Preparing the Future Workforce in Advanced Manufacturing: The Case of South Korea

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Advanced manufacturing has led South Korea's economy for the past several decades. It accounts for 4.5 million jobs, which is about 10% of South Korea's population. However, the era of the Industry 4.0 is transforming the nature of the workforce in advanced manufacturing industry. A lot of workers could lose their job to automation, but it is likely that they will also find new jobs in similar occupation. Thus, it will be crucial for various stakeholders in the industry: employee, employers, educators, and policymakers to prepare for this changing nature of the workforce. However, our review of policy and research suggests that little is known about the extent to which South Korea is ready for the changing nature of the workforce in advanced manufacturing industry. In this paper, we will explore South Korea's readiness for the change in advanced manufacturing workforce. Specifically, we will provide a review of literature relating to the impact of automation in advanced manufacturing workforce and how South Korea is preparing workers for the Industry 4.0. We will conclude with promising directions for research. Taken together, this paper will offer several promising directions for further investigation into how South Korea can prepare for the impact of automation in advanced manufacturing workforce.

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Introduction

Advanced manufacturing (AM) has played a crucial role in South Korea's economy for past several decades. It has led rapid economic development in South Korea and made the 12th largest in the world. AM also accounts for 4.5 million jobs, which is about 10% of South Korea's population [1]. However, the era of the Industry 4.0 is transforming the nature of the workforce in advanced manufacturing industry. A lot of workers could lose their job to automation, but it is likely that they will also find new jobs in similar occupation. Thus, it will be crucial for various stakeholders in the industry: employee, employers, educators, and policymakers to prepare for this changing nature of the workforce [2]. However, our review of policy and research suggests that little is known about the extent to which South Korea is ready for the changing nature of the workforce in advanced manufacturing industry. In this paper, we will explore South Korea's readiness for the change in advanced manufacturing workforce. Specifically, we will provide a review of literature relating to the impact of automation in advanced manufacturing workforce and how South Korea is preparing workers for the Industry 4.0. We will conclude with promising directions for research. Taken together, this paper will offer several promising directions for further investigation into how South Korea can prepare for the impact of automation in advanced manufacturing workforce.

Industrial Revolutions

Over the past three centuries, industrial revolutions have been very important developments in human history [3]. Figure 1 illustrates the timeline of industrial revolutions.

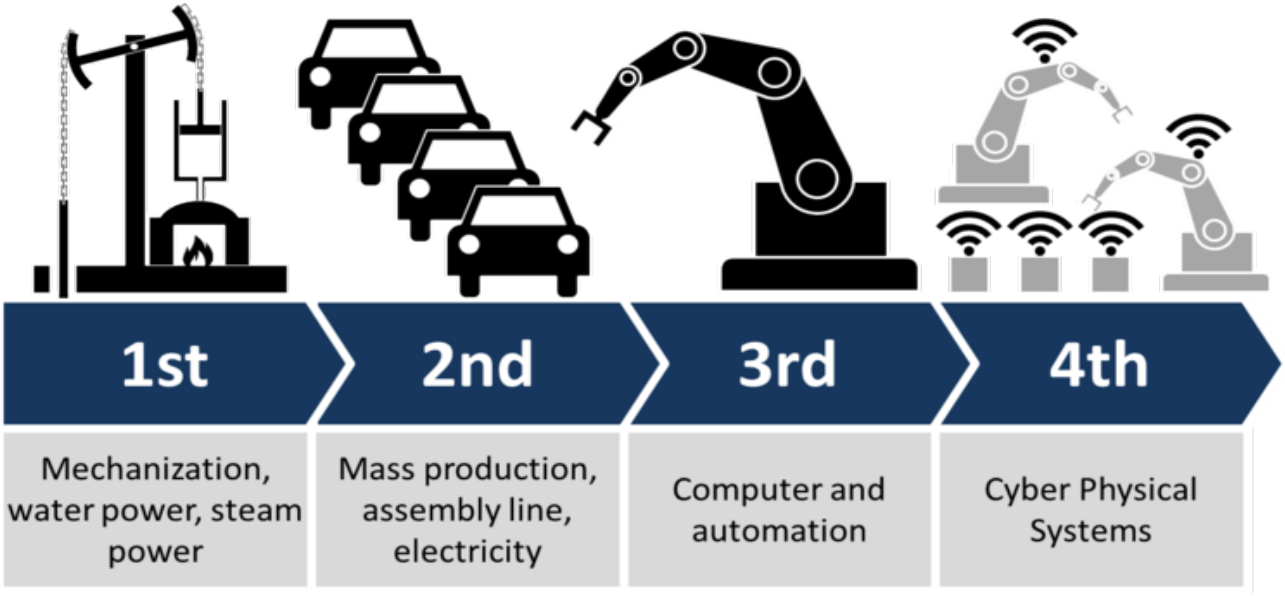

Figure 1. Timeline of Industrial Revolutions

The First Industrial Revolution, driven by mechanization and steam engines, began in the 1780s in Great Britain and lasted until the 1840s. This extreme increase in productivity [4] resulting from changing from an agricultural economy to one based on industry [3].

The Second Industrial Revolution, 1850s-1920s, was initiated by the emergence of new energy sources such as electricity, gas, and oil, which led to industrial mass-production [5] and to chemicals advancement, developed synthetic fabric and fertilizer [6]. The Third Industrial Revolution, starting in the 1970s with the advent of electronics, telecommunications, and computers, produced digital systems and communications. These rapid advances in computing power have enabled new ways of generating, processing and sharing information [7]. These technologies have led to the automation of an entire production process [2].

The Fourth Industrial Revolution, which is also known as Industry 4.0, is centered on the use of information and communication technologies (ICT) within and across industries [2]. In Industry 4.0, computers are connected and communicate with one another to ultimately make decisions without human involvement. These smart and autonomous systems are driven by the Internet of Things (IoT), data analytics, and artificial intelligence. The combination of all these technologies results in cyber physical systems, such as smart factories [7].

Industry 4.0 and the Future Workforce

Industry 4.0 is characterized by new technologies such as Cyber Physical Systems, Internet of Things, and artificial intelligence. Driven by these new technologies, Industry 4.0 will change the nature of existing jobs and transform the entire employment landscape [8]. The impact on jobs include both job creation and displacement, and increased labor productivity to widening skills gap [2]. These significant changes are accompanied by concerns about the future of jobs and wages.

According to McKinsey Global Institute [9], by 2030, globally, about 50% of all work tasks could be automated by currently demonstrated technologies. Moreover, 60% of current jobs consist of 30% of work activities that could be automated. This report [9] also indicated that by 2030, due to automation, between 75 million to 375 million workers of the global workforce will need to switch occupational categories [9]. Training solutions should be developed for workers so that they can adapt to these changes [8].

In contrast, some scholars claim that automation will have a positive effect on jobs: Thomas Frey, an American futurist, suggested that 60% of future jobs have not been created yet [10]. Also, scholars like Gali [11] and Uhlig [12] have argued that in the United States, new technology adoption increased unemployment rate in the short term, but had no significant effect on the long term employment rate. In addition, a study on OECD countries in 2016 concluded that it is unlikely that automation will destroy large number of jobs [13]. The impact of Industry 4.0 in the future workforce is still debatable. Nevertheless, in this rapidly changing employment landscape, businesses, governments and individuals must anticipate and prepare for future skills requirements and job content.

South Korea's Readiness for the Future Workforce

Advanced manufacturing (AM) will be a major industry heavily impacted by Industry 4.0 and the emergence of smart factories: "A smart factory refers to a fully integrated technology-based manufacturing system, which connects the entire production process" [14]. South Korea is

already embracing smart factories in manufacturing because of the decline in working-age population. Since South Korea is aging at the fastest rate among OECD countries, productivity growth is vital to maintain its economy. The South Korean government has stated that smart factories will help maintain its productivity growth; the public and private sectors have set up a plan to increase the number of smart factories to 30,000 by 2025 [15].

South Korea is one of the countries that is most exposed to risk from automation. In the midst of the global loss of about 20 million, or about 8.5%, manufacturing jobs due to automation, South Korea is projected to lose nearly 800,000 jobs over the next decade [16]. Like many other developed countries around the world, rural areas in South Korea are most vulnerable to automation [15]. Seoul, the capital and biggest city in South Korea, is the least vulnerable since it is not heavily dependent on manufacturing jobs; however, the country's rural areas like Incheon and Daegu regions are at risk because of their concentrated manufacturing factories.

In response to these looming concerns, in the past few years, South Korea has been trying to prepare its economy for Industry 4.0. The government is pressing businesses to adopt new technologies like Internet of Things, cloud computing, and artificial intelligence. The country's manufacturing industry is also accelerating automation to bolster productivity and profitability. Automation in manufacturing is expected to continue as it is very difficult to meet productivity targets without automation. In response to this trend, the South Korean government pledged to provide support for training 40,000 skilled workers to operate fully automated manufacturing sites through various training and educational programs [14]. The government is also preparing low-skilled workers who will most likely to be replaced by automation and will face difficulties in getting rehired. The initiative "learning factories" will help about 50,000 people to develop skills to handle robots and automated machines by 2022 [14].

Nevertheless, South Korea's preparation for Industry 4.0 also faces challenges. The major challenge comes from the country's education system. Although most South Korean students are familiar with the term Industry 4.0, they do not seem to have a deep understanding of its concept and any related training. Tinmaz and Lee [17] conducted a study to assess Korean university students' readiness level for Industry 4.0. Three of this study's main conclusions were: 1) very few South Korean university students knew about Industry 4.0 and 2) most students lacked facility with key Industry 4.0 technologies like sensors; 3) South Korean universities have very limited support for retraining programs and lifetime education [18]. Without educating the current and future workforce, South Korea will face a critical issue as a significant amount of work is expected to be replaced by automation [9].

Conclusions and Future Directions

In this brief review of literature relating to Industry 4.0's implications for South Korea, it is clear that Industry 4.0 has the potential to transform South Korea's future workforce. This developing phenomenon offers several opportunities for researchers. Promising areas for exploration include:

1. What sorts of competency skills would be required for advanced manufacturing workers to survive in Industry 4.0?

McKinsey Global Institute [9] recommended that workers seek additional education and training to adapt to an automated workplace. In the context of South Korea's two-year technical college programs, researchers may wish to investigate the extent to which current curricula contains advanced manufacturing topics and reflects manufacturing employers' desired worker competencies. Similar work has been conducted in Florida in relation to AM technicians [19] – [23]. These studies concluded that the gap between employer needs, curriculum content, and new professionals' actual job responsibilities was significant and that economic development depends on an alignment between all stakeholders.

2. How should South Korea adjust or transform their education system to prepare people for Industry 4.0 and beyond?

Policymakers agree that a fourth global industrial revolution [2], [24] is underway and that this transformation affects many manufacturing industry sectors. However, the breadth of these changes is difficult to predict in a fast-moving environment in which stakeholders may not agree on what advanced manufacturing is and what an advanced manufacturing technician should know and be able to do across industries. Essential to moving forward with educational and workplace reform is consensus on the boundaries of advanced manufacturing and a deep consideration of what the participants in this fourth revolution do that is different from prior moments in industrial history. For example, researchers may wish to investigate whether momentum exists among key players to not only coalesce around a definition of AM (such as the exploration discussed in [21].) and are able to model the knowledge structures common to subsectors, as explored by Oh [25].

3. The governments in other countries, such as the United States, China, Germany, and Japan are also preparing their future workforce for Industry 4.0. How are their policies similar or different from the South Korean government's policies?

Industry 4.0 is also expected to have a huge impact on countries around the world. Accordingly, many governments are introducing new policies so that they can position themselves better for Industry. 4.0 [26]. However, their policies have different approaches and goals due to each country's socioeconomic environment and technological capability. By comparing major countries' policies to South Korea's policy, researchers will be able to explore unique opportunities and challenges that South Korea will be facing in the era of Industry 4.0.

In this literature review, we sought to review the impact of automation in advanced manufacturing workforce and how South Korea is preparing workers for the Industry 4.0. We also explored Industry 4.0 and its impact on future workforce, and South Korea's Readiness for the Future Workforce. Taken together, this paper offers several promising directions for further investigation into how South Korea can prepare for the impact of automation in advanced manufacturing workforce.

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