Asian Journal of Innovation and Policy (2019) 8.2:288-301
DOI: http//dx.doi.org/10.7545/ajip.2019.8.2.288

Challenges for Innovative HRD in era of the 4th Industrial Revolution[1]

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Abstract This paper aims to link the basic structure of the revolution to skill needs and further to education, although there are risks of thin discussion in each domain. Many writings describe or analyze the job characteristics related to the 4th Industrial Revolution without discussing the interlinkage of the revolution. It attempts to give better understanding the whole features of the revolution and further discuss about challenge for innovative HRD. It overviews the technological competition in the 4th IR, the change of work with skills need and the new labor and the change of education focusing on new competence. After that, it brings the challenges for innovative HRD.

Keywords 4th Industrial Revolution, skills change, human resource development, education

I. Introduction

1. The Problem

New era called the 4th Industrial Revolution(IR) coming. The discussions for the 4th IR start from the writings of Ha and Choi (2015) and Klaus Schwab (2016). These writings sparkled the related writings, in particular in Korea. in Korea, there were 2 academic papers on the subject in 2015, 67 in 2016, and 323 in 2017 (Moon and Seol, 2017). This means that there are huge discussions on the revolution in Korea. If the changes are great, What are the job competencies needed for the future? What kinds of education are needed for the new skills and competences? Are these discussions based on the overall features of technological change or solely from the perspective of job?

Many studies pointed out the impact on skills and education by the changing technologies and products. The points, however, are mostly on small and

Submitted, June 23, 2019; 1st Revised, August 20, 2019; Accepted, August 23, 2019
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[1] Early version was presented in ASIP conference in Bankok 2018 and Forum on the Impact of Education Policies on National Productivity Growth by APO, Manila 2018.

partial aspects of skills and education, or judgment first and the following discussions about facts. The reasons why many discussions are small, partial or vague are from the limited understanding of the whole structure of the revolution: Partial understanding of the revolution and each sector, or partial understanding of technology side, or partial understang of both. This kinds of segmented discussion may be from the difficulties describing the linked features of technology and skills and jobs. Therefore, many discussions may make people be confused and leads to wrong illusion about the changing societies.

This paper aims to link the basic structure of the revolution to skill needs and further to education, although there are risks of thin discussion in each domain. Many writings describe or analyze the job characteristics related to the 4th Industrial Revolution without discussing the interlinkage of the revolution. It attempts to give better understanding the whole features of the revolution and further discuss about challenge for innovative HRD.

2. Approaches to the Topic

This paper wants to map the whole features of the discourse on skill needs and education along with the progress of the 4th Industrial Revolution. The scope of this paper is relatively bigger than normal papers.

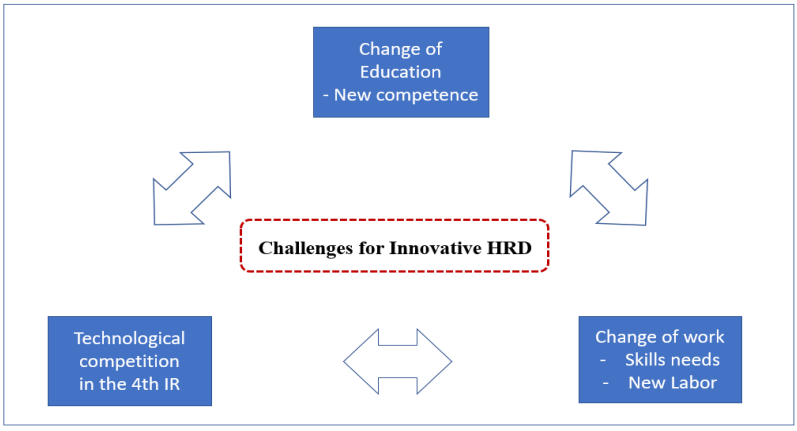

Figure 1 Conceptual framework

Therefore, to overcome limitations about the thin discussion, this paper adopts several complimentary tools. First, this paper is based on the relatively big scope studies as possible, which cover the whole features of each domain. Second, this paper introduces the technology-based view for the linkage

between technological change to work change compared to the job perspective such as job-based, task-based, and job information-based. Third, references published by authoritative authors and institutions as possible are chosen.

It overviews the technological competition in the 4th IR, the change of work with skills need and the new labor and the change of education focusing on new competence. After that, it brings the challenges for innovative HRD.

II. Technological Change and Social Impact

1 The Structure of the the 4th Industrial Revolution (IR)

Moon and Seol (2017) pointed out the fact that discussions about is three; the techno-economic paradigm (for example, Perez, 1983), studies on microelectronics revolution or simply ME revolution such as Mably (1980) and Forester (1980), and the discussions on industrial revolution following the lecture note of Toynbee (1894). The point they highlighted is the time variable on the discourse. Simply the revolution needs time to be in full bloom. The time requirement they mentioned, can be separated into productization time, industrial diffusion time and socio-economic impact time. They identified the structure of the revolution as shown in the table 1; Science and technologies and applications and supporting institutions. The technologies are divided into two types; core technologies and supporting technologies. The core technologies includes IoT, AI, cloud, big data, robot, and 5G communication. The base technologies covers data security, sensor, new material, and genome technologies.

Table 1 Structure of the expected 4th revolution

Area	Sector	Technologies/applications
Technologies	Science	
	Core	IoT, AI, cloud, big data, robot, 5G communication
	Base	Data security, sensor, new material, and genome technologies
Applications	Products	Wearables, synthetic biological products
	Smart systems	Smart car, smart factory, smart security, smart medicare, smart defence, smart city, smart energy
Institutions	Legal Institutional	Data properties, test & certification, guidelines for smart applications,

Source: Moon and Seol (2017)

Table 2 is the historical response to the discourse of each technological revolution such as the ME Revolution in 1981 and the 4th Revolution in 2017. The discourse in the starting stage of the revolution is not just from the technological aspects, but from society and education. Even it takes longer time than technology sector, society has more concern on the technological revolution.

Interesting facts on the table are two; about 42-43% are from technology and industry side. The responses to two different revolutions are quite similar. Second, the labor/employment response to the ME Revolution was bigger than the current trend. At the current trend, education issue is bigger than employment issue.

Table 2 Response by sector on each technological revolution (%)

	2017 for the 4th	1980 for the ME
Technology	15.8	21.4
Industry/economy	26.3	21.4
Labor/employment	3.6	14.3
Education	19.1	42.9
Society	24.5	
Policy	10.7	
Total	100(392)	100(42)

Source: Moon and Seol (2017)

2. Technological Competition of Key Technologies in the 4th IR

The pattern of the registered US Patent allows intuitive snapshot of technology competition. The time trends of patent over 1991-2016 are reviewed by patent assignee's nationality in relevant technology.

In Artificial Intelligence, total 16,369 patents were registered during 1991~2016, which is constituted by 113 patents in 1991, 1,036 patents in 2010 and 1,908 patents in 2016, In the comparison by country, the United States is overwhelmingly 11,777, which is followed by 909 in Japan, 238 in Canada, 204 in Germany, 197 in the UK and 177 in Korea.

While the hyper-connectivity of information is one of the key conditions of the Fourth Industrial Revolution, the total number of registered patents in the IoT is 5,687, with rapid increasing around 2014. The number of US assignee patents is 3,535, followed by 525 in Korea, 289 in Sweden, and 193 in Japan.

In pursuing the use of information through AI, IoT and cloud computing, big data related technologies are indispensable elements for gathering and analyzing information. 27,338 patents were filed by US assignee, followed by 4,774 in Japan, 923 in Germany, and 681 in Korea.

Robot technology is an all-round technology under the Fourth Industrial Revolution that can be used in the whole industry. But still the overall number of patents is not as high as other technologies. The United States has the largest number of 335 patents, followed by 131 in Korea, 128 in Japan, and 27 in Germany.

In selection of the representative products under the 4th industrial revolution, self-driving vehicles will not be able to come out. Self-driving vehicle technology is an intensifier of the technologies discussed above, so looking at the state of the technology will be a measure of the blueprint for the Fourth Industrial Revolution. The United States is the largest with 1,709 cases, followed by 102 cases in Germany, 62 cases in Japan, 49 cases in the United Kingdom, and 43 cases in Korea.

3. Active Technology Fields by Patent Activity

In the periodical comparison of the last five years (2012 ~ 2016) to the total patents from 1991 to 2016, big data, AI, and robots occupy about 50%. Cloud computing, IoT and synthetic biology have more than 75% over the last five years. In the case of big data, AI, and robots, innovation has been continued from the previous period, but cloud, 3D printing, and synthetic biology are seen as relatively emerging technology. Overall in comparing the US, Germany, Japan, and Korea over the past five years (2012 ~ 2016), the jumping of Korea is vivid in comparing with the longer period 1991~2016 shown on previous grapes.

Table 3 Patents in US PTO (unit: %)

Class		Proportion of recent five years (2012 ~ 2016) to the total (1991 ~ 2016)	Country proportion in recent five years (2012 ~ 2016) (%)			
			US	Germany	Japan	Korea
ICT convergence technologies	AI	49.5	74.2	1.2	3.3	1.3
	IoT	75.1	57.4	1.5	3.0	12.3
	Cloud computing	96.3	84.9	2.1	2.9	0.7
	Big Data	47.0	70.6	2.7	9.9	2.4
Manufacturing	3D printing	79.9	61.8	4.1	3.0	0.9
	Robots	53.5	35.6	2.9	11.8	22.2
Transportation	Self-driving vehicles	68.7	75.2	3.5	1.6	2.0
	Drone	70.1	79.2	0.7	0.6	0.6
Energy	Management of energy	58.7	68.4	1.9	8.8	2.7
Bio	Synthetic biology	76.7	79.5	0.8	3.4	1.1

Source: author's calculation

The US overwhelmingly dominates all of areas, even though considering it based on US PTO. After that, even following group, such as Germany, Japan, and Korea have showed a considerable gap. Typically, Japan shows relative strength in the big data, energy management, synthetic biology, Korea in the Internet and robot, Germany in 3D printing. In the emerging areas of cloud, 3D printing, and synthetic biology, Japan and Germany are relatively good, and Korea seems to have a relative strength in areas where existing R&D has progressed to some extent.

III. Change of Works

1. Change of Skills Needs

In recent technological changes, much attention was paid to how the future employment structure of society will be changed. Early discussions, including discussions at the World Economic Forum in 2016, focused on the changing employment structure based on "Occupation". It was predicted that many occupations would have disappeared within the next 20 years and the number of employees would shrink considerably. However, the basis of these claims was simply based on existing companies and existing occupations, and new companies and new occupations are systematically overlooked.

On the other hand, it is pointed out that the future employment structure is not merely a change in the form of size (increase or decrease) of the employment but qualitative changes of the 'Task'. According to the OECD task-based approach, only 9% of all individuals in the US face to at least 70% automatability (Arntz et al, 2016: 14). Similar to work activities, Mckinsey (2017: 5) also showed that less than 5 % occupations confronts to 100% automable and that about 60% of occupations has at least 30 % of automable tasks.

Hwang and Chang (2016) conducted a research about the change of skills' needs based on the occupational information of the United States, O*NET (Occupational Information Network). O*NET provides workers with the requirements they need to successfully perform their jobs, which reflects changes of demand in the labor market through periodic updates[2].

After principal component analysis of 35 key indicators in about 650 common occupations in 2002 and in 2016, the overall results are as following:

[2] This is very important data and is widely utilized in human resource policy and labor market policy research not only in the United States but also in other countries.

The importance of cognitive skills and social skills is continuously increasing.

Resource management ability is emerging as a new skill factor. The importance of information ability is increasing. Integration of machine related skills and decrease of its role.

Table 4 Change of skills needs

2002		2016	
34%	High-level Cognitive Skills and Resource Management	High-level Cognitive Skills	33%
21%	Mathematical Science Problem Solving	Machinery and Equipment Management	25%
20%	Machinery and Equipment Management	Mathematical Sciences Information	15%
14%	Social Services	Social Services	13%
7%	Machine Analysis and Design	Material and Financial Resource Management	10%
4%	Machine Operation and Installation	Machine Operation and Installation	3%

Source: Jang and Hwang (2016: 66).

While there has been expansion of IT related technologies, the trend of skills changes over 2002~2016 seems to be persistent or even accelerated. In the network economy, the ability to manage individual networks and sporadically distributed resources is more important. In the Hyper-Connected Society, where everything is connected, the process of production, equipment, goods, and services become obsolete at a rapid pace and long-term ownership is disadvantageous. Therefore, innovation cycles are becoming shorter and more demanding in the network-based economy for managing resources (Jang, 2017).

2. New Labor: Platform Work

The Fourth Industrial Revolution is expanding the on-demand economy and bringing about changes in the form of labor. It includes part-time, temporary work, freelance, self-employment, on-demand work. Ail of them can be called 'platform work' from the reason of relying on the digital platform. Platform work is a work temporarily with choosing time, place and amount of work rather than being hired regularly.

Platform labor makes it possible for someone with traditional employment relationships to do what they could only do through the intermediary site, due to the complexity of job subdivision. This changes business opportunities and

the way people recruit. Since the job is subdivided, the company can increase productivity. To do this, companies and workers must re-establish the elements that make up the work.

As the functions of companies such as logistics, manufacturing and marketing are applied without boundaries through the digital platform, the employability is shifting from industrial expertise to functional expertise. In addition, with the increase in short-term employment, it is predicted that the transition will be accelerated by providing contract work or project-based work. In other words, the concept of full-time work is blurred, and most jobs are likely to change into contracts (short-term), and self-employed or professional freelancers seem to become common.

There is a concern that platform work will create a blind area in employment and strengthen the polarization of labor. Unlike conventional employment relationship, platform works face various problems as they do not belong to the social protection system such as working standards and minimum wage, in the process of facing consumers without mediating the employer. In particular, with job instability, income stability could be seriously threatened.

According to Hughes et al (2016), platform workers receive lower incomes than their efforts. One of the reasons for this is that there are no organizations that will protect individualized platform worker negotiate wages. Platform worker will keep demand for simple and repetitive tasks on a global basis, keeping the wages of simple repetitive tasks at the bottom.

However, despite the negative aspects of platform labor, this type of employment and the on-demand economy underlying it are likely to be the essence of the Fourth Industrial Revolution. The expansion of the on-demand economy and the spread of platform labor are not only products of the Fourth Industrial Revolution but also a socio-economic system that drives the Fourth Industrial Revolution.

3. Future Skills by Patent Information

In the manpower policy, quantitative and qualitative prospects of manpower supply and demand are called for, especially the demand for qualitative prospects. ILO and Cedefop (European Center for the Development of Vocational Training) have discussed about the method of future skills needs, but it is still at the level of using labor market information (LMI) or proposing employer survey.

Alternatively, based on the idea of deriving skill's needs from technical information, patent analysis in exploring future skills needs has been attempted by Hwang et al (2015) and the adaptability of this methodology was examined. It analyzed 174,155 patents in the information security sector, which are

applied and registered to Korea PTO by September 2013. The IPC (international patent classification) code is mapped to the job code derived from the job analysis and the time trend of the number of patents mapped to the job code is examined. After deriving the projection of the skills' needs for 2015 based on the trend over 2005 ~ 2010,[3] the confirmation is tested with expert survey.

IV. Direction of Change of Education

1. Innovation for Human Resource Development

As the debate about the talent capacity required by the 4th Industrial Revolution era is heated, each major country in the world is establishing and implementing an innovative educational policy in order to improve human resources. McKinsey & Company (2017) suggests that the Skill Gap has emerged as a major social issue. In the United States, 40% of employers find it hard to find talent with the capabilities their company desires, and 60% of the reasons are due to lack of competent preparation to perform their jobs. This is not the only problem in the United States. It is similar in Korea (Kim, 2017)

The EU, developed countries, as well as global corporations, are investing in research, especially with a strong interest in the core competencies required in the future society. One such example is the "Assessment and Teaching of 21st Century Skills (ATC21S) Project," sponsored by global companies such as Cisco, Microsoft and Intel, as well as Australia and Finland. At ATC21S, significant suggestion of making a change in evaluation method is achieved as a leverage of educational innovation by developing a method to measure the core competency required in 21st century future society. In this project, the required competence in the 21st century is divided into four areas: Ways of thinking, ways of working, tools for working, and living in the world.

School education for future generations will need to innovate the curriculum and environment in accordance with these social changes. The changes in future skills needs will lead to major changes in the way of education and the role of schools. What is the future competencies due to the Fourth Industrial Revolution In general? The core competencies of future talents seem to be a set of creative intelligence, the sound view of the world and global consciousness.

[3] Rapid technological change in the field of information security allows the realization of new technology within 5 ~ 10 years.

The expected people is a person who has lifelong learning, a person who can respect and cooperate with diversity, a person who is enthusiastic about cultivating humanity through consideration and sympathy for others, a person who has creative and active attitude. Most of all, soft skills (eg, ability to communicate, symphysis and cooperate with others; learning competencies etc.) are much more demanding than technical skills in a limited area (eg, specific-task oriented skills including equipment operation etc.)

Table 5 The 21st century core competence by the ATC21S project

Ways of thinking	1. Creativity and innovation 2. Critical thinking, problem solving, decision making 3. Learning to learn, metacognition
Ways of working	4. Communication 5. Collaboration (teamwork)
Tools for working	6. Information literacy 7. Information and communication technology literacy
Living in the world	8. Citizenship – local and global 9. Life and career (adapting to change; managing goals and time; being a self-directed learner; managing projects; working effectively in diverse teams; being flexible; producing results; guiding and leading others) 10. Personal and social responsibility (including cultural awareness)

Source: Ontario Public Service (2016), 21st Century Competencies

2. Institutional Consideration: Beyond HRD

The United Bank of Switzerland assesses the relative readiness of different economies to take advantage of the Fourth Industrial Revolution. The assessment is based on the Global Competitiveness Index (GCI) of the World Economic Forum (WEF), 'Labor structure flexible', 'Skill level high', 'Education allows adaptive skills', 'infrastructure suitability' and 'legal protection'.

Switzerland(1), Singapore(2), the Netherlands(3), Finland(4) and the United States(5) are the top ranking in preparation of the 4th Industrial Revolution and Japan(12), Germany(13), and Korea(25) in middle among 45 countries. In detail, Korea ranked highly in terms of education innovation and skill level, ranking 19th and 23rd, respectively, while 'labor market flexibility' is ranked 83th[4].

From the point of view that the labor market should be flexible enough to be beneficial to the industrial and market economies of the fourth industrial revolution era, the United Bank of Switzerland regards ‘labor market

[4] Ranking in individual criteria is not among 45 countries but the ranking in GCI of WEF.

flexibility' as 'labor market efficiency'. This means that flexibility in the labor market is necessary to effectively cope with changes in the future work structure.

Table 6 Criteria for the preparation level of the 4th Industrial Revolution

Evaluation criteria	Detailed criteria
Labor structure flexibility?	Labor market efficiency
Skill level high?	Higher education & Training
Education allows adaptive skills?	Innovation
Infrastructure suitability?	Technology Readiness, Infrastructure
Legal protection?	Property right and protection, Judicial Independence, Ethical behavior of firms

Source: UBS (2016)

What this result mean? Education or human resourse development is not enough for the new skills and education. Further, social institutions should support the effort of education or human resource development. This is the lessons from the study of the industrial revolution as shown in the table 1. Many discussants say the HRD innovation, but not fully say about the change of institutional contents.

V. Discussions and Conclusion

1. Discussion

This is a try to connect the discourse about the 4th Industrial Revolution and skill needs and further education. This paper wants to show the tri-steps link from technological change to education, even if there are risks in short discussion in each domain. Second, this paper introduces the skill needs based on technology acitivity, different from the perspective of job experts. This try is based on the fact that the change of education should be based on the change of skill needs, and further, the change of skill needs should be based on techo-economical change.

2. Challenges for Innovative HRD in Korea

In Korea, during the process of catching-up development, acquisition of existing knowledge was enough, with simple memorization and functional training. However, the creation of new knowledge is now expected, but the

inertia (excessive emphasis on acquiring existing knowledge) is becoming an additional constraint. In order to preemptively respond to changes in the future society, there are at least two layers: first one is formal education system and second one is re-education and re-training.

Let's start aspects of formal education. The suggestions of the ATC21S project should be fully applied in Korea. However, the problem is whether these standard proposals can actually be applied. In the meantime, it is skeptical whether the suggestions of ATC21S project will be able to be accepted in spite of its validity, because of excessive school competition, heated over-education, and lack of jobs after graduation of college. Education problems in Korea are not in a position to be solely treated as educational issues while being in close proximity to social status acquisition and economic compensation problems. Therefore, the response of innovative HRD required in the Fourth Industrial Revolution is the nature to be fulfilled in social consensus in terms of a larger social reconstruction.

However, the issue that should be resolved even prior to the general education reform is that the recognition that no further development is possible without identifying and responding to the new needs of the future should spread to not only the students but also the ordinary citizens. Without identifying and responding to the new needs of the future, there will be no realization of new business opportunities, the emergence of new companies, and no further social development.

Let's look at the second issue of re-education and re-training. In recent years, improvement of training and retraining are continuously emphasized to meet the demands of future society. There are persistent emphases on upskilling and reskilling the competency required by the future society such as 'Transferable Skills' and 'Complex Problem Solving Abilities'. In addition, the demand for new competency acquisition and for convergence of various competencies are increasing in the form of 'Hybrid Jobs'. In order to cope with changes in occupations or jobs due to technological change, the challenges of re-learning in new fields are increasing (Economist, 2017). In response to these demands, the experiences of Udacity in USA is referable: using a MOOC service to open a specialized nano-degree program that specializes in technology and job processes required by companies.

The Korean government prepares mid- to long-term manpower policies In the short term, the government is establishing a tailor-made vocational training system in response to the convergence of technologies, and in the long run, it is promoting the transition to lifelong education centering on core competencies. This direction itself is not a problem, but some improvement needs can be pointed out in detail. In the short term, there has been a direction to personalized vocational training system responding to the convergence between technologies, but there is a lack of a complete basis (teacher, etc.) to

perform this. It is also pointed out that although a tailor-made vocational training system is a short-term direction, there is not enough linkage with mid- to long-term improvement points. In the medium to long term, the specificity of the transition to lifelong learning centered on core competency development is not satisfactory and the guarantee of mid- to long-term policy continuity is not realistic.

On the other hand, mid/long term strategy responding to digital polarization should be prepared. In recent years, many people are worried that intelligence information technology and Internet of things, etc. will lead to job loss and changes in the employment structure. The main concern is the change in income rather than the change or disappearance of the job itself. Especially, those who are older or have lower education are more likely to be subject to alienation and exclusion because they are less receptive or responsive to change than those who are not.

3. Conclusion

As mentioned in the starting discussion, this paper deals with the wider scope than general papers. Therefore this study has very short description of each domain, although this paper adopts several approaches to compliment the facts introducing the representative studies in each domain. Also, this paper cannot introduce the detailed contents for the reform of education and education system that may be the final issue to prepare the future. This limit can be a next research topic.

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