to Bughi et al. (2017).

Government need to consider the following activities to foster the development of education under Industry 4.0. For example, revising strategic plan with respect to Industry 4.0, in which the collaboration among government - industry - universities must be highlighted and promoted by specific measurements from all relevant parties.

Besides discussed matters, Industry 4.0 still have many other impacts on education. For example, it can also affect the gap of gender equality/equity in education. This could be another direction for further study./.

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