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

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Abstract This paper aims to link the basic structure of the 4th Industrial Revolution to skill needs and further to education, though there is little discussion in these domains. Much of the literature describes or analyzes the job characteristics related to the 4th Industrial Revolution without discussing the interlinkage inherent in the revolution. This paper seeks to give a better understanding of the whole range of features of the revolution and further discusses the challenges for innovative human resource development (HRD). It provides an overview of the technological competition in the 4th Industrial Revolution, the changes in the skills needed, the new labor practices, and the change in education focusing on new competences. Then, the paper examines the challenges for innovative human resource development.

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

I. Introduction

1. The Problem

A new era called the 4th Industrial Revolution (IR) is coming. Its characterization is based on the writings of Ha and Choi (2015) and Klaus Schwab (2016). They triggered a scholarly treatment in Korea. Two academic papers were published on the subject in 2015, 67 in 2016, and 323 in 2017 (Moon and Seol, 2017). This shows the huge interest on the revolution in Korea. If the changes are anticipated to by very substantial, what are the job competencies required for the future? What kind of education is 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 seeking?

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Many studies pointed to the impact of the changing technologies and products on skills and education. Attention, however, focuses mostly on small and partial aspects of skills and education; conclusion seems to be reached before an examination of the facts. The reason why much of the discussion is partial and shallow is that it is based on a limited understanding of the overall structure of the revolution - partial understanding of the revolution and each sector, partial understanding of the technology involved, or partial understanding of both. This segmented examination is rooted in the difficulties of describing the features linking technology, skills and jobs. Therefore, the analysis can be confusing to many and may lead to wrong apprehension of the changing societies.

This paper aims to link the basic structure of the 4th IR to skill needs and further to education, though there is little discussion in these domains. Much of the literature describes or analyzes the job characteristics related to the 4th IR without discussing the interlinkage inherent in the revolution. This paper seeks to give a better understanding of the whole range of features of the revolution and further discusses the challenges for innovative HRD.

2. Approach to the Topic

This paper maps the range of features in the discourse on skill needs and education, along with the progress of the 4th IR. The scope of this paper is thus more ambitious than the current literature.

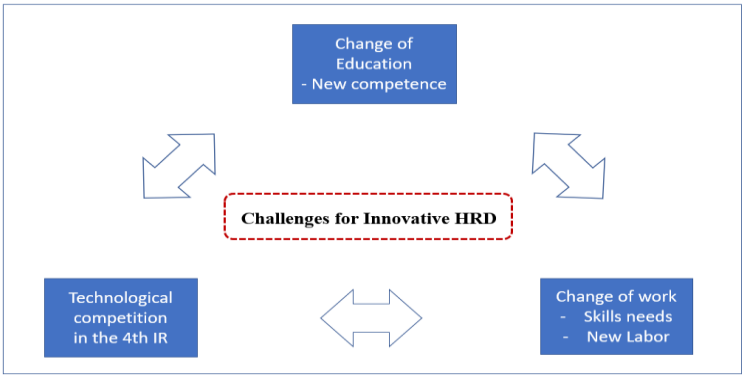

Figure 1 Conceptual framework

Therefore, to overcome limitations of the existing narrowly-focused discussion, this paper uses several complementary tools. First, the examination is based on a large-scale review of the studies, which cover the whole features in each sector. Second, it proposes a technology-based view of the linkage between technological change and the evolution of the working environment in

the context of the industry requirements based on new job, task-based, and job information. Third, the paper makes reference to authoritative authors and institutions. It offers an overview of the technological competition taking place in the 4th IR, changes in employment skills need, new labor practices and change in education focusing on new competence. Finally, the paper examines the challenges for innovative HRD.

II. Technological Change and Social Impact

1. The Structure of the 4th Industrial Revolution

Moon and Seol (2017) says there is a three-pronged discussion: a) the techno-economic paradigm (for example, Perez, 1983), b) studies on microelectronics revolution or simply ME revolution such as Mably (1980) and Forest (1980), and c) a conversation on the industrial revolution following Toynbee's lecture notes (1894). The two authors highlight the time variable in the discourse. Simply put, the revolution needs time to be in full bloom. The time requirement they mentioned can be separated into production time, industrial diffusion time and socio-economic impact time. They describe 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. Core technologies include Internet of Things (IoT), artificial intelligence (AI), cloud, big data, robot, and 5G communication. The basic technologies cover 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 illustrates the historical response to the discourse on each technological revolution such as the ME Revolution in 1981 and the 4th IR in 2017. The discourse of the revolution is not just taking place from on the technological aspects, but from society and education. It highlights two notable facts; first, about 42-43% of the responses relate both the technology and industry components in 2010s as well as 1980s. Second, the labor/employment response to the ME Revolution was bigger than the current trend. Currently, education is a bigger issue than employment.

Table 2 Importance (%) of response on each technological revolution (%)

Response	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 in Key Technologies in the 4th IR

The pattern of registered US patents offers an intuitive snapshot of the technology competition. The timescale regarding patents over the 1991-2016 period is categorized by patent assignee's nationality in the relevant technology.

In Artificial Intelligence, a total of 16,369 patents were registered between 1991 and 2016 - 113 patents in 1991, 1,036 patents in 2010 and 1,908 patents in 2016. Ranking countries, the United States comes on top with 11,777 patents registered, followed by Japan with 909, Canada 238, Germany 204, the UK 197 and Korea 177.

While the hyper-connectivity of information is one of the key conditions of the 4th IR, the total number of registered patents in the IoT is 5,687, rapidly increasing around 2014. The number of US assignee patents in this sector is 3,535, followed by Korea 525, Sweden 289, and Japan 193.

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

Robot technology is an all-round technology under the 4th IR that can be used across industries. But still the overall number of patents is not as high as in other

technologies. The United States claims the largest number of patents, 335, followed by Korea 131, Japan 128, and Germany 27.

In a selection of representative products under the 4th IR, self-driving vehicles will not feature. 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 4th IR. The United States is the largest market 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

Examining the number of patents over the 1991-2016 timeframe, 50% of patents on big data, AI, and robots were registered during 2012 and 2016, and 75% of patents on cloud computing, IoT and synthetic biology. In the case of big data, AI, and robots, innovation has been continuing from the previous period, whereas cloud computing, 3D printing, and synthetic biology are seen as emerging technology. Analyzing the US, Germany, Japan, and Korea over the 2012-2016 period, the jump in the number of patent registrations in Korea is staggering, in comparison to the longer 1991-2016 period.

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 areas. There is a considerable gap with the countries that follow such as Germany, Japan, and Korea. Typically, Japan shows relative strength in big data, energy management, and synthetic biology; Korea is strong in the Internet and robotic, and Germany in 3D printing. In the emerging areas of cloud computing, 3D printing, and synthetic biology, Japan and Germany are relatively strong, whereas Korea seems to have relative strength in areas where existing R&D has progressed steadily.

III. Change of Jobs

1. Change of Skills Needs

With recent technological changes, much attention is paid to how the future employment structure of society is evolving. Early discussions, including exchanges at the World Economic Forum in 2016, focused on the changing employment structure based on 'occupation'. It was predicted that many occupations will have disappeared within the next 20 years and the number of employees would shrink considerably. However, the basis of these claims was essentially based on existing companies and existing occupations; new companies and new occupations were systematically overlooked.

On the other hand, it is pointed out that the future employment structure is not merely a change in the size (increasing or decreasing) of the employment, but also a qualitative change of 'tasks'. According to the OECD's task-based approach, only 9% of the workforce in the US face would be impacted by automation in at least 70% of cases (Arntz et al, 2016, p14). Looking at the nature of the work, Mckinsey & Company (2017, p.5) showed that less than 5% of occupations will be confronted by 100% automation, and about 60% of occupations will be subjected to at least 30 % of automated tasks.

Hwang et al (2015) and Chang et al (2017) 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 information they need to successfully perform their jobs, in a context of changing demands in the labor market[2].

After analyzing 35 key indicators in about 650 common occupations in 2002 and in 2016, the research's overall results are as following: the importance of cognitive skills and social skills is continually increasing. Resource management ability is emerging as a new skill factor. The importance of using information is

[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.

increasing. Integration of machine-related skills carries on and its role is decreasing.

Table 4 Change of skill 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: Hwang, Jang and Lee (2016, p.66)

While there has been an expansion of IT-related technologies, the trend in skill changes over the 2002-2016 period seems to be persistent or even accelerate. 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, 2016).

2. New Labor: Platform Work

The 4th IR is expanding the on-demand economy and bringing about changes on the labor front. It includes part-time, temporary work, freelance, self-employment, and on-demand work. All of them can be called 'platform work' for the reason they rely on the digital platform. Platform work refers to temporarily contract where people choose the time, the place and the amount of work to be performed rather than being hired for a full-time job.

Platform labor makes it possible for individuals in a traditional contractual employment relationship to do what they can to access jobs otherwise intertwined in a complex job subdivision. This modifies business opportunities and the way people are recruited. Since the jobs are subdivided, the company can increase productivity. To do this, companies and workers must re-establish the elements that make up the working relationship.

As company operations such as logistics, manufacturing and marketing are performed without boundaries through the digital platform, employability is shifting from industrial expertise to functional expertise. In addition, with the increase in short-term employment, the job transition is predicted to accelerate through the provision of contract work or project-based work. In other words, the concept of full-time work is blurred, and most jobs are likely to evolve into short-term contracts, self-employment or professional freelancers.

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 wages than their efforts call for. A reason is that no organizations will likely protect individualized platform worker on wage negotiation. Platform worker will keep demand for simple and repetitive tasks on a global basis, consequently keeping the wages for this type of tasks at the bottom.

Irrespective of 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 4th IR. The expansion of the on-demand economy and the spread of platform labor are not only products of the 4th IR, but also of the socio-economic system that drives that Revolution.

3. Future Skills Based on Patent Information

In manpower policy, the quantitative and qualitative prospects of supply and demand are called for, especially the demand for qualitative prospects. The International Labor Organization (ILO) and the European Center for the Development of Vocational Training (CEDEFOP) have examined the method to identify future skill needs, but the tools is still based on the use of labor market information (LMI) or employer survey.

Alternatively, based on the idea of using technical information, Hwang et al (2015) have attempted to analyze patents to explore future skills needs. They have looked at the adaptability of this methodology. They analyzed 174,155 patents in the information security sector, applied and registered to Korea PTO by September 2013. The international patent classification (IPC) code is mapped to the job code derived from the job analysis and the timeframe of the number of patents mapped to the job code. After deriving the projection of the skill needs

for 2015 based on the trend over the 2005-2010 period,[3] the confirmation is tested with an expert survey.

IV. Direction of Change in Education

1. Innovation for Human Resource Development

As the debate about the talent availability required by the 4th IR era heats up, each major country is establishing and implementing an innovative educational policy to improve human resources. McKinsey & Company (2017) suggests that a skill gap has emerged as a major social issue. In the United States, 40% of employers have difficulty finding talent required by their company activities, and 60% of the reason is due to a lack of training to perform the jobs. This is not a problem unique to the United States; Korea is faced with this similar problem (Kim, 2017)

The EU, developed countries, as well as global corporations, are investing in research, especially targeted to the core competencies required in the future. 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, there have been important suggestions to change the evaluation method as a way to leverage educational innovation by developing a new method to measure the core competency required in the 21st century. 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 the environment to meet these social changes. The evolution in future skill needs will lead to major changes in education and the role of schools. Generally speaking, what are the future competencies required by the 4th IR? They revolve around creative intelligence, the sound view of the world and a global consciousness.

The ideal people is a person who is into lifelong learning, a person who can respect diversity and cooperate with others, a person who is enthusiastic about cultivating humanity through a consideration and sympathy for others, a person who value creativity and who has a positive attitude. Most of all, soft skills (e.g., ability to communicate, sympathize and cooperate with others; learning

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

competencies, etc.) will be in greater demand than technical skills in limited areas (e.g., 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)

2. Institutional Consideration: Beyond HRD

UBS, the Swiss bank, assessed the relative readiness of different economies to take advantage of the 4th IR. 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'.

Out of the 45 countries surveyed, the top ranking countries most prepared for the 4th IR are Switzerland 1), Singapore (2), the Netherlands (3), Finland (4) and the United States (5), followed by and Japan (12), Germany (13), and Korea (25). Korea ranked highly in terms of education innovation and skill level, 19th and 23rd, respectively, while the country ranks83th on 'labor market flexibility'[4].

From the view that the labor market should be flexible enough to be beneficial to the industrial and market economies in the 4th era, the UBS research regards 'labor market 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.

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

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 does this mean? Education and human resource development are not enough to develop new skills and education. Social institutions should support the efforts to ensure education and human resource development is fit for the 4th IR. This is the lesson from the study of the industrial revolution as shown in the Table 1. Many commentators call for HRD innovation, but few mention the required change of institutional content.

V. Closing Remarks

1. Challenges for Innovative HRD[5]

In Korea, during the process of catching-up development, the acquisition of existing knowledge was seen as enough, based on 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 that have to be looked at – the formal education system and re-education and re-training.

1) 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, whether the suggestions of the ATC21S project will be accepted in spite of its validity, is uncertain because of the excessive level of school competition, heated over-education, and lack of jobs after college graduation. Education problems in Korea cannot be solely treated as educational

[5] This part is a developed version of Choi, Y., Chae, C., Hwang, G., Chung, J. and Jang, H. (2017).

issues; social status acquisition and economic compensation problems are key as well. Therefore, the promotion of innovative HRD required by the 4th IR needs to be addressed in terms of social consensus in a larger social reconstruction.

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

2) Re-education and Re-training

In recent years, improvement in training and re-training are continually emphasized to meet the demands of the future society. There is persistent emphasis on upskilling and reskilling the people to meet the needs of the future society such as 'transferable skills' and 'complex problem solving abilities'. In addition, the demand for the acquisition of new competencies and for the convergence of existing competencies is increasing in the shape 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 experience of Udacity in USA is a good reference: the use of a MOOC service to open a specialized nano-degree program that specializes in technology and job processes required by companies.

The Korean government sets up 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. In the long term, 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 toward a personalized vocational training system that responds to the convergence between technologies, but there is a lack of basis (teacher, etc.) to perform this objective. 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 milestones. 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- and 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 (IoT), 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

feeling alienated and excluded because they are less receptive or responsive to change than those who are younger and more educated.

2. Further Discussion

This paper seeks to connect the discourse about the 4th IR to the skill needs and further education. It examines attempts to show the 3-step link from technological change to education, even if discussion in each domain is limited. Second, this paper introduces the analysis of skill needs based on technology activities, which is different from the perspective of job experts. This approach is rooted on the fact that the change in education should be based on the change in skill needs, and in turn the change in skill needs should be based on techno-economical change.

As mentioned in the start of the discussion, the scope of this paper is wider than current papers. Therefore, of necessity, this study only offers a very short description of each domain it is addressing, although it adopts several complementary tools and approaches. Also, this paper is limited in proposing detailed contents for the reform of the education system, a topic for a future research.

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