A Decade of Dynamic Development in Science and Technology in the Republic of Korea, 2000-2009

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2009

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Contents

Preface

The World Conference on Science for the Twenty-first Century: A New Commitment, held in Budapest, Hungary in June 1999, was co-organized by the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Council for Science (ICSU), and the Hungarian government to foster closer ties between the scientific community and society at large. Despite the increasing importance of science in today's knowledge-intensive society, the scientific community is confronted with the dilemma of wavering public support for science. The Conference was organized to address this issue and called for new commitments by government policymakers and scientists to bridge this divide between science and society. Furthermore, the Conference set out guidelines and an action plan to achieve the goals identified during the meeting by adopting the "Declaration on Science and the Use of Scientific Knowledge" (hereafter referred to as the *Declaration*) and the "Science Agenda - Framework for Action" (hereafter referred to as the *Agenda*).

Issued on the occasion of the tenth anniversary of the World Conference on Science, this book is an attempt to review developments in the Republic of Korea's science and technology sector and its efforts to address the challenges facing it during the decade, based on the core subject areas identified in the *Declaration* and *Agenda*: Science and Technology Policies, Science Research, Science Education, Science Ethics, Science Culture, and Widening Participation in Science. Six researchers from science and technology research institutions, think tanks, and a university in Korea were asked by the Korean National Commission for UNESCO to conduct such reviews and analyses, and their collaborative work has resulted in this volume. Each chapter presents an overview of the past developments in the field, particularly focusing on the changes since the World Conference on Science in 1999, analyzes the challenges facing each field, and puts forward proposals with a view to achieving the goals set out in the *Declaration* and the *Agenda*.

Chapter One

The first chapter provides a review of Korea's Science, Technology, and Innovation (STI) policies during the 2000s. It observes that Republic of Korea's STI policies has shifted from a strategy of imitating the technological advances of other countries in areas considered Korea's most important industries, such as shipbuilding, steel and automobiles, to a strategy that encourages innovative research and development (R&D) and creativity in knowledge-intensive industries, such as semiconductors, flat panel displays, and mobile telephones. The establishment of the National Science and Technology Council (NSTC) and the enactment of the Science and Technology Basic Law are indicators of this shift. The chapter proposes that a new STI policy be developed based on a long-term roadmap and extensive consultations with the civil society sector.

Chapter Two

The second chapter reviews the history and current status of scientific research in Republic of Korea. Major scientific research in Korea began in the 1970s with the establishment of public research institutes, which were later followed by university-based research centers and private institutions. Korea has experienced a dramatic increase in research activities thanks to an average yearly increase of 20% in government R&D investments since the early 2000s. However, in spite of these developments, the chapter identifies problems in the field, including a focus on research in practical and applied sciences at the expense of pure sciences, a lack of interdisciplinary studies, especially between natural and social sciences, and ineffective means of sharing scientific knowledge with the general public.

Chapter Three

This section provides an overview of the status of Republic of Korea's science education and the roles of its educational institutions and the government in relation to science education. The chapter particularly focuses on changes made in the Seventh National Curriculum, finalized in December 1997 and implemented from 2000, in comparison with the Sixth National Curriculum. The main point is that the Seventh National Curriculum was designed to address the problem of decreasing interest in science among young students. It is suggested that more action is needed to shift the current trend of students' wavering interest in science, particularly on the part of the government.

Chapter Four

This chapter reviews developments in the field of science ethics in Korea since 1999, and analyzes the major challenges. Awareness of the importance of science ethics gradually increased in Korea after the World Conference on Science in 1999. There have been improvements in the number of science ethics courses in university curricula, studies on bioethics and research ethics, and scientific associations adopting codes of ethics. Relevant public institutions and government committees have also been established. Still, this area is confronted with a lack of science ethics experts and education materials, and overemphasis on research ethics rather than the broader field of science ethics.

Chapter Five

Defining science culture as the effort to promote science literacy, increase public understanding of science, and bridge the gap between science and society, the chapter reviews the progress made in Korea over the past decade to promote a vibrant science culture through founding science culture research centers, establishing science media outlets, including internet science newspapers and science TV channels, and opening the National Science Centers. It highlights the role of the Korea Foundation for the Advancement of Science and Creativity (KOFAC) and its efforts to bring science closer to the public through informal education measures, and to produce creative human capital.

Chapter Six

This chapter reviews the efforts of the Korean government, public institutions, and non-governmental organizations to promote and expand participation in science and technology in the period following the World Conference on Science in 1999. It particularly focuses on efforts to promote the participation of women and young scientists in the science and technology sector. It outlines the legal measures, government master plans and related programmes in place to encourage their involvement. The chapter identifies in this regard such problems as low levels of employment for disadvantaged groups in the private sector, lack of training and re-employment programmes, and the need for a more family-friendly work environment.

These six chapters provide a sketch of both the progress and the challenges in Korea's efforts to attain the goals of the *Declaration* and the *Agenda*. Thus, they contain a brief description of the experiences Korea have had in the course of last ten years. It is hoped that it will serve as a starting point for future in-depth studies, from the viewpoint of the commitments made by the international community at the World Conference on Science, with respect to the development of science and technology in Korea. It will also contribute to the sharing of experiences with other countries with a view to making science and technology better serve society.

The Korean National Commission for UNESCO appreciates the support the Ministry of Education, Science and Technology of Korea and the National Research Foundation of Korea have provided for this project. The Commission is also thankful to the researchers involved in the project for their valuable contribution.

1

Science, Technology and Innovation Policy of the 2000s:

Pursuit of "Creation" and "Integration"

Science, Technology and Innovation Policy of the 2000s: Pursuit of “Creation” and “Integration”

I. Introduction

Technological innovation in Korea in the 2000s requires a new approach because the mode of technological innovation formed during the industrialization period is no longer sustainable. During the industrialization period, the major purpose of technological innovation was to solve problems by leveraging imported technologies and customizing them to the Korean situation. However, entering into the 2000s, Korea started to emerge as a leading country in such areas as semiconductors, digital electronics, mobile telephones, and shipbuilding, which also changed the characteristics of the challenges facing Korea.

| Table 1-1 | Characteristics of technological innovation by period

Classification	1960s~70s	1980s	1990s	2000s
Strategy	Importing and improving advanced foreign technologies	Catching up with advanced countries	Catching up with advanced countries	Transforming into a creative mode
Key activities	Supporting technologies required at the manufactory level	Developing technologies for key export industries	Developing technologies for high tech industries	Developing technologies for basic/original technologies
Lead	Government-funded research institutes (GRI)	GRIs, private enterprises	GRIs, private enterprises, universities	Private enterprises, universities, GRIs
Key industries to be supported	Petroleum, chemicals, electronics, steel	Shipbuilding, auto, steel, semiconductors	Semiconductors, high tech electronics, mobile phones	Mobile telecommunications, bioindustry

Source: Partially modified from the National Science and Technology Council (2009a)

Unlike the "catch-up" strategy that relies on learning and imitating for technological innovation of advanced economies, post catch-up innovation activities require a new policy approach to science, technology and innovation (STI). Activities to create new technology require a new social system, in which diverse and creative ideas are encouraged and well accommodated. In order for a new technology to be utilized fully for social and economic development, a social eco-system that is conducive to innovation has to be created. Therefore, to move to a stage of post catch-up innovation, scientific research and technological development should be supplemented and complemented by human resource development, institutional changes, new industrial policies, and a new regional development policy. In other words, a holistic approach is needed that considers innovation in a broader context.

Korea's science, technology and innovation policies of the 2000s show such trends in a variety of areas. However, these new trends have not been fully diffused or institutionalized because of the inertia of the old practices inherited from the "catch-up" period. As such, the innovation policy of Korea in the 2000s shows characteristics of a transitional period, in which the old and new coexist.

This report reviews the Korean STI policies in the 2000s. Section II discusses the changes in Korean STI activities in the 2000s, including the changes in inputs and outputs of S&T activities. Section III describes the new trends in STI policy that emerged in the 2000s, while Section IV is devoted to the discussion on new policy challenges that lie ahead.

II. Current status of science, technology and innovation

1. Inputs and outputs

Korea's aggressive investment in R&D continued into the 2000s. Korea's R&D investment almost doubled from 13,848.5 billion won in 2000 to 27,345.7 billion won in 2006. Over the years spanning from 1997 to 2006, Korea's R&D investment has been growing at an annual average growth rate of 8.9%, the highest in the world. The ratio of gross expenditures on R&D to GDP increased from 2.39% in 2000 to 3.47% in 2007, showing that Korea spends more of its income on R&D than other advanced countries, including the U.S. and Japan.

| Table 1-2 | International comparison of total R&D investment

Classification	Korea (2007)	U.S. (2007)	Japan (2006)	Germany (2007)	France (2007)	U.K. (2006)	China (2006)
Total R&D spending ($ billion)	33.69	368.8	148.53	83.82	53.88	42.69	37.66
Index	1.00	10.9	4.4	2.5	1.6	1.27	1.12
Ratio in GDP(%)	3.47	2.68	3.39	2.53	2.08	1.78	1.42

Source: OECD, *Main Science and Technology Indicators*, December 2008

Government R&D budget, which stood at 2,937.5 billion won in 1998, increased to 6,736.8 billion won in 2005 and to 8,139.6 billion won in 2007. The annual average growth rate of the government R&D budget during the period of 2005-2007 was 11.95%, much higher than the growth rate of total government budget (6.3%), educational budget (5.7%) or defense budget (7.8%).

Private R&D investments have also increased steadily, The number of private industrial R&D labs grew from 7,110 in 2000 to more than 10,000 in 2004 and to 15,000 in 2008, raising R&D intensity (the ratio of R&D spending to sales revenue) of private industries to 2.4% in 2007 from 2.0% in 2000.

Growth of R&D investment has been accompanied by growth of R&D manpower. The total number of researchers which was 160,000 in 2000 increased to 289,100 in 2007, increasing the number of researchers per 10,000 population from 34 to 59.7 during the same period.

Increases in inputs resulted in increases in outputs. The number of patents applied to the Korea Industrial Property Office (KIPO) increased to 172,649 in 2007 from about 100,000 in 2000. More notable is that the number of patents granted by the USPTO increased by 56.1%, from 3,314 in 2000 to 5,908 in 2006, making Korea one of the top five nations in terms of US patent counts. The number of triad patent families registered with patent authorities in the US, Japan, and Europe increased 3.9 times from 820 in 2000, to 3,158 in 2005.

| Table 1-3 | Key S&T related indices

		2000	2001	2003	2005	2006	2007
Economic index	GDP($ billion)	5,118	4,820	6,080	7,913	8,875	9,699
	GDP growth rate (%)	8.5	3.8	3.1	4.2	5.1	5.0
	Per capita GDP ($)	10,841	10,159	12,717	16,413	18,401	20,045
R&D investment	R&D investment(billion won)	138,485	161,105	190,687	241,554	273,457	313,014
	R&D investment/GDP(%)	2.39	2.59	2.63	2.98	3.23	3.47
	R&D investment by private sector (%)	72.4	72.5	74.0	75.0	75.4	73.7
Research manpower	No. of researchers (1,000)	160.0	178.9	198.2	234.7	256.6	289.1
	No. of researchers per 10,000 in the population (person)	34.0	37.8	41.4	48.8	53.1	59.7
No. of enterprise affiliated R&D center		7,110	9,070	9,810	11,810	13,324	14,975
Industrial property rights	No. of patent applications (no. of cases)	102,010	104,612	118,652	160,921	166,189	172,469
	No. of registered patent on new devices (no. of cases)	37,163	40,804	40,825	37,175	32,908	21,084

Source: Partially modified pages 53 and 56 of Korea Industrial Technology Association (2008)

The number of SCI publications by Korean authors has also grown remarkably from 12,475 in 2000 to 23,286 in 2006, raising the world share of Korean-authored publications from 1.39% in 2000 to 2.05% in 2006. The number of publications per 100 researchers, a key indicator of R&D efficiency, also rose from 7.8 in 2000 to 9.07 in 2006.

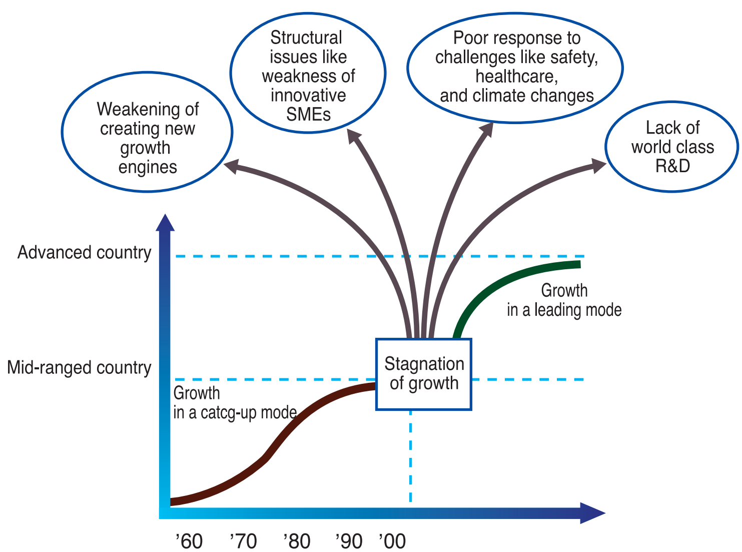
Such developments in science, technology and innovation has made it possible for Korea to achieve the industrialization and to establish world prominence in not only in traditional industries like shipbuilding, steel, and automobiles, but also in new technology-intensive industries, such as semiconductors, flat panel displays, mobile telephones, and so on.

2. Issues in science, technology and innovation

Though Korea has demonstrated impressive performance in S&T development, it is yet to overcome serious barriers to further advancement (NSTC, 2009a) toward a post catch-up stage in science, technology and innovation.

The National Science and Technology Council (NSTC) points out as one of the issues the delay in creating new growth technologies. So far, the Korean economic growth has been driven by such industries as semiconductors, flat panel displays, mobile telephones, shipbuilding and so on, but the growth will not be sustained into the future unless new technologies emerge to replace those technologies as locomotive of economic growth. Though significant R&D investment has been made to develop new growth engines, including biotechnology, nanotechnology, and green technologies, the results do not appear to be so positive as to promise the emergence of new growth engines.

| Figure 1-1 | Limitations of the “catch-up” growth mode and issues with the Korean S&T activities



Source: National Science and Technology Council, 2009a

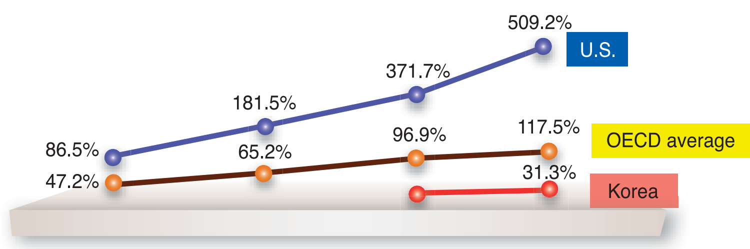
What makes the situation worse is weak innovation capability of small and medium enterprises (SMEs), which are the grass root industries. Though various efforts are being made to promote technological innovation of SMEs, including start-up companies, the profitability of SMEs continues to decrease.

This again weakens innovation activities and profitability of the whole industries, creating a vicious circle. In fact, the profit rate (profit/sales) of SMEs declined from 5.44% in 2000 to 4.31% in 2006. The weakened profitability has led to reduced investment capability, and reduced R&D investment. SMEs accounted for only 24.1% of the industrial R&D expenditures in 2007.

As Korea pursued an industrial development strategy with a focus on final products during the catch-up period, the country's capabilities of developing original technologies in components and materials till remain very weak. Companies producing final goods adopted a strategy of purchasing foreign technologies, rather than developing core components and materials through indigenous efforts. Moreover, rapidly globalization of economic activities has made it less attractive for domestic companies to work together for the development of original core technologies. Partly for this reason and partly for others, Korea has been suffering from chronic trade deficit with Japan that reached 18.68 billion dollars in 2007. Due to the deepening dependence of Korean industries on foreign components and materials, the structure that links export-oriented final goods industry to SMEs has been weakened, and thus the employment effect of exports has also been lessened. Thus, the gap between export-oriented companies and companies focusing on domestic markets has been widening, and so has the gap between large enterprises and SMEs.

Starting in the 2000s, the importance of science, technology and innovation policy in enhancing quality of life has become more widely recognized, but such a change in perception has not yet been reflected in the government's R&D investment priority. Until recently, government R&D investment has been focused on industrial development, and relatively small resources have been allocated for the improvement of public welfare. It may be due to the long-standing policy orientation of the Korean government that places top priority on economic development. As of 2006, R&D investment in environment and healthcare remained at 31.3% of that for industrial development. This shows a sharp contrast with other OECD countries which, on the average, spend more on public welfare R&D than on R&D for industrial development. Since the society's demands for better quality of life are expected to rapidly increase alongside income, it is necessary to expand government R&D investment in public welfare.

| Figure 1-2 | Government R&D investment in environment and healthcare vs. economic development



Source: National Science and Technology Council, 2009a

The quality of scientific publications and patents, along with other outputs of S&T activities, is not high. Though Korea's R&D investment has expanded volume-wise, Korea is still ranked 30th in the world in terms of the number of citations of SCI papers. There are only 12 Korean scientists among 5,000 most cited researchers. In the case of patent, the current impact index of US patents owned by Koreans is 0.83, which is lower than the standard 1.0. The quality of Korean patents is well reflected in Korea’s patent income, which is significantly lower than those of other foreign patents. This is a natural result of the catch-up growth model, focused on imitating foreign technologies and conducing application and development research.

III. Changes in science, technology, and innovation policy

1. Strengthening the status of science, technology and innovation policy

In the past, science, technology and innovation policy was considered as a sub-policy of economic or industrial policy. So, its role was limited to supplementing economic policy while its scope was confined only to science and technology-related areas. Beginning from the late 1990s, however, the role of science, technology and innovation policy has been elevated and its scope expanded. As the source of socio-economic development has shifted from investment capabilities to innovative capabilities, science, technology and innovation have emerged as a major national policy agenda, going beyond the boundaries of the S&T field. The importance of science, technology and innovation policy was fully reflected in the policy agenda of the Kim Dae-jung government (1998-2003) that pursued a transition toward a knowledge- based economy and also in the policy priority of the Roh Moo Hyun government (2003-2008) that stressed the development of an innovation-driven development.

The establishment of the National Science and Technology Council (NSTC) and the enactment of the Science and Technology Framework Law under President Kim Dae-jung in January of 1999 signaled a new start of the shift. The NSTC, which is presided over by the President, evaluates and coordinates R&D programs and reviews major policies. Before the establishment of the NSTC, policy coordination activities were conducted through "Inter-ministerial S&T Deliberation Meetings" and "S&T Ministerial Meetings" chaired by the Minister of Science and Technology. However, with the NSTC in place, the President directly coordinates the policies.

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The Science and Technology Framework Law is an umbrella law that provides a legal system for science, technology and innovation policy. This law, indeed, marked a departure for a legal system for a knowledge-based economy away from the old legal system designed for industrial society. Based on this act, the government formulated the "Science and Technology Basic Plan" that included a mid-term vision, goals, and implementation strategy for S&T development. The 1st Basic Plan (2003-2007) was implemented by the Roh Moo-hyun government, and the 2nd Basic Plan (2008-2012) is under implementation by the Lee Myung-bak government. By aligning the time periods of the master plans with the term of the government, the master plans have been made more effective.

During the Roh administration STI was a key policy agenda. The government set forth a vision of creating a °ÆS&T based society.' As national policy initiatives to realize the vision, the government developed various policy programs, including the making Korea an R&D hub in Northeast Asia. To realize the policy goal of establishing Korea as an S&T competitive country, the government tried to establish a system that links science and technology to socio-cultural and economic development.

The S&T administration system was revised in 2004. The core of this revision was to elevate the minister of science and technology to a deputy prime minister level and to create the "Office of Science, Technology and Innovation (OSTI)"within the Ministry of Science and Technology to support NSTC and the S&T Deputy Prime Minster. With the perspective that national policy initiatives should be pursued through S&T policy, the S&T Deputy Prime Minister coordinated industrial, human resource, and regional policies. The S&T Deputy Prime Minister is responsible for the coordination of overall STI policy, while serving as vice chair of the NSTC.

As secretariat of the NSTC, OSTI was responsible for the overall coordination and allocation of R&D budgets for various ministries.

With the inauguration of President Lee Myung-bak in 2008, S&T administration was reorganized. The former Ministry of Science and Technology (MOST) and the former Ministry of Education and Human Resources (MOEHR) were merged into the Ministry of Education, Science and Technology (MEST). The new government also reorganized the Ministry of

Commerce, Industry and Energy (MOCIE) into the Ministry Knowledge Economy (MKE) which is responsible for industrial research and technology development. In addition, many government committees have been closed down, except for the NSTC. As a consequence, the position of S&T deputy prime minister and OSTI were abolished, causing fundamental changes to the overall STI policy coordination system (Ministry of Education, Science and Technology, 2008).

2. New attempt for creative technological innovation

Creative technological innovation that creates new technological trajectories is an activity of high uncertainty. When the goal was to imitate existing technologies, there was not much of need for planning activities. Since the goal of technological innovation was already communicated, what was important was to act swiftly and in a uniform manner. For creative technological innovations to occur, it is necessary for Korea to select and develop its own path, planning activities that consider forecasts for the future. In addition, technological innovation activities should be backed by the creativity of researchers, and a multilateral approach that can take all possible opinions and paths into consideration.

The “National Technology Road Map (NTRM)” project in 2002 was a national technology planning project initiated to promote creative technological innovation. Though there had been planning activities led by individual ministries at ministerial level, the NTRM was the first attempt made as part of comprehensive planning of technology development at the national level. As result of this project, 10-year achievement goals were defined, along with core technologies and a road map outlining a path to achieving these goals.

Over time, these activities have been further strengthened to produce the "Total Road Map," a mid/long-term development strategy for national R&D projects. This strategy, to be implemented over the next 10 years, contains portfolios of nine major technology categories and 90 specific technologies to focus on at the national level, along with implementation strategies for national R&D projects. The strategies include strengthening basic research, development of core technologies, promotion of fusion technology development, expanding national R&D infrastructure, and implementing national strategic projects. The project also recommended to increase investment in biotechnology, energy, and basic science, while at the same time, leaving R&D investment in machinery, information and electronics technologies to the private industries.

Along with strengthening overall technology planning activities at the national level, a new mode of national R&D projects was introduced to facilitate creative innovation. The Creative Research Initiative Project, begun in 1997, and the Frontier R&D Program that started in 1999 are the examples of such moves. As a new approach to science and technology development, these projects helped Korea form a new organizational structure of R&D in a new operational mode. Both the Creative Research Initiative Project and Frontier R&D Program adopted an organizational model called research center-based system, enhancing the autonomy of researchers through strengthened empowerment of project managers not only in budget execution but also in researcher recruiting. The research center system operates independently, without following the organizational practices of universities or GRIs. This organizational model was introduced to replace the old practice of imitative research.

Over time, these policies have constituted a set of institutional base that have facilitated the transformation of the national innovation system from an “innovation system trying to catch up with advanced countries” to a “system for creative innovation.” The need for such a transformation was explicitly reflected in the Korean government’s effort to make Korea an ecosystem conducive to innovation.

Under Lee Myung-Bak government, creativity has become a catch-word for national development. In December 2008, the Science and Technology Basic Plan of the new government was finalized at the NSTC, and the government announced an ambitious plan to increase R&D investment to 5% of GDP by the year 2013. Lee Myung-bak’s STI policy emphasizes nurturing scientists and engineers who are capable of conducting world-class research, along with strategic concentration of R&D resources on creative, original research. In this context, the government plans to double the share of basic research in total R&D expenditures of the government, while stepping up its efforts to produce creative talents by integrating education with science and technology (ROK Government, 2008b).

3. Emergence of integrated innovation policy

The theory of national innovation systems laid the foundation for approaching STI policy from a broader perspective, asserting that the technological innovation performance of a country is affected by the alignment of networks and systems of players participating in technological innovation. This concept of national innovation system was first adopted in Korea during the Kim Dae-jung administration. During this period, the national innovation system was used as a theoretical concept to analyze the overall innovation phenomena, but it was not utilized as a policy framework for solving S&T and innovation issues from a systemic perspective.

However, starting with the Roh administration, the establishment of the national innovation system emerged as key policy agenda and the systemic perspective was introduced in a full-fledged manner. In order to promote technological innovation, this systemic perspective calls for an inclusive approach that considers not just interactions between innovation players like industries, universities, and research institutes, but industrial development, human resources development systems, the financial system, regional innovation, and labor-management relations that surround these players. Once governments adopt this perspective, it requires an "integrated innovation policy" that relates STI policy to policies in other areas.

To establish a national innovation system, the Roh administration adopted an integrated approach considering the relations between different policies that had previously been pursued separately. So the new policy attempted to integrate STI policy not only with corporate innovation, human resources development, social and economic development, regional development and so on, while promoting cooperation between industries, universities, and research institutes.

This perspective was also reflected in the revision process of the S&T administration system, an attempt to search for a new administration system based on the understanding that the existing system, led by the Ministry of Science and Technology, was not enough to serve the needs of the entire innovation process. To make this policy approach to work, a system for the coordination between S&T- related industrial policies, human resources policies, and regional innovation policies at the national level was put in place and the overall coordination was directed by the Deputy Prime Minister of Science and Technology.

During the later half of the Roh government, policies to improve quality of life through science and technology were presented. With the development of “Measures to Improve Quality of Life Based on Technology (2007),” quality of life issues that had remained a mere political rhetoric began to receive real attention both from the public and private sectors. R&D resources were allocated to promote and facilitate R&D for public welfare. In addition, the National Emergency Management Administration was launched in May 2004 to effectively deal with natural disasters, and the government also formulated the “Basic plan for developing technologies for disaster and safety management” in 2007, which boosted the implementation of policy programs for social safety and disaster management (ROK Government, 2008a: 41).

Through this process, the boundaries of STI policy has been expanded, and STI has evolved into a broad-based policy with links to social policies beyond the boundaries of economic growth.

Under President Lee Myung-bak, “Low Carbon Green Growth” has emerged as a key national policy agenda. Based on the policy direction, the new government adopted an integrated approach to technological innovation, environmental protection, and energy policies. “Low Carbon, Green Growth” policy aims to promote the development of competitive green industries, while at the same time, improving quality of life by reducing CO2 emission and saving resource and energy through green technological innovation. In March 2009, the government announced the “Measures to promote R&D on Green Technologies” and launched several initiatives geared to improving environmental quality, developing green industries, and creating green jobs through the development of green technologies. In this way, STI policy is linked to environmental policy, industrial policy, and employment policy.

IV. Limitations

1. Target-focused policy

The importance of STI policy is now better recognized in Korea than in earlier periods. By defining new goals, shifting from imitation to creation, and broadening the span of STI policy to quality of life, the Korean government has upgraded the policy framework based on a more systematic process.

However, due to the legacy of the “development period,” many policies are still target-oriented, concentrating government support in the selected areas. Though the policy process has become decentralized and made open to public participation to a certain extent, government directives still remain a defining force.

First of all, though the concept of a national innovation system started to emerge in the 2000s, policies are still focused on strategic S&T fields. A systemic perspective on science, technology, and innovation activities and policies is not yet widely accepted by policy makers. Government-led targeting of strategic industries and technologies, which was a main policy approach during Korea’s development period, is still considered as an important policy device. As it takes a long time for actual impact of policies to be known, it is difficult to draw the attention of the press or public, and, in turn, the will to enforce these policies tends to dissipate.

In the current situation where the transformation to a creative innovation system and green development have become key national policy agendas, investment in science and technology needs to be linked to the construction of this new system.

2. Insufficient participatory governance

In the 2000s, noticeable changes have taken place in the governance of STI policies, including efforts to promote the participation of various stakeholders in the policy-making process. However, these changes have not been initiated from the grass-roots level, but instead top-down reforms led by the government. This offers the private sector and frontline scientists and engineers opportunities to participate in policy-making in various ways, but they do not have the power to influence the formation of policy agendas. The development of key policy agendas and policy direction are still solely in the hands of the government.

The Science and Technology Framework Law of 2001 laid a foundation for general public’s participation in the policy making process. Based on the law, an open policy process that guarantees civilian participation was introduced, but it is still in an infant stage. The technology assessment led by expert groups is now open to public participation for preliminary assessment of risks of new technology. However, all these efforts have been superficial. Though technology assessment plays a role in identifying social and ethical issues related to the development of new technologies, it does not have much influence on policy development or R&D project planning.

3. Policy development system in catch-up mode

In the decision-making process, short-term policy development task force teams are formed to develop policies in a very short period of time using a small group of government officials and experts. Therefore, in the process of policy formulation, they cannot afford to consider fully the changes in S&T environments, critically review the current innovation system, and thoroughly evaluate past policy experiences. Under such circumstances, the interests of stakeholders and civil society cannot be fully considered or reflected in the policy-making process.

Short-term task force teams led by a small group of experts in policy development were effective when the government adopted an imitative policy-making model. By quickly customizing the exiting foreign policies to the Korean situation and swiftly implementing them, the Korean government successfully handled technology and innovation issues with minimal turnaround time between policy setting and results. However, with the emergence of new policy issues and challenges in developing new and innovative policies, it is very likely that this short-term focused approach will not bring about intended impacts.

4. Excessive policy competition and limited policy learning

As the status of STI policy is elevated and is recognized as a growth area in policy development, inter-ministerial competition in policy-making is being further intensified. Under the Korean system of a five-year single presidential term, presidents tend to enjoy high support rates early in their terms of office, and strong policy drives are possible while approval rate is high. Individual ministries can make various policies around key agendas (e.g. S&T-based society, Green Growth, etc.) during these periods, as well, and policy development focused on the visibility of policies is often witnessed. However, a side effect of the single presidential term has been the early onset of "lame duck" phenomena, making it difficult to maintain and sustain policies in the later part of the presidential term. Because of this phenomena, policy learning mechanisms that understand the impact of policies and policy improvements accordingly are quite weak and act as a key barrier to the advancement of policies.

Though efforts are being made to coordinate policies through the National Science and Technology Council, many policies still tend to be developed from a short-term perspective or are simply securing ministerial turf instead of pursuing long-term visions or integrated perspectives. Even though the integrity of policies is emphasized through the NSTC, policies are being sporadically developed by individual ministries. Therefore, it is necessary to strengthen the power of NSTC with a view to consolidating links and enhancing the strategic aspects of policies.

V. Conclusion

Starting in the 2000s, Korea's STI policy began to change as its status was elevated and the scope of policy was expanded. Now there is a clear voice calling for departure from the old practice of imitating foreign technologies to a new creative strategy and a new development path. Basic perspectives, characteristics, achievements, and limitations of STI policy of the 2000s are summarized in Table 1- 4.

At the moment, stakeholders in Korean science and technology are striving to build a new system recognizing the need for changes. The limitations of old imitative strategies are apparent and a sense of urgency has emerged, changing not only corporate strategies, but also the national development framework at a macro level. However, old legacies still exert influence, producing conflicts and competition between old and new components.

In order for STI policy to be stabilized, it requires a new way of working and a new culture. Rather, it should be obtained through experiments and policy learning with clear vision; STI policy of the 2000s requires strong transformational leadership.

| Table 1-4 | Korean S&T innovation policies of the 2000s: characteristics, achievements, and limitations

Policy elements	Changes in STI policy
Innovation Perspective	• Introduction of a NIS perspective; however, the legacy of linear perspectives and targeting approaches focused on strategic areas is still prevalent.
Policy goals	• Expansion of policy goals covering such issues as economic growth, improved quality of life, and green growth.
Policy areas	• Expansion of the boundary of STI policy through links with other ministries
Key actors of policy	• Tendancy to expand from government officials and a few experts to various groups including companies, civil activist groups, and experts from the private sector with government playing a leading role
Role of government	• Though the government exerts strong political leadership, it is difficult to maintain policies due to institutional characteristics
Achievements	• Enhanced status of STI policy • Pursuit of a creative innovation system • Emergence of integrated STI policy addressing issues like quality of life and regional development • Changes in the governance of STI policy
Limitation	• Delays in reflecting and institutionalizing a national innovation system or governance concept in national policies due to the legacy of Korea's earlier developmental state • Short-term oriented TFT style policy development and excessive policy competition

Source: Partial modification of Seong and Song (2008)

References

English Publications

Seong, J. and Song, W. (2008). "Innovation Policy and Administration System in the Era of Post Catch-up: The Case of the Roh Moo-hyun Administration's Innovation Policy". *Asian Journal of Technology Innovation*. Vol 16. No. 2.

Smits, R. and Kuhlmann, S. (2004). "The Rise of Systemic Instruments in

Innovation Policy". *International. Journal of Foresight and Innovation Policy*. Vol. 1. No. 1/2.

Korean Publications

Ministry of Science and Technology (2003). "5-year Achievements in Science and Technology by the People's Government".

Ministry of Science and Technology (2008). *40-year History of Korean Science and Technology*.

Ministry of Education, Science and Technology (2008a). *2007 Yearbook on Science and Technology*.

Ministry of Education, Science and Technology (2008b). "Whitepaper on S&T Statistics".

National Science and Technology Council (NSTC) (2009a). "Analysis of National R&D and Its Implications".

National Science and Technology Council (NSTC) (2009b), "Vision of New Growth Engine and Development Strategy".

Government of the Republic of Korea (2008a), "Whitepaper on S&T Policy of the Participatory Government".

Government of the Republic of Korea (2008b), "Basic Plan for Science and Technology of the President Lee, Myung-bak Government".

Park, Kiyoung (2006), "Background and meaning of government organizational reshuffling for S&T innovation". Paper presented at Fall Academic Conference of the Korean Technology Innovation Academy.

Korea Industrial Technology Association (KITA) (2008). *30-year History of Korean Industrial Technology*.

2

Scientific Research

Chapter

1. Science, Technology and Innovation Policy of the 2000s: Pursuit of "Creation" and "Integration"
2. Scientific Research
3. Science Education
4. Science Ethics
5. Science Culture
6. Widening Participation in Science

Scientific Research

I. Introduction

In Korea, the scale of R&D expenditure expanded rapidly after 1980. The total national R&D investment in 2007 was 31.3014 trillion won, the 7th largest investment in the world, and the ratio of R&D investment to GDP was 3.21%. The total number of science and technology researchers in 2007 was 289,098, among which 221,928 were full-time employees, which was the 5th largest R&D workforce in the world. Along with expansion of R&D investment, R&D activities in the public and private sector increased, and R&D support infrastructure has improved. This chapter examines the four issues raised by the *Declaration* and *Agenda* of the World Conference on Science: Institutional support for scientific research, the direction of scientific research activities, the promotion of interdisciplinary research activities, and utilization of traditional knowledge systems. It examines the status of research activities in view of the spirit and recommendations of the *Declaration* and *Agenda*.

II. Institutional support for scientific research

1. Status of research institutions and R&D activities

Major research institutes in Korea may be divided broadly into three types: Government-funded Research Institutes (GRIs), university research institutes, and Private Research Institutes (PRIs).

| Table 2-1 | Science & technology GRI in Korea

Korea Research Council of Fundamental Science & Technology (KRCF)	Korea Research Council of Industrial Science & Technology (KRCI)	Agencies controlled by the Ministry of Education, Science and Technology (MEST)
Korea Institute of Science and Technology (KIST) Korea Basic Science Institute (KBSI) National Fusion Research Institute (NFRI) National Institute for Mathematical Sciences (NIMS) Korea Astronomy and Space Science Institute (KASI) Korea Research Institute of Bioscience and Biotechnology (KRIBB) Korea Institute of Oriental Medicine (KIOM) Korea Institute of Science and Technology Information (KISTI) Korea Research Institute of Standards and Science (KRISS) Korea Ocean Research and Development Institute (KORDI) Korea Polar Research Institute (KOPRI) Korea Aerospace Research Institute (KARI) Korea Atmoic Energy Research Institute (KAERI)	Korea Institute of Industrial Technology (KITECH) Electronics and Telecommunications Research Institute (ETRI) National Security Research Institute (NSRI) Korea Institute of Construction Technology (KICT) Korea Railroad Research Institute (KRRI) Korea Food Research Institute (KFRI) Korea Institute of Geoscience and Mineral Resources (KIGAM) Korea Institute of Machine & Materials (KIMM) Korea Institute of Materials Science (KIMS) Korea Institute of Energy Research (KIER) Korea Electrotechnology Research Institute (KERI) Korea Research Institute of Chemical Technology (KRICT) Korea Institute of Toxicology (KITOX)	Korea Advanced Institute of Science and Technology (KAIST) Korea Institute for Advanced Studies (KIAS) Gwangju Institute of Science and Technology (GIST) Daegu Gyeongbuk Institute of Science and Technology (DGIST) Korea Institute of Nuclear Safety (KINS) Korea Institute of Radiological and Medical Sciences (KIRAMS) Korea Institute of Nuclear Nonproliferation and Control (KINAC) National Research Foundation (NRF) Korea Institute of Science & Technology Evaluation and Planning (KISTEP) Korea Institute of R&DB Human Resources Development (KIRD) University of Science and Technology (UST)

GRIs in Korea originated in the 1960s, when the Korea Institute of Science and Technology (KIST), a general science and technology research institute, was established. A series of GRIs specialized in different sectors were established in the 1970s, when GRIs dominated scientific research activities in Korea due to the insufficient research capabilities of universities and private enterprises. As of 2009, there are 26 science and technology research institutes under two research councils (KRCF, KRCI) of the Union Council, as shown in Table 2-1.

Research capabilities in the private sector grew rapidly in the 1980s. In the late 1990s, venture businesses experienced drastic growth in areas such as information technology (IT) and biotechnology (BT). Research institutes attached to companies, on the other hand, were hampered by financial difficulties in the same period; however, they grew rapidly through the 2000s, and there are 11,998 research institutes attached to companies as of 2009. The total R&D investment of the private sector was 23.0542 trillion Korean won in 2007, or 73.7% of the total R&D expenses that year. Moreover, it shows that R&D activities in the private sector are expected to grow, as shown in Table 2-2.

The turning point for universities was in 1973, with the establishment of Korea Advanced Institute of Science (KAIS). KAIS was then under the Ministry of Science and Technology (MOST, now MEST) and it was the first research-oriented university. Moreover, it made this transformation from an education-oriented organization to a research-oriented organization through expansion of the graduate program.

| Table 2-2 | Growth trend of R&D institutes in Korea

		1985	1990	1995	1997	1999	2001	2003	2005	2007
Number of organizations	Government funded research institutes	119	167	178	184	169	188	169	137	188
	Universities	217	220	257	271	285	276	310	256	322
	Research institutes attached to companies	928	1,718	2,150	2,507	2,605	6,337	6,648	7,368	10,690
Number of researchers	Government funded research institutes	7,154	18,407	15,007	15,185	13,986	13,921	14,395	15,501	20,342
	Universities	14,935	43,582	44,683	48,588	50,151	53,717	59,746	64,895	83,123
	Research institutes attached to companies	18,996	63,523	68,625	74,665	70,431	111,299	124,030	154,306	185,633
Yearly R&D expenses (hundred million won)	Government funded research institutes	2,802	7,310	17,667	20,689	19,792	21,602	26,264	31,929	41,024
	Universities	1,188	2,443	7,709	12,716	14,314	16,768	19,327	23,983	33,341
	Research institutes attached to companies	751	2,374	69,030	88,453	85,112	122,736	145,097	185,642	238,649

Source: MEST & KISTEP, 'Report of the Survey of Research and Development in Science and Technology in Korea', each year

Research organizations of general universities were reorganized and began research activities at a larger scale in the 1990s. Policies that differentiated the level of support according to results of university evaluations and support programs for engineering programs in public universities played a key role in this stage. The Korean Council for University Education has employed an evaluation system to grade universities since 1992 and differentiates support for universities according to the evaluation results. Universities have consequently expanded their faculty, and educational and research facilities to conform to the evaluation standards.

| Table 2-3 | Trends in the number of graduate students and doctorates produced

		2000	2002	2004	2006	2008
Number of graduate schools		829	945	1,030	1,051	1,055
Number of graduate students in science and engineering	Master's degree	59,485	61,601	60,893	60,560	65,315
	Doctorate degree	18,648	18,584	19,318	21,199	22,313
Number of doctorates produced	Science	1,116	1,176	1,318	1,453	1,436
	Engineering	1,803	2,106	2,414	2,616	2,542
	Agriculture and fisheries	229	262	267	251	189
	Total	3,148	3,544	3,999	4,320	4,167

Source: Statistical Yearbook of Education in Korea

As a result, the number of graduate schools increased from 303 in 1990 to 1,055 in 2008. The number of graduate students in science and engineering also increased from 45,745 MSs and 12,584 PhDs in 1990 to 65,315 of master's degrees and 22,313 of doctorates awarded in 2008. Accordingly, the number of doctorates produced in Korea in science, engineering, and agriculture and fisheries expanded from 644 in 1985 to 4,167 in 2008, as shown in Table 2-3.

2. Legal and institutional devices and financial resources for scientific research support

The Science and Technology Basic Law passed in July 2001, obliges the government to support scientific research nationally and devise necessary framework systems and financial measures. “Government shall plan and implement policies that provide support to businesses, university and research institutes or their members to exchange and share their manpower, knowledge and information” (Article 5. 2). By developing the Science and Technology Five Year Master Plan, the government must set plans to promote R&D and R&D collaboration, to diffuse of research outputs, to advance pure sciences, and to provide financial resources for science and technology development (Article 7.3, Article 15, Article 17, Article 21). In addition, “the government shall also establish a science and technology development fund to support not only science and technology research activities, but also enterprises which perform R&D activities” (Article 22.3).

Along with the expansion of R&D activities, the government has worked to secure the R&D. Due to the rapid growth of R&D investment, the proportion of R&D expenses allotted to government has been reduced; however the government R&D budget has increased by an average of 19.4% yearly, exceeding the 15.0% growth seen in the private sector. The government R&D budget increased from 3.7495 trillion Korea won in 2000 to 11.0784 trillion Korean won in 2008, forming 4.0% of the total budget.

3. Cooperation between public sector and private sector in scientific research

In Korea, high-quality science and human capital, especially those with PhDs, primarily work in universities, which employ 61% of the total R&D human capital as of 2007. Among researchers in private research institutes, 6.6% of them hold a PhD, 30.1% an MS and 63.3% hold a bachelor's degree or less. Researchers with master's or bachelor's degree form the backbone of research manpower for many of these firms.

GRIs carry out mainly research of basic science that cannot be done in the private sector. GRIs are where high-quality human capital is concentrated and 51.6% of their total researchers have doctorates. Applied science research and development research consist a large part of GRI activities (36.6% and 39.1% respectively as of 2007), making them responsive to demands from industries.

From a national point of view, it is possible to allocate basic research to universities and applied and development research to GRIs. However, recently there has been much emphasis on the importance of interdisciplinary research, and the significance of these distinctions is in decline. In Korea, collaboration between the public and private sectors in research is taking place by means of exchange and cooperation programs between industry-university-research institutes and the financial support scheme of the government for research activities in the private sector. The exchange and cooperation program among industry-university-research institutes is supported by the National Research Foundation of Korea (NRF) and the industry-university-research institute joint research consortium program is managed by industry-university-research institute research meetings and the Small and Medium Business Administration (SMBA). There are also MS and PhD programs jointly managed by GRIs and universities.

| Figure 2-1 | Issues of industry-university-research institute cooperation

⁎ Unbalanced development of cooperaration system of industry-university-research institute	⁎ Cooperation system led by GRI and university - Inadequate efforts to develop cooperation infrastructure with incentive-oriented policy ⁎ Lack of spontaneous efforts of cooperation from the industry ⁎ Weak collaboration due to linear model-based cooperation system
⁎ Coopereration structure alienated from industrial demand	⁎ Low participation from industry in national R&D programs - Expenses used by the industry: 16.3% (2007) ⁎ Insufficient field training in S&E college education - lack of collabaration with the industry ⁎ Limited system for cooperation - limitation for holding additional post, thesis-oriented professor evaluation system, PBS (Project-Based System). etc
⁎ Lacking interactivity among cooperation programs	⁎ Individual project, individual department-oriented R&D programs - One-time, simple cooperation-oriented ⁎ Inadequate system for information sharing cooperation among programs with similar purposes - Limitation of diffusion across regions and areas ⁎ Inadequate role of intermediate agencies for cooperation

⁎ Low efficiency of national R&D investment due to poor cooperation system of industry-university-research institute
- Technology transfer between university and industry: 33th (2009, IMD), cooperation of businesses: 38th(2009, IMD)

A diversity of cooperation programs of industry-university-research institutes are underway in Korea, but the impact is less than in other advanced countries. In the International Institute for Management Development (IMD) index, Korea ranked the 27th in national competitiveness, 3rd in science infrastructure competitiveness, and 14th in technology infrastructure competitiveness in 2009. However Korea was 33rd in technology transfer between universities and businesses, and 38th in business to business cooperation.

4. Mobility of scientists

One of the key issues in Korea for human capital in the science industry is the unidirectional movement of researchers towards university work due to complex factors of culture, social perception, salary, and research environments. As of 2007, universities housed 69% of researchers with doctorates, but account for only 10.7% of total R&D expenses. Its research environment is poor compared to those of private enterprises and GRIs in terms of the scale of research expenses and research facilities. According to the research done by KISTEP (Korea Institute of S&T Evaluation and Planning) on the mobility of PhDs in science and engineering, from 1994 to 2006, most researchers moved to universities. The number of PhDs in science and engineering who moved to university research during the same period was 552, or 84.7% of the total number of PhD's who changed their place of work, as shown in Table 2-4. Researchers with a PhD still prefer universities in such large numbers that national government measures may be necessary to reverse the trend.

| Table 2-4 | Mobility of doctors in science and engineering domestically and internationally (1994~2006)

(Unit: Number of people, %)

Korea → Korea		Previous workplace		
		Industry(I)	University(U)	Research Institute(R)
Present workplace	Industry(I)	17(2.6, 9.3)	11(1.7, 3.7)	6(0.9, 3.5)
	University(U)	148(22.7, 80.9)	258(39.6, 86.9)	146(22.4, 84.9)
	Research Institute(R)	18(2.8, 9.8)	28(4.3, 9.4)	20(3.1, 11.6)
	Total	183(28.1, 100.0)	297(45.6, 100.0)	172(26.4, 100.0)

(Unit: Number of people, %)

Overseas → Korea		Previous workplace (overseas)		
		Industry(I)	University(U)	Research Institute(R)
Present workplace	Industry(I)	3(1.3, 12.5)	3(1.3, 2.2)	1(0.4, 1.4)
	University(U)	21(8.9, 87.5)	125(53.2, 91.2)	65(27.7, 87.8)
	Research Institute(R)	0(0.0, 0.0)	9(3.8, 6.6)	8(3.4, 10.8)
	Total	24(10.2, 100.0)	137(58.3, 100.0)	74(31.5, 100.0)

Source: KISTEP (2006), 'A case study on the nurturing and utilizing human capital in science and engineering, and its working conditions'

International mobility of scientists has become an issue recently, especially the movement of Korean scientists to overseas positions. The trend started when Korea was restructuring after the Asian financial crisis and the U.S. was promoting a policy to induce high-quality human capital from overseas to feed their domestic IT boom. International movement of scientists can be personally desirable for the individual scientists, but on a national level it leads to a loss of educational investment and research capability, and sometimes the leak of valuable research information. In addition, the number of students who study overseas is increasing, from 160,000 in 2003 to 220,000 in 2007, and the percentage of doctorates in science and engineering who study in U.S. without returning to Korea after their studies finish is also increasing, from 31.3% (1996-1999) to 46.3% (2000-2003) (Science and Technology Framework Plan, August 2008). The government should pay more attention to these phenomena connected with brain drain overseas.

III. Direction of Scientific Research and Diffusion of Research Outcomes

1. Direction of scientific research

Pure science research is given relatively little weight in national R&D programs in Korea. Pure science research only accounted for 15.7% of the public R&D budget in 2007. Applied science researches based on demands from the industry are still given more weight in Korea. Also, it is speculated that government support for development research will continue, especially as global competition in science and technology intensifies. Even in universities, pure science researches only account for 41.1% (2007) of the total research expenses. The current Lee Myung-bak administration has reinforced its policy to promote pure science research, with a stated goal of investing 50% of the total government R&D expenditures into pure and fundamental science and technology research by 2012.

| Table 2-5 | Change of R&D expenditures by Research Stage

(Unit: hundred million Korean won, %)

Year	Pure		Applied		Development		Total	
	R&D	Percentage	R&D	percentage	R&D	percentage	R&D	percentage
1999	16,255	13.6	30,652	25.7	72,311	60.7	119,218	100
2000	17,461	12.6	33,701	24.3	87,323	63.1	138,485	100
2001	20,250	12.6	40,759	25.3	100,096	62.1	161,105	100
2002	23,732	13.7	37,636	21.7	111,882	64.6	173,250	100
2003	27,586	14.5	39,740	20.8	123,361	64.7	190,687	100
2004	33,994	15.3	47,121	21.2	140,738	63.4	221,853	100
2005	37,068	15.3	50,341	20.8	154,144	63.8	241,553	100
2006	41,433	15.2	54,301	19.9	177,723	65.0	273,457	100
2007	49,187	15.7	62,108	19.8	201,719	64.4	313,014	100

Source: MEST & KISTEP, 'Report on the Survey of Research and Development in Science and Technology', each year

2. Diffusion and sharing of scientific knowledge

The Korean government has been organizing overall framework and systems for the diffusion of scientific knowledge to prepare for a more knowledge-based society. Government and public research institutes are issuing various types of statistics and yearbooks in science and technology, and the government has recommended its agencies and government-funded institutes to increase access to their research results. The results of these efforts are included in the evaluation of GRIs to improve their effectiveness, which is having positive results. The government is also working to build a database of national R&D information and publicize the results on the internet. More complete information on national R&D programs is available to the public through the National Science & Technology Information Service (NTIS) website (http://www.ntis.go.kr).

NTIS provides R&D services such as program management, equipment and materials, outcomes, manpower, local R&D information, science and technology statistics, along with information distribution services for national R&D projects and classification. The National Research Foundation of Korea (NRF) has supported the establishment of research information centers in 16 universities nationally in 21 areas since 1995, and has been building a database of research information. The Korea Foundation for the Advancement of Science and Creativity (KOFAC) opened a science information website as part of efforts to introduce scientific knowledge not only to experts but also to the public.

IV. Promotion of Interdisciplinary Research Activities

1. Science, technology and society

Article 14 of the Science and Technology Basic Law that passed in July 2001 mandates that a survey must be conducted to evaluate the impact made by the advancements of science and technology. The results of this survey must also be reflected in future government policies.

Korea has a difficult environment for interdisciplinary research, especially between natural and social sciences. The distinction of social and natural sciences is clearly made in high school curriculum, university entrance exams, and the choice of majors at the university level. This is in stark contrast to western countries, where interdisciplinary research between natural and social sciences has an independent research base. Many universities currently have courses and forums that deal with interdisciplinary areas of natural and social sciences, such as the Moon-Jin Forum and Fusion Forum, which shows that recognition of the importance of interdisciplinary research is expanding. In the environmental field, interdisciplinary research is taking place in the areas of education, research, and policymaking to cope with environmental issues. Recently, the ethics of biotechnology has become a major area of interdisciplinary research.

|Table 2-6 | Sub-fields of Science and Technology studies and Technological Innovation in Complex Science

G50200 Study of Science and Technology
G50201 History of Science
G50202 History of Technology
G50203 Philosophy of Science and Technology
G50204 Ethics of Science and Life
G50205 Sociology of Science
G50299 Others

G50300 Technological Innovation
G50301 Innovation Theory
G50302 Classification and Standardization
G50303 Technology Forecasting and Assessment
G50304 Economics of Technological Change
G50305 Technology Evaluation
G50306 Technology Planning and Strategy
G50307 R&D, Technology Management
G50308 Science and Technology Law and Policies
G50309 Intellectual Property Right
G50399 Others

Source: NRF website (http://www.nrf.go.kr)

Support for research dealing with social issues is extremely poor, because research support and academic activity is mostly determined by the traditional classification of fields of study. Currently, the National Standard Science and Technology Classification does not include interdisciplinary research. Research field codes classified by NRF, however, include Interdisciplinary Science, which covers Science and Engineering Information Education, Science and Technology Studies, Technological Innovation, Informatics and Information Technology, as shown in Table 2-6.

2. Interdisciplinary research in science and technology

The government has emphasized recent trends of fusion and convergence in science and technology research, putting priority on the research in national R&D programs and encouraging researchers from various fields of study to participate. “Specialized basic research programs” managed by NRF are the key R&D programs aimed at promoting interdisciplinary research. This program is designed to support approximately 100 million Korean won for less than five years for an interdisciplinary research that collaborates in more than two different areas among natural science, biology and engineering. In addition, the Medical Science and Engineering Research Center (MRC) was established in 2001 as a cornerstone of interdisciplinary research for clinical medicine, basic medicine, and biotechnology.

In spite of the expansion of recognition of the importance of interdisciplinary research, it is still difficult to perform such research in Korea. In order to carry out collaborative research, experts from different fields of study need to have at least a basic knowledge of the other fields. However this is difficult to achieve due to the university education system in Korea.

3. Utilization of traditional knowledge systems

Traditional knowledge areas currently in the limelight in Korea are oriental medicine and food processing. Oriental medicine is growing in a new direction through a convergence with western science and technology while still adhering to a traditional Asian view of the human body and disease. Such research is performed mainly at oriental medical colleges in Korea and the Korea Institute of Oriental Medicine, established in 1994. Research results pertaining to the effects of traditional foods and local specialties, such as fermented foods and ginseng, are being utilized as part of the modernization of traditional food processing and medicine developments.

Relics and remains of architecture and crafts of the past are being newly recognized nowadays, owing to modern science and technology. Preservation science and restoration is reviving artifacts by means of high-tech facilities and technologies, the results of which are available online. In addition, manufacturing products using traditional industrial arts such as traditional architecture and dyeing process is being tried, and efforts are being made to connect them with modern science and technology.

V. Conclusion

To overcome the limitations of the current situation, future science research support should be expanded for basic research so that research can be conducted in a more fundamental and problem-oriented direction, in accordance with the recommendations of the *Declaration* and *Agenda*. It is also necessary to increase R&D investment for universities, who are the key performers of basic research and where high-quality human capital is concentrated. The current Lee Myung-bak administration has set a goal of expanding investment in pure and basic science research to 50% of the total government R&D investment by 2012. Continuous support by the government is necessary for continued success.

Sharing and diffusion of science and technology research outcomes

In order to spread science and technology results to researchers and the public, we need to build and operate a science and technology based database (DB) that is easy to use and satisfies user needs. A professional science and technology DB that includes research outcomes and research trends needs to be provided for researchers, and include explanatory information for the public. Institutional measures to inform science and technology outcomes and study their impact on society should also be implemented. There is a need to expand measures for major national R&D programs to use expenditures in a way in which the public and social implication of the study outcomes is clear and in the public interest.

Promotion of interdisciplinary research activities

In order to promote interdisciplinary research in natural and social sciences, a system to cultivate new human capital equipped with knowledge of interdisciplinary subjects and research abilities should be built. An effective support system for the promotion of existing interdisciplinary research activities is also needed.

Utilization of traditional knowledge system

Understanding and study of traditional knowledge is a prerequisite for the utilization of traditional knowledge systems. One method is to support the study of the history of science and industrial technology, along with research on science and technology remains and restoration projects, the outcome of which needs to be reincorporated into scientific knowledge. A support system for those who possess traditional knowledge or skills need to be made so that their knowledge can be passed on to the next generation. Finally, a system to support research to modernize and utilize traditional knowledge needs to be built. Besides support for research on agriculture, the environment, and traditional medicine, there is need for support for scientific research on folk craft such as traditional dyeing, paper making, and crockery, as well as for the development of a modern manufacturing system.

References

English Publications

Lee, Jang-jae (2008). “Korea’s Science and Technology Policy”. *2008 KISTEP R&D Management Program for High Level Policy Makers*. Seoul: KISTEP.

Organization for Economic Cooperation and Development (OECD) (2008). “Main Science and Technology Indicators”.

Korean Publications

Korea Institute of Science & Technology Evaluation and Planning (KISTEP) (2008). “A case study on the nurturing and utilization of human capital in science and engineering and its working conditions”.

Ministry of Education (2000~2008). *Statistical Yearbook of Education in Korea*.

Ministry of Education, Science and Technology (MEST) and Korea Institute of Science & Technology Evaluation and Planning (KISTEP) (1985~2007). “Report of the Survey of Research and Development in Science and Technology in Korea”.

National Research Foundation of Korea website. Accessed at http://www.nrf.go.kr.

National Science and Technology Council (2008). “Science and Technology Framework Plan of the Lee Myung-bak Government”.

National Science and Technology Council and Korea Institute of Science & Technology Evaluation and Planning (KISTEP) (2009). “Performance Evaluation of National R&D during the past 40 years and its Implications”.

National Science and Technology Council and Ministry of Education, Science and Technology (2009). “2009 Survey and Analysis of National R&D Programs”.

Science and Technology Policy Institute (STEPI) and the Korean National Commission for UNESCO (2001). *Monitoring S&T Activities in Korea as a follow-up of the World Conference on Science*.

3
Science Education

Chapter

Science Education

I. Introduction

The issues of science education in the *Declaration* and the *Agenda* of the World Conference on Science (WCS) can be classified into the following themes: The role and objectives of science education, contents and structure of science curriculum, role of educational institutions, and the role of the government. This report uses the same thematic classification as a framework to review and examine today's science education in Korea. The analysis and evaluation of the science education were conducted mainly via literature review and expert discussion. The report analyzed the contents of the Revised Curriculum of 2007 concerning issues of the role and objectives of science education and contents and structure of science curriculum. As for the role of educational institutions and government, the report reviewed literatures published by the government and science education-related organizations and carried out discussions with experts in the field.

II. Role and Objectives of Science Education

In the *Declaration* and *Agenda* of the WCS, the role and objectives of science education are referred to as follows:

(1) Science education is essential for development of human beings, creating of endogenous scientific competency, and cultivation of active, cultured citizens (Article 10 of the *Declaration*).

(2) A broad sense of science education is the presumption to secure democracy and continuous development.... In order to improve participation of the masses on decision-making associated with application of new knowledge, it is rather necessary to develop and expand cognition on abilities and skills for reasonable thought and ethical values, as well as scientific literacy in every culture and social sector (Article 34 of the *Declaration*).

(3) Scientific knowledge and skills are strategically necessary for a nation's competitiveness and improving the standard of living. As a part of such education, students should learn how to solve specific problems and to satisfy social needs by using knowledge and functions of scientific technology.

The role and objectives of science education identified in the *Declaration* and *Agenda* may reflect the properties of modern scientific technology. In the Revised Curriculum for science of 2007, "science" is defined as a subject that is learned by all students between the 3rd and 10th grade and that is needed to develop scientific accomplishments to understand the basic concepts of science and to solve problems in daily life creatively and reasonably by cultivating abilities and attitudes for scientific research. Also, in the Revised Curriculum of 2007, the general purpose of science is "to understand the basic concepts of science by researching natural phenomena with curiosity and interest, and to cultivate scientific literacy necessary to solve problems in daily life creatively and scientifically by promoting science literacy and creative problem-solution." The detailed objectives are as follows:

1) to understand the basic concepts of science and apply them for solving problems in daily life;
2) to develop the ability to study nature scientifically and use it for problem-solving in daily life;
3) to enhance curiosity and interest in natural phenomena and science learning and to develop an attitude to scientifically solving problems in daily life;
4) and to recognize the relationship between science, technology and society.

The person sought by Korea's science curriculum resembles the role and effect of science education identified by the World Conference on Science. Korea's science curriculum seeks to foster a person who searches for individuality on the basis of holistic human development, who carves their way based on wide-ranged liberal arts, and who contributes to the development of community based on democratic citizenship. This perception of person is connected with Article 10 and 45 of the *Declaration*. However, it is generally recognized that, in the actual status of Korean education, realization of the person sought out by the Curriculum may not be possible due to the education focusing on admission to universities. The purpose of science subject in Korea is still concentrating on knowledge acquisition and enhancement of scientific research, and recognition of ethical value described in the latter part of Article 34 is not presented in the objectives of Korean science subject.

III. Contents and Structure of Science Curriculum

The contents and structure of science curriculum in the *Declaration* and the *Agenda* of the World Conference on Science are referred to as follows:

(1) Science curriculum should include ethics of science, as well as history of science, philosophy of science, and training on cultural effects of science (Article 41 of the *Declaration*).

(2) Science curriculum should be modified in consideration of effects of new technologies on scientific work (Article 20 of the *Agenda*).

(3) Curriculum related to science and technology should encourage scientific approaches to problem solving (Article 37 of the *Agenda*).

(4) New science curriculum, teaching methodology, and educational measures should consider gender, cultural diversity, and should be developed by a national educational system to meet changing needs of education in society (Article 43 of the *Agenda*).

(5) Organizations of educational institutions and curriculum used in the

institutions should be open and flexible enough to be adaptable to needs raised in society (Article 60 of the *Agenda*).

In consideration of trends in science education of foreign countries and the problems of the 7th Curriculum, the directions of the Revised Curriculum for science in 2007 are as follows:

(1) the new curriculum for science is to seek creativity;

(2) the new curriculum for science focuses on research activities;

(3) the new curriculum for science intensifies contents related to Science, Technology and Society (STS);

(4) the new curriculum for science is optimized in curriculum contents;

(5) the new curriculum for science intensifies affective domains;

(6) the new curriculum for science partially introduces diversification and autonomy of curriculum management;

(7) and the new curriculum for science is concrete for teachers to understand the levels, scopes, objectives, methods, and evaluation of the curriculum contents.

(8) and lastly, the new curriculum for science was developed to be realized in schools.

Meanwhile, the directions of the curriculum for high school elective subjects are as follows:

(1) the contents are improved by reflecting requirements of the nation and society;

(2) the amount and level of curriculum is optimized;

(3) and the learners are presented of significant learning experiences.

Science curriculum should present knowledge and experience that is needed for learners to understand natural phenomena, to solve problems in daily life, or to major in relevant domains. In this context, Course I of each subject is organized to provide significant learning experiences to all students regardless of their courses by using materials and contents in daily life that students are interested in, via topic-centered approaches. Meanwhile, Course II of each subject is organized to present preparation for students who want to major in areas of science and engineering.

In the new Curriculum, the units of science subjects for 1st-grade high school students increased from six to eight (one hour per week enhanced), and the units of Course I of each elective subject for 2nd and 3rd grade high school students increased from four to six.

| Table 3-1 | Formation of Science Subjects

School	Primary				Middle			High		
Grade	3	4	5	6	7	8	9	10	11	12
Hours(Unit)	3	3	3	3	3	4	4	8	Physics I (6) Chemistry I (6) Biology I (6) Earth Science I (6)	Physics II (6) Chemistry II (6) Biology II (6) Earth Science II (6)

* The hours of primary and middle schools indicate hours per week, and one hour means one hour per week for a year. As for high school, the number means unit, and one unit means one hour per week for a semester.

The content domain of the basic subjects was indicated to be the biggest problem in the 7th Curriculum: The subdivision of units induced difficulty in integrating teaching of the contents and preventing overlapping in contents; the inclusion of concrete activities led to excessive activities and burdens of teaching due to reduction in class hours; excessive arrangement of content and its higher levels compared to relevant grades, and low interests of students in science were pointed out as other problems. In order to supplement these issues, the revised science curriculum has been structured as follows:

- The contents for lower grades are phenomenon-centered and those for higher grades are concept-centered, according to the principles of the 7th Curriculum.
- The principle of equal arrangement for physics, chemistry, biology, and earth science is excluded, and the contents are constituted to meet characteristics of each grade. Although the number of units per domain is same, the sizes of the units are differentiated according to characteristics of each unit.
- As for unit constitution, the unit subdivision of the 7th Curriculum is exclusive, and the units are integrated to teach relevant units via systematic integration. By doing this, systematic teaching of concepts is encouraged and the amount of learning is reduced by removing overlapping factors.
- The contents are stated with concrete achievement levels for teachers to understand the scopes and levels, while not limiting teaching methods.
- In order to ensure a feasible curriculum, minimum research activities should be required with consideration of class hours per year and conditions of

laboratories and instruments in schools.

- Topics of “free science research” should be established for around six sessions per school year, in order to induce interests of students and promote autonomy, localization, and openness of curriculum management.

“Free science research” was first introduced in the new Curriculum based on the following logic and background. Science education in schools has been constituted on the basis of concept-centered system rather than interests of students. The research activities were designed as guidance for the course to induce results rather than for self-directed performance of students, for the first and second session. In such research activities, there have been few opportunities of carrying out general research activities including problem recognition, experimental design and execution, result interpretation, and deducting conclusion.

As a result, Korean students showed lower levels of confidence in science, lower recognition of the value of science, and interests in science in international comparative studies of academic achievements. In this context, it is important for the next curriculum to promote students' interests in science and to induce them to choose science courses. Therefore, in the new Science Curriculum, it is important to establish “free science research” sessions per each school in order to supplement the above-mentioned problems. The purpose of “free science research” is as follows.

- By encouraging students to choose interesting topics for self-research, students are able to gain a general understanding of science research, and enhance their interests in science.

- Teamwork is enhanced by encouraging students to choose interesting topics and explore them with peers.
- The impact of science on technology and society and of technology and society on science are recognized via researching topics related to daily life.
- Aptitude of science is discovered and choosing science course is considered via various research topics.
- Creativity is promoted by designing research methods and presenting research results.

Table 3-2 and Table 3-3 show the content structure of the 2007 Revised Curriculum and examples of unit contents.

| Table 3-2 | 2007 Revised Science Curriculum Content Structure

Grade / Field	3rd	4th	5th	6th	7th	8th	9th	10th	
Motion and Energy	• Properties of magnets • Light traveling in a straight line	• Weight • Heat transfer	• Speed of an object • Electric circuit	• Light • Energy • Magnetic fields	• Force and motion • Electro-statics	• Thermal energy • Light and waves	• Work and energy • Electricity	• Motion of an object • Electroma-gnetism	• Energy in nature
Material	• Object and Materials • Liquid and Gases • Separation of Mixtures	• Phase change of water	• Dissolution and solution	• Acid and base • Various gases • Combustion and extinguishment	• Three Phases of matters • Molecular motion • Phase change and energy	• Composition of substances • Compounds around us	• Nature of Matter • Electrolytes and ions	• Regularity in chemical reaction • Various chemical reactions	
Life	• Life cycle of animals • Animal's world	• Life cycle of plants • World of plants	• Plant structure and functions • World of microorganism • Human body	• Ecosystems and environments	• Organization and diversity of living organisms • Plant nutrition	• Digestion and circulation • Respiration and excretion	• Stimulus and response • Reproduction and development	• Inheritance and evolution • Life science and the future of the human species	
Earth and Space	• Weather and Our Life	• Geological strata and fossils • Volcanos and earthquakes • Change in the earth surface	• Earth and the moon • Solar system and stars	• Weather changes • Seasonal changes	• Earth's crust materials and changes • Tectonic movements and plate-tectonics	• Solar system • Stars and the universe	• Characteristics of atmosphere and weather change • Composition and movement of sea water	• Earth system • Movement of celestial bodies	

| Table 3-3 | 2007 Revised Science Curriculum Contents

Seventh Grade Contents (2007 Revised Science Curriculum)
A. Three phases of matters
(a) To observe the various phase changes such as vaporization, liquefaction, solidification, melting, and sublimation and explain them by using models.
(b) To compare the differences in molecular arrangement depending on the phase of matter, and to realize the importance of model usage and its limitations.
1) Research activities
(a) To express the phases of matter using models.

As in the structure of science subject, the contents of ethics of science, history of science, philosophy of science, cultural effects of science presented in Article 41 of the *Declaration* are rarely included in the contents of the Korean Science Curriculum. On the contrary, the "teaching and learning methods" presented in the Korean Curriculum include plans of learning guidance, preparation and utilization of materials, methods of teaching, guidance of experiment and practice, and guidance of in-depth and supplementary learning. In the new Curriculum, a guide for "creativity promotion," science writing, and discussion were added, and methods of guidance on the newly-introduced "free science research" course was also presented.

| Table 3-4 | 2007 Revised Science Curriculum Contents (continued)

1) Lesson Plan
(3) Lessons are planned to allow science writing and discussion about societal issues related to science and science contents.
(5) For 'free science research', appropriate topics are selected at the beginning of a semester, and times and teaching strategies are planned while referring to examples of

given topics for 'free science research' at individual grades.

※ Examples of topics: third grade (animals, safety), fourth grade (plants, dinosaurs), fifth grade (health, robots), sixth grade(fire, environment), seventh grade (ridings, natural disaster, sports and science), eighth grade (universe, optical instruments, plastic), ninth grade (oceans, science in our home, misuse and abuse of drugs), tenth grade (future science, professions and careers, electromagnetic waves)

2) Preparation and Utilization of Materials

(2) Use objects and materials related to advanced science in our surroundings in order to enhance the interests and curiosity towards science.

(3) List science reading for discussion and science writing about advanced science, scientists, science history, etc.

(6) Prepare materials needed in school levels for favorable performance of "free science research."

3) Teaching Strategies

(5) Assign science writing and discussion tasks, and discuss the societal issues related to science to nurture scientific thinking, creative thinking, and communication skills.

(9) Introduce the science contents of advanced science, scientists, and current events in order to instill interest and curiosity.

(10) For 'free science research', students should plan themselves and creatively perform topic selection, making plans, conducting researches, and making presentations. Because 'free science research' is considered as a long term task, frequently check task progress and provide the proper encouragement and advice.

The main contents of teaching and learning methods of the 2007 Revised Curriculum can be said to include the contents of Article 41 of the *Declaration* and Article 20, 37, 43, and 69 of the *Agenda*. However, for these methods to be applied, consistent efforts are needed to include the subjects in the content structure of the curriculum as well, and not only in its teaching and learning methods.

After establishment of the 2007 Revised Curriculum, the PISA 2006, which is an international comparative study of academic achievements conducted by the OECD, showed that the academic achievements of Korean 15-year-old students (usually the 1st graders of high schools) had gradually decreased (see Table 3-5). The average science literacy index of the OECD was 47 to 65%, while the average Korean index was very low (15 to 34%). In particular, 31% of Korean students thought that they learnt science quickly and only 20% thought that science was easy, indicating that most Korean students regarded science to be difficult. Meanwhile, the average of students who were interested in science was 47%, lower than that of the OECD average (63%). The average of students who said solving science problems is pleasant was 27%, relatively lower than that of the OECD (43%).

It is doubtful whether the decrease in academic achievements and the negative attitude on science literacy can be reversed only by revisions of the national curriculum.

| Table 3-5 | Science Achievements of Korea in PISA 2000, PISA 2003, and PISA 2006

		PISA 2000	PISA 2003	PISA 2006
Whole Survey	Korean Rank	1	4	11(7~13)
	Average Score	552	538	552
	OECD Average	500	500	500
Upper 5%	Korean Score	5th Rank (Tie)	2	17
	Average Score	674	695	662
	OECD Average	662	668	652

Meanwhile, in the 2008 College Entrance Examination in Korea, many students selected human and social science courses than science subjects because only 27.2% of colleges designated science as a compulsory subjects for natural science majors and only 18.4% of colleges designated science as compulsory subjects for engineering majors. Furthermore, the government announced that elective subjects of science will be reduced from the maximum four to two since the 2012 national scholastic achievement examination for the college entrance, in order to reduce the learning burden of students and household spending in private education.

In this context, in order for students to choose science and to consistently pursue a career in science in the future, follow-up measures and efforts are needed to increase interest in science and encourage science studies in addition to the revision of the national curriculum. Given the effects of college entrance exams on school education, efforts to prevent weakening of science education should be actively sought through relevant policy measures.

IV. Role of Educational Institutions in Science Education

The *Declaration* and the *Agenda* of the World Conference on Science states the role of educational institutions as follows:

(1) Educational institutions should encourage students to contribute to decision making on education and research (Article 44 of the *Agenda*).

(2) Educational institutions should offer basic science education to students

who major in fields other than science. Also, educational institutions should provide opportunities of lifelong learning in science field (Article 47 of the *Agenda*).

The STS teaching-learning model is regarded to be the model in which the process of decision making is a key framework, as stated in Article 44 of the *Agenda* (Piel, 1993). The US and Britain have already established training decision-making as a new objective science education (Solomon, 1993; Stahl and Stahl, 1995). The American Association for the Advancement of Science (AAAS, 1993) and the National Science Teachers Association (NSTA, 1990) emphasize decision-making in science education. The AAAS argues that students can be promoted of their decision-making ability via researching social, environmental, political, technical, and scientific cases. It also argues that there are always various alternatives to a problem and that students can gain decision-making abilities through analyzing alternatives and potential risks. As for Korea, some practices of decision-making for students are being conducted in science teaching-learning by STS approaches and in education of ethical aspects of science. However, the dominant approach continues to be the traditional teaching-learning method. In this context, the new Science Curriculum intensifies contents related to Science, Technology, and Society (STS) to actively reflect the relevant contents in learning process, and include free science research activities to help students to recognize the impact of science and technology on society and vice versa via exploring topics related to daily life.

In Korea, as for Article 47 of the Agenda, there are education universities in each city, province, and region, in addition to the national and private universities that have teachers' colleges. Apart from universities, science research centers, research centers for technology development, industries, and factories are included in the relevant institutions. But the manpower and facilities of relevant institutions in universities or local communities cannot be utilized sufficiently for science education. Also, universities and relevant institutions are passive in research on and contribution to school science education.

In particular, there are several problems related to teaching basic science in schools. First, there is lack of opportunities of individual experiments: Group experiments are performed much more than individual ones. Because a group consists of six to eight students, it is not possible for all members of a group to participate in an experiment. Also, not all the schools have science laboratories: According to the data, the rate of schools having science laboratories in 2000 differed greatly between cities and provinces (66% to 100%). As for the rate of science laboratories per school grade, that of primary school was 85%, middle school was 79%, and that of high school was 76%. In other words, the rate of having science laboratories in primary schools, where use of the laboratories is not essential, was higher, while that of middle schools, where the laboratories are frequently used, was lower. Though around 50% of middle schools have experiment preparation rooms, many schools located in rural areas whereas those located in big cities do not have experiment preparation rooms and store various experiment instruments within their laboratories. Thus, it is difficult to ensure safety of dangerous materials and there is inadequate space for experiment activities.

Furthermore, classes experience the problem of insufficient opportunities for outdoor lectures and field studies. The national curriculum does not prescribe outdoor lectures and it is difficult for the schools to independently plan field studies due to lack of sufficient hours for science education.

In addition, most education processes and methods at institutions for science teachers are focused on concepts and theories. Due to this emphasis, teachers experience difficulty in understanding the structure and logic of science, developing a wider understanding of science, and indentifying applications of science in daily life. Most primary school science teachers are not confident in science education because they failed to understand its in-depth concepts and have not been trained in science researches. Thus, they tend to be reluctant to teach science or teach misconceptions that later on served as obstacles in developing an interest in science education. In particular, teachers experience difficulties in teaching scientific concepts, methods of scientific research, concept of creativity, and ethics of science presented within the curriculum.

V. Role of Government in Science Education

In the *Declaration* and the *Agenda* of the World Conference on Science, the role of government is referred to as follows:

(1) Governments should place top priority on improvement in science education conducted in all levels....measures should be taken to promote development of professional competence of teachers and educators facing changes (Article 41 of the *Agenda*).

(2) For science teachers and those who work for non-formal science education in all levels, opportunities should be given to renew their knowledge consistently in order to perform their educational jobs as much as possible (Article 42 of the *Agenda*).

(3) National agencies and support institutions should promote roles of science museums or science centers as an important factor of science education for the masses (Article 49 of the *Agenda*).

(4) Non-governmental organizations should perform important roles in the process of teaching science and sharing experiences in education (Article 46 of the *Agenda*).

(5) National policies including consistent and long-term support on scientific technology should be adopted in order to secure intensification of human resource basis, establishment of science institutions, promotion and improvement of science education, integration of science into pan-national culture, development of substructure, and promotion of technological and innovative competence (Article 55 of the *Agenda*).

In Korea, curriculum to improve science education in primary, middle, and high schools and capacity building of teachers has been raised to be an important policy area due to the decline in academic achievements in science. For instance, scientific literacy of the first graders of high schools has considerably been on the decline: It was 1st in 2000, 4th in 2003, and 11th in 2006 in PISA. In this context, Korea is enlarging support in policy to develop teaching methods of science via development of science textbooks for next generation. The textbooks for the first graders of high schools were distributed to 355 schools after authorization in 2007, the textbooks for the third and fourth graders of primary schools and for the first graders of middle schools have been used in experiment schools after development in 2007. The textbooks for the fifth and sixth graders of primary schools and the second graders of middle schools are being developed. Also, training for current science teachers to intensify their expertise is being promoted by using universities with research competency. For instance, the training center for high-tech science teachers was established at Seoul National University in November 2007, where 500 science teachers per year are being trained.

Meanwhile, with the start of the Ministry of Education, Science and Technology, the previous Korea Science Foundation was reformed to be the Korea Foundation for the Advancement of Science & Creativity (KOFAC) in order to benefit from the synergic effects of science and education. The foundation is conducting investigation, research, policy development to support the cultivation of creative human resource, development of science curriculums and training of experts in education of creative human resource. Also, it is making interdisciplinary efforts to cultivate human resource for scientific technology via “Basic Plans of Cultivation and Support for Human Resource in Science and Engineering from 2006 to 2010.”

Conclusively, Korean government has realized the importance of following the guidelines proposed by the *Declaration* and the *Agenda* but there is still room for improvement. Constant and active efforts by the government are needed to improve science education.

VI. Conclusion

The following suggestions to improve science education can be drawn from the above-mentioned discussion. First, there is need to reexamine the role and purpose of Korean science education. It is important to establish objectives not for the stake of having them, but ones that can be realized in science education. It is necessary to establish concrete and feasible objectives to meet requirements and needs in today's knowledge-intensive society.
Second, it is necessary to assess the science curriculum and to intensify studies on the assessment criteria. Curriculum that is newly announced without assessment of previous curriculum or that is revised periodically as time passes cannot include content structure to meet the requirements of the world today. Furthermore, revision of science curriculum should be accompanied with sufficient time for research and various opinion gathering efforts.

Third, there is need to expand science and technology courses at the university level. In particular, subjects on various aspects of science and technology and topics integrating natural, human and social sciences are needed.

Fourth, support of government departments should be intensified in order to develop science education and to improve its quality. Support from relevant authorities such as the Ministry of Education, Science and Technology is needed in order to realize the objectives and role of science education presented by the National Curriculum. Support for improving job performance of science teachers is also required. In particular, the Ministry of Education, Science and Technology needs to expand its support for the popularization of science to the public.

References

English Publications

American Association for the Advancement of Science (AAAS) (1989). *Science for All Americans*, Washington D.C.: AAAS Publication.

American Association for the Advancement of Science (AAAS) (1993). *Benchmark for Science Literacy*. Washington D.C.: AAAS Publication.

Blosser, P.E. and Helgeson, S. L. (1990). *Selected Procedures for Improving the Science Curriculum*. ERIC Document Reproduction Service No. ED325303.

Blosser, P. E. (1994). *Current Projects and Activities in K-12 Science Education Curriculum Development*. Accessed at http://www.ed.gov/databases/ERIC-Digests/ed324194.html.

Nakakiri, G. (1992). "Topics in the Science Curriculum, Grade K-12", in *Science Curriculum Resource Handbook*, edited by Cheek, D. W. Kraus

International Publication.

National Science Teachers Association (NSTA) (1993). *Scope, Sequence, and Coordination of Secondary School Science: Vol. 1. The Content Core*.

Korean Publications

Cho, H. H. (1994). *STS and Science Education*. Seoul: Kyoyookkwahak publishing company.

Kim, B.K., Kwun, J.S., Kim H.N., Paek, S.H., Jeong, W.H., Jeong, J.W., and Choi, B.S. (1977). *A Study on Development of the Seventh Science Curriculum Amendment*. Chungbuk: Research Committee on the Amendments of the Science Curriculum of Korean National Universities of Educations.

Kim, J.H., Hong, M.Y., Lee, M.K., Jeong, E.Y., Kwak, Y.S., Sim, J.H., Lee, C.H., Choi, W.H., and Park, S.K. (2006). *A Study on How to Improve the Elective Courses based on the Seventh National High-School Science Curriculum*. Seoul: Korea Institute for Curriculum and Evaluation.

Lee, B.H., Kim, J.H., Lee, Y.R., Hong, M.K., Lee, M.K., Lee, C.H., Shin, I.Y., Sim, J.H., Kwak, Y.S., Jhun, Y.S., Kim, D.Y., and Jang, J.H. (2005). *A Study on How to Improve the Seventh National Science Curriculum*. Seoul: Korea Institute for Curriculum and Evaluation.

Lee, Y.R. (2007). "In search of development of primary school science textbooks for the next national curriculum". *A Research Material for the 52nd Study Meeting*. Seoul: Korean Society of Primary Science Education.

Lee. Y.R. (2008). "The Results of Science Assessments of Education Achievements from PISA 2006", *A Research Material for the 53rd General*

Meeting. Seoul: Korean Association for Science Education.

Lee, Y.R., Park, J.K., Lee, B.W., Park, S.K., and Jeong, Y.K. (2004). *Analysis and Evaluation of the Content Relevance in the Primary and Secondary Science Education*. Seoul: Korea Institute for Curriculum and Evaluation.

Ministry of Education, Science and Technology (1997). *Science Curriculum (7th National Curriculum)*.

Ministry of Education, Science and Technology (2007). *Science Curriculum (2007 Revised National Curriculum)*.

Park, C., Jeong, E.Y., Kim, K.H., Han, K.H., Jun, H.J. and Lee, S.Y. (2004). *Teachers, Instruction, and Achievement based on TIMSS 1999*. Seoul: Korea Institute for Curriculum and Evaluation.

4
Science Ethics

Science Ethics

1. Introduction

The World Conference on Science in 1999 provided an important momentum for science ethics in Korea. The government supported its follow-up activities including a study on the charter for scientists and engineers. Prof. Hwang Woo-suk's controversial research on stem cells drew attention both at home and abroad, and when considerable parts of his research outcomes were turned out to be faked in 2005, the importance of research ethics was strongly emphasized. This incident of falsification of a stem cell research paper was a wake up call to the awareness of research ethics in Korea.

This chapter reviews and evaluates the status of science ethics and related matters over the past 10 years in Korea, with an emphasis on the subjects included in the "Declaration on Science and the Use of Scientific Knowledge" (the *Declaration*) and the "Science Agenda-Framework for Action" (the *Agenda*) of the WCS, including Education in Science Ethics, Studies on Science Ethics, Role of Scientific Bodies, Scientists' Awareness of Ethical Issues, Provision of Advice by Scientists, and Roles of Governmental and Non-governmental Organizations. Before going into these subjects, the chapter starts from an overview of science ethics in Korea since 2000.

2. Overview of Science Ethics in Korea since 2000

The World Conference on Science (WCS) held in Budapest in 1999 provided a significant impetus for science ethics in Korea. The Korean government sent a delegation led by the Minister of Science and Technology, and as a follow-up, the Korean National Commission for UNESCO and the Science and Technology Policy Institute carried out a project to examine science and technology activities in Korea from the viewpoint of the *Declaration* and the *Agenda* adopted at the WCS and published its results as *Monitoring Science and Technology Activities in Korea* (2001, in Korean) and its shorter English version, *A Review of Science and Technology in Korea: Towards a New Contract between Science and Society* (2002). As another follow-up contribution, the Korean National Commission for UNESCO also published in the Korean language *Ethics of Scientific Research* (2001) and *Science, Technology and Human Rights* (2001).

In parallel to these activities, the Korean Academy of Science and Technology embarked on a project, “A Study on the Charter for Scientists and Engineers” which was supported by the Ministry of Science and Technology (MOST) in 2002. An interdisciplinary team of 17 researchers was set up and led by Prof. Song Sang-yong who was President of the Korean Bioethics Association. Having studied in-depth on the result of the WCS and follow-up works done by UNESCO and ICSU, and engaged in a series of intensive discussions, the research team came up with a draft charter for scientists and engineers which consisted of the following elements: (1) value of science and technology; (2) necessity of the development of science and technology; (3) sound development of scientific and technological community; (4) social responsibility of scientists and engineers; (5) ethics of science and technology; (6) institutionalization of items 4 and 5; (7) relationship between science and technology on the one hand and humanities and social sciences on the other; (8) studies and education on ethics. This draft was submitted to MOST, but there was no follow-up action to establish a charter or code of conduct for scientists and engineers.

Then came the Hwang Woo-Suk scandal. In 2004, Hwang *et al.* published a paper in *Science* claiming to have succeeded in deriving human embryonic stem cells from a cloned blastocyst. Before, as a veterinarian at Seoul National University, Hwang Woo-Suk had cloned mammalians like cows and gone on to work on human embryonic cloning. Catholic churches, NGOs, and bioethicists were critical to Prof. Hwang from the outset. Particularly, as regards the 2004 paper in *Science*, the Korean Bioethics Association, the Center for Democracy in Science and Technology, and Prof. Lee Pil Ryul at the Korea National Open University raised ethical questions such as the validity of the institutional review board approval of research protocol, authorship, and acquisition of eggs. The Korea Bioethics Association later adopted a statement urging Prof. Hwang to have an open discussion on these problems, but he rejected this call saying that the allegations were groundless and that ethicists were trying to hamper the development of technology. A TV program also questioned the veracity of Hwang's research and a group of young scientists revealed crucial flaws in it. All this led to the official investigation by Seoul National University, which concluded that the two papers Prof. Hwang published in *Science* were falsified. Consequently, Hwang was dismissed from Seoul National University, and the prosecution brought him to court under charges of fraud and the trial is still going on.

In 2000, the Ministry of Science and Technology (MOST) established the Bioethics Advisory Committee (KBAC) which would make policy recommendations on human cloning and stem cell research, including drafting the Bioethics Law. After having 13 meetings in seven months, KBAC reached an agreement on the recommendations which included such provisions as prohibiting reproductive and therapeutic cloning and allowing temporarily stem cell research on the surplus frozen embryos created through *in vitro* fertilization. However, it was not MOST but the Ministry of Health and Welfare that submitted to the National Assembly a bill 'Bioethics and Biosafety Law' which was similar to the recommendations of KBAC. Apart from this bill, a member of the National Assembly and former Minister of Science and Technology tabled a different bill 'Prohibiting Human Cloning and Stem Cell Research Law' which strongly supported embryonic stem cell research. After dragging on for three years, the Bioethics and Biosafety Act finally saw the light of day in 2004. Bioethicists and civil society groups criticized that this law was very much like the bill supporting embryonic stem cell research. They pointed out two important problems in the law. First, human embryonic cloning was permitted if approved by the Stem Cell Research Committee.

Second, the law could be interpreted to allow research where a genetic mix between humans and animals takes place. The law was to enter into force in 2005 after one year of deferment. Bioethicists and civil society groups believed that if the government had taken the recommendations of KBAC, the Hwang scandal could not have happened.

In the wake of the Hwang scandal, the government has been focusing on the promotion of research ethics. The government prepared guidelines and a source book on research ethics, and advised universities and academic societies to establish their own guidelines on research ethics. In addition to government actions, there have been efforts to make a code of conduct for scientists and engineers and to strengthen ethics education.

3. Education in Science Ethics

Article 71 of the *Agenda* emphasizes that ethics and responsibility should be an integral part of education and training of all scientists, while Article 50 emphasizes the basic principles of peace and coexistence. Article 41 of the *Declaration* states that science curricula should include science ethics, as well as training in the history and philosophy of science and its cultural impacts.

All these statements emphasize the importance of education in science ethics at higher education institutions which educate and train scientists. They also stress the need to build a system to raise awareness among students of the ties between science, technology and society, including the societal influence, ethical implications, social issues, role of scientists, and other aspects of the relationship between science and technology and the greater world. Especially, curriculum for future scientists and engineers should be improved to build their social capacity in the future as a bridge between science, technology, and society, while working in their respective research and development fields.

Monitoring Science and Technology Activities in Korea describes the status of liberal arts curriculum related to science, technology, and society (STS). The analysis of science ethics education was based on a survey of the curriculum of 90 universities whose information was available on the web. The survey was conducted in August 2001 to find the extent of education in science and engineering ethics at colleges of natural sciences and engineering in Korea. The survey revealed that of 90 universities, only 16 provided courses in science and engineering ethics. To make matters worse, the majority of the courses were focused on the environment and bioethics, which indicates a heavy imbalance in science ethics education.

Considerable improvement in science ethics education was reported in 2006 by the study conducted by Son Wha-Chul, “Analysis of Current Research Ethics Education in Korean Universities.” The scope of the study covers ethics related to research process, publication of research outcomes, joint research, operation of research labs and management of research funds, and social responsibility of researchers. The results of the study concerned not only research ethics, but the whole scope of science ethics.

A survey was conducted in 2006 on the courses offered by 163 universities and colleges selected from a total of 232 institutions registered with the Ministry of Education and Human Resources. Of the 163 schools, 132 responded to the survey. According to the survey, 75 schools, or 56.8%, offered courses related to research ethics. This figure is a remarkable increase from 17% in 2001. The status of courses related to research ethics in 2006 is as follows:

|Table 4-1| Status of Courses related to Research Ethics

	Engineering Ethics	Bio-Medical Ethics	Professional Ethics	Science, Technology and Society	Total
Number of Schools	21	43	28	36	75
Number of Curriculums	23	64	28	69	184
Number of Courses	208	127	80	267	682

Source: Son 2007

The survey showed that the number of courses related to research ethics increased significantly from 2001 to 2006. However, out of 682 courses related to research ethics, 196 courses, or 29%, were offered by four schools. It also showed that about 30% of courses related to ethics of engineering and the relationship between science, technology and society (STS) were offered by very few schools, revealing a serious imbalance.

Compared to other categories, courses related to bio-medical ethics were distributed evenly among the schools, but not many students could enroll because the number of offered courses was relatively low. Usually, courses related to bio-medical ethics and professional ethics are offered as part of the major while courses related to engineering ethics and STS are offered as part of general education. Even in 2006, 4 out of 10 schools were not offering any courses related to science ethics at all. In addition to the unavailability of courses, lack of experts and teaching materials is one of the major problems in science ethics education.

These problems arise mainly because of the interdisciplinary nature of the study of science ethics. It is difficult to assign it to a certain university department or a field of study established under conventional classification. This makes it hard not only to foster professional manpower but also to provide teaching opportunities for professionals. Considering research funds are provided according to classifications of academic fields, efforts should be made to ensure a proper position for science ethics in the classification of scientific and technological fields.

According to an opinion poll of professors and instructors who teach courses related to science ethics, in-depth and systematic teaching materials are the most important institutional tool for science ethics education. Educational materials should be developed which are effective in and relevant to the Korean situation.

In addition, it is necessary to organize academic meetings and develop training programs for those who teach science ethics in order to improve the quality and methods of their teaching. For example a teaching method which engages both an ethicist and a professional working in a scientific field and familiar with the actual research environment to teach as a team would be one solution. Currently, science and science ethics are taught in separate courses. This system should be improved so that ethics is treated as an integral part of science education.

4. Studies on Science Ethics

Article 72 of the *Agenda* stipulates that research institutions should foster the study of ethical aspects of scientific work. Since the WCS in 1999, studies on science ethics have increased greatly in Korea. Particularly, the Hwang Woo-Suk scandal had an important impact. Until his papers turned out to be falsified, the government and the media had been supporting his research and trying to make him a national hero. Voices of ethicists and civil society groups, most notably, the Korea Bioethics Association and the Center for Democracy in Science and Technology, questioning the ethical aspects of his research process were disregarded as an obstruction to technological development. Furthermore, government support was discontinued for academic events discussing science ethics like the Korea Bioethics Association Bioethics Forum for lawmakers and journalists. But, as the Hwang scandal proceeded, reflections and public discussions on the problems plaguing the research system were provoked, which led to the revitalization of studies of research ethics and the establishment of regulations to ensure the respect for research ethics. These reflections and actions, however, were generally limited to research ethics; due to over-emphasis on research ethics, other problems related with science ethics tended to be blurred.

That studies in science ethics have accelerated in Korea after the WCS is demonstrated by the number of books and dissertations, academic societies, and academic events which are related with science ethics. A search of the database of the National Library of Korea shows that the number of books on science ethics published in 2000 was 36 and this number increased to 60 in 2008, while 25 dissertations on science ethics were published in 2000 and 57 in 2008.

The Korean Association of Science and Technology Studies, established in 2000, publishes its journal twice a year, as well as holding its regular academic conference twice a year and other academic meetings several times annually, including an STS Colloquium. The Korean Bioethics Association, founded in 1998, publishes *Bioethics* and holds a regular academic conference twice a year along with irregular events. Other organizations active in science ethics include the Korea Society for Medical Ethics and the Korean History of Science Society.

The Korean National Commission for UNESCO has played an active role in the promotion of studies on and awareness of science ethics by organizing conferences and workshops such as the Seoul session of the Ethics around the World Programme in 2004 and the Asia-Pacific Workshop on Bioethics Education in 2006. It also co-organized the International Conference on the

Ethics of Nanotechnology with the Korea Academy of Science and Technology in 2007.

The Korean government has been promoting research ethics in domestic scientific and technological circles by holding symposiums and forums for professionals and researchers. The results of these studies and meetings are found in the website Good Research Practice (www.grp.or.kr), which serves as a center for information sharing and exchange of opinions among researchers and experts in science ethics. Attempts to institutionalize the assessment of ethical, legal and social implications (ELSI) have also been made. For instance, the Center for Functional Analysis of Human Genome carried out research under the ELSI program as an effort to earn public trust for human genome research.

The Technology Assessment, based on the Basic Law on Science and Technology, is conducted with respect to new technologies with economic and socio-cultural effects. The law provides that "the government shall evaluate the impact of new advances in science and technology on the economy, society, culture, ethics, and environment in advance of their applications and reflect the results on policies." Currently the Technology Assessment is conducted exclusively by the Korea Institute of Science and Technology Evaluation and Planning under the Ministry of Education, Science and Technology. The Institute evaluated technological impacts of nano-bio-IT fusion technology in 2003, RFID technology in 2005, stem cell technology and ubiquitous computing technology and nano-material technology in 2006, technological countermeasures against climate change in 2007, and technological countermeasures against national disasters and diseases in 2008. The results of those evaluations are reflected in formulating relevant national policies.

5. The Role of Scientific Associations

Article 41 of the *Declaration* and Article 75 of the *Agenda* require scientific professions to establish a code of ethics. Article 74 of the *Agenda* urges scientific bodies to comply with ethical norms, respect the freedom of scientists to express themselves on ethical issues, and to denounce misuse or abuse of scientific or technological advances. These statements indicate that the role of scientific associations is important in promoting science ethics.

As mentioned in the overview, the Korea Academy of Science and Technology conducted a study on a charter for scientists and engineers and produced a draft for it in 2002. Two years later, in the midst of turmoil brought about by Prof. Hwang's paper in *Science*, the government requested the Korean Federation of Science and Technology Societies (KOFST) to prepare a charter for scientists and engineers. A 15 member drafting group worked for three months and put forth one page document stressing contribution of science and technology to happiness and peace, value of autonomy in scientific research and a sense of social responsibility and ethics, education of future generations for the development of science and technology, public understanding of science and technology, and contribution to traditional culture and national unity. This charter for scientists and engineers was announced on 11 November 2004, World Science Day. It was hoped that the one page charter would be expanded into a more comprehensive code of conduct for scientists and engineers, but this hope was not realized in a situation where raising ethical questions related with scientific research was seen as an obstacle to the development of science and technology. But, then Hwang scandal broke out, and research ethics became the main issue. KOFST and the Korea Academy of Science and Technology (KAST) developed their own code of research ethics respectively. These two versions were merged into the Code of Ethics for Scientists and Engineers. For this work, KOFST and KAST formed a special committee, and the National Academy of Engineering of Korea and the Korean National Commission for UNESCO joined them. This code of ethics was announced on 20 April 2007. The code is composed of a preamble and 12 main items, which describe the standard practices, social responsibility, integrity, compliance with relevant laws and regulations, and respect for the research. It is not mandatory for researchers to follow the code, but it is expected to serve as guidelines for research organizations in preparing their own ethical regulations or guidelines.

In 2001, most major scientific and technological societies did not have any ethical codes or guidelines of their own, or any mention of ethics in their bylaws, with the Korea Medical Association and the Korean Society of Productive Medicine being key exceptions. But around 2005, interest in science ethics began to increase. The Korean Society for Molecular and Cellular Biology adopted its code of ethics for bio- scientists and researchers in

October 2005 and the Korean Society for Biochemistry and Molecular Biology code of ethics for bio-scientists. The “2008 Survey and Analysis on Research Ethics Activities of Universities and Academic Societies in Korea,” conducted by Prof. Lee Inje, indicates an increase in the number of committees and codes on research ethics. According to the report, as of 2008, 103 (75.7%) universities, 390 (63.3%) academic societies, and 26 (89.7%) government-funded research institutes had committees for research ethics, while 97 (71%) universities, 526 (85.4%) academic societies, and 26 (89.7%) government-funded research institutes had regulatory documents (codes, regulations, or guidelines).

Another investigation was conducted by Prof. Lee Inje in 2006 for the same purpose. A comparison of the two shows that efforts have been made by scientific organizations to establish science ethics at the university and committee level.

Because of the lack of detailed contents, such regulatory documents are not sufficient as guidelines for research or as standards for determining unethical acts. In spite of the increase in the number of universities and academic societies which adopted such documents during the period of 2006 to 2008, there were not sufficient systematic regulatory documents on research ethics. This can be seen in the following table. Most scientific organizations have regulations on research ethics, but there are few ethical codes or charters.

|Table 4-2| Status of Availability of Regulatory Documents on Research Ethics

	Total Responses	Research Ethics Included in General Provisions	Charters/Codes on Research Ethics	Regulations on Research Ethics	Detailed Guides
Univ.	136	97	23	91	20
Soci.	616	526	270	500	290

Source: Lee 2008

It was also found that committees on science ethics, when existent, were rarely active. Most of them meet only when a specific incident occurs. Universities, academic societies, and government-funded research institutes should lead efforts to refine regulations on science ethics and regularly hold ethics committee meetings to review the status of science ethics and educational activities and take necessary action, rather than wait until an incident takes place. Efforts to promote awareness of and actual compliance with science ethics on individual levels are essential, including the establishment of relevant regulations and committees.

Since codes of ethics are not mandatory, regrettably few efforts have been made to monitor how well they are being followed or to take appropriate action when problems arise. Additionally, not many organizations have codes of ethics that meet their specific needs, emphasizing only research ethics. It is not desirable that scientists and engineers dominate the process of formulating guidelines for science ethics while few professionals in humanities or social sciences are invited to participate.

6. Scientists' Awareness of Ethical Issues

Articles 21 and 22 of the *Declaration* maintain that scientists have a special responsibility to avert applications of science which are ethically wrong or have an adverse impact. This means that scientists should always keep ethical issues in mind when they perform research.

In Korea, awareness of ethical issues related to science and technology has been gradually enhanced among scientists and engineers. As research on bioscience has accelerated since 2000, issues of bioethics have drawn keen interest from the public. This trend has led scientists to reflect on ethical issues which may be caused by their research activities, as reflected in the survey on "Interest in Safety and Ethical Issues Probable in Research Process in Bioscience" conducted for bioscience researchers by the ethics committee of the Korean Society for Molecular and Cellular Biology in December 2004.

According to the survey, only 20.1% of the researchers responded that they clearly knew whether a situation was considered a safety issue or not, while 66.3% answered they did not. When asked if there are ethical rules which should be followed in the process of bioscience research, 95.7% answered yes, and 72.6% of the respondents said that they believed that following ethical rules would ultimately help bioscience research. The Hwang scandal in 2005 raised the question of the importance of research ethics in Korea. The incident led the government to support various studies on research ethics, and led universities, academic societies, and government-funded research institutes to make regulations on research ethics and organize ethics committees.

The problem, however, is that among scientists, there is a gap between the recognition of ethical issues and the actual compliance with ethical rules. The survey revealed that many of the scientists and engineers would not follow the ethical rules as established, nor try to correct the wrongs of others if discovered.

Awareness of ethical issues has continued to grow among scientists, but problems still exist, such as an atmosphere in favor of economic competitiveness over ethical behaviors, the atmosphere of laboratories, cheating in scientific research, unfair recognition of contributions in publishing research papers, and discrimination within the lab. Appropriate social and legal measures are still needed. On the whole, many more improvements are needed to firmly establish a sound ethical culture in the science and technology community.

7. Provision of Advice by Scientists

Article 62 of the *Agenda* says, “Scientific advice is an increasingly necessary factor for informed policy-making in a complex world.” It goes on to say that scientists and scientific bodies should consider it an important responsibility to provide independent advice on issues of great concern to society.

As the impact of science and technology grows, not only for the national economy but the whole spectrum of society, problems caused by scientific and technological advances also increase. Scientists have provided advice based on their professional knowledge for solving national problems, such as the Saemangeum development project in 2005, mad cow disease in 2008, and the spread of swine flu in 2009. In the case of public protests against importation of US beef in 2008, scientists made efforts to calm public fears by providing advice from an objective scientific viewpoint and clarifying facts of the disease. Although the media reported their advice, responses from the public were not as favorable as those of the media, due to public doubt in the veracity of government-associated scientists and researchers.

Small activist groups with the motto “Social responsibility for scientists” are more active in providing advice grounded on scientific professionalism than mainstream scientists and scientific bodies organized for academic purposes. Civic organizations involving scientists are noticeable mainly in the fields of bioscience, environment, and health and medical services. Good examples are the Center for Democracy in Science and Technology, the Promotion Proclamation of the Citizen's Coalition for Scientific Society, the Young Scientists and Engineers Network, the Committee for Science and Technology of Citizen’s Coalition for Economic Justice, the Citizen’s Institute for Environmental Studies, the Environment and Pollution Research Group, the Association of Physicians for Humanism, the Korean Pharmacists for Democratic Society, and the Korean Dentists for Democratic Society.

The general public as well as the government began to have a keen interest in stem cell research as it made progress in 2000-2003. The government reduced support for events related to bioethics, and mainstream scientists refrained from expressing concern over the ethical aspects of such research. However, civic groups, led by those interested in science and technology and particularly the Center for Democracy in Science and Technology, played an important role in advocating for a law on bioethics.

8. The Role of Government

Article 40 of the *Declaration* and Articles 58, 73, 75, 76, 77 of the *Agenda* ask governments and NGOs to develop ethics training programs for scientists and organize public debates on ethical implications of scientific research, while establishing an appropriate institutional mechanism to deal with ethical issues arising from scientific knowledge and its applications. The Korean government has been making efforts to promote science ethics by setting up a separate department responsible for ethical matters, launching a pan-governmental ethics committee, establishing related decrees and systems, and publishing and distributing public information materials.

The Master Plan for Science and Technology 2002-2007 includes plans to promote the social responsibility of scientists and engineers by establishing a Charter for Scientists and Engineers and offering lectures at universities to enhance awareness. The Plan for 2008~2012 includes an expansion of research ethics promotion programs as one of the major tasks. The programs include reinforced assessment of ELSI and ethics education for researchers.

As described in the overview, the government established the Bioethics

Advisory Committee in 2000 to consider ethical matters arising from the development of bioengineering. The committee consisted of 20 members, including five humanities and social science professionals, two civic organization representatives, three from religious circles, five life scientists, and five medical scientists. The Committee operated until 2001, and put forward recommendations regarding cloning and stem cell research.

In April 2005, the National Bioethics Committee was launched in accordance with the Bioethics and Biosafety Act. As an advisory body to the President, the Committee is composed of government ministers and experts from scientific and ethics circles. It deliberates on matters concerning research, development, and applications of bioscience and bioengineering which can have serious ethical and social impacts. Its mandate includes the establishment of national policies on bioethics and biosafety, the kind and scope of research using residual embryos, transplantation of nuclei of body cells, prohibited genetic tests, and kinds of diseases eligible for genetic treatment.

The government has also established a separate department whose job is to promote research ethics. The Ministry of Education, Science and Technology established the Academic Research Ethics Division to put research ethics in good order, organize forums, and handle relevant matters. Through the Division, the government concentrated efforts to establish systems for research ethics, including relevant governmental decrees until 2007. Efforts for consolidating research ethics and preventing irregularities in research have been made through the publication and distribution of guidebooks (*A Guide* *to Research Ethics* in 2007; *Practical Research Ethics* in 2007, and *Cases of Research Ethics Practices at Foreign Universities* in 2007), and organization of symposiums on research ethics.

Such efforts have been extended to youths, as well. Educational materials in animation form have been developed and distributed to middle and high school students to encourage them to be honest and impartial in their academic activities, including task performance and evaluation.

9. Conclusion

The development in science ethics continued in Korea since the WCS in 1999. This chapter has reviewed the issues of education on science ethics, role of scientific associations, scientists' awareness of ethical issues, scientists participation in policymaking and the role of the government in regards to science ethics in Korea.

The increase in the number of courses related to science ethics indicates an improvement in science ethics education. It should be pointed out, however, that those courses are not broadly available, and limited to a few schools and academic fields. Fostering professional manpower related to science ethics is still needed. Improvements should be made in educational materials and teaching methods so that education in science ethics can be more effective.

Improvements have also been made in research on science ethics, demonstrated by an increase in the number of related books and dissertations, academic societies, and academic events, as well as systems for technological impact evaluation. The role of scientific bodies and associations has been revitalized through the establishment of ethical codes and regulations, as well as?formation and operation of ethics committees. It is yet to be seen whether such systems, codes, regulations, and statements by scientists, engineers and their associations will be put into practice or be one-time gestures.

Awareness of ethical issues by scientists is not low, but there still remains a gap between awareness and action. Small activist groups are providing advice based on professional scientific knowledge more effectively and actively than mainstream scientists and scientific associations organized for academic purposes.

The Korean government has made various efforts to promote science ethics, raise awareness, and encourage action through establishing a responsible body and a pan-government committee, and issuing related decrees, while putting in place a system for the publication and distribution of information materials, particularly since the Hwang scandal of 2005. It is regrettable that these developments have arisen not out of self-reflection but as part of government initiatives. Attention has been concentrated on research ethics, not the whole spectrum of science ethics.

In view of these changes in the state of science ethics, Korea has advanced in the past 10 years. The advancement, however, has been slow and small when compared to the overall development of science and technology in Korea. Interests in and efforts for advancing science ethics has been far less than those for developing science and technology. Although the notion that emphasis on ethics obstructs the development of science and technology has changed since the stem cell scandal in 2005, the imbalance is still serious and calls for improvement. Scientists and ethicists should continuously engage in dialogue and collaborate on ethical problems.

References

English Publications

Korean National Commission for UNESCO and Science and Technology Policy Institute (2002). *A Review of Science and Technology in Korea: Towards a New Contract between Science and Society*.

Song, Sang-yong (2006). "The Rise and Fall of Embryonic Stem Cell Research in Korea", *Asian Biotechnology and Development Review*. Vol. 9, No. 1, pp 65-73.

Song, Sang-yong (2007). "The Hwang Woo-Suk Scandal Hasn't Ended", *Journal of Korean Bioethics Association*. Vol. 8, No. 2.

Korean Publications

Lee, Inje (2008) *Survey and Analysis on Research Ethics Activities of Universities* *and Academic Societies in Korea*. Seoul: Ministry of Education, Science and Technology.

Son, Wha-Chul (2007). "Analysis of Current Research Ethics Education in Korean Universities", *Philosophy and Thoughts*. Vol. 24.

Song, Sang-yong et al. (2001). *Research Ethics Related to Biotechnology*, Presidential Advisory Council on Science and Technology.

Song, Sang-yong et al. (2003). *A Study on the Charter for Scientists and Engineers*, Ministry of Science and Technology.

Science and Technology Policy Institute and the Korean National Commission for UNESCO, eds. (2001). *Monitoring Science and Technology Activities in Korea*.

5
Science Culture

Chapter

Science Culture

I. Introduction

Korea has achieved an impressive record of advancement in public understanding of science since the World Conference on Science in Budapest in 1999. At this conference, one of the themes was "science for peace and sustainable growth" that called for broad consideration of the negative side effects of science and technology development. The term Science Culture is used interchangeably with the concept of "public understanding of science" and its definition varies from country to country depending on the popularization of science and technology, the public awareness of science, public communication of science and science culture. This paper uses the concept of science culture from a more action-oriented viewpoint. In this sense, science culture is activities that intend to promote science literacy, earn public support, and advance the public understanding of science, which includes actions that intend to open communicative channels between science and society.

Science culture has evolved through three stages. The first stage emerged at the start of the 18th century French Enlightenment Movement and aimed to expand logical thinking and the scientific mind. In the second stage, attempts were made to increase public knowledge about science in order to change lifestyles and win support for science and technology. It was in this stage that science-related organizations started to establish themselves and become more dynamic.

The demand for public participation in science-related government policies started to take off in the 21st century, when science became increasingly influential over society. There is now increased awareness of the importance of opening communication channels between society and science. It was during this third stage that the power shifted from suppliers of scientific knowledge to the people who need and use it.

In the last ten years, science culture in Korea has been changed by two social issues. One was the trend that started in 2002 among Korean youth when the number of students studying science and engineering dramatically declined. This change inspired people to reflect on the important long-term solutions to ensure the supply of human resources skilled in science and technology. The second issue occurred in 2005, and brought ethical problems in emerging biotechnology to the fore. The importance of accurate science information, knowledge, sharing, and distribution became more significant, and instigated the emergence of a strong belief in the necessity of a science culture.

In this report, science culture activities that took place during the past ten years in Korea are summarized in three major areas. First, there emerged the foundation for connecting science and society. Second, there was more participation in science culture by diverse actors. Third, there was an increase in activities that intend to narrow the regional gaps in science culture.

II. Public Understanding of Science

1. Building Communication Channels between Science and Society

A. Beginning Research & Education for a Science Culture

In the past ten years, Korea has established a legal and systemic infrastructure to ensure research and education for science culture. The Science Culture Research Center (SCRC), with three regional headquarters in Seoul National University, POSTEC, and Chonbuk National University, has conducted diverse research on issues related to the ethical, legal, and social implications of science and technology. These affiliates analyzed issues associated with the advancement of science and research on measures to solve obstacles with the support of the Korea Foundation for the Advancement of Science and Creativity (KOFAC).

The SCRC and KOFAC established a graduate course in science communication and a short-term training course called the Science Culture Academy, in partnership with Sogang University. The Science Culture Academy offers a ten-week course in science communication skills for those involved in the field. In addition, KOFAC offered overseas training programs for journalists that specialize in covering science.

B. Emergence of Science-Dedicated Media

Over the past ten years, online media has increased rapidly, along with advanced IT technology. In 2004, KOFAC launched the internet science newspaper Science Times (www.sciencetimes.co.kr), and DaedeokNnet was started by the Science Research Complex in Daejeon. Science Times is published five days a week, and the number of subscribers has reached more than a million. In 2008, another online newspaper called The Science (www.thescience.co.kr) was launched by Science Dong-a, a specialized magazine.

Along with on-line media, an online portal called ScienceAll (www.scienceall.com) was launched to provide schoolchildren with science related information and knowledge. As of 2009, ScienceAll has more than 1.5 million members, and the National Broadcasting Commission selected the website as the best site for children. In addition, research institutes and science associations publish an on-line webzine and newsletter for the public. The Korea Federation of Science and Technology Societies started publishing STS Observer in 2005, while the Korea Institute of Machine & Materials publishes Kikyerang, the Korea Institute of Science and Technology Information (KISTI) started publishing the Scent of Science, the Korea Research Institute of Bioscience and Biotechnology publishes the Biozine, and the Korea Atomic Energy Research Institute publishes e-Atom. However, the most impressive development is the opening of Science TV, a dedicated broadcasting channel. In 2007, a leading Korean news channel YTN (under the support of KOFAC) started offering 24-hour-a-day programming through the Science TV channel.

C. Opening of National Science Centers

A science center in any country is an essential institute for the popularization of science and technology where visitors can enjoy and learn about science through hands-on science experience and scientific exhibits. However, there is a shortage of science centers in Korea compared to other advanced countries. In 2003, the Korean government decided to establish a five-year plan (2003-2007) to promote science centers and increase the number of science centers from 56 to 62, as well as open a National Science Center near Seoul. In November 2008, largest of these new Science Centers opened in Gwacheon, a satellite city of Seoul, drawing some 860 thousand visitors since then.

Plans to build science centers in local regions were carried out as well. With the introduction of the local government system in Korea, each city and town began competing to have larger and larger spaces dedicated for science culture. Currently, science centers are under construction in both Daegu and Gwangju, to cover the eastern and western portions of the peninsula. These will open for visitors in 2011. For regions with less than 200 thousand people, 21 theme-oriented science centers are currently being constructed.

2. Diversifying the Main Actors of a Science Culture

A. Expanding Government-Funded Organizations: KOFAC

Science culture became a major social issue in Korea in the 1990s. In 1996, the Korean Foundation for the Promotion of Science became the Korea Science

Foundation, and was designated as a public organization in charge of science related cultural projects and activities. However, the total budget and overall public interest in science culture was weak compared to science and technology in general.

In 2002, the situation improved after the percentage of youth interested in science and technology increased. The Korean government supported the Korea Science Foundation (KSF) as the central body for science culture for Korea. The KSF (now KOFAC) doubled the budget for many new projects and programs to promote an active dialogue and encourage youth to study science and technology. The Korea Science Festival, the biggest science festival in the country, hosted 190,000 participants for a week-long event with 510 programs. The International Science and Engineering Camp (ISEC), a research-oriented camp for youth aged 15 to 17 hailing from 11 countries, is held every two years. Moreover, the KSF established the Science Ambassador program, which designates some 1,000 scientists and engineers as ambassadors and sends them to schools to promote science education. The KSF also launched the Korea Science Culture Award and selects a science television producer, journalist, and writer every year.

In 2008, the government combined the Ministry of Science & Technology and the Ministry of Education & Human Resources to become the Ministry of Education, Science and Technology. In September, the existing Korea Science Foundation was re-born as a new entity under the name Korea Foundation for the Advancement of Science and Creativity (KOFAC).

KOFAC has three essential roles: First is making scientific knowledge and information widely available among the public. Second is the fostering of creative human resources by building an educational environment that focuses on creativity. Third is the convergence and communication to reinforce the public ability to respond to global issues such as climate change, water resource management, diseases, food supply problems, energy conservation, and changes that the future will bring.

With an increased budget and staff, KOFAC is the central organization devoted to science culture and actively networks with local governments, universities, industries, and NGOs to enhance the level of science education for school children and public awareness of global issues. KOFAC recently opened the Creativity Resources Center to support creativity education for schoolchildren and teachers. In addition, it established an international network called the Asian Science Culture Network between Korea, China, and Japan for stronger future collaboration.

B. Science Culture Activities by Science and Technology Related Associations and Societies

In Korea, science and technology research and development activities grew rapidly in relatively short period of time, and research on diverse subjects began to proliferate with the rapid increase in government funding for R&D. The result is an increase in the number of science-related associations and societies, now numbering more than 400. The Korea Federation of Science and Technology Societies is the largest science and technology organization in

Korea. As of 2009, it has a total 128,284 members from 432 science-related organizations. In 2003, the Korea Federation of Women's Science and Technology Association was founded with 23,000 members from 27 organizations. These two large associations publish a webzine and arrange public events promoting science culture. The Korea Federation of Women's Science and Technology Associations also hosts a science camp for young girls.

The Korean Academy of Science and Technology and the National Academy of Engineering in Korea are two organizations for outstanding scientists and engineers in Korea. These two organizations are involved in providing expert advice for governmental science policies that present recommendations to better realize the advancement of science and technology. The Korean Chemical Society is the largest single society, with over 6,500 members. The Korean Chemical Society works with youths to support science related activities, such as the development and distribution of small chemistry experiment kits. The Korean Physical Society is another large society that successfully hosted the IphO-2004 in 2004. The Korean Mathematical Society offers educational programs designed to expand the networks of those interested in math, and for the public to discover the use of math in daily life.

C. Active Participation of Science-Related NGOs

Korea witnessed a rapid increase of NGOs when the democracy movement became more prominent in the 1990s. Science-related NGOs can be divided into two groups: The first group includes organizations of people involved in science and engineering, such as the Korea Science Invention Organization, involved in the development of scientific devices and hosting science events; and the Scientists Reporter Association for journalists covering science-related issues. The other group is composed of progressive environmental and grassroots organizations. The People's Solidarity for Participatory Democracy's Citizen's Science Center is proactive in encouraging the public to participate in science and technology by issuing statements on science and engineering issues, and offering recommendations and opinions. Another organization is the Center for Energy Alternative, who offers various workshops on the ecosystem and energy, in addition to other diverse activities.

3. Narrowing the Gap in Science Culture

A. Science Korea Campaign for All Koreans

In 2004, the Science Korea Project for All Koreans started as a nationwide grassroots science movement and public campaign that resulted in narrowing the science culture gap between different regions and social classes. The Science Korea Project had four missions: Establishing a common ground by building a science-oriented society, encouraging young students to dream of a future in science and engineering by helping them develop an interest in science, and building a social and cultural foundation to popularize science as part of everyday life.

One of the main programs of Science Korea was the Science Culture City, which was designed to transform local cities into hubs of local science activity.

In this program, the Everyday Science Class was designed to take advantage of venues in local city offices for science experimentation and a Youth Science Club program was devised to support education of young scientists. After being designated a science culture city, science classes are opened and clubs related to science at primary, middle and high schools receive activity funding.

Other programs of Science Korea include the active use of mass media. A science section called “Science and Future” is issued every week by The Joongang Daily Newspaper, and a tabloid edition of “Science and Economy for Schoolchildren” is issued every month by the the Maeil Economy Newspaper. In addition, the science TV programs “Quiz Korea” and “Science Café” by the Korea Broadcasting Service were broadcast from 2004-2005.

B. “Everyday Science Class” reaching out Socially Isolated Groups

The Everyday Science Class program was inaugurated in 2004 with the goal of taking advantage of human resources with degrees in science and engineering. In the first year, the program was offered in 48 town and village centers; however by 2009, the number had increased to 450. This is considered one of the most successful models for grassroots science culture. The Everyday Science Class program is composed of four different units. First is the hamlet, village, and town-level Everyday Science Class offered once every week at a local venue. The program targets primary school students by offering a wide variety of fun and exciting science experience-oriented programs. The second is the Visiting Everyday Science Class program for those who are not mobile enough to visit town halls or hail from isolated regions. Outstanding science programs are offered continuously through this program for geographically disadvantaged people. The third kind of program is comprised of locally customized programs that cater to the special conditions of certain regions. Finally, there is an instructor re-training program designed to advance the qualifications and competitiveness of science instructors.

The Science Ambassador program was designed to encourage young students to build their career dreams in science and engineering fields, and to advance individual knowledge about science in general. Designated science ambassadors visit local primary, middle and high schools, and offer expert lectures to a wide variety of people including students, parents, and community members. This program has contributed to advancing public understanding of science and narrowing the gap of scientific experiences. In 2008 alone, the program offered more than 5,000 lectures by science experts around the country. There are additional special lectures available for socially disadvantaged people and students in remote small towns. This program has grown into a channel through which high-level science reaches the public and scientists make direct, tangible contributions to society.

C. Science Book Start Campaign for Local People

Science Book Start campaign is especially for socially isolated groups in remote regions. The campaign is designed to distribute science books to primary students in those regions and offer more field trips and education that narrows the knowledge gap between urban and rural communities. In 2008 alone, over 34,000 books were distributed to primary, middle, and high schools. Each year, KOFAC distributes over 30,000 books to socially and geographically disadvantaged people.

Despite the presence of the Korea Science Festival, the opportunity for rural people to enjoy science is very limited. Local science festivals held in five or so local cities offer residents and youth a chance to personally experience science by providing a wide variety of science events and exhibits. It is an experience-oriented science program, and greatly contributes to an increase in interest. In a partnership with local organizations, the festivals have been critical in the popularization of science, along with the Korea Science Festival.

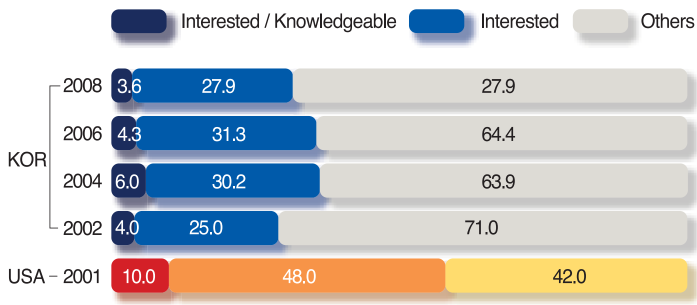
III. Public Awareness of Science Technology

1. Survey on the Public Attitude of Science Technology

A. Results Based on 2002-2008 Biannual Survey

The Korea Foundation for the Advancement of Science and Creativity has conducted a survey of public understanding of science every two years since 2002. The Survey of the Public Understanding of Science ask questions to 1,000 adults, along with 1,000 students (in 2002 and 2004 only adults were surveyed).

| Figure 5-1 | Survey of the public understanding of science



B. Major Shifts

The results of the 2008 survey revealed that 3.6% of the respondents answered that they were interested in and knowledgeable of science and engineering. In 2006, the number was 4.3%. Those who answered that they were "interested" accounted for 27.9%, a decrease from 31.3% in the previous survey. In the case of young students, 5.8% responded that they were very interested and knowledgeable in science, and 28.1% responded that they were simply interested. Younger students returned higher points in the "very interested and knowledgeable" category, but had a lower percentage in the "simply interested" category when compared to the adult group.

The level of the interest and understanding showed a gradual yearly increase until it reached over 60% in 2008. This index measures the degree of interest and understanding of science based on the degree of interest in new scientific discoveries, the use of new inventions, and the applications of technology. The average point of this index is considered the degree of public interest and understanding in science.

Participants responded that TV, Radio, and the Internet were the main media from which they learned about science. However, the number of individuals who claimed that they obtained science knowledge from the internet has been gradually increasing. The internet as a source of learning was reported at 46.9% among students in 2008. On the other hand, the significance of periodicals and magazines has declined consistently.

From 2002 to 2008, respondents showed a gradual increase in the degree of interest and understanding of science. However, there are many other sources that show students are trying to avoid science and engineering majors and science education in general. Efforts are needed to improve the qualifications of science teachers and reinforce science education.

References

English Publications

Shiele, Bernard, et al. (1994). *When Science Becomes Culture*. Canada: University of Ottawa Press.

Korean Publications

Chang, Ho-ik, Choi, Young-rak, Song, Seong-soo, and et al. (2001). *Inspecting Korean Science Technology Activities as Post-Measures of International Science Conference*. Seoul: STEPI.

Cho, Sook-kyoung (2007). "Science Communication as a Practice of Science Culture". *Journal of Science and Technology Studies*.

Kim, Moon-jo (2003). *Science Culture in Korea: The Present and Future*. Seoul: Saenggakeuinamu Publisher.

Korea Science Foundation (2002). "Public Understanding of Science and Technology Survey Results Report".

Korea Science Foundation (2003). *Overview and Future Plan for a Science-Dedicated TV Channel*.

Korea Science Foundation (2004). "Public Understanding of Science and Technology Survey Results Report".

Korea Science Foundation (2006). "Public Understanding of Science and Technology Survey Results Report".

Korea Science Foundation (2007). *Forty Year History of the Korea Science*

Foundation.

Korea Science Foundation (2004~2008). *Monthly Magazine of Science Culture*.

Korea Foundation for the Advancement of Science and Creativity (KOFAC) (2008). "Public Understanding of Science and Technology Survey Results Report".

Park, Seung-jae, et al. (2005). *Reference for Korean Science Centers*. Seoul: Science and Technology Policy Institute.

Ministry of Science and Technology (2006). *Science and Technology Annual Report 2006 Edition*.

Ministry of Science and Technology (2007). *Science and Technology Annual Report 2007 Edition*.

Ministry of Education, Science and Technology (2008). *Science and Technology Almanac 2008 Edition*.

Ministry of Education, Science and Technology and Korea Institute of Science and Technology Evaluation and Planning (2009). *White Book on Science Statistics*.

6

Widening Participation in Science

Chapter

1. Science, Technology and Innovation Policy of the 2000s: Pursuit of "Creation" and "Integration"
2. Scientific Research
3. Science Education
4. Science Ethics
5. Science Culture
6. Widening Participation in Science

Widening Participation in Science

I. Introduction

Having defined women, young scientists, the physically challenged and ethnic minorities as disadvantaged groups, the *Declaration* and *Agenda* of the World Conference on Science held in Budapest in 1999 called for increased participation of minority groups in science and technology (S&T). Participants in the conference specifically emphasized the importance of institutional efforts for eliminating discrimination in S&T education and research, pursuing equality, and building statistical data in S&T evaluation[1].

In the ten years since the World Conference on Science, the Korean government has developed and implemented various policies to promote the participation of these disadvantaged groups, including women and young scientists, in S&T. This move was driven by the policy of gender mainstreaming, which became a major global issue after the 1995 World

1. Article 42 of *Declaration on Science and the Use of Scientific Knowledge;* Article 56, 78, 82 & 90 of Science Agenda – Framework for Action; and Article 90 of the Follow-up Document.

Conference for Women in Beijing.

By emphasizing the importance of gender mainstreaming, the Beijing World Conference for Women helped enlighten Korean leaders and politicians. Following the conference, the Korean government enacted the “Basic Law for Developing Women” in 1995, developed and implemented the “1st Master Plan for Women’s Policies for 1998-2002”, and established the Ministry of Gender Equality in 2001. Though gender equality policies did not fully highlight the importance of female participation in science and technology, it reinforced gender awareness and provided momentum for female scientists to participate in key S&T committees. Furthermore, these policies were institutionalized with the enactment of the “Law for Fostering and Supporting Women Scientists and Engineers” in 2002 and the development of the “1st Master Plan for Fostering and Supporting Women Scientists and Engineers for 2004-2008”.

The Korean government’s efforts to promote women and young scientists’ participation in S&T increased with the recognition of Korean youth’s decreasing interest in majoring in science and engineering starting in the early 2000s. Analyses of the root cause of this problem revealed that poor job stability, lack of socio-economic status, the research environment, and inappropriate science education were key barriers pursuing a future in science and technology. As a result, to reverse this trend, the Korean government developed policies aimed at strengthening labor market stability in science and technology, expanding research support, and enhancing the social status of scientists and engineers. These policies were based on institutional foundations including the Special Law for Strengthening National S&T Competitiveness of 2004 and the "1st Master Plan for Science and Engineering Majors to Strengthen National S&T Competitiveness for 2006-2010."

This chapter will review the details and characteristics of policies promoting the participation of women and young scientists in S&T, and summarize and evaluate policy performance for the past ten years. In addition, the chapter will also analyze policies for other disadvantaged groups beyond women and young scientists, and explore measures to improve participation by introducing the best practices of gender equality efforts.

II. Policies supporting women scientists and engineers

1. Policy planning process

Beginning in the 2000s, the Korean government started to introduce projects that supported female participation in science and technology led by the Ministry of Science and Technology[2]. This was due to the diffusion of gender awareness and requests by women leaders in the Korean S&T community.

2. The Ministry of Education and the Ministry of Science and Technology were merged into the Ministry of Education, Science and Technology in 2008.

Female scientists and engineers launched the “Association of Korean Women Scientists and Engineers (KWSE)” in 1993 with the objectives of increasing the number of women scientists and engineers, and resolving gender inequality. The KWSE proposed various measures to support women scientists and engineers by hosting panel discussions, seminars, and talking directly to key government officials.

Key policies introduced during the early 2000s include the “Women Scientists and Engineers Research Project (2000),” the pilot of the “Women in Science & Engineering (WISE) Project (2001-2002),” and the establishment of the “Women Scientists of the Year Prize (2001)” (Chapter 8 of Chang et al., 2001). Despite their limitations and unsystematic approach, these projects brought increased attention to the issue by the Korean government.

The turning point of this policy approach was the decision by the Ministry of Science and Technology (MOST) in 2001 to introduce the “Recruit target system of women scientists and engineers” (hereafter referred to as Recruit Target System). The Recruit Target System was first proposed by women scientists and engineers in 1995 (Kim et al., 1995), but was controversial for being perceived to be violating the merit-based spirit of science and technology. However, recognizing the growing emphasis on gender awareness, the then Science and Technology Minister Kim Younghwan decided to introduce the Recruit Target System (Lee, 2009). The system was first applied by 25 government-funded research institutes under the MOST. Subsequently, in 2002, the government enacted the “Law for Developing and

Supporting Women Scientists and Engineers" to expand the application of this system to other national or public research institutes and universities. By enacting the law, the scope of policies for women scientists and engineers expanded. The new law included specific clauses for eliminating gender inequality in S&T, including the Recruit Target System. It also required the government to develop a 5-year master plan to support women scientists and engineers, promote women's entry into S&T, and support their future career paths. By implementing the Recruit Target System and the "Promotion Target by Job Levels," the law put forward affirmative action measures to overcome the so-called "glass ceiling." Furthermore, the law mandated establishing positions of responsibility for women scientists and engineers at public institutions, opening support centers for them, and conducting statistical surveys on them.

The "1st Master Plan for developing and supporting women scientists and engineers for 2004-2008" was developed to provide a basic framework for policies supporting women scientists and engineers. The 1st Master Plan can be summarized in the following nine key policy initiatives.

Nine Key Policy Initiatives

① Develop and operate female student friendly science education programs
② Maintain an appropriate proportion of female students among science and engineering majors
③ Implement affirmative action to facilitate the utilization of women scientists and engineers

④ Strengthen the capabilities of female students majoring in science and engineering
⑤ Enhance competitiveness of women scientists and engineers
⑥ Promote job creation through retraining and expanded training of women scientists and engineers
⑦ Build supportive infrastructure, including the establishment of "Women Scientists and Engineers Support Center"
⑧ Create a positive social culture and promote motivation
⑨ Promote the development and utilization of women scientists and engineers based on region

2. Key policies

A. Promote women's career in science and technology

The major avenue being used to promote women's careers in science and technology is mentoring. Mentoring programs provide opportunities to meet leading women scientists and engineers who can be role models and advisors for female students. The WISE Center provides education opportunities in science and technology for female students, including online and offline mentoring, science competitions, and internships for female students at primary, middle, and high schools. The purpose of this project is to inspire female students' interests in S&T. The program began with a pilot launch in 2001, and has opened regional centers throughout the nation starting in 2002. As of 2009, a total of 14 centers are in operation, including one hub center.

The WATCH21 program helps female students attending high school, college, and graduate school build intellectual capabilities, leadership, and network skills while conducting research activities. Participants are divided into teams with one woman scientist or engineer and a science teacher. The program began with 40 teams in 2004, and was expanded to 60 teams in 2008.

The WIE program is designed to introduce women-friendly curriculum to engineering colleges and improve the education environment. Unlike science departments, where over half of the enrolled students are female, female students in engineering departments amount to approximately 20% of enrollees. The program started to address this issue in 2007, and is now implemented in 5 leading universities throughout Korea.

In addition, the government has introduced training programs and established databases and support measures to facilitate employment of women scientists and engineers. Led by the WIST Center, these programs mainly target women scientists and engineers who have completed their education. As of 2009, one NIS-WIST is under operation in the Seoul metropolitan area and there are 4 regional centers in local provinces.

B. Enhancing competitiveness of women scientists and engineers

Policies aimed at enhancing the competitiveness of women scientists and engineers are designed to help them overcome entry barriers and break through the glass ceiling. A key example is the implementation of bonus scores for women researchers. This policy provides certain advantages to institutions hiring female project managers or members of their research teams when applying for national R&D projects. However, there are disputes over its effectiveness and it is still under consideration, pending further analysis.

In addition to the “bonus score” measure, there are research projects including the “Program to Support Progressive Research by Women Scientists” and the “Program to Strengthen Competitiveness of Promising Women Scientists and Engineers” that only involve female researchers. The former program provides research grants of around 25 million Korean won for 3 years. The latter supports unemployed women scientists with Ph.D. degrees by providing employment opportunities at universities or research institutions through a research grant of 40 million won per year. Without sufficient data, it is difficult to assess the performance of these programs.

C. Affirmative action

The Recruit Target System and the “Promotion Target System for Women Scientists and Engineers” are the major affirmative action policies for women in S&T. The Recruit Target System, first adopted in 2001 by 25 government-funded research institutes, set an annual female recruitment target of 10% for 2002, 15% for 2005 and 20% for 2010. After the enactment of the “Law for Fostering and Supporting Women Scientists and Engineers,” the system was introduced to additional research institutes. As of 2009, a total of 74 S&T institutions (99 including affiliated institutions) have adopted this system. The recruit system is planned to continue until the ratio of women scientists reaches 30% at public institutes. This system has contributed to the gradual increase of women scientists and engineers in public institutes, as can be seen in Table 6-1.

However, since the Recruit Target System only applies to new recruits, it does not guarantee employment of women scientists and engineers overall. While women were more than 20% of the new recruits in the past 5 years, the ratio of women continues to be low, around 1.6%. There needs to be further deliberation on the effectiveness of this system to ensure constant employment of women scientists and their promotion to top decision-making positions.

| Table 6-1 | Female employees at 99 public research institutes by year (2004-2008).

(unit: person, %)

Year	New recruit			Incumbent		
	Total	Women	Ratio of women	Total	Women	Ratio of women
2004	1,022	204	20.0	16.588	1.863	11.2
2005	1,042	218	20.9	16,978	1,995	11.8
2006	1,043	223	21.4	17,495	2,105	12.0
2007	859	211	24.6	17,875	2,300	12.9
2008	569	126	22.1	18,096	2,317	12.8

Source: "2008 performance and future plan of 'Recruit Target System for Women Scientists and Engineers'" p. 6, April 28, 2009, Ministry of Education, Science and Technology

The other affirmative action measure, the "Promotion Target System for Women Scientists and Engineers," helps overcome the glass ceiling and help women be promoted to decision-making positions. Unlike the "Recruit system," the "Promotion system" sets a final target of 30% instead of an annual target per year.

|Table 6-2| Performance of "Promotion Target System" for women scientists and engineers at public institutes (2008)

	Institute	2007			2008		
		Total	Women	Ratio of women	Total	Women	Ratio of women
1	25 government-funded research institutes	566	65	11.5	609	88	14.4
2	66 national and public research institutes	119	20	16.8	24	0	0.0
	19 national research institutes	94	15	16.0	14	0	0.0
	47 public research institutes	25	5	20.0	10	0	0.0
3	8 government-invested research institutes	62	5	8.1	74	8	10.8
Total 99 institutes concerned		747	90	12.0	707	96	13.6

Source: 2008 performance and future plan of the Recruit Target System of Women Scientists and Engineers, Ministry of Education, Science and Technology

D. Build a foundation for supporting women scientists and engineers

Programs including conducting current status surveys, policy research and statistical reviews are also important to support women scientists and engineers. These programs are mostly led by the WIST (Women in Science and Technology) Center and the four regional centers.[3] The current status

3. The WIST center (www.wist.re.kr) provides various reports written in Korean and English on policies supporting women scientists and engineers and surveys on women scientists and engineers.

surveys provide an overview of women scientists in the field, and a basis to devise future policies. This survey is different from other existing statistical research, with more detail and a broader scope and range. Moreover, it provides additional statistics on gender-specific issues such as the existence of women-friendly facilities, ratio of women managers, and number of women part-time employees.

3. Evaluation of policies for women scientists and engineers

For the past 10 years, policies fostering women's participation in science and technology have greatly expanded. First, these policies provide more information and training to prepare women students for a career in science and technology. Second, these policies help support women scientists with masters or doctorates with their employment, career development and research activities. Third, it provides an overview of the current status through surveys and studies led by the WIST center. However, there has been a lack of effort to promote science education at schools and encourage employment at private companies. This is mainly due to the fact that these policies were first implemented by the Ministry of Science and Technology based on proposals from science professors and researchers. School education, childcare, and employment at private institutes are issues beyond their scope.

Also, despite the higher level of career dismissals in S&T, there has been a lack of effort to improve the environment in the sector. Economic activities of women often show an M-shaped pattern as women return to the workplace after temporary leave due to childbirth and childcare. However, in the case of S&T, it is near impossible for women to return to the workplace afterwards, making the pattern an L-shape. This implies the need for a policy to ensure the reemployment of women after temporary leave. These would include capability development, promoting recruitment of experienced women scientists, and elimination of gender inequalities.

The 2nd Master Plan for developing and supporting women scientists and engineers emphasized issues such as achieving excellence in performance, preventing unfair career dismissals, and ensuring long-term employment. The key objectives are producing 30,000 female graduates with M.S. or Ph.D. degrees in the next 5 years, and securing a 25% level of female students in engineering majors at colleges. To this end, the government has planned new initiatives to support gifted women students in S&T, create S&T jobs friendly to women scientists, and build a family-friendly culture and workspace. In addition, these programs are going beyond the universities and public institutes to private companies and institutes.

In summary, policies promoting the participation of women scientists and engineers in science and technology have made a dramatic progress. One of the key achievements is reinforcing the necessity of gender awareness in S&T. There is now a consensus that active government intervention and policies are needed to eradicate gender discrimination in S&T. This recognition has resulted in the establishment of new laws and master plans that support women in science and technology.

III. Current status of developing and utilizing women scientists and engineers[4]

1. Trends in developing women scientists and engineers

A review of women scientists and engineers reveals that the education level of women scientists and engineers has increased over the past 10 years. In terms of number of graduates, female students account for about 55% of the total science graduates and about 20% of the total engineering graduates. Among those with M.S. or Ph.D., the ratio of women has steadily increased regardless of their majors (See Table 6-3 & 6-4). While government policies have helped, this positive trend has been mainly due to the advancements in society with an increase in overall education levels for women.

Despite these gains, the gender imbalance in science and engineering remains a challenge. It is noticeable that the ratio of women majoring in engineering is especially low at the M.S. and Ph.D. level, compared to bachelor's degrees. The problem of securing more women students at the graduate level in engineering has been included in the 2nd master plan.

4. Data for this section has been quoted from annual reports on "Status assessments on women scientists and engineers" published by the NIS-WIST.

| Table 6-3 | Female graduates of 4-year universities majoring in science & engineering

Area		2000	2001	2002	2003	2004	2005	2006	2007
Science & Engineering	Women	28,909	31,659	32,597	33,174	34,191	34,437	33,164	31,421
	Ratio	33.3	32.3	33.1	31.7	32.2	32.5	31.9	30.0
Science	Women	19,397	20,083	20,441	20,205	20,842	20,715	20,022	19,397
	Ratio	55.1	54.5	54.8	54.7	56.2	56.8	55.4	54.6
Engineering	Women	9,512	11,576	12,156	12,969	13,349	13,722	13,142	12,024
	Ratio	18.4	18.9	19.9	19.1	19.3	19.8	19.4	17.4

| Table 6-4 | Number of science and engineering graduate students

Area			2000	2001	2002	2003	2004	2005	2006	2007
Master's degree holders	Science & Engineering	Women	3,065	3,628	4,083	4,423	4,616	4,499	4,218	4309
		Ratio	17.2	18.7	21.3	22.1	22.5	22.9	22.6	24.2
	Science	Women	2,070	2,430	2,564	2,711	2,771	2,753	2,614	2641
		Ratio	37.3	41.2	42.3	43.9	41.2	44.3	43.7	46.8
	Engineering	Women	995	1,198	1,519	1,712	1,845	1,746	1,604	1668
		Ratio	8.1	8.9	11.6	12.4	13.3	13.0	12.6	13.7
Ph.D. degree holders	Science & Engineering	Women	431	502	506	529	574	674	706	705
		Ratio	16.0	17.9	16.4	16.6	16.3	18.4	18.5	19.5
	Science	Women	359	420	417	436	467	525	538	518
		Ratio	31.0	31.5	30.3	30.6	30.2	34.3	33.4	34.2
	Engineering	Women	72	82	89	93	107	149	168	87
		Ratio	4.7	5.6	5.2	5.3	5.4	7.0	7.6	8.9

2. Current status of women scientists and engineers

A. Participation in economic activity

Women scientists and engineers' participation in economic activities is very low compared with their male counterparts. The participation rate of female college graduates, in particular, remains low. As of 2007, the participation rate of women scientists and engineers in economic activities is 64.2%, compared to 88.6% of their male counterparts. The participation rate of women medical and pharmaceutical science majors stands at 75.1%, the highest among science-related majors. Still, this is lower than the average participation rate of male scientists and engineers. Increasing the economic participation of college graduate women scientists and engineers is an urgent task.

| Table 6-5 | Economic activity of science and engineering majors (as of 2007)

Gender /Major		Economically active population		Economically non-active population	Economic participation rate	Unemployment rate
		Employed	Unemployed			
Female	Total	3058419	104387	1764956	64.2	3.3
	Natural science	500427	18031	306657	62.8	3.5
	Engineering	293634	13626	133089	69.8	4.4
	Medical/pharmaceutical science	260878	3923	94985	73.6	1.4
	Non medical /pharmaceutical science & engineering	2003480	68907	1230225	62.7	3.3
Male	Total	5474351	197189	726876	88.6	3.5
	Natural science	782111	28006	87286	90.3	3.5
	Engineering	2504973	80622	201756	91.4	3.8
	Medical/pharmaceutical science	145269	4119	11728	92.7	2.8
	Non medical /pharmaceutical science & engineering	2491998	84442	423106	85.8	3.3

Economic activity by women scientists and engineers differs by major and age. Women participation in engineering, medical, and pharmaceutical sciences are high in their 20s, but decreases in their 30s and 40s, and increases again in their 50s. Meanwhile, for the natural sciences, the participation rate is around 70% of women in their 20s, but decreases drastically to 40% in their 30s and maintains that level afterwards. This trend is due to the difficulties women scientists face with re-employment after leaving the workplace for childbirth or childcare. Furthermore, re-employment is often in different fields than science, except for medical and pharmaceutical majors. These statistics points our attention to the importance of devising policies that support the re-employment of women scientists and engineers in their 30s or older.

B. Current status of women scientists and engineers in R&D

There has been a gradual increase in women researchers employed in R&D. As of 2007, the total number of researchers employed in R&D is 198,638, of whom 15.4% are women. Universities (21.6%) and public research institutes (18.8%) hire more women researchers than private research centers (9.2%). However, the percentage of full-time women professors is only 11-12%, implying that most female researchers at universities are part-time employees, including graduate students and post-doctoral fellows. In private companies, the percentages of women researchers are high in food, beverage and textiles, while the percentage is low in metal, machinery, and construction industries.

In addition, despite that 15.4% of the total researchers are women, they suffer from employment instability. In the R&D sector, the percentage of part-timers is much higher for women than men (see Table 6-6). The percentage of women in full-time positions in the R&D sector is around 10%, and the situation is even worse at private companies and research centers. The percentage of project leaders at small- and medium-sized companies also remains low at 1-3% (see Table 6-7).

| Table 6-6 | R&D manpower by type of institute (2007)

(Unit: person, %)

	Total		Full-time			Part-time		
	Total	Female	Total	Female	Ratio of female	Total	Female	Ratio of female
Total	198,635	30,591	138,130	13,530	9.8	60,505	17,061	28.2
Science and engineering college and university	77,785	16,778	24,661	2,737	11.1	53,124	14,041	26.4
2-3year college	19,536	5,623	6,438	1,058	16.3	13,053	4,565	35.0
4 year university	59,249	11,155	18,178	1,679	9.2	40,071	9,476	23.6
Public research institute	28,647	5,372	21,973	2,566	11.7	6,674	2,806	42.0
National/public research institute	6,747	2,197	5,001	1,139	22.8	1,746	1,058	60.6
Government-funded research institute	15,453	2,408	11,251	888	7.9	4,202	1,520	36.2
Government-invested research institute)	1,455	145	1,360	108	7.9	95	37	38.9
Non-profit research institute	4,992	622	4,361	431	9.9	631	191	30.3
Research center affiliated to private company	92,203	8,441	91,496	8,227	9.0	707	214	30.2
Food/beverage and textile	3,707	1,484	3,584	1,392	38.9	123	92	74.8
Chemicals	10,874	1,953	10,806	1,922	17.8	68	31	44.9
Metal	2,612	118	2,599	113	4.3	13	5	38.6
Machinery	63,230	3,571	63,825	3,504	5.6	415	67	16.1
Construction	2,395	146	2,344	131	5.6	51	15	29.5
Service	9,386	1,169	9,348	1,165	12.5	38	4	11.1

| Table 6-7 | Distribution of project manager by R&D player (2004~2006)

Key R&D players	2004			2005			2006		
	Project manager	Male	Female	Project manager	Male	Female	Project manager	Male	Female
National/public research institute	1,086 (5.1)	948 (4.9)	138 (6.2)	1,095 (5.1)	938 (4.9)	157 (6.7)	1,149 (5.6)	970 (5.2)	179 (9.7)
Government-funded research institute	2,459 (11.5)	2,251 (11.7)	208 (9.4)	2,660 (12.3)	2,386 (12.3)	274 (11.7)	2,512 (12.3)	2,305 (12.4)	207 (11.2)
University	10,818 (50.4)	9,362 (48.7)	1,456 (65.6)	11,473 (52.9)	9,823 (50.8)	1,650 (70.2)	9,784 (48.0)	8,595 (46.4)	1,189 (64.4)
Large company	499 (2.3)	486 (2.5)	13 (0.6)	497 (2.3)	484 (2.5)	13 (0.6)	703 (3.5)	691 (3.7)	12 (0.7)
Small/medium company	5,490 (25.6)	5,159 (26.8)	331 (14.9)	4,663 (21.5)	4,515 (23.4)	148 (6.3)	5,150 (25.3)	4,973 (26.8)	177 (9.6)
Government ministry	-	-	-	-	-	-	91 (0.4)	65 (0.4)	26 (1.4)
Others	1,105 (5.1)	1,032 (5.4)	73 (3.3)	1,289 (5.9)	1,181 (6.1)	108 (4.6)	982 (4.8)	926 (5.0)	56 (3.0)
Total	21,457 (100.0)	19,238 (100.0)	2,219 (100.0)	21,677 (100.0)	9,327 (100.0)	2,350 (100.0)	20,371 (100.0)	18,525 (100.0)	1,846 (100.0)

The number of female researchers in management positions serves as a good indicator that shows the status of women scientists and engineers in research institutions. Interestingly, there is only marginal difference of the percentage of female managers among institutions. The percentage of female researchers in management positions at S&T colleges and universities are similar to that of the female professors. At public research institutes, only half of the female researchers have experience in serving in management roles. The situation is worse at private companies, where there are few female researchers to start with. There are only a handful of female project managers overall in the field.

| Table 6-8 | Female researchers in management position by institution type

Unit : person, %

		S&T colleges & universities	Public research institutes	Private research centers	Total
2004	Total	7152	3554	1636	12342
	Female	740	158	145	1043
	Ratio of females	10.3	4.4	8.9	8.5
2005	Total	7176	3865	2221	13262
	Female	778	198	88	1064
	Ratio of females	10.8	5.1	4.0	8.0
2006	Total	7668	4085	14252	26005
	Female	897	202	546	1645
	Ratio of females	11.7	4.9	3.8	6.3
2006	Total	7190	4109	15865	27164
	Female	851	197	625	1673
	Ratio of females	11.8	4.8	3.9	6.2

The absolute number of managers increased as the number of samples from private research centers has been expanded since 2006.

A review of the current status presents the following policy implications: First, there should be increased effort to promote employment of women scientists and engineers at private companies and research centers. Second, this goal can only be achieved by creating women-friendly workplaces at private companies. Third, effective training programs and re-employment measures are in need to secure career stability for women scientists and engineers. These measures can best be implemented in R&D services and S&T education-related jobs.

IV. Policies promoting young scientists and engineers

1. Impact of the youths' decreasing interest in science and engineering

Policies devised to promote interest in science and engineering among youth groups are important to secure a stable work-force in S&T. The shift to a knowledge-intensive society has made S&T human resources policies focus more on the quality of the work-force than the quantity. Hence, the key components of policies related to young scientists and engineers include S&T education, vocational training, information sharing, and career development support for science and engineering majors. Related polices are broadly divided by age groups: One for primary, middle, and high school students, and the other focused on college and graduate students. Details of the former group, including informal science education programs, are addressed in the "Master Plan for Building S&T Culture," while education and research support for the latter group is included in the "Master Plan for Developing and Supporting Scientists and Engineers." Furthermore, the government has developed and implemented a separate plan to foster gifted and talented young scientists and engineers since 2008.

These policy approaches were triggered by the decreasing interest of youth in science and engineering. Various programs were implemented in the 1990s to promote the importance of science for teenagers and support the development of a sound S&T workforce. Key examples of these programs include the post-doctoral fellowship program, support for new recruits in

R&D, and internship programs for unemployed young scientists and engineers (Chang et al., 2001, Chapter 5).

However, reluctance to major in science and engineering was exacerbated by the decreasing interest of teenagers in science and engineering subjects and the increased number of drop-outs of science and engineering majors at the college and university levels. The primary causes of this trend has been the focus on the college entrance examination, allowing cross-applications between science and liberal arts during college applications, and an increased preference for liberal arts and social science majors compared to natural sciences and engineering. In addition, experts have also indentified a lack of research support, deprived research environment, reduced job stability, and insufficient socioeconomic compensation for scientists and engineers as major causes of the decreasing popularity of science and engineering majors (Lee, 2006).

As a result, the Korean government has introduced a two-phase system of long-term policies geared toward infrastructure and systemic reform, and short-term policies that can bring visible and immediate change. First, the government revised the college entrance system to restrict cross-application between the liberal arts and natural sciences. It established the position of “Information, Science, and Technology Advisor to the President” to enhance the importance of S&T and to open up a senior position for scientists and engineers in the government. The government also implemented programs and established positions such as the “S&T Ambassador” to present role models for young scientists and engineers. Furthermore, it introduced the "Presidential Science Scholarship" program in 2002 to support overseas studies of young scientists and the "Prize for Talented Scientists and Engineers" in 2003 to support promising research.

Long-term policies focused on changing the overall culture and changing the environment. Key examples are the "Creating an S&T Culture" and "Developing Young Scientists and Engineers" programs. The S&T culture program has been implemented since 2002 as part of a 5-year Master Plan, which included various activities such as science clubs, festivals, and publications.

In addition, within the boundaries of the existing S&T human resource policies, the "Special Law to Support Science and Engineering Majors for Strengthening National S&T Competitiveness" (hereafter referred to as the "Special Law for Science and Engineering") was enacted in 2004 to systematically implement policies supporting young scientists, including graduate and undergraduate students, to improve their professional prospects. The law directed the government to develop a 5-year master plan, conduct surveys, and provide information to support young scientists and engineers. Furthermore, it proposed to seek opportunities for scientists and engineers to enter the government, including as high-rank government officials, and facilitate employment at private companies.

Realizing the limitations of the previous policies, the new administration under

President Lee Myung-bak, who came into office in 2008, devised new policy positions and expanded the scope of education for scientifically-gifted students to university level. This detailed policy position was summarized in the “Master Plan for Identifying and Supporting the Talented and Gifted in Science.” This master plan aimed to “identify the top 0.7% of students that are gifted in science at all grade levels, and systematically support and mange their education by 2012.” In accordance with this new policy position, in-depth research and education programs have been implemented to help identify gifted students at the primary and secondary school levels, and support their education until they finish university.

2. Policies to develop S&T human resources

Other government policies to support the development of S&T human resources outlined in the “Special Law for Science and Engineering Majors” include innovative college education for S&T majors, developing core research capabilities, producing demand-oriented talents and skills, ensuring the welfare of scientists and engineers, expanding international exchange among scientists and engineers, and building a solid S&T human resource infrastructure. The innovation of college S&T education is implemented through the “Engineer Education Certification System,” with support from the “Engineering Education Innovation Center.” This program aims to reform engineering education so that it can reflect new developments in S&T and the demands from the private sector. As of 2008, 60 universities are operating “Engineering Education Innovation Centers.”

Policies to develop core research capabilities aim to develop S&T research groups that have global competitiveness. Related programs include the "Excellent Research Lab" program and "World Class University" program which supports large-scale research groups, as well as programs that provide scholarships to high caliber graduate and undergraduate students. Programs that are geared towards developing demand-oriented talents and skills focus on building a skilled S&T workforce in promising fields that can provide frontline research and regional specialties. These programs include support for graduate and undergraduate student's participation in research, providing scholarships, and establishing training programs on specialized fields.

The government has also devised programs to support the international exchange of young scientists and engineers, including training programs in the form of overseas internships and financial support for doctorates to work as visiting researchers at foreign research centers. Establishing joint education programs in S&T with foreign universities also belongs to this category.

Young scientists and engineers are in need of support to provide them with job stability and additional compensation. The average social status and salary of young scientists and engineers is below that of medical and pharmaceutical specialties, as well as human and social science graduates. Programs in this category support the expansion of employment for scientists and engineers with doctorates, and the re-employment of retired scientists and engineers. For instance, the government provides financial support to small- and medium-sized companies that hire doctorate researchers for a certain period, which will both improve the employment of S&T doctorates and the technological capabilities of small- and mid-sized firms.

Efforts to build a solid S&T human resource infrastructure first aim to understand the current status and major issues of the S&T workforce, and use these understandings for policy research and planning. The "Survey of the Science and Engineering Workforce," conducted in accordance with the "Special Law for Science and Engineering Majors," has only around 3,200 samples as of 2008. However, the Survey included additional items from past surveys, such as the "Report on R&D Activities in Science and Technology," including job satisfaction, salaries, and future plans that are useful in understanding the current status of the S&T workforce. When completed, the survey will serve as a useful indicator for developing effective S&T human resource policies.

Programs to improve education for the scientifically-gifted emphasize overcoming the phenomenon of young students' decreasing interest in S&T by focusing on the quality, rather than the quantity of the young scientists and engineers. Accordingly, programs are structured to identify and support gifted students at an early age and provide support and systematic management so that they can become the core of Korea's S&T capability. The training centers for the scientifically gifted operated by the district education office are mainly responsible for education at the primary school level, while science centers run by universities are responsible for advanced education at the secondary and higher levels. At the high school level, science high schools and the Pusan High School for the Scientifically Gifted in particular, established in 2005, play a leading role in science education for the gifted. Moreover, the government is planning to establish additional high schools for talented and gifted students. In addition, it is also planning to promote high-level research at the university level through various programs (see Table 6-9), revise existing laws to be favorable towards education of the scientifically gifted, establish research organizations, and conduct surveys on the outcomes and progresses of such policies.

| Table 6-9 | Structure of programs for the scientifically gifted students

	Programs	Ratio of the beneficiaries
Challenge & Creativity Program	• Offer education for gifted students focusing on experiment and research to maximize their creativity; • Focused management at the national level	Top 0.1%
In-depth Program	• Support separate education of science and mathematics; • Lay the foundation for the education for the scientifically gifted focused on experiment and research	Top 0.3%
Basic Program	• Provide opportunities for the education of the scientifically gifted	Top 1~1.3%

※ Detailed targets for the education of the scientifically gifted and talented studnets (2012, per grade): elementary school (4th~6th grades, some 8,100 students; 1.3%), middle school (some 6,300 students; around 1%), and high school (some 2,100 students; around 0.3%).

The government has also revised its national scholarship program providing direct financial support for young scientists and engineers. The national scholarship programs have been merged into a single source, called the "Korean Student Aid Foundation," established in 2009. The program provides scholarships for high school seniors entering college in all fields, including science and engineering. While the general scholarship program mainly provides financial support for poor students, the science and engineering scholarships are mainly offered based on academic excellence. There are detailed sub-categories for the scholarship including the Presidential Science Scholarship, National Scholarship for Science and Engineering Majors, Research Scholarship for Science and Engineering Graduate Students, and Scholarship for Excellence at Local Universities.

5. Participation of the disadvantaged group in science and technology activities

The *Declaration* and *Agenda* of the 1999 World Conference on Science mentions various groups including women, young scientists, and the physically challenged as disadvantaged. Since S&T is affected by factors including education, employment, and industrial structures, policies to support S&T differs from country to country. Compared with other countries, Korea is regarded as strong in higher education and has a relatively wide range of career opportunities in S&T. As of 2008, around 84% of the high school graduates enter college, with some 40% of the total college enrollments being in science and engineering majors, including medical and pharmaceutical sciences.[5] This is not much different from the 42.3% enrollment in human and social sciences.[6]

5. “2008 Basic Statistics on Education, Ministry of Education, Science and Technology

However, there remain groups that are deprived of these opportunities. These groups lack the same opportunities due to low income, age, area of residence, and difference in race. In Korea, there is a widespread gap between the rich and poor in private education. According to a 2008 survey, 39.7% of the households with a monthly income of over 7 million Korean won spend over 5 hundred thousand won per month on private education, while only 0.5% of the households with monthly incomes less than 1 million won do so (Hyundai Economic Research Institute, 2009). Teenagers from low income families are also excluded from government support measures that focus on the scientifically gifted students. While there are programs such as the "Everyday Science Class" and "After-school Science Class" that provide science education at relatively cheap cost, the level of participation of students from low income families is not clear. Therefore, it could be beneficial to introduce a voucher system as a means to facilitate the participation of students from low income backgrounds in these science education programs.

Age also acts as a hindrance to science education. The government has implemented programs to encourage the re-employment of retired scientists and engineers by providing support to public and private research institutes for hiring retirees. In addition, it is also providing diverse training programs to

6. The number of students enrolled at 4-year universities in 2008 was 321,752, of whom 136,186 were liberal arts and social science majors, while 130,504 were science and engineering majors (including medical/pharmaceutical science), 15,549 were education majors, and 39,623 were art and athletics majors. The number of basic science and engineering majors except for medical/pharmaceutical majors was 116,636, 36.2% of the total enrollment (Source: 2008 Basic Statistics on Education)

support their re-employment. However, the main targets of these programs are a small number of experienced researchers, rather than the overall majority of scientists and engineers.

Area of residence can be an obstacle to pursuing an education or career in S&T, since most of the resources are concentrated in the Seoul Metropolitan Area. Graduates from local universities are bound to have limited opportunities in S&T. The former Roh Moo-hyun administration emphasized the importance of a balanced regional development, and encouraged regional equality in developing S&T human resource policies. For example, the government offered exclusive research projects, scholarships, and programs to strengthen the capacities of regional universities and regional research institutes. However, the government still lacks adequate support for the employment of science and engineering graduates from regional universities.

Children from multi-ethnic families are also in need of support. According to an official survey in May 2009, there are 103,484 children from multi-ethnic families, of which 87% are under 12 and 60% are under 6. This means that one quarter of the children from multi-ethnic families are attending primary school and over half are under school age. While race has not been a major social issue in Korea as of yet, the number of multi-ethnic families is on the rise and they are in need of more support, as indicated from the survey results. Though the “Law to Support Multi-ethnic Families” was enacted in 2009, there are yet no policies that promote science and technology education and opportunities for multi-ethnic groups.

6. Conclusion

In the 10 years after the 1999 World Conference on Science, Korea has made impressive achievements in promoting participation in science and technology. In particular, while policies to promote the participation of women in S&T did not exist before 2000, now these policies have become a major pillar of the government approach through the enactment of relevant laws and development of master plans.

The scope of the “2nd Master Plan for Developing and Supporting Women Scientists and Engineers” has been expanded not only to education and research activities, but also to increased employment and re-employment and the prevention of career dismissals by building a family-friendly education/workplace environment. In addition, separate laws have been enacted and enforced to promote and facilitate the activities of young scientists. As a result, the education and research environment in the S&T sector has improved, as is evident in the increased number of graduate and undergraduate students majoring in science and engineering.

However, in addition to the existing policies, the government should pay special attention to supporting minority groups to enhance their participation in science and technology. With the national goal emphasizing increases in the national competitiveness in S&T, the majority of government programs are focused on providing support to the scientifically gifted. However, considering the importance of S&T in employment and the standard of living, it would be disastrous for the government to neglect support for other disadvantaged groups that suffer from lack of adequate education and career opportunities due to factors such as income, age, ethnicity, and place of residence.

References

English Publications

Lee, Eunkyoung (2009). "Boundary Agenda between Gender and Human Resource: The Establishment of Policy for Women in Science and Technology in Korea". *Asian Women*. Vol.25, No.2, pp. 29-47.

Korean Publications

Jin, Misuck and Um, Mijung (2007). *Future Changes of HRST Policy Environment and New HRST Policy Strategies in Korea*. Seoul: Science and Technology Policy Institute.

Kim, Taehong, et al. (2005). *The Development of Evaluation Model for the Policies of women Scientists and Engineers by Life-Cycle*. Seoul: the Ministry of Science and Technology.

Lee, Eunkyoung (2001). *Policy Issues on Science and Technology and Women*. Seoul: Science and Technology Policy Institute.

Lee, Eunkyoung (2006). "Differentiated Community of Scientists and Engineers in Korea". *Journal of Science & Technology Studies*. Vol.6, No.2, pp. 77-102.

Lee, Eunkyoung, et al. (2003). *Basic Plan for Fostering and Supporting women Scientists and Engineers*. Seoul: Ministry of Science & Technology.

Ministry of Science & Technology (MOST) (2006). *The First Basic Plan for Education and Support for Manpower in Science and Engineering (2006-2010)*.

Ministry of Education (1980, 1985, 1990, 1995, 2000). *Statistical Yearbook of Education*. Seoul: the Ministry of Education.

NIS-WIST (2005~2007). “Report on the Status of Women in Science and Engineering”.

NIS-WIST (2007). *Why and How Must They Be Supported?*.

NIS-WIST (2009). *Report on Women in Science and Engineering*.

NIS-WIST. “Newsletters”.

Rees, Teresia (2000). *National Policies on women and Science in Europe*. Luxembourg: Office for Official Publications of the European Communities.

Zhang, Hwe-Ik (2001). *Monitoring S&T Activities in Korea as a Follow-up of the “World Conference on Science”*. Seoul: Science and Technology Policy Institute.

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