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The Activation of Transferable Skill of Advanced S & T (Science & Technology) Manpower with the Global HRD Convergence Research*

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Abstract

Purposes – This study propose the following 4 methods to establish Global HRD system focusing on transferable skill which is attracting attention as future science and technology Manpower. The activation of convergence research creates new industries in the era of 4th industrial revolution.

Research design and methodology –This study was conducted by using research methods and expert interviews focused on document analysis. This study also reflects trends through books and materials that cover the latest issues such as the Fourth Industrial Revolution.

Results – 4 Things are reflecting the policies of S&T Manpower and securing execution capability, developing competence-based transferable skill model, enhancing science and technology convergence R&D and performance capability, and developing customized HRD program.

Conclusions – Transferable skills will contribute to strengthen the national competitiveness of science and technology in the long term by establishing the foundation of technological innovation that can create new industries and secure future growth power in the 4th industrial revolution era. Practically, it was suggested that science and technology professionals should be able to refer to the HRD program design and HRD program design by suggesting the view of transferable skill and the activation plan reflecting the insight.

Keywords: Transferable Skill, Science & Technology Manpower, Global HRD, Convergence Research

JEL Classification Code: M10, M31.

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1. Introduction

Recently, the new technology of the fourth industrial revolution has changed the economic system and the social structure rapidly (Schwab, 2015). While the first revolution was driven by power, the second by automation, and the third by digitization, the fourth industrial revolution is expected to bring new technological innovations by converging technologies in various fields (Beak, Kim, & Kim, 2016).

In the future society, the rapid development of new emerging technologies will differentiate social demands for expert knowledge in various directions. As a result, the demand for major knowledge is becoming more and more specialized, and interdisciplinary and convergence research will continue to increase (Hong, et al., 2013).

The application area of science and technology extends beyond the traditional range of manufacturing to service and distribution, and its strength is increasing. This generality of science and technology has brought about a great change in the job structure and skill demand of the specialists in science and technology field. The acquisition of so-called transferable skills such as organizational skills, collaborative ability, and communication has become important as collaboration and communication have become necessary, and the need for professional contributions of S&T manpower such as interpersonal services, culture, arts, social welfare, (Park, 2015).

In the past, the role of S&T manpower was sufficient as a function of the specialist, focusing only on his / her specialized research field. However, the ability of a generalized specialist capable of approaching R&D in a macroscopic and comprehensive manner from R&D to management, evaluation and policy is required (Ministry of Science and Technology, 2006). Therefore, it is important to cultivate S&T manpower to cope wisely with dynamic environment change and to lead change in future society.

However, according to the results of the National Science and Technology Council (2016) survey, it is found that S&T manpower has difficulty in continuing career development due to lack of education and training programs and support systems for technical expertise. In the fourth industrial age, there is a need for active expansion of technologies such as AI, Bio, shared economy, and IoT. In addition to general education and training programs, there is a lack of detailed and systematic research on HRD in order for S&T manpower to have the competencies needed in the Fourth Industrial Revolution.

In this study, the literature is composed of HRD and skill-related papers. The Future Creation Science Department (Ministry of Commerce, Industry, and Energy) and related organizations (Science & Technology Policy Institute, Korea Institute of Vocational Education and Research) and Training), periodicals, internal data, and statistics. It also reflects trends through books and materials that cover the latest issues such as the Fourth Industrial Revolution.

This study proposes a method to establish HRD system centered on transferable skill, which is expected to be equipped with future S&T manpower. As the transferable skills of S&T manpower improve, they will be able to adapt to a variety of neighboring sectors, rather than focusing on specific fields. This will lead to the activation of fusion research with other fields.

This activation of convergence research creates new industries in the era of 4th industrial revolution. It will also lay the foundations for technological innovation that will secure future growth engines and contribute to strengthening national competitiveness in science and technology over the long term.

2. Science and Technology and HRD

The Special Law on Science and Technology Support for the Strengthening of National Science and Technology Competitiveness, enacted in March 2004, S&T manpower is a person who majored in science and engineering field and related interdisciplinary fusion fields. (Lee, et al., 2008).

The Organization for Economic Cooperation and Development (OECD) defines S&T manpower as both those who have completed tertiary education in science and technology, or who are practically involved in the field.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) conducts scientific and technological activities directly in a specific institution or sector, and sees the S&T manpower who receive compensation for services as a scientist. The National Sanitation Foundation (NSF) defines S&T manpower as undergraduates, scientists, or engineers who major in science or technology and who are under 75 years of age.

These categories include a more comprehensive discipline than the OECD or UNESCO categories. This inclusive definition may be desirable when reflecting recent trends in the convergence of science, technology, humanities and society (Jin & Um, 2007).

In the end, the scope of S&T manpower is variously classified according to educational background, occupation, and related work, but the basic thing is collectively called manpower engaged in work related to science, technology, R&D (Kim, Bea, & Choi, 2015). The R&D system of Korea is centered on public research institutes. This study focuses on the S&T manpower performing R&D at public research institutes.

According to the Basic Law on Human Resource Development, Human Resource Development (HRD) is a system in which human resources are cultivated, distributed and utilized by national, local governments, educational institutions, research institutes, and corporations, and related social norms and networks are formed. It can be defined as all kinds of activities. These HRDs consist of three components: personal development, career development, and organizational development.

First, personal development is an activity that improves performance and changes behavior by providing necessary skills and knowledge related to the job currently being performed by an individual. Second, career development is an activity that develops individual competencies and activities needed for job activities that an individual wishes to perform. Third, organizational development is an activity to develop and operate new and creative solutions to improve organizational efficiency by improving existing organization's strategy, structure, culture, process, mission, and practice.

Skills formed by human resource development can fundamentally enhance the capacity of human resources not only by strengthening the capacity of individuals and organizations, but also by interaction between individuals, organizations, and organizations (Jin & Um, 2007).

According to a survey by KISTEP (2013), 54.0% of S&T manpower have experience in participating in education and training programs. In the case of public research institutes, participation in education and training programs was 59.4%, slightly higher than the overall average (<Table 1>).

Table 1: Experience in participating in the training program (since January 2013)

(Unit: case, %)

Division			Total	Yes	No
Total			1,673(100.0)	903(54.0)	770(46.0)
Work Type	Firms	sub-total	1,041(100.0)	551(52.9)	490(47.1)
		Medium / large companies	541(100.0)	320(59.1)	221(40.9)
		Small Venture	394(100.0)	173(45.2)	216(54.8)
		etc.	106(100.0)	53(50.0)	53(50.0)
	Public research institute	sub-total	401(100.0)	238(59.4)	163(40.6)
		Government	203(100.0)	129(62.0)	79(38.0)
		Public	124(100.0)	77(62.1)	47(37.9)
		etc.	69(100.0)	32(46.4)	37(53.6)
	etc.		107(100.0)	57(53.5)	50(46.7)
	Unemployed		55(100.0)	28(50.9)	27(49.1)
	Unclear		48(100.0)	20(41.7)	28(58.3)
	Invisible		21(100.0)	9(42.9)	12(57.1)

Q. Have you ever been involved in a training program for your career development since January 2013 ?

Source: Korea Institute of S&T Evaluation and Planning2013.

The education and training programs most needed by industry, academia, and research institutes appeared in the field of technology and research. In the case of corporate employees, the demand for R&D planning and management and universities are high in general management and public research institutes. The public research institutes are in need of education (13%), general management (15.2%), R&D planning management (25.2%), current fields (28.7%), related fields (16.2%) there was.

The role of science and technology, which is the basis of creating high added value, is being emphasized in order to transform the economic structure of Korea from the latter-type to the innovation-driven type. In order to develop science and technology as a condition for economic development, it is necessary to acquire advanced S&T manpower (Kim & Kim, 2008) it is important.

Developed countries are pursuing science and technology policies to organically link R&D policies and manpower development policies. In particular, emphasizing that the subject of science and technology innovation activities is S&T manpower, emphasizes the need for balance and efficiency linkage between S&T manpower development and research and development policies (Jung, 2008). HRD and R&D are the policy instruments to achieve the policy vision and goal of strengthening national competitiveness, and at the same time constitute the target system linking knowledge, technology and people as a factor to strengthen national competitiveness (Hwang, 2008).

The link between R&D policy and manpower development policy aims to create and strengthen an innovative national system, ultimately creating national wealth. In other words, when creative human resources developed on the basis of human resource policy actively participate in research and development activities within the national innovation system, the creation of the national wealth will be efficient (Jung, 2008).

3. Transferable skill Recognition

3.1. Research Model Conceptual Understanding of Transferable Skill

Skill means ability of a worker to perform work on the job site. As a result, the quality of the labor supply is differentiated from that of the labor force (Hwang, 2007), because it is acquired through many learning activities or through long-term training and experience.

Even a Ph.D. degree is entering into various business and related fields. According to Auriol (2011), a comparative analysis of the career paths of doctoral degree holders in 12 countries shows that 80% of Polish doctoral candidates enter the academia, while 21% of Australians.

In Australia, Belgium and the United States, more than a third of the number of doctoral students in the business sector, not academia, is more than a third (OECD, 2010; 2012).

In Korea, there is a tendency that career paths of Masters and Masters Degrees are diversified (<Table 2>). That is, 46% of the graduate students and 16% of the doctoral graduates are engaged in fields other than science and engineering (Kim. & Hong, 2013). In addition, due to the increase of high-level professional manpower, there is a continuing decline in the relationship between work and doctoral degrees combined with convergent demand in other fields to flow into the fields other than traditional related work (Park, et al., 2014). Indeed, the turnover rate of S&T manpower moving from traditional public research institutes to non-university entrepreneurs is steadily increasing from 54.1% in 2013 to 69.5% in 2015 (Hwang, et al, 2016).

Table 2: Relationship between work and degree

(Unit: case, %)

Degree relevance	Total	Year of acquisition					
		1983-1987	1988-1992	1993-1997	1998-2002	2003-2007	2008-2012
Less than 25%	9.0	2.4	4.5	6.4	5.0	10.0	14.2
25%-49%	8.9	1.5	3.9	5.5	11.1	8.3	11.8
50%-74%	25.1	14.4	12.6	17.2	25.2	23.6	34.7
75%-100%	57.0	81.8	79.0	70.8	58.7	58.2	39.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source : Park, et al.(2014)

In the industrial society, the acquisition and utilization of knowledge and the development and utilization of technology were important. However, knowledge and technology are limited to cope with the complex social needs of the 21st century. Therefore, comprehensive and comprehensive it is necessary to have competence (Rychen & Salganik, 2003). In other words, talented people with specialized competence and ability to interact with various areas have become important. In the Japan Science and Technology Talent Committee (2009), the core keywords of future talent are defined as creativity, convergence, and integral competence, and emphasize the importance of integral ability to integrate various depths and widths of innovation activities (<table 3>).

Table 3: Scope of transferable skill proposed by European Scientific Fund

Division	Included skills
Interpersonal skills	- Working with others / Working with team - Mentoring and surveillance technology - Negotiation skills - Networking technology
Organizational ability	- Project and time management technology - Career planning skills
Research capacity	- Fund support technology - Research management and leadership - Research methods and technical knowledge above doctoral degree - Research ethics and integrity
Cognitive ability	- Creativity and abstract thinking ability - Problem solving
Communication ability	- Presentation technology - Ability to communicate with general audiences - Education Technology - Ability to reflect on policy decisions
Business related ability	- Entrepreneurship - Innovation - Commercialization, patent, transfer of knowledge

Source: OECD (2012); Hong, et al. (2012).

Bennett (2002) suggests that transferable skills include the ability to directly contribute to work, such as communication with others, social skills, and creativity. Lee & Laredo (2010) defined a transferable skill as a skill required for all tasks other than direct research activities to science and technology researchers. Recently, according to the definition of European Science Foundation, transferable skill is a technology that can be used in other fields as well as technology used in a specific field. It is used for interpersonal skills, organizational skills, research capability, and cognitive ability, In particular, the inclusion of business-related skills such as entrepreneurship, innovation creation and knowledge transfer in transferable skills means that start-ups and commercialization are becoming one of the major career paths of researchers (OECD, 2012).

3.2. HRD needs centered on transferable skill

Recently, technological change is changing rapidly. It is expected that 50% of the knowledge learned in the first year of admission to the four - year course in major disciplines will not be useful or useful in graduation. The government therefore recommends that the education system be reconsidered, strengthen lifelong learning and ensure retraining at the lifecycle level for the entire existing workforce (World Economic Forum, 2016). Researcher career development is a key link in enabling the use of created knowledge (The Impact and Evaluation Group, 2010). Researcher career development is an important component that can realize research potential and maximize investment performance in research and development (OECD, 2012).

The cultivation of S&T manpower and their careers are important policy issues. Transferable skill Interest in education is steadily increasing. As the career path of doctor of science and engineering has evolved into various forms due to the increase of utilization of science and technology, more doctoral students than professors, increase of migration among different professions, expansion of exchange of human resources between different fields, The importance of education is increasing (Gilbert, et al., 2004).

Many previous studies have suggested the effects of transferable skill education for S&T manpower. If a doctoral student acquires a transferable skill in a degree program, it will help with project implementation and employment. In addition, this can increase the efficiency of work and increase the likelihood of taking advantage of other opportunities (OECD, 2012). However, there are three problems with the transferable skill. First of all, transferable skill education among doctoral degree programs has problems such as difference from research contents, learning time and cost. Second, it is a question of at what stage a particular transferable skill is needed. Finally, it is necessary to clarify the roles that various stakeholders and governments should carry out. Although previous studies have suggested sharing responsibility for transferable skill education, the potential role of government from strategic monitoring to funding is expected to be significant (OECD, 2012; Kim & Hong, 2013).

4. Activation of convergence research through transferable skill

4.1. Reflecting policy on S&T manpower and ensuring implementation ability

As the share of science and technology in national and social development has increased, most countries have been pursuing science and technology policies. Science and technology have characteristics of public goods and can be developed and utilized for accumulation of knowledge, advancement and sustainable development of society, international cooperation, etc. rather than the purpose of profit-seeking enterprise. In this regard, governmental intervention in the field of science and technology is a very important topic (Korea Science and Technology Academy, 2015).

The S&T manpower project is the means by which these policies are manifested in the human resources sector. The budget of government R&D budget was 1.39 trillion KRW, about 6.9%, of which KRW 18.9 trillion was implemented in 738 projects (as of 2015). There are 14 departments and agencies in the business, including 68% (885.8 billion won) of the Ministry of Education, 21% (273.6 billion won) of the Future Creation Science Department and 9.5% (124 billion won) of the Ministry of Industry and Commerce.

In this way, it is very likely that there will be similar redundancies in the areas of beneficiary and development with other departments in the process of securing the budget by 14 institutions competitively. Of course, the relevant ministries and agencies jointly establish the "Basic Plan for Scientific and Technical Talent Development and Support" every five years, but it is difficult to manage the policy goals and business integratively. It should be clear that there is a mid-term roadmap for each area and a close linkage between the plan and the project when establishing it as it is a government-level official plan for the upbringing, distribution and utilization of S&T manpower.

If the government develops or provides educational programs at the national level, the government may adjust the economy in view of the economies of scale and may act as a coordinator for transferable skill education methods. Therefore, the "Fourth Science and Technology Talent Development and Support Basic Plan" (Hong, et al., 2012). It is important to reflect the transferable skill improvement of S&T manpower as an important plan and to be implemented as a concrete business.

4.2. Developing competency-centered transferable skill model

In the future society, the core of education is changing from knowledge base to competency center. In the 21st century, emphasis is placed on the importance of competencies such as knowledge and information society, smart society, and creativity society among competencies (Kim, et al., 2013; Lee, et al., 2012). In industrial society, if importance is given to the acquisition and utilization of knowledge and the development and utilization of technology, future generations need a comprehensive capability that includes cognitive and non-intellectual aspects beyond knowledge and technology that can cope with complex social needs. Having a core competency is considered to be a key factor in enabling individuals to succeed in their future lives and to develop society continuously(Rychen & Salganik, 2003; Lee, et al., 2014).

For advanced S&T manpower, it is necessary to clearly identify the necessary competency systems in addition to R&D activities and to establish measures to continuously secure and improve individual competencies. For example, one researcher should establish guidelines for a human resources development system that will enable a variety of competencies necessary for effective capacity development to be developed in a comprehensive researcher competency development system from high school education to retraining of the workplace. It would be possible to build a system that supports (Hong, et al., 2012).

Research on competency models of S&T manpower in Korea is still in its early stages. Hong, et al. (2011) presented communication skills, organizational skills, research abilities, cognitive abilities, and entrepreneurial abilities. In addition, research on competency models remains at the theoretical level that suggests knowledge and academic competence, individual research performance generating capability, research literacy and management competence, collaborative activities, and performance diffusion capability(Hong, et al., 2013).

It is necessary to develop competence models, methodologies, and indicators that can comprehensively understand transferable skills of fluency, such as the Researcher Development Framework of the UK VITAE, a world-class professional development program. The development of the competency model is based on the related ministries, educational institutions (Korea Institute of Vocational Education and Training), Korea Institute of Science and Technology, and Science & Technology Policy Institute. Etc.) Through joint research, so that diverse and comprehensive opinions can be reflected through planning and implementation.

4.3. Reflecting policy on S&T manpower and ensuring implementation ability

In the international institute of technology, Olin Institute of Technology and MIT Media Lab, it is important to cultivate human resources capable of realizing new value by fusing humanities and cultural arts competence to scientific knowledge base. Future S&T manpower will be able to create new ideas that can differentiate them from existing values in human society, and innovators who present solutions through the process of constantly raising questions and solving them in order to realize ideas.

In order not only to constantly learn new knowledge and experience, but also to cultivate talented people capable of analyzing from various perspectives and creating new values, a wide knowledge is needed as well as a knowledge base. It is required to build up convergence knowledge in the field (Hong, et al., 2013).

The convergence of humanities and culture and arts based on science and technology enhances the creativity of S&T manpower and broadens the scope of research. Despite the increasing demand for convergence between science and technology and humanities and the potential for future development of new industries, the convergence research of science and technology and human society in Korea is still lacking (Korea Science and Technology Academy, 2015).

In Korea, researchers' preference for convergence research environment of S&T manpower is high, but government R&D support is not enough. According to Lee & Kim (2015), the current field of Ph.Ds in the field of science and engineering is 39.9%, whereas the field of convergence research is 59.1%. However, investment in convergence tasks during government R&D is low. In 2014, the convergence research investment amounted to 3,115.3 billion won, accounting for 17.66% of the total R&D investment. The number of convergence researches is 11,281, which is 21.09% of the total number of researches (53,493). The size of investment per research was 276 million won for convergence research, which was smaller than general research (340 million won / task) (Center for Future and Integration Research Policy Center, 2015). Convergence R&D has increased from 9.8% in 2010 to 11.5% in 2011 and 13.2% in 2012(KISTEP, 2013). However, the number of tasks should be dramatically increased and the research cost per task increased. Such an increase in convergence tasks will be a driver who will recognize the importance of the transferable skill of S&T manpower and actively seek to improve their competencies.

In the survey of Korea Institute of S & T Evaluation and Planning (2015), 84.4% of respondents intend to conduct convergence research in the future, and 19.6% will actively research convergence research topic. However, it feels great difficulty in lack of convergence manpower, such as acquiring convergence technology experts (69.6%) and securing convergence research leaders (59.0%). 75.5% of all respondents answered that they need to train convergence research leaders. convergence research leader pointed out comprehensive thinking and decision making ability as the most important item (93.0%). transferable skill When designing HRD programs, you need to be able to train convergence research leaders by improving the competencies needed to perform convergence research.

4.4. Developing customized HRD program

Career development of S&T manpower has a great impact on the organization's performance beyond individual level. However, Korea's job-related career development participation is the lowest among the OECD countries, and the bigger problem is that career development satisfaction is on a steady decline trend.

The career development system of an organization that can meet the career development needs of S&T manpower is still insufficient. Especially in small and medium enterprises and public research institutes, rather than large corporations. Only 56.6% of all researchers are currently developing job related career, and 63.4% of the remaining 43.4%, or 27.5% of all researchers, do not have career development due to lack of support, lack of information and financial burden (Lee, et al., 2014).

In order to develop a transferable skill training program tailored to the customer, individual career orientation analysis, growth phase configuration, and continuous feedback system should be considered. Public sector researchers have a relatively clear career orientation as they pursue a career path based on expertise in a particular field. This career orientation is likely to influence the career path of the researcher himself (Park, et al., 2010).

For example, there are differences in the required competence of S&T manpower as they have various career orientations such as professional orientation, managerial orientation, and entrepreneurial orientation. Within the professional orientation, there is a difference in research orientation. There are researchers who are interested in continuing to deepen their professions, but there are also researchers who are interested in fusion fields with their professions or other areas not related at all (Byun, et al., 2013).

Therefore, personalized transferable skill HRD program should be designed based on individual career orientation analysis. It is also the composition of the HRD program for each stage of growth. Research trends are different depending on the stage of growth of S&T manpower, such as young researchers and middle-level researchers. Newer researchers tend to prefer relatively challenging research and midsize researchers prefer integrated research using diverse human networks (Byun, et al., 2013). Based on the scope of the transferable skill of the European Science Fund, HRD programs centered on research capacity and cognitive ability are given to new researchers, HRD programs centered on interpersonal skills, communication skills, Should be provided.

Finally, it is the establishment of an all-time feedback system. Depending on the plan, a career development education program of various types and fields preferred by the researcher should be developed or should be provided with time and financial support in connection with professional organizations. It should be supported from the standpoint of counseling or coaching to continuously measure and evaluate the results of career development and to enable members and organizations to grow together based on evaluation results (Byun, et al., 2013).

In addition, the results of the individual career orientation analysis presented above and the specific steps needed to complement the current core competencies and future competencies for each stage of the researcher's growth should be presented.

5. Conclusion

In the 1960s and 1970s, the supply of industrial manpower and manpower needed to foster heavy and chemical industries was given top priority, and S&T manpower was supplied mainly through studying abroad. Since then, it has grown quantitatively and qualitatively to nurture advanced S&T manpower in Korea through the 80s and 90s. Therefore, the theme of science and technology talent policy has also evolved into the improvement of qualitative competitiveness and world - class leap.

In the 21st century, the paradigm shift from the pursuit-oriented economy to the leading type, and the social demand for creative talents have increased steadily (Park, et al., 2014).

As the use of science and technology increases in the entire industrial sector, the potential career path of S&T manpower is expanding. In addition, the number of technologies that S&T manpower should have is increasing. As the research structure of academia over time, collaboration with industry and interdisciplinary exchanges are emphasized, and the boundaries between research and application are becoming blurred. This is due to increased demand for technology related to management, interdisciplinary project management, and intellectual property (Hong, et al., 2013). Transferable skill is recognized as an essential factor for actively developing various career paths (Lee & Kim, 2015).

Therefore, in developed countries, the government has set up a policy to improve the transferable skills of S&T manpower and is investing heavily. In Korea, however, discussions on transferable skills have not yet been activated, and related support policies and HRD programs are lacking.

There is a considerable time lag of at least 5 years and up to 10 years between the point at which 'new skill requirements' appear according to technological innovation and 'when skilled workers with new skills profiles enter the labor market' (Tessaring, 2003).

The existence of this time lag means that a skill mismatch related to transferable skill in the field of science and technology is inevitable. However, on the other hand, if the transfer of skills can be quickly adopted, the skill requirements for S&T manpower should be clarified and individualized by a structured HRD program, it may be expected to alleviate the problem of skill mismatch due to time difference and shorten the time gap.

Academically, this study suggests strategic ways to improve the transferable skill, which is the essential competence of S&T manpower, which plays a leading role in the fourth industrial revolution era. The significance of practical this study is that research on transferable skill is insufficient first. Thus, it has been combined with various topics such as competency model and HRD linkage, providing the basis for carrying out research in various aspects. In practical terms, it was suggested that science and technology professionals should be able to refer to the HRD program design and HRD program design by suggesting the view of transferable skill and the activation plan reflecting the insight.

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