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Education Reform in Response to the Fourth Industrial Revolution¹

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1. Fourth Industrial Revolution and Educational Reform

Google Deepmind's artificial intelligence AlphaGo beat Go world champion Sedol Lee in a 4 to 1 victory, bringing shock to the public. AlphaGo's victory is just one face of the Fourth Industrial Revolution. Digital technology has been integrating with fields of chemistry and biology at an exponential rate, and as a result, the world has been experiencing groundbreaking technological advancements that include cloud computing, big data, artificial intelligence (AI), Internet of Things (IoT), and 3D printing. Some call this rapid technological change the Fourth Industrial Revolution. According to the Fourth Industrial Revolution report presented at the 2016 Davos Forum (Schwab, 2016), 21 tipping points are bound to happen by 2025, meaning AlphaGo is only a mere prelude to forthcoming events.

Within the next ten years, 90% of mobile phone users will use smart phones and have regular access to the Internet with unlimited and free storage. It is expected that 10% of the population will wear clothes connected to the Internet, 10% of the cars in the US will be driverless, the first city with more than 50,000 people and no traffic lights will appear, 1 trillion sensors will be connected to the Internet, 5% of consumer products will be printed in 3D, the first 3D-printed car and artificial liver will be in use, the first implantable mobile phone will be available commercially, the first robotic pharmacist will be developed in the US, 30% of corporate audits will be performed by AI, the first AI machine will be on a corporate board of directors, a government will replace its census with big data source, tax will be collected for the first time by a government via a blockchain, and 10% of global gross domestic product will be stored on blockchain technology. (Schwab, 2016). The Davos Forum has prompted

various discussions because of the prospect that a more fundamental change will occur once arriving at these tipping points.

Education is an important dimension of the Fourth Industrial Revolution. How can we educate the next generation in the face of rapid technological change? In the following 10 to 20 years of the Fourth Industrial Revolution, 47% of all jobs in the US are susceptible to computerization (Frey and Osborne, 2013). In particular, telephone operators, tax examiners, insurance processors, umpires and referees, paralegals, restaurant and café waiters, real estate brokers, farm workers, administrative workers, drivers, deliverymen fall under a 90% probability of computerization (Frey and Osborne, 2013). It is possible that by the time current elementary school students graduate high school, more than half of today's jobs would have disappeared.

Today's lecture-oriented classrooms in South Korea put an emphasis on rote memorization, and continuing this education model will be preparing students for jobs that will disappear with the Fourth Industrial Revolution. The aforementioned occupations that are under the risk of disappearing are not only jobs of low-skill physical labor but also jobs that deal with the mechanical organization of knowledge and information. Capabilities required by the Fourth Industrial Revolution is no longer memorization, which means that today's lecture-oriented classrooms are in urgent need of reform. Keeping up with the rapid technological change of the Fourth Industrial Revolution signifies the need for life-long learning, which makes self-directed learning, or "learning to learn," essential. In addition, it will be important to be able to work in teams to generate new ideas, goods, and services. This ability requires creative problem-solving skills and communication-based cooperation. Education must

be reformed to help develop these skills in students so that they are not replaced by machines but rather become leaders of the Fourth Industrial Revolution.

2. Establishing a Future-Oriented Education System

South Korea's education reform thus far has focused on diversifying classrooms, decreasing the costs of private education, and strengthening professional education required at industries while building institutions to develop university research programs for South Korea to progress as a knowledge-based economic society (Park, Lee, and Kim, 2016). Now that twenty years have passed since the education reform in 1995, it is necessary to evaluate the outcomes of the reforms and actively publicize the need to develop a future-oriented education system in response to the Fourth Industrial Revolution. The focus of the reform should be on total inclusivity to implement transformation that applies to all students.

A. Transforming Pedagogical Models to Focus on Project-based Learning and Performance Evaluation

Our education has been overly dependent on rote learning and multiple-choice based standardized testing. As a result, students have lost interest in learning, and teachers have lost a sense of self-worth. Reforming South Korea's education is an urgent and necessary task in the face of the new revolution. The new education model should build on surface learning, which emphasizes knowledge acquisition, to allow for deep learning, which emphasizes the ability to extrapolate and create (Fullan and Langworthy, 2014).

As an effective learning method that encourages deep learning, many have pointed to the student-oriented project-based learning model in which students collaborate in group work to solve problems and complete tasks. Student-oriented learning helps develop self-directed learning, problem-solving help develop creative analytical skills, and collaborative group work helps develop communication-based cooperation abilities.

The most exemplary cases of project-based learning have been at schools in California, home to many of the world's biggest tech companies. New Technology High School, located in Napa, a city near San Francisco, created the New Tech Network with 157 other schools across the states while San Diego's High Tech High School established a network with 12 other schools, becoming subject to in-depth studies by education scholars. Despite the growing importance and progression towards project-based learning, education reform developments in South Korea have been slow; according to OECD's Teaching and Learning International Survey (TALIS), South Korea's middle schools integrate the least amount of project-based learning among the 33 surveyed countries (Lee et al., 2016).

South Korea's system of academic evaluations has been largely dependent on multiple choice assessments, and this dependence has come with repercussions. More than anything, it is difficult to develop cognitive skills that are more complex than the limited recognition ability assessed by multiple choice tests. To tackle this problem, a performance assessment system had been introduced to classrooms late 1990, but it has yet to find its roots in the classroom. In an analysis of performance assessment reports, a third of the surveyed classrooms did not contain any aspect of performance assessments and 75% scored tests by comparing

answers or counting numbers on an answer sheet (Lee, Ryu, and Lee, 2014). As shown, performance assessments have not been able to take root in classrooms because teachers do not incorporate projects that inherently require performance assessments. As a result, students continue to use the help of private tutors or their parents to achieve high performance assessment scores. Another obstacle to the active implementation of project-based learning is that nearly all students must prepare for college admissions, which places a considerable weight of importance on the CSAT (College Scholastic Ability Test), or suneung, a multiple-choice standardized test that only requires rote memorization.

Consequently, it is important to fund and encourage teachers to implement project-based learning and teaching methods that use performance evaluations while developing a reformed college admissions system that avoids the repercussions of the multiple choice testing format of the CSAT.

B. Computational Thinking and Career and Technical Education

Mathematics and science education should encourage computational thinking. Computational thinking means assessing a problem and finding a solution in an efficient manner (Chung, 2016). To successfully respond to the Fourth Industrial Revolution, it is necessary that mathematics and science education at elementary, middle, and high schools strengthen computational thinking. Teacher development, reeducation, and the admissions process also need a fundamental change in their systems.

In this domain, countries such as England have already made daring steps to establish change. In 2014, England made computing courses mandatory

so that by the time students begin computing classes in kindergarten and graduate high school, they are able to complete most tasks that college admissions and companies require (Chung, 2016). The issue has been addressed and discussed in Korea as well, but progress has been slow. Mathematics, science, and technical education should be revised to strengthen computational thinking to compete with machines (Park, Lee, and Kim, 2015).

Career and technical education has been improving with the development of Meister schools and career counseling programs, but it must be even more strengthened. In response to the crisis at regular public schools, it is necessary to give attention to vocational schools. With the increasing popularity of Meister schools and specialized vocational high schools, students who are unable to attend these schools resort to regular public schools. As the Career Academy in the States does for its students, vocational classes at regular public schools should provide public health, IT, and finance courses either at or outside of schools and also offer part-time work opportunities (Cha, 2016). The Career Academy of the US has proven to result in positive outcomes for students of low-income families; eight years after having completed classes, their salaries increased by 20% (Holzer, 2014).

C. Transforming Universities to Become Central Hubs of Innovation Ecosystems

Universities that lead global change either already play the role or aim to play the role of the central hub of an innovation ecosystem. A representative example is Stanford University of Silicon Valley, the leader of the world's most high-tech innovation cluster. The American government has developed its national defense strategies and technical skills by sponsoring large scale military electronics research

projects through funding or service contracts. As a result, Stanford has produced many Nobel laureates from fields of magnetic resonance and nuclear fission. As Stanford produces many successful start-up entrepreneurs, successful alumni contribute to university development by donating to the school, creating a healthy ecosystem with Stanford being at the center of that ecosystem. In the United States, not only internationally prestigious universities like Stanford but other universities have also been making efforts for change. At University of Arizona's College of Technology and Innovation, all courses are structured around addressing local industrial or social issues. Also in the past ten years, the school has removed 69 academic departments and has created 30 new interdisciplinary programs (Blumenstk, 2012).

For Korean universities to also become the center of innovation ecosystems, schools must continue to transform and develop methods to strengthen their positions in the technical innovation cluster, increase research production within schools, strengthen cooperation among schools, institutions, and industries, and encourage youth entrepreneurship with universities at its center. The government must also break away from the tradition of regulation-based policies.

In order to boost the research capabilities of Korea's research universities, government institutions, as federal research institutions do in the US, should commission work in the GOCO (Government-Owned Contractor-Operated) system. As a result, the autonomy and openness of government-funded research institutions will increase exponentially as well. Alternatively, as with American federal research institutions, government-funded research institutions can open their facilities at universities, posting research fellows in teaching

positions and create a system where these fellows collaborate with professors on joint-research projects and encourage graduate students to contribute to education and research. Additionally, it is also important to consider the integration of research universities and government-funded research institutions, the transformation of government-funded research institutions to research universities, and other ways to break down barriers between universities and government-funded institutions to create a more open space.

It is also important to link the innovation cluster policies of the government to the education policies that support specialized programs at universities. To achieve this, the government must also undergo transformation to function as mediators in strengthening the cooperation between universities and agents of innovation such as techno parks, research and development, and industrial complex manager, and related parties (Lee, 2015). Continuous reform efforts must be made at Korean universities to become centers of innovation ecosystems.

3. Reforms to Foster Holistic Education

To establish a new education system in response to the Fourth Industrial Revolution, it is important that education reform fosters holistic education. In the past, education reform has been extensively bureaucratic, which has prevented many reform plans from being put into practice. In addition, under the single five-year presidential system, sustaining lasting consistency has proven to be difficult. To overcome these issues, reform should take a bottom-up approach by initiating onsite change that gives authority to schools and universities, prioritizes the long-term development and implementation of future-oriented education reforms through an

education reform committee that is not restricted by the five-year presidential term, and creates a more open and horizontal management structure at the Ministry of Education and Offices of Education to cooperate and communicate with citizens and public organizations.

A. Activating Change from Below

The focus of education reform needs to be shifted to bring change at the grassroots level. In the past, reform plans that successfully took root in classrooms have persisted throughout changes in presidency, but plans that were not implemented on site have been suspended or neglected overtime.

The importance bottom-up change can be seen in the dissemination of project-based learning across the US. In the late 1990s, New Technology High School in Napa Valley, California, began project-based learning by integrating at least two school subjects, promoting interdisciplinary education. The context that made this possible was the BIE (Buck Institute of Education) that studied project-based learning and the Bill and Melinda Gates Foundation that funded this research. As seen in this case, private foundations, unlike the government organizations that initiate change from the top, have played a fundamental role in facilitating change from below. Having gained momentum by these private foundations, more than 170 new technology schools have been established across the country, where necessary training for instructors happen at the network system's center and funding happens internally at local school districts. A big role in the process of triggering change from below via private foundations is addressing the desire for education reform at schools. What triggered the Gates Foundation to fund project-based learning in California was the need expressed by the region's IT

industries for individuals trained through project-based learning.

It is possible to create onsite change through South Korea's currently implemented free-semester system or college admissions system, but if change is not funded and ignited from below, practical change will not be materialized on site. Using the following methods, project-based learning and performance assessments must become activated at schools, starting change from below.

First, there must be a training system that strengthens project-based learning and performance assessments. It is important that there is an opportunity for teachers to train specifically for transformations in teaching and assessment methods. These training sessions should provide a space for teachers to discuss problems that occur in the transformation process and receive professional feedback from experts. The education departments at universities and colleges of education should emphasize the transformation of teaching and assessment models.

Second, there must be an information and consulting system that consistently funds the practical application of project-based learning and performance assessments in classrooms. Most urgent are providing information and training opportunities to aid teachers in implementing new teaching and assessment methods. Not only teachers but also experts must contribute to creating departmental-specific guidelines to implement project-based learning and performance assessments, and this information should be provided on an open online consulting platform. In addition, it is necessary to support teacher-learning method research activities.

Third, there must be a system that funds and

spreads project-based learning and performance assessments to all schools. Autonomous schools, schools that function on the free semester system, and other school types that are leading change need full support and help from experts where regular instructors can also contribute so that success cases can disseminate to other schools.

Fourth, there must be a teacher incentive system for project-based learning. Classrooms must eventually replace multiple-choice assessments with performance assessments—“low-stake exams” that do not put too much pressure on college admissions and also encourage change in school teachers and administrators. There has already been a significant amount of research and development done for the English NEAT assessment, which should be applied to English textbooks. Outstanding students and exemplary teachers should be awarded for their work of project-based learning assignments, and there should be a system that encourages the most qualified teachers to lead the movement as teacher-education experts.

Fifth, several of South Korea’s industries have begun to prioritize graduates of specialized schools and have shown interest in education donation. As a result, South Korea’s education reform needs more intermediary organizations to deliver these social needs to schools. Freedom and autonomy should be increased at existing specialized organizations such as KEDI (Korea Education Development Institute) or KERIS (Korea Education Research Information Service) to activate practical transformation from below.

There is no country like South Korea that has as much potential for education reform to start from below. More than anything, the capabilities of teachers have been recognized internationally

as some of the best. It can also be said that Korean society puts an emphasis on education that is unparalleled around the world. Consequently, education reform must be rethought in terms of change from below. Universities also need to undergo change that is triggered from below. Approximately 80% of South Koreans attend private universities, meaning that more than any other country, South Korea has the potential to profit from the autonomy of universities to experience change from below.

The role of universities in the process of establishing a future-oriented education system that successfully responds to the Fourth Industrial Revolution is becoming the center of the innovation ecosystem. In order to establish such an ecosystem, it is necessary to avoid a vertical system where the federal government makes one-sided commands as it has the past, but a horizontal system where innovation and entrepreneurship are developed at the local level on a foundation of autonomy and freedom by encouraging youth to cooperate and communicate.

Similarly, change at universities should not follow a top-down approach that passively complies with the government but create a horizontally structured community built on principles of autonomy and openness where leadership and participation are formed at the lowest level.

The most fundamental reform necessary to activate change from below is to reorganize the management structure at schools and universities and to give more autonomy to schools and universities by reducing governmental intervention. For this objective, there have been initiatives such as establishing independence at public universities and introducing autonomous private and public schools.

However, independence has only been implemented at Seoul National University, and the expansion of autonomous schools stopped at Lee's presidential administration. On the other hand, public charter schools in the US and academies in England have reorganized their management structures to increase their autonomy. There must be more publicity that South Korea also needs reform efforts for its public and private schools to undergo change that increases their autonomy.

B. Institutionalizing a Future-Oriented Education System and a National Education Curriculum

The CSAT was introduced in 1993 to prevent harm done by school assessments that place too much emphasis on rote memorization. Despite the fact that the CSAT has undergone twelve trials of revisions in the past 23 years, the potential for change is inherently limited by the fact that it is a multiple choice test issued by the government and not by universities or private organizations. The CSAT has been criticized for stifling problem-solving skills by favoring answer selection speed (The Professors Times, 2015). Until now, the government has seen the CSAT as a necessary admissions criterion, avoiding the fundamental problem with the CSAT.

Now that the Fourth Revolution has taken momentum, the faults of the CSAT will become more apparent. If the current generation of students who have only been able to develop the capability for choosing answers quickly fall behind during the Fourth Industrial Revolution, the costs will be too high. Also, the conditions for talks on the discontinuation of CSAT and the fundamental problem with the college admissions process have been slowly developing. Efforts to lessen the importance of the CSAT have finally become more materialized. The system of admissions officers that

first ran as a trial during Noh's administration was solidified during Lee's administration and continues today in Park's administration. For the incoming class of students in 2017, 18.9% of admitted students will be selected by admissions officers using a holistic review system. Also in 2017, the holistic review system will make up 60.3% of the entire selection criteria. As seen by such measures, the importance of the CSAT has been on the decline. However, if we want to avoid past failures in our efforts to revise the CSAT and implement other college admissions reforms, we should heed the following proposals to make a fundamental change.

First, it is necessary to establish an education reform committee that is unlimited by the single five-year presidential term so that it can study and propose ways to implement a future-oriented admissions system. South Korea needs an organization that functions beyond a president's five-year administrative term to tackle and fix the chronic problem of South Korea's college admissions process. Public opinion has also favored this direction, which makes achieving a national consensus a possibility.

Second, the education reform committee should develop specific measures to abolish the CSAT by 2025 and add more flexibility to the admissions process and submit these proposals to the president and National Assembly. The year 2025 is the year indicated by Davos Forum's Fourth Industrial Revolution report when the world will experience "tipping points" that signal the full-fledged arrival of the new revolution. In addition, 2025 will give enough time for students and teachers to prepare for the substantial changes to the admissions process that excludes the CSAT.

Third, in addition to reforming the college

admissions process, the education reform committee must also study and propose ways to develop and implement a future-oriented national education curriculum. Because the national curriculum and college admissions process are evaluations of education, they must be initiated simultaneously. All previous presidential administrations have made numerous reform efforts for the college admissions system, but they were unable to overcome the shortcomings of Korea's extensive bureaucracy and failed to achieve any substantial change. For instance, if the national curriculum were to reduce a certain subject matter's weekly class time by an hour, given that there are 60,000 middle and high school classes throughout South Korea, 3,000 teachers who are in charge of approximately 20 hours of teaching per week must change their majors, and recent graduates of that particular major will find significantly decreased employment availability in the near future (Chung, 2016). Despite these difficulties, establishing a foundational change in our education for the Fourth Industrial Revolution means that the education reform committee must be given the authority to develop and submit measures to continue long-term developments for our future generations.

Fourth, the education reform committee must consist of experts of various fields whose terms last at least 10 years to avoid the issue of reform efforts dying out in accordance with the end of a five-year presidency. Of course, while it is crucial to listen to the voices of teachers, university presidents, parents, students, and businesses and give authority to political circles and education-related organizations, in order to become truly autonomous and free from interested parties and relations, the committee should be formed of experts who can focus solely on the long-term national development for our future generations.

C. Reforming the Ministry of Education and Metropolitan Offices of Education

In the era of the Fourth Industrial Revolution, the government must also undergo a transformation in which it does not depend on its current vertical management structure but a more horizontal structure to communicate and cooperate with other public organizations. The first step in establishing a future-oriented education system is reforming the Ministry of Education and metropolitan Offices of Education. In addition, human capital and reform-related government structure and functions also require a foundational reform.

More than any other country's government, South Korea's has played an active role in developing human capital and innovation. However, the government's strengthened regulation and excessive intervention since 1990 have been criticized for stifling change and innovation in private sectors. In particular, as the Ministry of Education has recently launched a reorganization initiative of university structures, even universities that must respect their autonomy have been evaluated and regulated using uniform standards, which will actually cause students who will be weeded out from the job market have their ends met with the support of the nation's taxes that forces parents and students to attend subpar universities.

For a fundamental change in the Ministry of Education, education administration that had been abolished with universities and schools being singularly controlled by the Ministry of Education should be reintroduced to separate universities from the Ministry and Education and transferred to a department that propels innovation. During the Fourth Industrial Revolution when universities must play the role as the central hub of the innovation

ecosystem more harmonious horizontal relationships and cooperation can be achieved between human capital and innovation-related departments.

Already during the year 2007 in England, former prime minister Gordon Brown proposed education reform as the government's highest priority task; he separated the administrative organization of higher education from the rest of the education department. In the education division, he added child and family welfare and published "DCSF: Department for Children, Schools and Families" and to the higher education division in 2009, added "BIS: Department for Business, Innovation and Skills". This allows the education administration to include adolescent issues and higher education administration to include science, industry, and innovation, thus allowing interdisciplinary administration.

The issue with government bureaucracy has been so severe that it is even dubbed "gwanpia" — a portmanteau of the words gwanryo, meaning bureaucracy in Korean, and mafia. It is important that we study and analyze the methods and models of advanced countries like England to restructure the government's current organization by implementing a horizontal approach that encourages cooperation in the domains of human capital and innovation.

Next, the central government's Ministry of Education and metropolitan government's Offices of Education are also in urgent need of structural reform. Most recently, some of the most serious issues that must be addressed in regards to education governance are the direct election of superintendents and local education autonomy. South Korea's local education autonomy is first, inefficient because autonomous education organizations are separate from other self-governing bodies, and second, minimal because educational

autonomy is monitored by primary local authorities (Park, 2015).

In 2007, electing superintendents has changed from indirect to direct voting, causing excessive voting costs and overheated ideology disputes among candidates; the professionalism and objectivity required for selecting superintendents were lost in this process, bringing attention to the need for an institutional change. In response, the running mate system, co-registrant system, among others, had been proposed, but the polarity of opinions on direct elections have been so extreme that reform talks have not made any progress. As Park (2015) has proposed, a potential compromise to this problem is allowing each city to decide on how to elect its superintendents. It is not entirely necessary that the election method is discussed at the national level; the city should be allowed to choose from the various running mate, indirect or direct election, or nomination systems. This way, cities will experience diverse processes, and the most efficient and appropriate method will eventually spread nationally.