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2010 Modularization of Korea's Development Experience: R&D and Technical Education

2011

MINISTRY OF STRATEGY AND FINANCE

KDI Korea Development Institute

2010 Modularization of Korea's Development Experience: R&D and Technical Education

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Preface

In the 21st century, knowledge is one of the key determinants of a country's socio-economic development. In recognition of this fact, the Ministry of Strategy and Finance (MOSF) and the Korea Development Institute (KDI) launched Knowledge Sharing Program (KSP) in 2004. The KSP aims to share Korea's development experience and knowledge to assist socio-economic development of partner countries.

The KSP is comprised of three parts: 1) the systemization and modularization of Korea's development experiences into case studies, 2) policy consultation through knowledge sharing with partner countries, and 3) joint consulting with international organizations. The systemization and modularization of Korea's development experience researches and documents Korea's successful policy experiences, such as the 'Five-Year Economic Development Plan' and 'Saemaul Undong (New Village Movement).' The policy topics are 'systemized' in terms of the background, implementation and outcome, and then, presented as case studies in order to achieve a complete understanding of the actual policies. These systemized policy case studies are further 'modularized' by sector so they can be utilized as concrete examples by partner countries to meet their interests in specific institutions, organizations or projects. For example, Korea's 'Export Promotion Policy' has been prepared as a systemized case study while 'the Establishment of the Export-Import Bank' has been modularized to provide a specific example of Korea's export promotion experience in export financing. The modularization of Korea's development experience traces back to a policy's inception and recapitulates the rationale for its introduction; its main content; and its implementation mechanism. The case studies also evaluate a policy's outcome and draw insights with a global comparative perspective. These case studies include literature reviews, surveys and in-depth interviews with the policy practitioners and experts who participated in the implementation process.

The systemization of Korea's development experience was initiated in 2007 and finished in 2009. Under the new Modularization Project, launched in 2010, the plan has been set out to modularize 100 case studies by sectors and topics in three years.

I would like to take this opportunity to express my sincere gratitude to Project Manager, Dr. Wonhyuk Lim, and all the Korean experts for their immense efforts in successfully completing the '2010 Modularization of Korea's Development Experience.' I am also grateful to Managing Director, Dr. Kwang-Eon Sul, and Program Officer, Ms. Ja-Kyung Hong, the members of the Center for International Development, KDI, for their hard work and dedication to this Program.

I earnestly hope that the final research results will be fully utilized in assisting the development partner countries in the near future.

Oh-Seok Hyun
President
Korea Development Institute

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Chapter 01

Cultivation of Highly Capable Scientists and Engineers Mainly at the KAIST

Yongsoo Hwang (Science and Technology Policy Institute(STEPI))

<Summary>

Since the 1960s, the supply of high-caliber human resources in the science and technology field to lead technology development has become an important issue with the implementation of economic development plan and the institution building for research and development. However, the competencies of graduate schools in Korea responsible for cultivation of human resources in the science and technology field were inadequate, thus it was probed to establish a special science and technology graduate education school to overcome this situation. Korea Advanced Institute of Science (KAIS) was established in 1973 with the help of a development loan by the United States. KAIS defined its objective aiming at cultivating individuals with in-depth knowledge and practical applicability in science and technology needed for industrial development. As demand-oriented education approach of KAIS satisfied the needs from the industries, KAIS accomplished a rapid growth to cover approximately 30% of master's and Ph.D. degrees in Korea at its initial development stage.

KAIS secured highly talented students from local universities by offering high-quality faculty, latest laboratory and research facilities, and various student benefits including scholarship programs, research funds, dormitory system and exemption of military service. As the needs for highly sophisticated professionals increased in the field of science and technology, KAIS integrated with Korea Institute of Science and Technology (KIST) to launch Korea Advanced Institute of Science and Technology (KAIST) in 1981. While concentrating its educational capacity in advancing the doctoral courses than the master's, KAIST enhanced collaboration network with other educational institutions. Especially, so as to foster the young professions in science and technology, KAIST reinforced linkages with special high-schools for

science and korea science and Technology University.

KAIS prepared its development plan based on a detailed feasibility study. And also, special act which allowed exceptions from the provision of “Education Act” to ensure the operational autonomy, self-rendering of degrees and special governmental supports, was enacted to promote the establishment. In order to cultivate young professions with excellence in science and technology, KAIST allowed no-department admission and no-examination admission. Also, by adopting both the master’s and Ph.D. combined programs and early graduation system, KAIST has been providing the industries with many young doctoral scientists in their 20s. KAIST has further enhanced the quality of education by introducing a flexible academic system; active minor and double major program, interdisciplinary major in master’s and Ph.D. programs, credit By Exam system, integrated undergraduate and graduate degree, early advancement to Ph.D. programs and equivalence system for credit earned in other universities in Korea and in other countries, and seasonal semesters.

Major achievements of KAIST are as follows:

(1) KAIST played a key role in supplying highly capable scientists and engineers for industry, academia and research institutions.
(2) KAIST contributed to pioneering science and engineering undergraduate and graduate school education, to providing a model of research-based graduate school development with related experiences.
(3) KAIST led the development of gifted education and outstanding research results to produce highly capable scientists and engineers.
(4) KAIST contributed to resolving the brain-drain issue by preventing outflow of highly talented young scientists and engineers and, on the contrary, promoting the inflow of Korean scientists living abroad.
(5) KAIST changed the university education system in Korea from a Japanese system to an American system.

Major implications of KAIST are as follows.

(1) The special education approach different from the conventional education system was effective in developing the science and technology human resources.
(2) The establishment of KAIST was an effective use of the development loans from the developed countries.
(3) Securing outstanding faculty members and students as well as the utmost support of government were the important success factors of KAIST.
(4) The demand-oriented approach in cultivating the young scientists and engineers enabled KAIST to achieve synergic development with the industry.

(5) A sufficient preliminary review and the willingness of the top authority gave power to select the best alternative and growth drivers.
(6) The efforts to evolve continuously in accordance to the changes in surrounding environments were critical in accomplishing the mid-to- long-term visions.

1. Background

1.1. Underlying Context

Since the 1960s, the supply of highly capable scientists and engineers to lead technology development has become an important issue in implementing the economic development plans including the institution building for research and development. However, the competencies of graduate schools in Korea were inadequate to produce capable scientists and engineers: the universities in Korea were mainly engaged in the undergraduate education having adopted the Japanese education system. Even in the case of Seoul National University, the most advanced university in Korea, only 48 students graduated with Masters in Physics during the 20 years between 1947 and 1966; and among 124 graduates with doctoral degree, Medical doctors accounted for 101, leaving only 23 Doctors in Science and Engineering during the 10 years between 1952 and 1961. In simple words, the graduate school education in Korea at the time was near to non-existence.

The causes of this backward status of the graduate school education in Korea identified by Korea Institute of Science and Technology (KIST) with “A Study on the Promotion of Science and Engineering University and Graduate Schools” in 1968 were: a) lack of professors, b) insufficient research funds including maintenance cost for research facilities and equipment, and c) inexistence of scholarship for graduate students.

Although all universities had graduate schools, their functions were limited. Therefore, many talented individuals were forced to go to graduate schools in abroad, mainly the United States, and extended their stay beyond the degree. Based on this diagnosis, the report asserted that separate science and engineering graduate schools should be established or appointed aside from graduate schools subordinated to universities, and that this system should be expanded based on the review after promoting the pilot cases.

Until the end of 1960s, despite of the fact that the number of science and engineering universities increased as well as KIST successfully induced some Korean scientists working abroad and scientists who received higher education abroad with government’s foreign training program and support returned, the demands for highly capable scientists and engineers were still far to be met. In this regard, President Chung Hee Park, decided to develop highly capable scientists and engineers as those in advanced countries, and ordered to establish a special independent science and engineering graduate school against strong protest of Ministry of Education including the education sector insisting that it would threaten the future of the existing science and engineering graduate schools.

Meanwhile, cultivation of highly capable scientists and engineers to meet the demands for technologies of strategic industries became more urgent, with the promotion of heavy and chemicals industries in the 1970s. Then a Korean-American scientist Keun Mo Chung proposed a need to establish a special science and engineering graduate school about which United States Agency for International Development (USAID) expressed to the Korean government its willingness to support financially, giving the green light to establish Korea Advanced Institute of Science.

1.2. Policy Objectives

The establishment of Korea Advanced Institute of Science (KAIS), a special science and engineering graduate school, to develop highly capable scientists and engineers was one of the most remarkable event in the science and technology sector during 1970s.

In 1971, the Korean government established KAIS, a special science and engineering graduate school to develop highly capable scientists and engineers that would lead the research and development as well as industrial innovation as a Korea-US Joint Support Project. While most of science and technology human resources had their degrees abroad until then, government actively launched the cultivation of high-caliber science and technology manpower to meet the demands for specific technology development required in strategic industries with the promotion of heavy-chemical industries. KAIS was put under supervision of the Ministry of Science and Technology rather than the Ministry of Education to cultivate high-caliber scientists and engineers away from the rigid education system of the conventional graduate schools and to produce high-quality manpower through intensive education. Unlike other national university, KAIS was established as a special corporation to ensure the independence and flexibility of operation, particularly aiming to produce young talents.

KAIS[1], therefore, as defined in its objective, aimed at “cultivating individuals with in-depth

1. There were some intentions to name the new special science and engineering graduate school as “Korea Advanced Institute of Science”. The initial name proposed was “Korea Science Technology Special Graduate School”. However, by accepting concerns of the Ministry of Education about diversification of

knowledge and practical applicability in science and technology needed for industrial development". Most of all, KAIS was to focus on producing high-caliber science and technology professionals that the industry require by aiming at professionals in practical areas rather than in theoretical specialty. In other words, its state-of-art facilities and faculties were devoted to cultivate science and technology professionals who can lead the industrial development instead of producing Nobel Prize winners. This objective is the principle that has been emphasized since the preparation phase of its establishment. KAIS's education forward "market not the Nobel Prize" helped it get recognized its reputation and roles in a relatively short period of time. In fact, many theses written by students to obtain their degrees involved practical issues related to Korean industry and national defense. Graduates of Korea Advanced Institute of Science were appreciated by the industry or research institutes based on this kind of education.

Established with these objectives, KAIS played a key role in producing high-caliber science technology professionals in science and engineering sector during the 1970s. In 1975, KAIS produced an important number of graduates while the total number of graduates of master's and Ph.D. degrees produced by science and engineering graduate schools in Korea was only 624. Every year, the number of KAIS's graduates grew: in 1979 and 1980, it reached as many as 243 and 303, consisting 25% and 33%, respectively, of total graduates of master's and Ph.D. degrees in science and engineering in Korea.

Table 1-1 | Number of Graduates of Master's and Ph.D. Degree in Science and Engineering in Korea

(Unit: Person)

Degree	'75	'76	'77	'78	'79
Master	530	625	721	841	907
Ph.D.	94	97	75	90	117
Total	624	722	796	931	1,024

Note: Number of master's and Ph.D.s in science and engineering from "Statistical Yearbook of Education (from 1970 to 1979)".

Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST*.

higher education, "school" was eliminated from the name. Also more comprehensive and futuristic meanings and expressions were sought rather than "technology" and "special". The English name Korea Advanced Institute of Science (KAIS) was as agreed with the United States that promised funds for the establishment. Dr. Hyung Seob Choi, the former Minister of Science and Technology, explained the reason of adopting "advanced" in the name, that other renowned education institutions such as MIT did not use in their name, as "assuming that experiences and activities of KAIS while settling the characterized traditions would bring symbolic effects to directly or indirectly improve the quality of science and engineering graduate school education, it was to reduce the function of producing master's and doctorate degree holders but to develop into a high research institute, organized with selected few researchers when the education and research competencies of other science and engineering graduate schools reach considerable level."

On the other hand, during the 1980s, demands for science and engineering human resources with high expertise were increased significantly. In particular, with the commencement of national R&D projects and increasing number of research institutes of private enterprises, demands for high-caliber science and engineering human resources that might take a leading role to improve the heavy-chemical industry and to intensify its technologies grew. Accordingly, in 1981, as an advanced science and technology human resources development system linking the research and the academia, Korea Advanced Institute of Science and Technology (KAIST) was established by consolidating KIST and KAIS. Further, the education system for the gifted students in science and technology flowing from science high-school to engineering colleges founded the fundamentals to strengthen science and engineering graduate school education of each university.[2]

2. Description of the Program

2.1. Establishment of a Special Science and Engineering Graduate School

When the proposal to establish a special science and engineering graduate school by KIST to locally develop highly capable scientists and engineers was refused by Economy and Science Deliberation Council to the President at the end of 1969 against strong oppositions of existing universities, the Korean government sought an alternative solution. Although the Ministry of Education and the academics also agree on the need to establish a special science and engineering graduate school, they refused the proposal based on the reason that it might result in diversification of higher education in Korea. The announcement of the US government's support for science and technology graduate school in Korea marked an important change in this regard. Upon receiving this news, President Chung Hee Park ordered the Ministry of Science and Technology, instead of the Ministry of Education, to establish an independent graduate school specialized in science and technology. Consequently, the Ministry of Science and Technology and Economic Planning Board proposed a "plan to establish an independent science and technology graduate school" based on the report prepared by Dr. Keun Mo Chung,

2. Since the 1980s, the competition among science and graduate schools has been started with development of KAIST, enhancement of the nation's graduate school education with a focus on science and engineering, introduction of Master's Officer system, success of Pohang University of Science and Technology established with support of Pohang Iron and Steel Company in 1985, as well as establishment of Gwangju Advanced Institute of Science and Technology in 1995. Currently, these universities cultivate highly capable scientists and engineers by competing with each other for the top ranking of science and engineering universities in Korea and recording international research results.

professor of Electrophysics at Engineering Division of Brooklyn College in the United States during the monthly economic trend reporting in April 1970.

The report, entitled "The Establishment of a New Graduate School of Applied Science and Technology in Korea" was prepared upon request of Dr. John Hannah. Dr. Hannah was appointed as the head of United States Agency for International Development in 1968, and announced that the economic support of the United States for underdeveloped countries would be made in form of investment in human resource development projects rather than monetary means or goods, on which Dr. Keun Mo Chung stressed that for sustainable development of Korea, the development of science and technology was essential and that a university at the international level was necessary to support it. This project was considered as a good case of the new foreign aid policy of the United States while transferring it from grants to indirect aids mainly on infrastructures, etc. The report asserted the need of high-caliber human resources from science and engineering graduate schools for economic development of Korea, and the need to establish a new graduate school specialized in science and technology for this purpose, in 16 steps. While emphasizing the role of the graduate school specialized in science and technology to support the economic development and industrial development of Korea, the report also affirmed that the new graduate school would prevent the brain-drain problem by meeting not only the short-term demands for science and technology professionals, but also mid-term demands for R&D human resources.

Box | Summary of the Proposal on "The Establishment of a New Graduate School of Applied Science and Technology in Korea" of Dr. Keun Mo Chung

- In advanced countries, the basic degree of science and technology professionals is moving towards master's degree (MS) from bachelor's degree (BS). This trend is clearly remarkable in new technology areas.

- Science and engineering undergraduate degree holders continue their studies after graduation or getting a job. In general, 50% of those obtain a master's degree.

- Research and development activities of science and technology professionals increase the development potential of the industry and found the fundamentals of international competitiveness.

- The second 5-year economic development plan of Korea shows clearly the industrial reorganization focusing on technology-intensive industries.

- Therefore, the cultivation of highly capable scientists and engineers is essential for long-term development of Korea.

- However, the education system in Korea shows the poor graduate school education, and lack of graduate education in new technology areas.
- Capacities of existing universities are not sufficient even for undergraduate studies, and inadequate in terms of faculty, facilities and curricula.
- The only solution for this problem is to establish a specialized graduate school to produce highly capable scientists and engineers such as Graduate School of Public Administration of Seoul National University. Establishing “Korea Graduate School of Applied Science and Technology” is therefore proposed.
- This new graduate school should be provided with an independent board of directors, stable financial support from government, adequate laboratory facilities, degree and non-degree programs, and a research institute.
- In particular, the graduate school should provide Ph.D. program in engineering subject to realistic thesis studies and master’s program required in Korean industries.
- Not only full-time students but also industry-academy collaboration programs should be admitted to give a continuing education opportunity to industrial professionals.
- The faculty should be organized competitively with Korean scientists and engineers working in the United States by adopting as full-time professors, research professors, adjunct professors and associate professors.
- Focusing on collaboration with the industry, the new graduate school should exert its efforts to form a community with the industry sector by admitting industry-academy collaboration students and research programs.
- It will have only graduate school programs. However, it should maintain relationship with the existing universities and carry out technology extension activities.
- To ensure stable facilities and financial conditions, the Korean government would provide the building and operating funds, while USAID would provide financial supports to secure research and development facilities and faculties. For this, USAID proposes to provide special education aids of 5 million US dollars.
- This project will help Korea develop into a developing country, and serve as an example of counter-brain-drain model.

Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST.*

The establishment of KAIS was progressed speedily based on the preliminary review. In August 1970, one year after the President's order to establish a new graduate school specialized in science and engineering, Korea Advanced Institute of Science Act that ensures the special operation and support of the new institution was enacted. This act prescribes special governmental support on the establishment and operation of KAIS, that provide grounds for highly capable scientists and engineers cultivated to stay in Korea.

While preparations to establish KAIS were under progress, USAID dispatched a group of professionals for advices necessary for the establishment. The report on the establishment of KAIS and operating principles submitted by the investigation team to each government served as important guidelines in the establishment and early operation of KAIS.

2.2. Development of Korea Advanced Institute of Science and Technology

2.2.1. Development into Korea Advanced Institute of Science (KAIS)

After the preparation phase, KAIS admitted 106 students in master's programs in 6 departments including Mechanical Engineering, Industrial Engineering, Mathematics and Physics, Material Science Engineering, Electrical and Electronic Engineering, Chemistry and Chemical Engineering in January 1973. In 1975, while producing 92 masters', 21 students were accepted in Ph.D. program. The first graduate of Ph.D. program was produced in 1978. Further, KAIS continued its development as follows:

a) In 1974, Department of Biotechnology was launched.
b) In 1977 and 1978, Professional Science and Engineering Master's program was offered.
c) In 1978, Department of Computer Science was spun off from Department of Mathematics and Physics.
d) In 1978, Department of Chemistry and Chemical Engineering was separated into Department of Chemistry and Department of Chemical Engineering.
e) In 1974, Department of Aerospace Engineering was launched, and
f) In 1980, Department of Management Science was launched.

Accordingly in 1980, KAIS grew into 10 departments and 3 specialties, with 87 students enrolled in Ph.D. programs and 374 students in Master's programs. Initial courses offered by KAIS were selected with emphasizing demand areas necessary to promote strategic industries. This approach of choosing the courses became an important factor to induce industrial concerns to recruitment of KAIS graduates.

Table 1-2 | Post-graduate Employment Statistics of KAIS (the Batch 1980)

(Unit: Person)

		Total	Mechanical Engineering	Industrial Engineering	Bio-technology	Physics	Material Engineering	Electrical and Electronic Engineering	Computer Science	Chemistry	Chemical Engineering	Production Engineering	Chemical Process Engineering	Industrial Electronics	Consulting
Total		306	25	29	20	21	34	26	18	28	18	35	20	21	11
National Scholarship		202	16	13	20	16	23	18	17	26	15	13	10	12	3
Industry Collaboration		104	9	16		5	11	8	1	2	3	22	10	9	8
Education Institutions	Subtotal	57(1)	9(1)	4	4	5	3	5	7	2	4	8	3	3	
	Specialized Universities	19	4					3	3		1	4	2	2	
	Universities	38(1)	5(1)	4	4	5	3	2	4	2	3	4	1	1	
Research Institutes		70(4)		5	11	4	10(1)	7(2)	6	10	5	4(1)	5	3	
Public Institutes		8(3)	1(1)	1			1		1	1	2(1)		1(1)		
Private Enterprises		109(95)	8(7)	16(16)	3	5(5)	14(10)	6(6)	1(1)	2(2)	3(2)	21(21)	10(9)	9(8)	11(8)
Ph.D.	National Scholarship	61(1)	7	3	2	7	6	8	3	13	3	2	1	6(1)	
	Industry Collaboration	(1)	(1)												
Others		1									1				

Note 1: the number in parenthesis signifies the students under industry-academy collaboration program.

2. Ph.D. students under industry-academy collaboration program were excluded in the total as they are already included in the number students by institutes.
3. 6 Students subject to loan scholarship (2 in Mechanical Engineering, 1 in Computer Science and 3 in Consulting) are included in national scholarship program.

Source: Korea Institute of Science and Technology (1992), Twenty Years of KIST.

From 1975 to 1981 when KAIS was consolidated with KIST into KAIST, KAIS produced 1,070 graduates from its Ph.D. and master's programs, including 918 master's degree holders, 120 professional master's degree holders and 32 Ph.D. degree holders. It constituted more than 30% of the total science and engineering Ph.D. and master's degree holders produced by all universities in Korea during the same period. Those graduates of KAIS got a job in various areas; for the batch of 1980, most of graduates got jobs in private enterprises. However a considerable number of graduates were recruited by research institutes and universities. Many others continued their studies in Ph.D. programs.

KAIS secured highly talented students from local universities by offering high-quality faculty, latest laboratory and research facilities, and various students benefits including adequate scholarship and research funds, dormitory and exemption of military service, and provided them with intense education. In particular, the exemption of military service after having less than ten weeks (usually three weeks) of military training and three years of services in related industrial, educational or research institutions after graduation was unprecedented benefit, considering the fierce conflict with North Korea. In addition, as KAIS was under supervision of the Ministry of Science and Technology rather than the Ministry of Education, it was enabled to operate independently, free from various limitations and controls implied upon other universities and graduate schools. The faculty members of KAIS were all Ph.D. degree holders. Total of 66 Korean scientists and engineers working abroad were recruited as full-time professors, and they presented 781 theses (546 theses in Korea and 235 theses internationally) by 1980, leading the related academic areas in Korea.

With the demand of the government to increase the number of students, KAIS grew in size: Along with additional departments, the number of students was twice greater than the initial plan. Accordingly, the government's financial support also increased. The government's investment for establishment and financial support for operating funds for the first five years of operation increased from 5.6 billion Korean won to 9.2 billion Korean won. The support was exceptional considering that the research and laboratory support provided by the government to universities nationwide was only 15 billion won. Although this unequal distribution of support to KAIS was unavoidable to achieve the policy objectives in a short period of time, it resulted also in feeling of deprivation and complaints in other sectors of science and technology.

2.2.2. Development into Korea Advanced Institute of Science and Technology (KAIST)

As KAIS and KIST were consolidated in the early 1980s, concurrent positions, researcher program[3], etc. were introduced to connect the functions of two institutes leading the education of highly capable scientists and engineers and the research and development in science and technology. The integrated KAIST began to develop high-calibre science technology human resources development system focusing on Ph.D. programs instead of master's programs, and promoted collaboration with other education systems for the gifted science and engineering students by creating linkages with science high-schools and Korea Science and Technology University. KAIST offered high-quality education based on latest education and research facilities with outstanding faculty members. It also adopted the early graduation system that is not usually accepted in regular education system, and provided institutional grounds to produce young Ph.D. degree holders in their 20s. However, in June 1989, the research division of KAIST was separated again to KIST in July 1989, and KAIST survived with absorbing Korea Science and Technology University. Then KAIST offered the undergraduate programs and graduate programs in the same campus as it moved to Daedeok Research Complex in April 1990. As of 1989, KAIST had 2,581 students in total, including 1,155 students in graduate programs and 1,426 students in undergraduate programs in 14 departments and 1 specialty. With 166 professors, KAIST had the best conditions compared to other universities. KAIST produced 5,843 master's degree holders and 904 Ph.D. degree holders from 1975 to 1990. The graduates of KAIST played a key role in science, technology and industry areas in Korea.

A semiconductors, computers, electronics devices, automobiles and vessel became main export products in 1980s, KAIST increased students and faculty members in these areas. These efforts brought out increased research fund and theses, as well as post-graduation employment rate, and contributed to changing the atmosphere of KAIST to "engineering-focused". Since the end of 1980s, the move among KAIST graduates of electronic engineering and computer science to create venture businesses expanded widely, leading the venture boom in the 1990s.

In 1989, KAIST with absorbing Korea Science and Technology University was opened in 1986 to develop creative science and technology professionals who would lead the advanced industrial society in the future. Korea Science and Technology University adopted a no-grade, no-department system that allows students to graduate earlier upon completing required credit hours. It provided unique supports to enrolled students, including no tuition fee, free dormitory, scholarship and overseas training. While maintaining the ratio of students to professors to 10:1, Korea Science and Technology University provided quality of education using latest laboratory equipments. Until 1987, the admission criteria limited the eligibility to students in science high school or completed three-year of regular high school education. However, it was changed in 1988 to students in science high school or completed two-year of regular high school education for early discovery of the gifted students in science.

In 1986, Korea Science and Technology University was established with 540 students in 4

3. Researcher program was made available for researchers of the industry or other research institutes as well as professors of other universities to obtain degrees while maintaining the current post.

Table 1-3 | Career Courses of Graduates of KAIST's Undergraduate Programs in 1990

(As of January 16, 1991, Unit: Person)

Institution	Physics	Bio-technology	Mathematics	Chemistry	Management Science	Mechanical Engineering	Material Engineering	Electrical and Electronic Engineering	Computer Science	Chemical Engineering	Industrial Design	Total
Institute of Science and Technology	14	5	4	8	6	19	12(	19	17	12	2	119
Pohang University of Science and Technology	3	2	2	3	2	8	1	6	5	2		34
Seoul National University		2	2					1	1			6
Foreign Universities	4	5	2	3	1	1		9	3	1	3	32
Industry		1	2		3	29	14	53	9	6	16	133
Research Institute		1			2	1		8	1			13
Education Institute		1		1	1			1				4
Other graduate schools	2											2
Others	3	5			4	5		8	4			29
Total	26	22	12	15	19	63	28	105	40	21	21	372

Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST.*

departments and 16 specialties; in 1989, total of 1,982 students were enrolled in Korea Science and Technology University. With integration of Korea Science and Technology University into KAIST in 1986, KAIST became a university that closely connected undergraduate, graduate and Ph.D. programs in one campus. It made it possible to accept talented science high school students targeting the gifted education and allow them to continue their studies in master's and Ph.D. programs at KAIST through intensive education. In 1990, among 372 graduates of bachelor's programs of KAIST, 32.0% of them continued master's program at KAIST, while 10.8% of them and 9.4% took master's program in other universities and foreign universities, respectively. And 35.5% of them entered the industry sector after graduation.

Box | Characteristics of Operations of Korea Science and Technology University

- Students are selected based on a special admission process not through the national test for university admissions
  - Gifted students in science and mathematics are discovered earlier and developed into science professionals
  - All second and third year science high school students are eligible to apply.
  - 600 points over 900 points of the admission test scores are allocated to mathematics and science.

- No-grade, no-department system
  - Even the second year high school student may be admitted to university with proven competencies. Early graduation is institutionally allowed upon earning 140 credits.
  - Students may select their specialties after exploring their aptitude and competencies through course works not upon admission. (This system was adopted by all universities in Korea 10 years later.) The purpose of this system is a) to strengthen experiments and laboratory works of basic science and to minimize compulsory subjects and maximize electives, and b) to select the specialty after thorough observation of their interest and capacity.
  - By maximizing the flexibility and the independence of university education system, the development of individual potentials may also be maximized.

- A seasonal semester and Credit By Exam system
  - For certain subjects, students with adequate understanding and knowledge may apply academic credits through an examination without attending the course.
  - It is similar to credit by examination system in the United States, used as one of the gifted education method, but very unique in Korea.

Source: Korea Technology Business Institute (2006). *A Study on Contribution of Science and Technology Policies to Economic Development*, The Ministry of Science and Technology.

Besides, KAIST established the foundation to develop various highly capable scientists and engineers that the country required according to the changes of time, by creating

Graduate School of Techno-Management and Korea Institute for Advanced Study in 1996 and Graduate School of Finance and Graduate School of Information and Media Management in 2006. In particular, Korea Institute for Advanced Study established in Seoul Campus has continued research activities in basic science and advanced science and engineering research human resources development by offering mathematics, physics and computer science. KAIST Graduate School of Techno-Management, Graduate School of Finance and Graduate School of Information and Media Management serve as successful models that minimize government support, by relying their operating expenses on tuition and other self-generated revenue. In addition, compared to conventional education for highly capable scientists and engineers, these are expected to contribute to the cultivation of fusion science and technology human resources by integrating conventional science and engineering with management and other finance areas. Also, in line with the trend toward conversion technology, academic specialties are gradually expanded with the medical science and the environmental engineering as a starting point.

The recent "KAIST Vision 2010" presents a long-term objective to be a global top-10 academic excellence by developing KAIST into the world's best research-based education institution. The plan includes: a) establishment of specialty-centered system to secure the best quality faculty members, innovative improvement of life-time researchers and promotion system, and achievement of 6:1 students to professor ratio, b) all courses provided in English to achieve the best quality education, and joint or double degree programs with internationally renowned universities, c) maximization of research influence to achieve the best quality of research and development activities, focused development of selected key fusion science and technology areas (such as bio-convergence engineering, hybrid system design, entertainment engineering, nano-engineering, etc.), and appointment of KAIST researchers, and d) funding of 1 trillion Korean won in seven years to establish the best level of infrastructure, expansion of seed capital for venture researches, and expansion of support for collaborative research facilities as strategic objectives.

2.3. Expansion of KAIST Model

2.3.1. Establishment and Operation of Pohang University of Science and Technology

2.3.1.1. Establishment and development

Pohang University of Science and Technology was established in 1985 based on efforts of Pohang Iron and Steel Company (currently, POSCO) as the first research-based university in Korea. Unlike KAIST, established with government support, Pohang University of Science and

Technology was established purely with support of a private company. Pohang Iron and Steel Company actively led all issues related to the establishment of the university by organizing a university creation steering committee, devoted to the establishment in the beginning of the preparation. Even after the opening, Pohang Iron and Steel Company continued its support, thereby continuing the development of the university.

Tae-Joon Park, the President of Pohang Iron and Steel Company noticed serious problems of the science and engineering university education in Korea at that time through several cases that he witnessed that newly recruited engineering school graduate may not be directly used in the field. Interested by resolving impracticability of science and engineering university education focusing on theoretical discussions isolated from industry fields, he developed an idea while planning the construction of Gwangyang Steelworks Complex, to establish a university through their own financial means to secure human resources to meet the needs for qualified science and technology human resources after the construction was finished.

An invitation letter sent in Tae Joon Park's name in August 1985 to induce overseas scientists and engineers mentions clearly that "the to-be-established Pohang University of Science and Technology will evolve into a research-based university focusing on graduate school education by researching and educating hi-tech as well as basic and applied science and technology areas based on fully equipped environment for study and research through inviting renowned professors, providing education facilities, establishing industry-academy-research institute collaboration and admitting a selected group of few number of talented students", providing a vision to develop Pohang University of Science and Technology as a global research-based university.

Pohang University of Science and Technology is formed as a science and engineering college not as a university, because its objective is to develop outstanding human resources in science and engineering needed by the industry sector. Also, realizing its vision of the first research-based university in Korea inspired many other universities in Korea to focus on research, serving as the best practice of cultivation of highly capable scientists and engineers at national level, not only in Pohang area.

Established in 1987 with 240 students in 9 departments, Pohang University of Science and Technology reduced the capacity of undergraduate programs to 1,200 students, 800 students less than its initial plan. And while maintaining the capacity of graduate programs, it reduced students in master's programs but increased those in Ph.D. programs. In addition, Pohang University of Science and Technology offers master's and Ph.D. courses in bio-technology, graduate school of information and industry, graduate school of iron and steel technology, and environment engineering collaboration programs. Based on its vision of a research-based university, Pohang University of Science and Technology focused not only on educational facilities but also on research facilities, providing grounds to be equipped with large-scale research equipments such as wind tunnel and light source.

The recent “POSTECH Vision 2020” presents a long-term objective to achieve global top-20 research-based university by 2020. Up to now, Pohang University of Science and Technology formed one-stop research system from basic science research to industrialization by grouping a think-tank through a close joint research system among Pohang Iron and Steel Company, Research Institute of Industrial Science and Technology and Pohang University of Science and Technology.

2.3.1.2. Operation model

Pohang University of Science and Technology benchmarked KAIST model in Korea, and Aachen University in Germany, California Institute of Technology in the US and Vienna University of Technology in Austria, internationally. These universities are focusing on the graduate programs, with low students to professor ratio, equipped with excellent faculty members including the Nobel Prize winners, and provide dormitory to graduate students.

Pohang University of Science and Technology invited internationally renowned professionals as professors, guaranteed the retirement age, and implemented a professor achievement evaluation system to develop itself into a world-class research-based university. It has adopted a course evaluation for all subjects opened in undergraduate and graduate programs since 1997.

In addition, to overcome its handicap to induce outstanding students for being located in a province, Pohang University of Science and Technology offers exceptional student benefits, including guaranteed employment for graduates, dormitory and scholarship for all students, and Ph.D. programs offered for excellent students until they obtain their degree.

Pohang University of Science and Technology brought a big change in the university admission system by implementing the early admission system that accepts talented students in science and mathematics among science high school students and second year regular high school students in 2000 in order to discover and develop science gifted students. As that time, no early admission of students in public and private universities was allowed for second year regular high school except KAIST.

To induce foreign students, one third of its capacity has been allocated to foreign students since 2002. Pohang University of Science and Technology is also concentrating the globalization of the education by dispatching 80% of its students abroad with financial support.

Based on this aggressive investment and special operation toward academic excellence, Pohang University of Science and Technology is known to be ranked the first in evaluation of universities in Korea, and 60-70 companies visit every year to recruit students one year before the graduation.

2.3.2. Establishment and Operation of Gwangju Advanced Institute of Science and Technology

2.3.2.1. Establishment and development

Gwangju Advanced Institute of Science and Technology was established in November 1993 with the objective to make a development driver of industry-academy-research institute by establishing a high-tech science and technology complex and launching the second KAIST, in order to achieve a balanced regional development. A "master plan of Gwangju High-tech Science industrial Research and Development Complex" was prepared by the Ministry of Science and Technology in 1989 to establish a research and production focused high-tech science city with Gwangju Advanced Institute of Science and Technology as a core. Established as a graduate school-based institute, Gwangju Advanced Institute of Science and Technology was meant to form a triangle of high-calibre science technology human resources development with KAIST in the central region and Pohang University of Science and Technology in the eastern region. Gwangju Advanced Institute of Science and Technology has developed focusing on graduate school programs since the beginning. Recently, with the establishment of undergraduate and graduate programs in Daegu Gyeongbuk Institute of Science and Technology, Gwangju Advanced Institute of Science and Technology also obtained the approval to offer undergraduate programs, giving it an opportunity to develop into a research-based university connecting the undergraduate and graduate education.

Gwangju Advanced Institute of Science and Technology contributes to the promotion of Gwangju High-tech Science industrial Research and Development Complex into a photonics industry complex by providing research manpower including photonics professors and graduate students for the development of the photonics industry, a specialized industry of the region, and by establishing photonics industry education facilities through a photonics industry center. Besides, by establishing Advanced Photonics Research Institute, the only research institute specialized in photonics industry that carries out education and research functions simultaneously under supervision of Gwangju Advanced Institute of Science and Technology, it conducts systematic researches on fundamental technologies necessary for the photonics industry promotion and provides business incubator services.

Gwangju Advanced Institute of Science and Technology aimed the following specialized development strategies at its establishment which played an important role to induce outstanding students during the early development phases.

a) Specialization of certain areas
- Five areas in information and communication engineering, materials science and engineering, electrical and electronic engineering, bio-sciences and environment engineering, which are not overlapped with KAIST but complements other universities and can lead the future industry of Korea, were selected.
- Unlike other universities that provide education in all areas and specialties, Gwangju Advanced Institute of Science and Technology concentrates in one or two areas with particular characteristics.

b) Education and research over different departments
- Science and engineering education and large-scale research projects that may provide answers to problems actually faced by the industry by adopting education and research over different departments that can overcome the non-communication of departments and specialties observed in other universities
- Innovative attempts that integrate electrical and electronic engineering, mechanical engineering, electrical engineering and computer science, and education and research that closely connect the basic science and applied engineering in other areas

c) Promotion of the industry-academy collaboration and the industrial complex
- Inducement of research institutes of private companies to directly link research results of the university to the production
- Establishment of a practical industry-academy collaboration by using experienced engineers of private research institutes as professors and by allowing participation of students and professors of graduate schools in research and development activities of private research institutes

d) Strengthened international collaboration in response to the globalization
- Active exchanges of human resources, information and academics with renowned education and research institutions worldwide
- Cooperation with MIT and Stanford University in the United States in recruitment of professors and development of curricula, and inducement of foreign professors, overseas Korean students as well as foreign students.

2.3.2.2. Operation model

Gwangju Advanced Institute of Science and Technology is based on a unique operation model to support these specialized development strategies.

Gwangju Advanced Institute of Science and Technology provides all courses in English to adopt the globalization of the education and the research. Also it implemented the “quality warranty of doctorate degree thesis” system that requires graduation thesis to be written in English and approved by foreign academics.

In order to induce foreign students, Gwangju Advanced Institute of Science and Technology provides various benefits including tuition and living fees support, accommodation, health insurance support covering 80% of the premium, guided tours to cultural heritages, and one-stop administration services that provide dedicated personnel for foreign students, etc. In addition, Gwangju Advanced Institute of Science and Technology offers a double occupancy dormitory to all students, and a 70-square meter apartment to married students, which also helps induce outstanding foreign students as research assistants. At the same time, recruitment of foreign professors was also actively pursued: in 1995, 10% of professors were foreigners, in 2000 and 2003, this proportion was evolved to 14.3% and 8.6%, respectively. Benefits provided to foreign professors include financial supports for research projects not exceeding 20 million Korean won per foreign professor and tuition assistance not exceeding 8 million Korean won per children attending school.

Gwangju Advanced Institute of Science and Technology continues the progress by showing remarkable research results based on its differentiated characteristics including the principle of “selected few” by maintaining the students to professor ratio to 5:1 and specialized development strategies. Since its establishment, Gwangju Advanced Institute of Science and Technology has been ranked on top in terms of number of SCI theses per professor and per graduate school student as well as in terms of volume of research funds on contract basis per professor.

2.3.3. Others

KAIST model was expanded and adopted in the establishment of Information and Communications University (ICU) to develop highly capable scientists and engineers in information and communication in 1998, the establishment of University of Science and Technology (UST) to develop highly capable scientists and engineers in new convergence technology as promoted jointly by government-funded research institutes, and the establishment of Daegu Gyeongbuk Institute of Science and Technology (DGIST) that would serve as a key point of research and development as well as cultivation of high-caliber human resources.

3. Pursuit of the Program

3.1. Feasibility Study and Development Plan

Upon official request of the Korean government for the education loan aids to USAID to establish Korea Advanced Institute of Science, USAID dispatched the Turman investigation team organized under leadership of the Vice Chairman Fredrick. E. Terman of Stanford University to review the significance of the establishment of Korea Advanced Institute of Science and its feasibility, as well as the establishment in July 1970. Dr. Turman, known as “the father of Silicon Valley”, was an important character in the development of science and engineering as well as the establishment of its system that contributes to the industrial fields and economic development.

The Turman investigation team surveyed and reviewed a) development direction and functions, b) facilities and the size of investment, c) organizations, d) collaboration with the academy, the industry and the science-technology, and e) support of the sister institute in the United States for Korea Advanced Institute of Science, through interview with the academics and officials of enterprises, research institutes and government bodies during their stay in Korea until the early September 1970. Based on the review, the Turman investigation team submitted “the report on the feasibility study of the establishment of Korea Advanced Institute of Science” in January 1971.

The Turman investigation team evaluated in the report that the special regulations enacted as well as the planning for the establishment of Korea Advanced Institute of Science is creative and practical, and concluded that establishing Korea Advanced Institute of Science as an independent institute is the only way to develop into a science and engineering graduate school in applied science required by the Korean economy. Also, the report suggested detailed guidelines on organization of departments, student capacity, faculty, operation and support from the United States. The suggestions were adopted as a framework in designing the operation of Korea Advanced Institute of Science through some modification, in the development plan of Korea Advanced Institute of Science.

Box | Suggestions of the Turman Report

(1) Organization of departments

- To concentrate on six areas including a) mechanical engineering, b) chemical engineering and applied chemistry, c) electronic engineering, d) communications and systems engineering, e) industrial engineering and management, and f) basic science and applied mathematics (including computer programming) during the first three to four years

(2) Student capacity

- To start with a lesser number of students around 40 in master's program then to increase to 100 students over three years.
- To emphasize the master's programs in the beginning, and to expand them by admitting a few number of Ph.D. candidates
- To postpone offering professional master's programs until that the master's program is well established
- In the institution's stabilization phase, the capacity of master's program in each department to be increased by 15 every year

(3) Faculty

- It is particularly important to organize professors of KAIS with experienced and reputed scientists since the success of KAIS ultimately depends on the faculty members.
- To adopt the True Merit System by applying the high standard professor evaluation, and to avoid traditional seniority system
- To allocate 5-10 full-time professors for 10-100 graduate school students. The capacity and the size of faculty members to be adjusted according to the appropriate level that provides the minimum number of persons required for effective carrying out of research activities.

(4) Operation

- Independent and autonomous operation
- Development of science and technology human resources urgently needed for economic development of the nation
- Establishment with a focus on science and technology activities in Korea
- Pioneering functions for graduate school education in Korea
- Flexible operating system of advanced universities in the United States

(5) Support from the United States

- In the early phase, official advice and support are necessary for various issues, including initial recruitment and training of faculty members, selection of subjects, establishment of facilities, laboratories and libraries, etc.
- Financial support estimated for the first five years of operation is around 5 ~ 6.5 million US dollars for a) development of faculty and curricula, b) selection of laboratory equipments, c) library facilities and materials, d) construction materials that may not be procured in Korea, and d) other special items, to be provided as grants or long-term low-interest loans from the United States.

Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST*.

Based on these suggestions of the Turman investigation team after the feasibility study, Korea Advanced Institute of Science established its development plan for a period from 1971 to 1975 as follows.

3.1.1. Departments

Seven departments including Mechanical Engineering, Industrial Engineering, Bio-Engineering, Mathematics and Physics, Material Engineering, Electrical and Electronic Engineering, as well as Chemistry and Chemical Engineering were to be opened in 1973. By department, different specialties were provided. Although Bio-Engineering was not suggested by the Turman report, it was included upon request from biology academics in Korea, thereby increasing the total number of initial departments from six to seven.

a) Under Mechanical Engineering, Mechanical Analysis and Applied Mechanics;
b) Under Industrial Engineering, Operation Research and Industrial Economics;
c) Under Bio-Engineering, Molecular Biology;
d) Under Mathematics and Physics, Applied Mathematics (Computer Science) and Applied Physics;
e) Under Material Engineering, Metallurgical Engineering and Ceramic Engineering;
f) Under Electrical and Electronic Engineering, Electrical Engineering and Electronic Engineering; and
g) Under Chemistry and Chemical Engineering, Applied Chemistry and Chemical Engineering.

3.1.2. Student Capacity

KAIS set the student capacity at 315 in total, including 105 Ph.D. students and 210 students under master's degree until 1976. However, there were some concerns that this capacity was too high considering the unpromising job market for highly capable scientists and engineers. The grounds for setting the total student capacity to be 500 are as follows. It was estimated by assuming that a) the student capacity of master's program is 150 students, for two-year course, the total students in master's programs will be 300 students; b) one third of 150 graduates of master's programs would continue their studies in Ph.D. programs, giving 50 students a year, for average of three-year course, the total students in Ph.D. programs will be 150 students; and c) other engineering degree. The estimated student capacity is based on the stabilization of KAIS.

Engineering Degree program is a unique system adopted by KAIS in March 1977 in between the master's and the Ph.D. programs, but closer to the Ph.D. considering the weight of required credits. However, in reality, Engineering Degree program remained at equivalence of professional master's degree different from the initial plan. In addition, although it was possible to apply to the Ph.D. programs during the master's program, school regulations state that "a student of KAIS may apply to the qualifying examination of Ph.D. with the approval of the President, after completing at least one year of studies."

3.1.3. Faculty

KAIS planned to provide 56 full-time professors by 1975.

The number of graduates of KAIS based on this development plan was significantly lower than the demands during the 1970s. It was because of the high preference over science and technology human resources with high-quality education of KAIS while the demands for highly capable scientists and engineers were increasing due to the development of the heavy-chemical industry. Whereas the demands for graduates were 775 in 1979, KAIS succeeded in producing only 23% of such demands, 178 graduates; similarly, while the demands for graduates were 528 in 1980, only 25% of such demands were met by producing 134 graduates. For the industry sector, whereas the demands for graduates were 352 in 1979, KAIS succeeded in producing only 13% of such demands, 45 graduates; similarly, while the demands for graduates were 99 in 1980, only 10% of such demands were met by producing 10 graduates.

Table 1-4 | Supply and Demand of the Graduates of KAIS

(Unit: Person)

Institutes	Batch of 1979 (Master's degree holders)			Batch of 1980 (Master's degree holders)		
	Demand	Supply	Ratio (%)	Demand	Supply	Ratio (%)
Specialized University	55	26	47	58	23	40
Government Body	42	16	38	18	6	33
Research Institute	272	78	29	202	56	28
University	54	13	24	151	39	26
Industry	352	45	13	99	10	10
Total	775	178	23	528	134	25

Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST.*

However, as KAIS expanded more rapidly than the expectations of the Turman report, some problems were noticed. The Turman report estimated the total student capacity of KAIS in 1977, the beginning of its stabilization, as 300 students including 200 students under master's program and 100 students under Ph.D. program in 6 departments. Accordingly, it suggested 50 full-time professors, giving 6:1 students to professor ratio. However, in 1980, the total number of students was increased to 949 while that of professors increased to 84, giving the students to professor ratio of 11:1, twice higher than the plan. Also due to increased demand for its graduates, the capacity for admission has tripled. In consequence, various problems were raised including degraded capacity of freshmen, insufficient dormitory, lack of laboratories, library and research facilities, and stagnation of research funds and scholarship compared to the inflation.

3.2. Enactment of Establishment and Promotion Act

Even after the establishment of KAIS was approved, resolving varying point of view among different government bodies concerning characteristics of special science and engineering graduate schools, relationships with existing universities, appointment of the head, and exemption of military services to develop outstanding science and engineering human resources was difficult without legal grounds.

On the one hand, to ensure the independence of KAIS, it may not be established as a national university; on the other hand, it may not be entitled to government support if it is established as a private university. In the end, a special act was necessary that allowed exceptions from the provision of Education Act to ensure the autonomous operation. There was a conflict between the strong demand of the Ministry of Education to supervise KAIS under its administration being an education institution, and the argument that a new act should be enforced for the new form of special education institution outside of Education Act. The opposition of the Ministry of Education was arranged by the Presidential Offcie, to place the establishment and operation of KAIS under administration of Ministry of Science and Technology. However, since the military service was one of citizen’s obligations prescribed by the Constitution and the exemption of military service was prohibited during the 1970s, there was a problem in negotiation with the Ministry of Defense at working level. It was only possible with the determination of the President. The exemption of military services offered to students of KAIS became the first case.

By resolving all these problems, Korea Advanced Institute of Science Act was announced in August 1970. The Act includes exceptional provisions including a board of directors for autonomous operation as a special corporation, operating funds to secure financial stability, military service exemption for students, and authority to render master’s and doctorate degrees at its sole discretion.

In December 1970, Enforcement Decree of the Act was enacted to emphasize the autonomy and responsibility of operation, and to select the council of academic evaluation as a legislative body. However, following amendments in October 1971 and in August 1974, “legislative” was modified to “reviewing” and “funds” of the act was modified to “budget”.

Special provisions of Korea Advanced Institute of Science Act for establishment and promotion of special science and engineering higher education institutions served as frameworks to enactment of related laws for Gwangju Advanced Institute of Science and Technology and Daegu Gyeongbuk Institute of Science and Technology.

3.3. Inducement of Professors and Design of Curricula and Laboratories

Inducement of professors and design of curricula and laboratories of KAIS were made through the control room in the United States.

The KAIS Coordination Room was in operation at Stanford University, to which the Turman investigation team belonged, for five years from 1971. Its main functions included a) cooperation with USAID, b) support of research equipments and books purchase, c) support of recruitment of professors, d) provision of collected science and technology information, e) support of professor training, f) recommendation for science and technology advice, and g) support of overseas activities and collection of related information. For this, 1.5 million US dollars of 6 million aids from USAID including technology consulting and operation were used.

Also, an academic advisors group was jointly run by Dr. Keun Mo Chung and other American professionals to select professors.

The academic advisors group determined the principles of professor recruitment guidelines by selecting qualifying candidates and deciding the appropriate candidates after explaining the needs of KAIS and qualifications, and discussed the process of recruiting professors. In addition, the academic advisors group discussed the preparation of the recruitment, evaluation of candidates and determination of the hierarchical grades, and ways to contact professors who would increase the academic reputation of KAIS. Also, they advised to allocate faculty members to different science and engineering areas in balance, by emphasizing the development of basic science for the development of engineering and applied science, and to select subjects to concentrate on the development of engineering during the early phase. Also, the academic advisors group suggested utilizing exchange professors system based on the competences of the professors rather than academic capacity, to equip laboratories and facilities reasonably, and to increase the budget allocated for the library to establish a world-class science and technology library to be used commonly.

After organizing the coordination room, KAIS recruited professors and selected candidates through letters, newspapers, conferences and interviews based on sister-alliance with Stanford University. After distributing application forms to 150 candidates and personal contacts, 50 candidates applied to KAIS. In addition, KAIS promoted targeting renowned engineering schools in the United States such as MIT, and science and technology related foundations including National Science Foundation and National Academy of Engineering, visited main cities including Boston to publicize KAIS to recruit professors. Through these efforts, 40 scientists submitted the application form, 22 scientists sent their resume, and including those who expressed their interests through correspondence, the total applicants reached 97.

To evaluate the applicants, a heavy importance was placed on the educational background, experiences in education, research experiences and achievements, appropriateness to the recruitment plan of KAIS and the timing to join. Objective evaluation including competencies and potentials as a scientist, competencies and experiences as a professor and research achievements were also considered. KAIS recognized that it is important to recruit outstanding professors and make them devoted to the education and research in stable environment to achieve its sound growth. Accordingly, high-quality professors were secured through strict criteria on the qualifications and experiences of professors, based on contracts which allow promotion and renewal of contracts through results of evaluation. At that time KAIS required a Ph.D. degree as a minimum requirement to apply for the professor position and recruited them openly. It was the first attempt in Korea and considered unconventional. The recruitment process was very selective: for example, the establishment of semiconductor laboratory had been postponed for three years to recruit an appropriate semiconductor specialist.

KAIS paid special attentions to provide stable working conditions. KAIS considered that to recruit outstanding professors and make them settled down to be devoted to the works of KAIS, it should first make their lives stable and offer a certain level of comforts to induce overseas scientists. In addition, KAIS provided salaries balanced to that of other research institutes in Hongreung R&D complex, a modern apartment, moving expenses for recruited overseas scientists, other benefits, and research funds for settlement. Accordingly, recruited KAIS professors were offered an exclusive apartment and salaries three to four times greater than that of professors of national universities.

3.4. Inducement of Outstanding Students and Special Education Programs

KAIST has provided the following benefits to induce outstanding students since its establishment:

a) Sufficient financial support including full-tuition scholarship for regular students and students under industry-university collaboration programs as well as double occupancy dormitory facilities,[4]

b) Exemption of military services by completing military training for less than 10 weeks,

c) Rewarding doctorate, professional master's and master's degree according to its own regulations,

d) Imposing the obligation to the graduates to render services for a certain period of time in the industry, educational institutions or research institutes in response to the exempted military services and government's support, and

e) Supports of industry-related organizations for a part or whole of tuition fees and admission of returning graduates under industry-academy collaboration programs in promoting industry-academy collaboration

By establishing institutionally these benefits, KAIST was able to induce the best science and engineering students at its introductory phase, evidenced by the statistics that 70% to 80% of the first year students in the master's program during the 1970s were graduates of Seoul National University. Especially the exemption of military services played a key role in inducing outstanding students. The competition among science and engineering students to join KAIST became fierce, called "KAIST qualification exam". It was a reason why other universities were jealous of KAIST.

KAIST provided education to the outstanding students that other science and engineering students may not experience, including emphasizing experiments, research projects with participation of students by selecting a practical research subject, mandatory dormitory life, strict class management and heavy volume of assignments, intensive computer education, 24-hour library, various seminars, laboratory training, visit to industry sites, etc. KAIST gave assignments to write experimental thesis as its education principle which forced students to use laboratory equipments or measurements and helped develop self-confidence in using them.[5] In

4. KAIST students were admitted in three categories, including national scholarship, industry-university collaboration program, researchers program on the following qualifications.
   a) National scholarship: All cost of the education is provided by KAIST for students under a certain degree program. All undergraduate students are under this category. Students under national scholarship program have an obligation to render services appointed by the government after graduation.
   b) Industry-university collaboration program: This program is offered to students under KAIST programs for promotion of Industry-university collaboration and acceleration of R&D while they still belong to their original institutions. All cost of the education is born by the respective institutions of the students. Students under this program return to their institutions after graduation.
   c) Researchers program: This program is for students under degree programs while continuing their research works in order to secure advanced human resources by the industry, universities and government-invested research institutes. All cost of education is born by KAIST or the respective institution. After graduation, the student is required to return to the institution and render services for a certain period of time.
5. Laboratory facilities purchased by KAIST with 6 million dollars of loan from USAID had general purposes for educational experiments as well as for research and development.

addition, assignments given to students were evaluated strictly while providing rigorous education on courses. Its level of education was very intense that although the lecture was given only for nine to twelve hours a week, it required three to seven hours of studies per credit hour to understand completely the subject and finish assignments. Besides, while improving the research competencies with participation of students in research projects, KAIST provided research-based education by paralleling education and research projects to develop on-the-job capacity. Also, to increase the quality of the doctorate degree, KAIST requires compulsorily the submission of doctorate theses to internationally renowned journals.

3.5. Flexible Operation

Established under a special act, KAIST is authorized to operate autonomously and flexibly. Its academic system starts with no-department admission which allows students to decide the specialty after three semesters according to his interests and potentials. Transfer to other specialty is also allowed. KAIST selects outstanding students with potentials of future leaders based on comprehensive evaluation of GPA, grades in mathematics and science and other documents proving competencies of the candidate, as well as intensive interview focusing on the personality, without examination. This policy was implemented for the first time in Korea in 1991 for master's programs, 1992 for undergraduate programs, and 1994 for Ph.D. programs. Also, based on integration of master's and Ph.D. programs and early graduation system, KAIST has produced many young scientists with Ph.D. degrees in their 20s.

Table 1-5 | Young Scientists with Ph.D. Degrees Produced by KAIST

(As of 1990, Unit: Person)

Type	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	Total
Total Ph.D.	2	17	13	21	18	49	43	64	72	121	133	165	186	904
Younger than 30 years old	1	7	5	14	10	37	33	47	48	82	76	104	93	557
Ratio (%)	50	41	38	67	55	75	76	73	67	68	57	63	50	62

Note: The youngest Ph.D. degree holder was 25 years old.
Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST*.

Besides, KAIST adopted a flexible academic system including active minor and double major program, interdisciplinary major in master's and Ph.D. programs, Credit By Exam system, integrated undergraduate and graduate degree, early advancement to Ph.D. programs and equivalent system for credit earned in other universities in Korea and in other countries[6], and seasonal semesters.

6. Through double-major programs with internationally renowned universities, KAIST provides different education opportunities and improves the capacity as a global leader.

Box | Departments and Programs offered by KAIST as of 2009

- College of Natural Science
  - Department of Physics, Department of Mathematical Sciences, Department of Chemistry, Graduate School of Nano Science Technology

- College of Bio-science and Technology
  - Department of Biological Science, Department of Bio and Brain Engineering, Graduate School of Medical Science

- College of Information Science and Technology
  - Department of Electrical and Electronic Engineering, Department of Computer Science, Department of Industrial and System Engineering, Department of Knowledge Service Engineering, Department of Industrial Design

- College of Engineering
  - School of Mechanical, Aerospace and Systems - Specialization in Mechanical Engineering, Specialization in Aerospace Engineering, Specialization in Marine Systems Engineering, Department of Civil and Environmental Engineering, Department of Chemical and Biomolecular Engineering, Department of Materials Science and Engineering, Department of Nuclear and Quantum Engineering, and Graduate School of EEWS

- College of Culture Science
  - School of Humanities and Social Sciences, Graduate School of Cultural Technology, Graduate School of Science and Technology Policy Program

- College of Business Management
  - Graduate School of Techno-Management , Graduate School of Finance, Graduate School of Information and Media Management

- School of Innovation
  - Limited to minor/double major of Department of Management Science, Specialized Graduate School of Techno-Management

- Affiliated Institutes
  - Korea Institute for Advanced Study, National Nano-Fab. Center, KAIST IT Academy, KAIST Language Center, Korea Science Academy

4. Evaluation

4.1. Achievements

Firstly, KAIST played a key role in supplying highly capable scientists and engineers for industry, academia and research institutions. When the quality development of science and engineering graduate schools in Korea was poor, KAIST supplied highly capable science and technology human resources to lead industry, academia and research institutions. KAIST, along with both Pohang University of Science and Technology and Gwangju Advanced Institute of Science and Technology which were established by expanding KAIST model, has been in charge of leading roles in supplying excellent science and technology manpower, even after the capacity of science and engineering graduate schools has been further developed. KAIST graduates comprised 73% of total doctorate degree winners in Korea in science and engineering sector in 1990. 30.6% of the KAIST graduates entered the education sector, while 36.8% and 27.6% joined research institutions and the industry, respectively. Also, 35% of KAIST's master's program graduates entered the industry sector to carry out functions of gatekeepers in development of new technologies of private companies (Korea Advanced Institute of Science and Technology, 1992). Graduates of KAIST's master's and Ph.D. programs who entered the industry after graduation contributed to the self-reliance of the industry by working as core researchers of private research laboratories, and led the venture business boom in Korea in the early 1990s by establishing venture companies such as Qnix, Medison, TurboTech, NHN, etc.

Table 1-6 | Career Paths of KAIST Doctorate Degree Holders by Institution

(Unit: Person)

Education Received \ Sector of Activity		Education Institution	Research Institution	Industry (Including Research Institutes)	Government Institutions	Total
In Korea	KAIST	285	325	239	18	867(73%)
	Others	7	2			9(1%)
Overseas	USA	132	50	41	3	226(20%)
	Others	31	24	8	1	64(5%)
Not identified		7	4	3	1	15(1%)
Total (%)		462(39%)	405(34%)	291(25%)	23(2%)	1,181(100%)

Note: Data up to 1990

Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST*.

Secondly, KAIST contributed to pioneering science and engineering undergraduate and graduate school education, to providing a model of research-based graduate school development with related experiences. The establishment and the success of KAIST with no precedent graduate school education cases in Korea proved that quality graduate school education is possible in Korea and that graduate school education may contribute to the development of the nation. The success of development of KAIST, establishment of Pohang University of Science and Technology and Gwangju Advanced Institute of Science and Technology inspired other universities and influenced the promotion of science and engineering education and R&D activities, resulting in quality competition of high-caliber science and technology human resources development. In addition, KAIST, Pohang University of Science and Technology and Gwangju Advanced Institute of Science and Technology progressed into research-based graduate schools that contribute to the development of graduate school education focusing on research activities based on excellent results in national research projects and thesis studies generated by team works of outstanding faculty members and graduate school students. The model and experience of such research-based universities and graduate schools, together with increased government investment in the manpower and facilities of graduate schools, increased research funds for basic researches, expanded exemption of military services for science and engineering graduate school students, and reward of research scholarship, provided fundamentals to develop science and engineering universities into research-based universities and graduate schools, simultaneously carrying out education and research. However, recently it is noticed that the differentiated characteristics and specialties of the special science and engineering universities and graduate schools are getting weak with the development of conventional science and engineering universities and graduate schools.

Thirdly, KAIST led the development of gifted education and outstanding research results to produce highly capable scientists and engineers. While implementing flexible special education such as early graduation/rewarding of degrees, flexible academic system, research and laboratory education, KAIST provided an excellent operation model of cultivating highly capable scientists and engineers. The innovative operation of the special science and engineering universities and graduate schools caused a revolution in science and engineering university and graduate school education which had been rigidly operated within the frameworks of Education Act. Also, special education provided by KAIST, Pohang University of Science and Technology and Gwangju Advanced Institute of Science and Technology helped develop science high schools, aided outstanding science and engineering students to select their careers in science and technology sector and facilitated the realization of their talents. In addition, KAIST reported research results 28 times higher than the national average from 1986 to 1988 by submitting 2.78 scientific theses, 1.11 engineering theses, in total of 1.51 SCI theses to internationally renowned journals.[7]

7. The following are backgrounds for the excellent theses results:
   a) KAIST provided environment to devote themselves to research and education by recruiting competent professors and providing high level of compensation and accommodation;
   b) KAIST provided various benefits for students such as exemption of military services and scholarships

Fourthly, KAIST contributed to resolving the brain-drain issue through preventing outflow of advanced talents and inducing overseas Korean scientists. In other words, KAIST established a counter-brain-drain environment by recruiting outstanding Korean scientists working in foreign countries, and provided an excellent opportunity to have science and engineering education without going abroad. Also, the exemption of military service system that obliged KAIST graduates to render services to the related industry, universities or research institutes for a certain period of time after graduation prevented the outflow of the talents to other countries. Excluding those who were not entitled to continue their studies in Ph.D. degrees due to compulsory service period, 91% of 3,861 graduates of KAIST's master's programs in 1990 and 1991 obtained or were enrolled in Ph.D. programs. This phenomenon is unprecedented in any other education institutions in the world, meaning that almost all graduates of KAIST's master's program obtain a doctorate degree. In addition, most of graduates of KAIST who have left Korea to obtain a Ph.D. degree in foreign countries returned back and contributed to highly capable graduate education or high-tech researches.

Table 1-7 | Doctorate Degree Acquisition of KAIST Graduates (after Master's Degree at KAIST, Classified by Countries)

(Unit: Person)

Institution Location	Korea		Foreign Countries			Total
	KAIST	Others	USA	Others	Not identified	
Total	904(67%)	9(1%)	334(25%)	70(6%)	19(1%)	1,335(100%)

Note: Data up to 1990.
Source: Korea Advanced Institute of Science and Technology (1992), *Twenty Years of KAIST.*

Lastly, KAIST changed the university education system in Korea from a Japanese system to an American system. Korean undergraduate and graduate education prior to the establishment of KAIS was affected mainly by Japanese education system. After the establishment of KAIS, American style graduate education system was introduced and disseminated. Most of professors recruited by KAIST, Pohang University of Science and Technology and Gwangju Advanced Institute of Science and Technology were educated in the United States, and many graduates educated by them joined other universities in Korea, expanding thereby American education system to science and engineering universities and graduate schools all over the country. Moreover, the most popular destination of KAIST graduates who had left Korea to acquire their

so that they can concentrate on studying without worrying about their futures;

c) KAIST provided a chance to benefit from relatively modern and high-tech research facilities equipped with foreign aids;

d) Professors and students of KAIST felt responsible for innovative education unlike other universities in Korea influenced by government's utmost supports for them; and

e) KAIST induced presentation of theses in international journals by providing such condition for promotion and acquisition of Ph.D. degrees despite the early opposition.

doctorate degree was also the United States, expanding again American education upon their return to Korea. Professors from KAIST, Pohang University of Science and Technology and Gwangju Advanced Institute of Science and Technology contributed to the qualitative improvement of science and engineering education by lecturing as they were educated through strict evaluation and laboratory works.

4.2. Implications

Firstly, the special education system outside of frameworks of the conventional education system was effective for the innovative development of science and technology human resources. The enactment of special act for establishment and promotion of KAIST, and supervision of the Ministry of Science and Technology rather than the Ministry of Education made it possible to provide special education system without problems imposed by the conventional education system and innovative operation. Moreover, with limited means to develop all science and engineering universities and graduate schools, the strategy to put priority to develop special education institutions and to expand later the operation model and successful case was effective.

Secondly, the establishment and promotion of KAIST is a successful case of using effectively development loans from advanced countries. Although many other developing countries failed to bring out fruitful results in their efforts to adopt development loans from advanced countries, KAIST not only succeeded in stably settling down and developing, but also gave birth to other special science and engineering graduate schools such as Pohang University of Science and Technology and Gwangju Advanced Institute of Science and Technology, further provided fundamentals for qualitative development of science and engineering graduate schools in Korea.

Thirdly, securing outstanding faculty members and students as well as the utmost support of government were important success factors of KAIST. By providing high working conditions and benefits to recruit excellent professors, KAIST was able to stably maintain the high quality of the competencies and educational backgrounds of faculty members. As professors created the culture to think and discuss in horizontal positions in studying and researching with students based on their democratic thinking that they obtained during their Ph.D. courses in renowned universities in the United States, students were motivated toward study and research. In addition, the exemption of military services was very effective to induce outstanding students and help them contribute to the country by realizing their intellectual capacities without being isolated from the society upon graduation in the conflict situation with North Korea.

Fourth, demand-oriented approach in cultivating science and technology manpower made

KAIST possible to achieve synergic development with linking demands on science and technology human resources manpower by the industry. As KAIST focused on cultivating science and technology human resources with depth knowledge and practical applicability needed for industrial development, professionals produced by KAIST entered the industry and thereby formed technology leader group of the industry. KAIST set up its education system to meet short- and mid-term demands of the industry on science and technology manpower through selecting its courses with prioritizing the needs of strategic industries. For short, linking the cultivation of high-calibre science and technology manpower with industrial development strategies was effective to development of KAIST as well as contribution of KAIST to the nation's economic development.

Fifth, sufficient preliminary review and the willingness of the top authority gave power to select the best alternative and growth drivers. Measures for the establishment were made and operation system was designed based on the in-depth analysis of principles, operation factors and approaches by using experiences and specialties of advanced countries after intensive preliminary research and promotion. In this regard, the challenging spirit of a young scientist as well as full trust and support of high officials became an important success factor. The top authority was the pillar of support to overcome the difficulties encountered in establishment of a new special education institution.

Lastly, the efforts to change and evolve are important according to the changes in demands and conditions in mid to long-term vision. KAIST forecasted mid to long term changes in demands for science and technology human resources required by the country and designed the development of the institute for the coming 10 to 20 years, with corresponding changes in the operating system as well. In case of KAIST, it concentrated selectively on the development and supply of highly capable scientists and engineers required by the industry, during the early phases, then expanded the areas and programs of human resources development gradually, and changed its function to develop high-calibre research and development manpower when competencies of other science and engineering universities and graduate schools are sufficiently progressed.

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Chapter 02

Activation of Research and Development Activities

Chapter 02-1

Establishment and Management of Government - funded Research Institutes Beginning with the KIST

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<Summary>

Establishments of government-funded research institutes mandated to induce industrial technology development through modern science and technology research in Korea were introduced during 1960s to 1970s pursuant to the industrialization strategy according to economic development plan. For instance, Korea Institute of Science and Technology (KIST) was established during 1960s as a new comprehensive research institute to absorb and assimilate advanced technologies required for industrialization. Other government-funded research institutes were further introduced during 1970s to meet the demands for technologies necessary for promotion of heavy-chemical industries. KIST provided a start point to build up domestic research and development capabilities with aiming at solving technological problems of the industry for internalizing advanced technologies. And, specialized government research institutes, which were established from spin-offs of KIST model or through transformation of national or public research institutes, pursued objectives to fulfill specific technological demands of strategic industries at their establishments.

Government-funded research institutes including KIST were established as non-profit organizations in order to overcome operational rigidities and limitations inherent to national and public research institutes as well as to maintain autonomy and independence in their operation. For this, government enacted “Act on Fosterage of Korea Institute of Science and Technology” that included major substances such as provision of governmental funds in construction and operating costs as well as operating funds of the Institute, transfers or rents national properties that the Institute may require for free of charge, institute’s self reporting of its annual business plan to the supervising minister, substitution of governmental audit with financial statements

reviewed by the Certified Public Accountant appointed by government, etc.

KIST considered the recruitment of competent science and technology manpower as a very important task, and thereby preceded active recruitment activities for Korean scientists working abroad with ensuring autonomy and stability of research activities and providing unprecedented financial treatment/benefits and social prestige. KIST's recruitment of scientists abroad was introduced internationally as the first case to overcome the brain-drain that developing countries typically suffer from.

KIST was launched with basic principles of a) ensuring independence of research; b) maintaining financial stability of the research institute, and c) creating vital research atmosphere. On the basis of these basic principles, KIST set its basic operating guidelines with benchmark of research institutes of advanced countries. Particularly, the contract-based research system that highlights KIST's operational model formed strong foundation in responding its research activities to research demand, ensuring responsibilities of researchers to their projects, securing financial stability of the research institute, and maintaining autonomy in research activities.

Major achievements from establishment and operation of government-funded research institutes including KIST are as follows:

(1) KIST provided the fundamental for science and technology catch-up and self-reliance of technology through developing domestic R&D capabilities.
(2) KIST supported industrialization and industrial development technologically. The functions and roles of KIST accompanied strategic areas of industrial development based on economic development plan.
(3) KIST trained and provided human resources for development of science and technology.
(4) KIST provided a solution to the problem of brain-drain that most of developing countries suffer from. Establishment of KIST and other government-funded research institutes provided an opportunity to induce many Korean scientists and specialists staying abroad.
(5) KIST took a leading role in pursuit of national research and development projects and establishing industry-university-institute R&D collaboration.
(6) KIST served as a think-tank for industrial development and technological advancement.
(7) While KIST promoted the expansion and the development of research and development infrastructure, it also affected negatively the balanced development of research and development system.

Major implications from establishment and operation of government-funded research institutes including KIST are as follows:

(1) Government-funded research institutes have made a demand-oriented role with linking their functions with industrialization strategy.
(2) It is important to set a benchmark model for the development of institutes.
(3) It is important to make continuous efforts to enhance operational efficiency of institutes in response to changing social-economic expectations.
(4) It is important to manage development of government-funded research institutes with observing long-term co-evolution of nation's research and development system.
(5) It showed a successful case of developing domestic research and development capabilities with a development loan from an advanced country.
(6) The willingness and interest of the top authority is important. In case of KIST, President Chung Hee Park placed research and development activities on the top priority of government policies as a founder, although often it may remain in the low priorities in national development of developing countries.
(7) The leadership of development of the institute holds an important role. Dr. Hyung Seob Choi showed an outstanding leadership in establishing the fundamentals of the new research institute as the first President of KIST for six years.

1. Background

1.1. Underlying Context

Establishments of government-funded research institutes mandated to induce industrial technology development through modern science and technology research in Korea were introduced during 1960s to 1970s pursuant to the industrialization strategy according to economic development plan. For instance, Korea Institute of Science and Technology (KIST) was established according to the 1st and the 2nd 5-year economic development plan implemented during 1960s as a new comprehensive research institute to absorb and assimilate advanced technologies required for industrialization. Other government-funded research institutes were further introduced with the 3rd and the 4th 5-year economic development plan during 1970s to meet the demands for technologies necessary for promotion of heavy-chemical industries.

1.1.1. Context to Establish Korea Institute of Science and Technology (KIST)

In the early 1960s, just before the establishment of KIST, Korea's industrial structure was typically that of an underdeveloped economy, with backward technologies. The industrial structure in 1961 showed 40.2% of the primary industry and 15.2% of the secondary industry.

The contribution of the secondary industry to the Gross National Product (GNP) was only 13%. The military government that took control of Korea through 5.16 coup d'état in 1961 launched and implemented in earnest economic development plan. The 1st 5-year economic development plan determined fertilizer, cement, plywood, textiles, power, etc as main strategic industrial sectors by aiming the direction of industrialization at production of commodities, substitution of imported goods and expansion of export. However, modern technologies required for industrialization were too poor then thus it a significant part of the technologies from advanced countries.

In promoting the 1st 5-year economic development plan, the military government acknowledged the importance of acquiring underlying technologies for industrialization. The 1st 5-year science and technology development plan focusing on the technology acquisition plan was prepared, accordingly, to supplement the 5-year economic development plan undertaken in 1962. The plan not only emphasized acquisition of technology manpower, but also promotion of foreign technology importation for industrial technology development and establishment of foundations for science and technology promotion.[1]

Owing to the promotion of the 1st 5-year economic development plan, Korea established fundamentals to develop into an industrialized nation. As a result, its industrial structure in 1966 showed more than 20% of the secondary industry with 18.5% of the manufacturing industry. As the manufacturing industry grew and exports increased gradually, the need for science and technology was also continuously claimed. In order for Korean products to be competitive in global market, securing high-quality technology was essential rather than depending on the use of raw materials and labor. The government as well as the industry realized that a certain level of technology is indispensable for selecting appropriate production facilities and using them, improving operation technology to enhance productivity and assimilating and applying imported technologies in Korean specific conditions.

However, no institution with research and development competencies existed in Korea that might be assigned to research and development activities of such modern technologies required.

1. It was evoked by a meaningful question that Chung Hee Park, Chairman of Supreme Council for National Reconstruction asked during the reporting on the economic development plan. During the new-year business reporting of Economic Planning Board held in early January 1962 focused mainly on the 1st 5-year economic development plan prepared just before the meeting. After the reporting, the Chairman asked "I am not sure that there is no problem in technology sector. We are now constructing new manufacturing facilities. But is it possible with our current level of technology and manpower? If not, do we have any alternative measure?" In response, the Vice-Minister of Economic Planning Board committed extemporaneously to submit a separate plan for "technology acquisition", the term that he just invented then. As a result, Technology Administration Division of Economic Planning Board was assigned to specify the technology acquisition plan.

Until the mid-1960s, research and development activities in Korea were mainly carried out by national and public research institutes. However, due to limited financial support from government, national and public research institutes were facing difficulties to significantly increase their budget or to secure the minimum budget necessary for new research projects. Moreover, the working conditions of researchers remained at the level of regular government employees, as a result of which outstanding researchers changed their works, or assigned with several projects that active and dynamic research activities were unlikely. research activities carried out were also limited to technology development with focusing on administrative supports including examination, analysis, experiment and investigation. At that time, research activities of national and public research institutes often failed to integrate with the industry due to limited R&D budget, insufficient R&D equipment and facilities and researchers' inappropriate knowledge on industrial technology and incompetence, and to commercialize the results of R&D projects. Similarly, research investment of university research institutes was also very weak, as well as the private sector was indifferent in R&D investment with doubtful return. Many of the research organization established were only to control product quality.

The government, in this situation, sought to establish a new modern research institute to effectively promote technological support for industrialization. With aids from the United States obtained during the visit of President Chung Hee Park, KIST, the first modern comprehensive research institute, was established as government-funded research institute.

1.1.2. Background to Establish Specialized Research Institutes

After KIST, a number of research institutes were established by specific technology. It is closely related to the government's promotion strategy for heavy-chemical industries pursued during the 1970s.

Based on fundamentals of industrialization set during the 1960s through developing the labor-intensive light industry into the export industry, the Korean economy sought industrial restructuring in the 1970s. The occurrence of the 1st oil crisis in 1973 with the degraded international trade due to world-wide economic depression in the early 1970s affected significantly the Korean economy which pursued economic development focusing on exports. The Korean government, thereby, declared its directions toward the heavy and chemicals industry. The processing-trade type of industry that imports intermediate materials and capital goods and exports the finished goods produced by combining low-wage simple labor showed limitation to export increase and caused the potential problems of high dependence on importation of intermediate materials and capital goods. In this regard, the government selected six heavy and chemical industry sectors including steel, nonferrous metals, machinery, shipbuilding, electronics and chemicals based on their effects on other related industries and contributions to the growth of the overall economy, and intensively invested in such sectors.

Until the early 1970s, the capital goods industry in Korea was limited to assembly machineries using simple techniques for the light industry such as agriculture, mining and textile industry. However, Korean industrialization turned a new page in 1973 with the government's efforts to localize production plants and to reduce conventional turn-key productions based on the "long-term machinery industry promotion plan" and building an industrial complex in Changwon. In other words, promoting the heavy-chemical industry paved a way for the intermediate material industry such as petrochemical, steel, etc. and capital goods industry including shipbuilding and automobile to form the key industry in Korea.

The need to develop the defense industry was another important factor for such industrial restructuring toward the heavy-chemical industry. The Blue House Raid on January 21, 1968 and US Pueblo Incident called attention to national security, and Nixon Doctrine announced in July 1969 to reduce the number of the U.S. military forces required the development of the defense industry for self-defense. Accordingly, the government decided to promote construction of four key manufacturing facilities for heavy machineries, iron casting, special steel and shipbuilding in order to secure defense industry facilities. However, this project did not bring out fruitful results due to failure to find necessary foreign capital and technologies although the project was initiated by targeting production and assembly through division of labor led by the private sector. This failure gave a meaningful lesson to the government that when the defense industry development is accompanied by the heavy-chemical industry, securing capital and technologies is much more facilitated.

The demands for technologies were highly increased with the promotion of the heavy-chemical industry. Especially, specialized technologies to support the five strategic industries including machinery, steel, chemicals, shipbuilding, and electronics industries became one of the urgent issues. However, Korean companies at that time were not only capable to develop necessary technologies required for such strategic industries, but also premature to make investments for technology development. Korea was relatively competitive in the labor-intensive light industry that requires almost no technology development. The heavy-chemical industry was limited to use and imitate foreign technologies through importation of capital goods under government's tax supports. Nevertheless, as the heavy-chemical industry including chemical, steel and machinery began to progress in earnest, the needs to develop capacities to use specialized technologies, to rapidly absorb and assimilate advanced foreign technologies, and to improve obsolete production facilities and production process were raised in order to enhance competitiveness of the export industry. Thus, the government allowed large enterprises to acquire foreign capital and technologies needed urgently and determined the need to establish specialized research institutes by strategic sectors in order to actively meet the increasing demands for technologies following the heavy and chemical industry in mid- to long-term.

The experience from KIST that has successfully supported industrialization by absorbing and assimilating advanced technologies since its establishment in 1966 had an important influence on this government action. Because it was possible to establish new specialized research institutes based on the existing research organizations of KIST, which was already carrying out technology researches and form an efficient operating system within the new research institutes by benchmarking KIST model.

1.2. Policy Objectives

Government-funded research institutes in Korea were established to develop endogenous R&D capabilities that could effectively support demands on industrial technologies from industrialization.

Established as the first modern comprehensive research institute, KIST was mandated to support industrialization in line with the economic development plan and to derive technology development of the industry. As a research institute that can resolve technical problems and deliver them effectively to the industry was needed in order to select appropriate technologies required for industrialization, to absorb and assimilate imported advanced technologies, and further to localize the technologies, such functions were assigned to KIST. Aiming at focusing on industrial technology research and development activities that would contribute to economic development in Korea, KIST selected five key R&D sectors including materials and metals, food, chemical and chemical engineering, electronic and machinery through surveying on the status of Korean industry, by reflecting the key industries promoted by the 2nd 5-year economic development plan set in 1966.

On the other hand, the objective of establishing a government-funded research institute by specialized technologies was to meet increasing demands on specialized technologies following the heavy-chemical industry pursued by government focusing on its five key strategic industries. Since the mid-1960s, the positive outcomes of using industrial technology researches by KIST and other research institutes in production has resulted in enhanced R&D capacities to advance technology self-reliance. In this respect, in order to support technology demands in sectors which were deemed to be important at national level as well as needed for promotion of the heavy-chemical industry, Korea Atomic Energy Research Institute, Korea Research Institute of Standards and Science, Korea Test Institute of Machinery and Metals, Korea Research Institute of Chemical Technology, Korea Nuclear Fuel Development Institute, Korea Energy Research Institute, Korea Research Institute of Geoscience and Mineral Resource, Korea Electronics Research Institute, Korea Electric Research and Testing Institute, Korea Electronics and Communications Research Institute, Korea Research Institute of Ship, Korea Science and Engineering Foundation, Korea Ginseng Research Institute, etc. were newly established by spinning-off from KIST or transforming from national or public research institutes in the mid-

1970s by expanding the government-funded research institute model of KIST.

These government-funded research institutes were established as non-profit organization to enhance its autonomy and independence in operation, in order to overcome the inherent limitations of national and public research institutes and to effectively support technology development of industries. In addition, these government-funded research institutes were required to maintain with financial stability and modern research environment to overcome limitation of research activities and inefficiency of the national and public research institutes as well as university and private research institutes.

The government-funded research institutes established to accomplish such policy objectives has been gradually changed their development goals by responding to the evolution and development of R&D system in Korea and to the changes in demands for technologies according to the different phases of science and technology development. Since 1980s, with governmental research and development plans, the initial policy objectives have been changed to meet the demands for key technologies in the industry and the public sectors and to link industry-university-institute collaboration, and further in 2000s, have been focusing on strengthening next generation source technologies development capacities. In addition, considering highly increased R&D capacities of the industry since 1990, R&D activities of these research institutes have been directed toward securing source technologies and convergence technologies to support technological competitiveness of the industry as well as to develop large-scale complex technologies that private companies may find difficult to develop in mid- to long-term, beyond its initial policy objectives to meet immediate demands for industrial technologies.

2. Description of the Program

2.1. Establishment and Operation of KIST

2.1.1. Establishment of KIST

In 1960s, the Korean government continued efforts to establish a comprehensive research institute that would overcome the limits of national or public institutes and to support technological development of the industry in line with the economic development plan. Different alternatives including a) establishing Korea Advanced Institute of Science and Technology (tentative) as a comprehensive research institute in science and technology sector in form of special corporation, initiated by Ministry of Education; b) converting national and public research institutes into Korea Research Institute of Science and Technology (tentative) in form of special corporation, initiated by Economic Planning Board; and c) establishing a new comprehensive science and technology research institute with Korea Research Institute of Mining and Fuel, initiated by Economic Planning Board were reviewed in depth.[2]

In this regard, President Chung Hee Park's visit to the United States in May 1965 turned a new page to plan establishment of a comprehensive science and technology research institute. During the summit talk between President Chung Hee Park and U.S. President Johnson, it was agreed to send the U.S.'s Science Advisor to the President to help industrial development and establishment of applied science research institute in Korea, which accelerated the project. When the issue to establish a research institute was raised during the discussion, President Park expressed immediately eager agreement. Following announcement of the joint statement, an implementation plan to establish a research institute with Technology Administration leading the progress, based on alternatives to establish a comprehensive research institute reviewed up to date. The U.S. government's proposition to support establishment of a research institute was known to be derived by Donald F. Hornig, a Science Advisor to President Lyndon Johnson, upon the request from President Johnson to prepare a meaningful gift for President Park's visit to the U.S. The technological support from the U.S. implied, most of all, compensation for Korea's troops dispatch to the Vietnam War, and also to provide a case to respond to the brain drain problem that developing countries were facing. At the same time, it was to reduce the opposition in Korea against Korea-Japan Treaty which was about to be finalized and to show that the U.S. government will continue its supports even after the treaty signed with Japan.

On the other hand, the fact that Korea accepted supports from the U.S. government to establish KIST signified symbolically that the US supports to developing countries in 1960s changed from grant-aid to development loan. Following its success, President Johnson adopted this model as a new form of technology support to developing countries and Dr. Hornig sought technology support as provided to KIST by visiting numerous countries.

To perform a feasibility study to establish a research institute, the US government investigation team, comprising Dr. Hornig and professionals from Bell Telephone Laboratory, Rockefeller Foundation and Battelle Memorial Institute, arrived in Korea in July 1965. They visited steel, electric, aluminum, petroleum, fisheries, chemistry, plywood and ceramics industry in industrial sector, Sogang University, Seoul National University and Kyungpook National University in academic sector, and Rural Development Administration, National Industrial Research Institute, Korea Atomic Energy Research Institute, Kyungpook Industrial Testing Laboratory and Korea Research Institute of Mining and Fuel in institute sector during one week. The investigation team also had a chance to visit the Korean government as well as to

2. It will be discussed further in details in Section 3. Pursuit of the Program.

meet leaders of the industry, science and education, and research institutes. The investigation team led by Dr. Hornig agreed to the Korean government's idea to establish the new research institute as a non-profit independent organization as considered internally during review of different alternatives to establish a comprehensive science and technology research institute. The team proposed that the new institute will target to reach the global standards in the concerned R&D areas and will be developed gradually according to the recruitment and activities of competitive and devoted scientists. Upon its return to the U.S., the Hornig investigation team submitted a report ascertaining that it is possible and feasible to establish a research institute. According to the propositions made by the report, United States Agency for International Development (USAID) and a technology research institute in the United States executed a preliminary contract to help establishment and operation of the research institute.

Following the Hornig investigation team's departure, the Korean government organized a science and technology research institute steering committee with leaders from science and technology sector as well as different industries to have advices related to the establishment of the research institute. The steering committee prepared measures regarding the form and organization of the research institute in cooperation with the Technology Administration of the government, confirmed the articles of association in form of foundation, and determined the name of the new research institute. The new research institute would be led by the President of the institute, not by the Chairman of the Board, different from other foundations. Also, it was entitled to receive financial support from the government, but its operating plan and closing statement were only to be approved by the Board of Directors, without approval from the government. As described, the articles of association of KIST enhanced independence of operation by clearly realizing the intent and the philosophy of restructuring research institutes. This model was adopted intact by other government-funded research institutes established during 1970s.

2.1.2. Establishment of Government-funded Corporation

In February 1966, KIST was finally established through the feasibility study conducted by Battelle Memorial Institute, with Dr. Hyung Seob Choi, head of Korea Atomic Energy Research Institute, as President.

KIST was established as a special corporation in form of non-profit organization, rather than a government-owned organization although it was established with financial support from the Korean and the U.S. government, and financed most of its operating budget from governmental support. KIST has adopted a system considered innovative at that time by permitting autonomy and independence of operation without being related to the budget and accounting system of government despite financial supports provided by government. Recruiting outstanding scientists from abroad as well as dynamic and flexible activities would have not been possible as a government-attached institute.

KIST provided exceptional conditions and independence to its researchers compared to government employees. Promising conditions for researchers was a strategic choice that permitted recruiting and localizing advanced science and technology manpower from abroad in spite of limited governmental support. Based on these efforts, researchers also devoted themselves to resolve technical problems that companies faced in the field, and helped operation of the early industrial facilities through advices and trainings.

Further, KIST developed "package deal contract research" in order to ensure financial stability of its research activities. Although it might be entitled to receive financial support for operating expenses in addition to construction cost, KIST determined that financial support for operating expenses from government will inevitably allow government's control over its operation which would not conform to its principle as a contract research institute. KIST, willing to accept financial supports from government for research fund not for operating fund, derived an idea of executing lump-sum contract. A lump-sum contract is to submit a pack of several research plans in various areas by KIST for which annual financial support from government is provided. This unique system was not found in other research institutes. Upon receiving lump-sum research fund, KIST determines specific research projects through internal review at its discretion. Newly joined researchers are provided with research projects before receiving outside research requests. Initially, the Korean government was against the lump-sum contract proposed by KIST, citing that providing research fund other than operating fund did not conform to related promotion act. KIST tried to convince judiciary committee members and specialists of National Assembly insisting that operating funds include research funds as well. Based on these efforts, government supports included research funds and in 1969, 42 million won was first appropriated for the purpose of promoting the electronics industry.

President Chung Hee Park was named as one of KIST's founders. It was one of the most important factors that KIST was able to receive governmental support while maintaining the autonomy and independency as a non-profit organization. President Park was a strong supporter of KIST and helped resolve various problems encountered during the early phase of operation as an arbitrator. This support from the President raised social recognition of KIST researchers and gave them sense of responsibility.

2.1.3. Selection of Initial R&D Areas and Early R&D Activities

2.1.3.1. Selection of Initial R&D Areas

KIST aimed to focus on industrial technology research and development activities contributing to economic development of Korea. Identifying the current status of Korean industry was a prerequisite step to determine research areas. For this purpose, an investigation team organized with 57 specialists of industry, academic and government agencies in Korea as well as 23 specialists from Battelle Memorial Research Institute conducted a research on actual conditions of Korean industries. The results of the research showed the following problems commonly observed in various industries in Korea (Korea Institute of Science and Technology, 1993).

a) The industry urged easy access to and use of technical information.
b) The industry acknowledged a serious need to adopt advanced science and technology and awaited related measures.
c) The industry highly required pilot projects.
d) The industry found it particularly difficult to secure materials including metals.

Based on such results of the industry study, and considering demands for economic development and industrial development, KIST selected R&D areas to cover.

First of all, the government stated design and manufacture of industrial machinery, chemical processing and chemical production, and research and development for metal and non-ferrous materials, etc. as key R&D areas to promote the steel industry, electronics industry, mechanical industry and petrochemical industry appointed as main industries by the 2nd and the 3rd 5-year economic development plan. In addition, the government also included the food industry related to nation's challenge to food problem and highly indigenous, as well as the electronics industry whose importance was rising in the R&D area. Accordingly, KIST selected materials, machinery, electronics, chemicals and foods as five R&D areas. Also by including technical information, electronic calculation, industrial economics, materials testing and chemical analysis, KIST assigned technological service, survey and economic analysis functions. In particular, a special emphasis was placed on industrial economics considering the importance of market analysis such as economic analysis as an industrial research institute.

R&D areas selected at this time have remained as main R&D areas of KIST and have developed into higher level and strengthened specialization according to the industrial development and technological improvement. Since the mid-1970s, these R&D areas have developed and spun off from KIST into specialized research institutes.

2.1.3.2. Early R&D Activities

Early R&D activities of KIST focused mainly on a) R&D for the industry, b) R&D upon government request, and c) problem-shooting on the field.

Firstly, R&D efforts for the industry had started with three research projects requested by respective industries, including research on performance of automotive engine lubricant in 1967.

Secondly, R&D projects such as research on long-term energy demand and supply plan in 1967 and research on long-term comprehensive policy for science and technology promotion in 1967 were conducted upon request from the government. Research projects requested by the government continued further to research on Korean electronics and related industries to promote the electronics industry in 1968, directions of modernization of the machinery industry in 1969, and comprehensive iron and steel plant construction master plan and economic analysis in 1969.

Thirdly, problem-shooting covered mainly a) technical training in production site of manufacturing companies or short-term applied and development research, b) trouble-shooting on site, assimilation of imported technologies, and simple modification of existing technologies, and c) technical training and short-term applied and development research (less than one year). These R&D activities comprised 45.8% of the early research and development activities of KIST.

Early industrial research projects carried out by KIST were mostly trouble-shooting and technical training, rather than research and development of new technologies and process. KIST was involved in solving technical problems arisen from applying technologies introduced from abroad, or in executing contract for introduction of technology to support in economic and technological aspects. It is known that ensuring successful transfer of technologies by supporting acquisition of foreign advanced technologies by private sector is one of the most important roles of research institutes in developing countries. KIST was also involved in this function as a technology transfer center, aside from its inherent technology development function.

During the early phases of KIST, the number of research and development projects covering up to industrialization of research results highly increased. KIST conducted not only laboratory study but also industrialization of the results obtained, thereby strengthening technology transfer to the industry through designing appropriate size of manufacturing facilities and development of pilot machinery and equipments, and accelerating industrialization. This type of research was mainly required by industrial economic sector. Typical examples include feasibility study for the 2nd comprehensive iron and steel plant in 1972 and management diagnoses and extension services to companies.

KIST responded efficiently to demands for industrial technology during the early industrialization phase by supporting technology importation and improvement following economic development based on these research and development activities. Through successful activities to solve technical problems on the fields provided by researchers, KIST stabilized its operation to meet expectations of the industry and general public.

2.1.4. Operating System of KIST

2.1.4.1. Basic Principles and Operating Guidelines

KIST was launched with basic principles of a) ensuring independence of research, b) maintaining financial stability of the research institute, and c) vital research atmosphere, in order to highlight the strengths of outstanding foreign research institutes and to resolve problems of traditional research institutes in Korea.

Firstly, KIST is to ensure independence of research. It is based on the firm belief that creativity and efficient research outcomes base on independency of research activities. Ensuring independency was prerequisite condition to achieve flexible and autonomous research activities, in view of the fact that national and public research institutes operating as government-owned organization whose researchers had government-employee status were not able to carry out remarkable researches other than testing and analysis to support administration. Various reports prepared in establishing KIST, including the report by the Hornig investigation team, report by Battelle Memorial Research Institute, and Korea-US Joint Support Project Agreement to create and operate Korea Institute of Science and Technology, all emphasized the independence of research.

Secondly, KIST is to maintain financial stability. As securing independence of research, maintaining financial stability was also important to secure the existence of the institute. Heavy investment was required to recruit excellent researchers and to equip modern research facilities in order to have an innovative research organization system different from others. Moreover, launched while the move of the industry sector toward technology development still remained inactive, continuous financial support from government was mandatory for long-term investment until its operation is normalized.

Thirdly, KIST is to create vital research atmosphere. KIST considered vital research atmosphere as important as independence and financial stability. Creating vital research atmosphere such as developing research projects, maintaining advanced research facilities, providing reasonable compensation, and offering high self-esteem of contributing to the development of the nation is an important factor to secure outstanding research manpower. This atmosphere resulted in active R&D activities conducted by its researchers which made KIST to be called “a research institute that never sleeps”.

Based on these basic principles of operation KIST established basic operating guidelines which would serve as standards of all future research activities. KIST’s basic operating guidelines were made through thorough study and review of establishment and operation of renowned comprehensive research institutes in advanced countries and adjusting them considering Korea-specific conditions.

National Research Council in Canada was referred to ensure independency despite financial supports from government, while Battelle Memorial Research Institute in the U.S. was to review the structure and the operation of a contract research institute. Commonwealth Scientific and Industrial Research Organization in Australia and Max-Planck Institute in Germany were reviewed respectively for selection of research projects for national development and for balancing basic research and applied research and for relationship between institutes and universities. Institute of Physics and Chemical Research in Japan was considered for research laboratory units and their independency as well as application of results of in-house researches.

Based on the review, the following basic operating guidelines were settled (Korea Institute of Science and Technology, 1993).

a) Science and technology research and development as well as accumulation for national development,
b) Balanced development of applied research directly related to industries as well as fundamental basic research that will serve as sources of applied research,
c) Close relationship with the industry sector to utilize results of research,
d) Wide exchanges and technology alliance with other research institutes in Korea as well as in foreign countries,
e) Recruitment of sufficient researchers to carry out independent and dynamic researches,
f) Recruitment of researchers based on competencies and contracts for research projects, and
g) Responsibility accounting system through accurate cost calculation

2.1.4.2. Introduction of Contract Research System

KIST adopted contract research system of Battelle Memorial Research Institute as one of operating guidelines[3] as proposed by the U.S. counterparty. The system, which was quite unfamiliar in Korea at that time, is to conduct researches based on contract executed with the requester, such as the industry sector, on a certain issue and to return the results of researches. However, the Korean government accepted the contract research system expecting that it would reform the research environment in Korea. That is to say the researcher is to exert his efforts to carry out researches actually demanded by enterprises and the enterprises are to realize that research and development activities are essential in business by applying the results of

3. Contract research system was proposed by the specialist group from Battelle Memorial Research institute as a result of feasibility study to establish KIST in order to secure its operation while maintaining the autonomy and the independence. However it was the initial idea that President Johnson and Dr. Hornig kept in mind from the beginning of the discussion.

requested research project. Undoubtedly, there also was an expectation that government's financial burden would be reduced if KIST succeeded to be financially independent through increased number of research contracts.

The basic principle of earning its operating funds through research contract is not just reducing government's financial burden, but rather to operate the institute with relying on government. Accordingly, contract research system was emphasized as one of the most important factors to maintain the autonomy and the independence of the institute. In order to maintain contract research system, KIST introduced responsibility accounting system by research unit based on the strict researcher cost calculation. The system is to create a research unit when there is a sufficient demand for research and researchers to meet the demand, and operate it as an independent business unit. The director of the research unit were authorized to manage research funds autonomously without external control, but also held responsible for the use of research funds, therefore by performing the functions of management, beyond that of a researcher-in-charge. Accordingly, if there is no research demand, it is possible to close down the research unit.

Stable operation of KIST as a contract research institute could be secured by sufficient research requests from the industry sector, which was not likely in Korea at that time. As enterprises dealt more with lack of capital and machinery facilities, as well as purchase and supply of raw materials as immediate problems, new product development or technology development to improve production process were not often considered with interests at that time. Therefore, during the early phases, KIST strengthened contacts with the industry and continued active promoting actions to call attention to research and development and to induce research requests. KIST contacted the industry first to develop research projects and to induce research contracts, and adopted a strategy to offer research contracts at relatively lower price to convince the unwilling industry sector to show the effects of R&D activities. In order to increase research request to KIST from the industry sector, the government reformed its taxation system to allow individuals or corporations making donations to or paying research expenses to KIST to deduct such amount in tax return.

Despite these efforts, the research revenue earned from industry requested projects remained only at 34%, from its establishment in 1972. The remaining part was research funds received from government through government requested research projects and financial support.

The government requested research projects during the early phases were more of fieldwork rather than laboratory studies. By conducting fieldworks to establish governmental industrial and scientific technology policies such as "research on long-term energy demand and supply" and "research on the promotion of the machinery industry" requested by Economic Planning Board as well as "research for establishment of long-term comprehensive policies for science and technology development" requested by Ministry of Science and Technology, KIST was involved in government's science and technology service as a think-tank. In addition, KIST also provided research services to government bodies requiring specific results of R&D activities, such as "research on high speed patrol craft design and building" based on contract with Korea Marine, "research on drying red ginseng and red ginseng extract" based on contract with Office of Ginseng and Tobacco, as well as "research on green-house construction" requested by Rural Development Administration. Research funds from these projects were typically higher than the actual R&D works. Moreover, research projects to computerize works of government bodies comprised a significant part of researches requested by government such as "research on EDPS of budget system" and "Research on EDPS system development for administration of telephone billing". Through these research projects, KIST expanded the value and need of research and development to government and the industry.

2.2. Expansion and Development of Government-funded Research Institutes

2.2.1. Establishment of Specialized Research Institutes

The government-funded research institute model launched by KIST was an innovative system in Korea and widely expanded following establishment of specialized research institutes to support strategic technology development in the heavy-chemical industry during 1970. Those research institutes were mandated to transfer and provide technologies necessary to private enterprises in strategic industries by selecting appropriate technologies and by assimilating and localizing the introduced technologies, and at the same time to lead promotion of domestic technology development. Under circumstances where research and development capacities of universities and industries were poor, the government adopted a strategy to derive research and development of the private sector by establishing specialized research institutes as non-profit organizations to study industrial technologies.

There are basically three types of establishing specialized research institutes. As in case of Korea Research Institute of Geosciences and Mineral Resource, national or public research institute was transformed into non-profit organization; in case of Korea Research Institute of Ships, a subsidiary research institute of KIST was first established then spun off; in case of Korea Electronics Research Institute, a separate institute was established through spin-off of KIST's organization and personnel; or in case of Korea Research Institute of Chemical Technology, a new research institute was established.

Daedeok Research Complex Construction Plan was proposed in 1973 to accommodate these specialized research institutes. The purpose of this plan was to centralize research institutes and universities to share research facilities and materials as well as to allow active exchange of manpower and information which would result in improved efficiency of research activities and promotion of comprehensive researches covering various areas. Construction began in 1976 by research institutes. Following Korea Research Institute of Standards and Science that first moved into the complex in September 1976, five government-funded research institutes, namely Korea Research Institute of Ships, Korea Research Institute of Standards and Science, Korea Atomic Energy Agency, Korea Research Institute of Chemical Technology, and Korea Energy Research Institute moved in until the end of 1970s.

Table 2-1 | Establishment of Government-funded Research Institutes (from 1960s to 1970s)

Concerned Office	Name (Year of establishment)
Ministry of Science & Technology	• Korea Institute of Science and Technology (1966) • Korea Ocean Research & Development Institute of Korea Institute of Science and Technology (1973) • Korea Advanced Institute of Science (1971) • Korea Scientific and Technological Intelligence Center (1964) • Korea Science and Engineering Foundation (1977) • Korea Atomic Energy Research Institute (1973) • Korea Atomic Energy Agency (1976) • Korea Atomic Energy Agency (1976
Ministry of Industry and Commerce	• Korea Institute of Metal and Machine Industries (1976) • Korea Research Institute of Ship & Ocean (1976) • Korea Institute of Electronics Technology (1976) • Korea Research Institute of Chemical Technology (1976)
Ministry of Energy	• Korea Energy Research Institute (1980) • Korea Research Institute of Geoscience and Mineral Resources (1976) • Korea Institute of Electrical Machine (1976)
Office of Monopoly	• Korea Ginseng Research Institute (1978) • Korea Tobacco Research Institute (1978)
Ministry of National Defense	• National Defense and Science Institute (1970)
Ministry of Postal Affairs	• Korea Telecommunication Research Institute (1977)
Industrial Advancement Administration	• Korea Research Institute of Standards and Science (1975)

Note: Korea Energy Research Institute (1980) was established by consolidating Korea Institute of Energy Conservation, established in 1977, and Solar Energy Research Institute, established as a subsidiary research unit of KIST in 1978.

Established with government's efforts to develop local R&D capabilities from 1960s to 1970s, government-funded research institutes focused on assimilating and internalizing foreign technologies as well as meeting local demands for technology development which remained inactive during the early phases due to their limited experiences. Government-funded research institutes launched in earnest its own research and development activities at the end of 1970s. As R&D competency and environment of universities and industries were inadequate, government-funded research institutes led most of the R&D activities and paved way to induce Korean scientists working abroad. Moreover, since these government-funded research institutes adopted contract research system and receive research funds from government as KIST initiated, the idea of contract research system and research funds from government expanded gradually amongst university and private R&D laboratories as well as institutes of humanities and social science.

2.2.2. Reorganization of Government-funded Research Institutes

The number of government-funded research institutes started in the mid-1970s reached in total 19, in August 1980, including 1 subsidiary organization. National Security Committee launched in May 1980 in preparation of the fifth republic in Korea initiated political, economic and social reforms, and as a part of which emphasized consolidate government-funded research institutes. It pointed out the following problems of the government-funded research institutes and established a strategy to consolidate and reorganize these institutes by resolving the mentioned problems in order to maximize the efficiency of R&D investment and R&D activities.

a) Compared to the total number of researchers, research facilities and size of R&D investment available in Korea, there were too many research institutes, resulting in lack of critical mass in terms of number of researchers, research facilities and size of R&D investment per institute, thereby causing low investment efficiency.
b) As a new research institute required new administrative personnel, increasing number of research institutes reduced research competency and forced changing status of researchers to administrative position.
c) There were overlapping functions and research areas among various research institutes causing redundant researches as well as fierce competition to obtain research contracts and research funds.
d) As research institutes were supervised by different government bodies, and cooperation among research institutes was inadequate, exchanges of research manpower and technological information or sharing of research facilities were difficult, resulting in reduced research efficiency and low utilization of research results at national level.
e) Lack of integrated control and supervision at national level, including selection of research projects, allocation of research funds, evaluation and application of research results, interfered efficiency of research investment.

In November 1980, based on the measures prepared by Ministry of Science and Technology to reorganize research and development system and to improve its operation, a government decision to consolidate government-funded research institutes was made. Principles of the measure were a) to give Ministry of Science and Technology the authority to supervise all government-funded science and technology research institutes, b) to consolidate institutes into units that ensure efficient supervision and operation, and c) to transfer functions other than research, namely test, examination and approval to related organizations including national and public laboratories. Accordingly, 16 government-funded research institutes were consolidated into 9 organizations, except for Agency for Defense Development, Korea Science and Technology Information Center, and Korea Science and Engineering Foundation, under supervision of Ministry of Science and Technology. In detail, KIST, Korea Ocean Research and Development Institute affiliated with KIST and KAIS were consolidated into Korea Advanced Institute of Science and Technology (KAIST); Korea Energy Research Institute and Korea Research Institute of Geoscience and Mineral Resource were consolidated into Korea Institute of Energy and Resources; Korea Institute of Machinery and Metals and Korea Research Institute of Ships were consolidated into Korea Institute of Machinery and Materials; Korea Electrical Research and Testing Institute and Korea Electronics and Communications Research Institute were consolidated into Korea Electronics and Telecommunications Research Institute; and Korea Ginseng Research Institute and Korea Tobacco Research Institute were consolidated into Korea Ginseng and Tobacco Research Institute.

Ministry of Science and Technology that took charge of integrated administration of government-funded research institutes in 1981 launched a mid- to long-term R&D plan and required national R&D projects to be conducted with government-funded research institutes taking a leading role in order to provide stable research fund. The research fund for national R&D projects served to promote research activities of government-funded research institutes.

However, there were also arguments regarding consolidation of government-funded research institutes that took place in the early 1980s. Especially the integration of KIST and KAIS into KAIST caused a serious conflict. The reason why government consolidated two organizations, each having different characteristics of research institute and education institute, was to complement two institute's competencies by linking research and education and to thereby improve the efficiency and effectiveness of operation. However, despite the initial objective to link research and education, human resources affairs and operation of KAIST focused on KAIS, reduced motivation of researchers from KIST. The consolidation of KIST and KAIS did not reached a perfect integration; KIST was separated and made independent in 1989 and returned to its initial status before 1980. The artificial integration did not lead to successful outcomes because the consolidation was pursued without necessary discussions and understanding of members of the concerned institutes and due to different organizational cultures.

Meanwhile, after the mid-1980s, a few government-funded research institutes were newly established or reorganized with necessary changes in administrating government body due to development of new technologies and expanded national research and development projects. In March 1985, Korea Electronics Technology Research Institute and Korea Electronics and Communications Research Institute were consolidated into Electronics and Telecommunications Research Institute; in December 1987, Korea Food Research Institute was established under Ministry of Agriculture and Fisheries; and in January 1988, Korea Institute of Construction Technology was established under Ministry of Construction and Transportation. In June 1989, KIST spun off from KAIST; in October, Korea Institute of Industrial Technology was established under Ministry of Commerce and Industry; in December, the name of Korea Energy Research Institute was changed to Korea Atomic Energy Research Institute. In June 1987, Nuclear Safety Center was established as a subsidiary organization of Korea Atomic Energy Research Institute, and separated in February 1990 as Korea Institute of Nuclear Safety. Besides, in January 1987, Center for Science and Technology Policy was established as subsidiary organization of KAIST; in August 1988, Korea Basic Science Support Center was established as subsidiary organization of Korea Science and Engineering Foundation; and in November 1989, Korea Aerospace Research Institute was established as subsidiary organization of Korea Institute of Machinery and Materials.

Further, in the early 1990s, securing advanced technologies and sources technologies became urgent facing specialization of science and technology. Accordingly, System Engineering Center (changed to System Engineering Research Institute in 1990), Genetic Engineering Center (changed to Korea Research Institute of Bioscience and Biotechnology in 1995), Korea Electronics and Telecommunications Research Institute, Korea Electric Technology Research Institute, Korea Ocean Research & Development Institute, Korea Astronomy and Space Science Institute, Korea Basic Science Support Center (changed to Korea Basic Science Research Institute in 1994), Korea Aerospace Research Institute and Korea Institute of Nuclear Safety were established either as a subsidiary or an independent organization. In 1993, Kwangju Advanced Institute of Science and Technology and Korea Research and Development Information Center were established. As various research institutes were established by specialized areas, a system where institutes respond to demands of administrating bodies was once again in practice. At the end of 1996, Ministry of Science and Technology had 21 government-funded research institute including 8 subsidiary organizations under its supervision; Ministry of Industry and Commerce had 4 institutes; Ministry of Construction and Transportation had 1 institute; Ministry of Agriculture and Fisheries had 1 institute; Ministry of Finance and Economy had 2 institutes; Ministry of Information and Communication had 2 institutes; and Ministry of Land, Transport and Maritime Affairs had 1 institute under its supervision.

Nonetheless, since the mid-1980s, the proportion of R&D activities carried out by government-funded research institutes in the total R&D activities in Korea has been reduced despite the increased number of institutes. It can be better explained by increased R&D activities of private sectors and universities since 1980s, rather by decreased functions of government-funded research institutes.

2.2.3. Changes in the Governance of Government-funded Research Institutes

As explained above, since 1980s the number of government-funded research institutes has been increased despite some consolidation, and so have been research institutes owned by private enterprises. In particular, research institutes of large enterprises remarked results by concentrating on technological innovation to enhance global competitiveness of their products based on high quality science and technology manpower and advanced equipments. Research competence of universities has also been strengthened. Unlike during the early phases of economic development where government-funded research institutes provided most of necessary technologies nearly in monopoly, since 1990s the competition among government-funded research institutes, research institutes owned by private enterprises and universities has become remarkable. This change in environment raised questions by government regarding functions of government-funded research institutes, and changed government policy for government-funded research institutes from support and promotion to competition and evaluation.

In the end of 1980s, as research competence of private sector increased and national R&D projects became goal-driven, it was claimed to reform the functions and roles of government-funded research institutes. Therefore, the government initiated actions to redefine roles of universities and private enterprises in national research and development system, thereby specializing functions of government-funded research institutes that conventionally participated in R&D projects in all related areas in the field. Government policies for government-funded research institutes in 1990s were accordingly directed toward differentiating them in response to the changing environment.

First of all, the government's efforts to strengthen differentiated competencies of government-funded research institutes by improving efficiency and productivity were realized through adopting the Project-based System (PBS). The Project-based System was introduced to induce competition among research participants and research units in conducting a research project by reorganizing the operating system of government-funded research institutes. It was an attempt to change the operating system of research institutes to flexibly and adequately respond to external demands by centralizing its operation on research projects. This system reflects the government's policy to first determine the demand for research, then to purchase research results based on the increased importance on the goal-driven national R&D projects. However, flexibly responding to the demands based on research projects, on the one hand, hindered stably conducting long-term and sustainable research. For this reason, essential business corresponding to the characteristics and inherent functions of each research institute was newly created to ensure independence and stability of business.

Meanwhile, policies to specialize research areas of government-funded research institutes were also enforced. In this regard, specific areas that government-funded research institutes may differentiate from private sector or university research institutes were selected for each government-funded research institute as key research areas in order to enhance its specialization. These government policies of specialization and characterization of government-funded research institutes were specifically realized through creating government-funded research institutes' research projects in national R&D projects. In addition, the concept of "Star Project" was introduced in 1995 for typical and representative research project to support priority projects by institute.

These efforts to reform the system derived changes in the governance system of government-funded research institutes in the end of 1990s. In the early 1990s, most of government-funded research institutes were under administration of Ministry of Science and Technology, although some institutes were transferred to other administrating bodies as a result of co-evaluation of government-funded research institutes. As of end of 1996, there were 29 government-funded science and technology research institutes in total; 21 under Ministry of Science and Technology, 2 under Ministry of Industry and Commerce, 2 under Ministry of Construction and Transportation, 1 under Ministry of Agriculture and Fisheries, 1 under Ministry of Finance and Economy and 2 under Ministry of Information and Communication. At this time, the government diagnosed the problems of government-funded research institutes as: a) lack of capacity to effectively respond to the changing research environment, b) excessive control and intervention of administrating bodies, c) limited independence and creativity, d) inadequate competition system, and e) overlapping research areas. To solve the mentioned problems and to enhance productivity, the government enacted the Act on the Establishment, Operation and Fosterage of Government-funded Research Institutions in January 1999 and charged the administration system of government-funded research institutes to council under supervision of the Prime Minister's Office. Based on the change in the governance, government-funded research institutes were changed to be used universally by all government bodies and supervised thereby.

Leaving only some research institutes such as KAIST, Gwangju Advanced Institute of Science and Technology, Korea Atomic Energy Research Institute, Korea Institute of Nuclear Safety, Korea Cancer Center Hospital, Korea Science and Engineering Foundation and KIST on evaluation and planning under supervision of Ministry of Science and Technology, other government-funded research institutes were transferred to Research Council of Fundamental Science and Technology, Research Council of Public Science and Technology and Research Council for Industrial Science and Technology according to the function. However, the supervision was transferred to Ministry of Science and Technology following enactment of "Act on the Establishment, Operation and Promotion of Government-funded Institutions of Science and Technology" enacted in 2004 with administration system reform, based on political intention to more closely linked functions of government-funded research institutes with science and technology strategies of government. Again in 2008, government-funded research institutes under supervision of Research Council of Public Science and Technology were separately transferred to Research Council of Fundamental Science and Technology and Research Council for Industrial Science and Technology. Then Research Council of Fundamental Science and Technology and Research Council for Industrial Science and Technology were placed under administration of Ministry of Education, Science & Technology and Ministry of Knowledge Economy, respectively.

Since government-funded research institutes were placed under supervision of respective councils, the evaluation system has been modified to evaluate performances of institutes annually. Act on the Establishment, Operation and Promotion of Government-funded Institutions of Science and Technology currently requires respective councils to evaluate research results and management performance of supervised institutes and to submit such results to the Minister of Education, Science & Technology and Minister of Strategy and Finance. The Article 32, Clause 2 of Framework Act on Science and Technology requires that the head of responsible administration shall evaluate government-funded research institutes that Presidential Decree prescribes and submit such results to National Science and Technology Council. In addition, the provisions of the Article 7, Clause 3 of Act on Performance Evaluation and Management of National Research and Development Projects require National Science and Technology Council to evaluate appropriateness of objectives and criteria, as well as objectivity and fairness of evaluation process and methods used in evaluation performed and submitted by the head of responsible administration and councils.[4]

4. However, as National Science and Technology Council was launched as a permanent organization, new possibilities to reorganize or to develop government-funded research institutes and to evaluate them are under discussion.

3. Pursuit of the Program

3.1. Review of Measures to Establish a Comprehensive Science and Technology Research Institute

The military government that took control of Korea through 5.16 coup d'état in 1961 showed much more active attitude towards scientific and technological issues. According to its slogan to improve the standard of living by solving economic difficulties of the general public suffering from desperation and hunger, the military government put its utmost priority to economic development, thus by emphasizing fosterage of science and technology. Supreme Council for National Reconstruction, the highest authority under the military government ordered an establishment of a research institute to promote science and technology, in response to which Ministry of Education organized Council on Establishment of a Comprehensive Natural Research Institute in September 1961. The Council was organized with renowned scientists in Korea with Vice-Minister of Education as the head to prepare measures to establish an comprehensive research institute of science and technology. Council on Establishment of a Comprehensive Natural Science Research Institute reported a tentative plan to establish Korea Advanced Institute of Science and Technology which derived absolute support of government. However, the institute proposed by the report was a special corporation rather than a national or public organization. Supreme Council for National Reconstruction decided to establish the Institute of Science and Technology under administration of the Prime Minister based on the report, and enacted regulations of Council on Establishment of the Institute of Science and Technology in November 1961 to study and establish related plans. It was discussed to mandate Institute of Science and Technology to absorb all science and technology organizations of different government bodies and arrange directions of research projects through Council of Science and Technology Evaluation. It was decided to consolidate and reorganize existing research institutes because establishing a new research institute required a heavy investment. And the institute proposed was not a simple research institute but a administrative agency that directs overall science and technology research and development activities of the nation. However, this alternative did not further advance due to objections of related government bodies regarding consolidation of existing research institutes, different point of view of science and technology sector as well as financial issues.

One of the main projects pursued by Technology Administration Division of Ministry of Development in the early 1960s that gave birth to science and technology policies was reorganization of national and public research institutes. At that time, national and public research institutes comprised the absolute proportion of the total science and technology research institutes in terms of numbers, manpower and size of research fund. However, these research institutes were mostly small in size, except for a few national and public institutes.

Even large-sized institutions such as Central Meteorological Office, Geological Survey of Korea, National Institutes of Health, National Fisheries Research and Development Agency, were in major part not dedicated to research and development activities. Meanwhile, most of national and public research institutes concentrated on testing and examination activities based on limited budget allocated and obsolete facilities, showing very low proportion of research activities except for 2 to 3 institutes. In addition, as a majority of researchers of national and public research institutes were government employees subject to Government Officials Act, the quorum per institute was prescribed and recruiting outstanding researchers were in principle inaccessible. Also, subject to Budget and Accounting Act, research institutes did not have any autonomy on accounting for its operations, which made it impossible to initiate new innovative research projects. Accordingly, the government exerted efforts to reform national and public research institutes into research institutes of new characteristics.

In 1963, Technology Administration initiated a wide-scoped survey to accurately identify detailed status of science and technology research institutes in Korea, and pursued measures to reform national and public research institutes into private organizations. It was to transform National Industrial Research Institute into Comprehensive Institute of Science and Technology as a special corporation. For this, agreement of Ministry of Budget, responsible for allocation of national budget was obtained and a bill for Act on Korea Institute of Science and Technology was prepared and submitted to the economic ministers' conference in the name of Minister of Commerce and Industry in 1963. The main purpose of this bill was to establish Korea Institute of Science and Technology as a special corporation by transforming National Industrial Research Institute, and to foster it to become a technology center for industrial development. However, the proposal faced a number of objections from government and other sectors. In particular, protests from the National Industrial Research Institute were strong against privatization. Thus the proposed bill was put off and then cancelled with other pending bills proposed under the military government upon launching of the third republic in Korea in December 1963. Although it has never been finalized, the attempt to resolve the problem of national and public research institutes by privatizing expanded the idea of establishing an "institute in form of private organization". At the time, related government bodies came to acknowledge the need of a research institute mandated to develop technologies for industrial progress.

The try to reform the research institute, discontinued with the cancellation of the bill of Act on Korea Institute of Science and Technology was again brought to discussion when the discussion was known to the President. In September 1964, after the presentation on the past efforts to reform the research institute, the President ordered the Minister of Economic Planning Board to review and report the feasibility of establishment of a comprehensive science and technology research institute through consolidating and reforming National Industrial Research Institute, Korea Atomic Energy Research Institute and Korea Research Institute of Mining and

Fuel. The mentioned three research institutes were at that time those with the best research environment and manpower. Especially Korea Research Institute of Mining and Fuel was a private research institute run by contributions of national and public enterprises with a very high level of manpower, compared to other national and public research institutes, as confirmed through the survey conducted by Technology Administration. Technology Administration submitted a report citing that it would be more effective to create a new research institute in form of foundation with Korea Research Institute of Mining and Fuel playing the central role, rather than artificial integration of three institutions with different characteristics. Also the report expected that research institutes directly related to industrial production could be pursued through expanding the support from national and public enterprises, providing research funds to Korea Research Institute of Mining and Fuel, and receiving supports from private enterprises. As responsible persons of related institutions and government bodies agreed to the alternative measure, the plan to establish a new comprehensive science and technology research institute began to be shaped up. Despite low progress due to financial issues, Technology Administration continued efforts to reform research institutes by preparing the principle directions in 1965.

Following Korea-US summit talk, Economic Planning Board prepared measures for comprehensive science and technology research development with help of Technology Administration. The measures were essentially to establish a comprehensive science and technology research institute, to create special accounting standards for science technology research funds, and to enact Science and Technology Promotion Act. It proposed to establish an Institute of Science and Technology as an integrated institute of basic and applied research based on comprehensive development plan of government, in form of private foundation which would permit the institute to provide better conditions to its researchers and to ensure the independence. This science and technology research and development measure was presented to the United States parties only 15 days after the announcement of Korea-US joint statement after President Chung Hee Park's visit to the United States. With the idea of Dr. Hornig to establish as a contract research institute, "Establishment of Korea Institute of Science and Technology" was prepared to realize the launching of KIST.

3.2. Execution of Korea-US Joint Support Project Agreement and Support from the U.S. Government

On behalf of each government, Economic Planning Board and USAID agreed to accept investigation report of Battelle Memorial Research Institute regarding establishment and organization of the institute, and executed Korea-US Joint Support Project Agreement on establishment and operation of KIST in February 1966 as follows. (Korea Institute of Science and Technology, 1977)

a) Korean government should take necessary measures for the Institute to be established as a non-profit organization with a Board of Directions that ensure autonomy. Economic Planning Board and USAID would consider the Articles of Association of the Institute as prescribed in Part B of the report prepared by Battelle Memorial Research Institute as agreed;
b) The size and scope of operation would be determined based on experiences, reflecting demands of Korean industry. The Institute would be established in the early 1966. Within 1966, 75 employees would be recruited and construction of administration building would be commenced. For the five precedent years, it was estimated that the Institute would be equipped with 210 employees and research laboratories and administration offices over the total area of 200,000 ft 2 (approximately 5,550 pyeong) with appropriate facilities;
c) The Institute would maintain a close relationship with its sister research institute. The sister research institute would improve the Institute's capacity by advising on the latter's organization and operation and by training the manpower, as well as cooperate to open and develop international technology exchanges;
d) The employees of the Institute will be recruited among the best competent scientists in Korea. Their salary and other benefits would be determined at the level appropriate to recruit Korean scientists working abroad or outstanding scientists from other countries;
e) The Institute would be an independent organization to provide feasibility studies, technology adoption and application, supply of scientific and technological information, special services and experimental researches in various specialized areas in science, technology and industrial;
f) The Institute would develop cooperative mutual relationship with universities, research institutes and other special technology institutions, existing or that would come to existence in the future; and
g) The Institute would perform contract-based research projects subject to research fund that correspond to the capacity and purpose of its establishment. Those research projects contract would be executed with private enterprises and government-invested enterprises. Researchers would maintain the confidentiality and intellectual rights of requesters in carrying out the requested research projects.

Based on the intentions of Korea-US Joint Support Project Agreement, Korea and the United States agreed and jointly support the fundamentals to establish KIST including its organization, legal form, size, support for establishment and operation, recruitment of researchers and scientists, roles and functions, relationships with related organization, and conduct of research projects.

As it was proposed by President Johnson, the United States supported actively in the establishment of KIST. The government of the United States, through USAID, provided 7,188 thousand dollars; namely 2,562 thousand dollars for construction materials, 170 thousand dollars for books and materials, 1,280 thousand dollars for research facilities and 3,176 thousand dollars for services provided by Battelle Memorial Research Institute, as grant aid, and 1,856 thousand dollars; namely 175 thousand dollars for books and materials, and 1,681 thousand dollars for research facilities, as loan for establishment of KIST.

Also, in the course of construction, the US government performed the construction supervision. Battelle Memorial Research Institute, that supported the construction and early operation of KIST, executed a contract with Albert C. Martin and Association with registered office in Los Angeles, the United States, to provide support and advice on the construction plan of the institute, and conducted a feasibility study of the site plan, space-division, layout, construction plan and design documents for the institute's research and administration functions. Based on this, KIST, ACMA, and Battelle Memorial Research Institute jointly prepared a material requirement planning for long-term construction plan for KIST in August 1966. The reason why the construction took three years from the date of commencement to the date of completion was because it was a joint project of Korea and the United States. It took time to derive agreement among KIST, ACMA, and Battelle Memorial Research Institute, and then approval from the Korean government and the US government for all steps of construction, from design to use of resources and material purchases. However, compared to other similar construction projects with grants from foreign government the construction was completed in a relatively short period of time, because the President expressed his interests in the construction, directly or indirectly, and dispatched Construction Control Unit of Korean Military to support the construction to encourage early completion.

3.3. Support from Battelle Sister Institute for Establishment and Operation of KIST

Battelle Memorial Research Institute in the United States is internationally renowned contract-research institute with long history and comprehensive credentials. Based on contract with USAID, Battelle Memorial Research Institute supported the establishment of KIST as a sister research institute, in areas such as selection of researchers, purchase of materials and preparation of operating system. Specialists from Battelle Memorial Research Institute provided services in defining the scope of long-term contract research activities, settling non-profit corporation and organizing the Board of Directors, establishing relationships with other research institutes, estimating financial fund required for five years, confirming the preparation and capacity of the Korean government, while staying in Korea from September to early December in 1965. Specialists from Battelle Memorial Research Institute prepared detailed guidelines of KIST, including legal form of KIST, organizational structure, scope of research, relationships with other research institutes and establishment schedule, aside from the needs and feasibility of establishing a new research institute as well as principles regarding the establishment prepared by the Hornig investigation team. The contents prepared by Battelle Memorial Research Institute were adopted almost without modification, providing the ground to establish KIST as a non-profit independent organization without being controlled by government or national assembly. The research on current status of Korean industry carried out by Battelle Memorial Research Institute with participation of 57 Korean researchers together with 23 Battelle specialists played an important role to guide selection of research areas and researchers.

Based on the Battelle investigation team's advice that a sister relation with a research institution in the United States with sufficient research facilities and comprehensive experience would be essential in establishment and operation of the institute, Battelle Memorial Research Institute participated intensively in overall planning and implementation of establishment and operation of KIST as a sister institute for five years.

The support from the sister institute was provided in two phases, namely the first phase from June 1966 to the end of 1967, and the second phase from 1968 to June 1971 based on extended agreement term upon request from KIST. (Korea Institute of Science and Technology, 1993)

The first phase covered the first two years of operation with active participation of Battelle specialists in the following areas:

a) Establishment of overall plans on the operation, research and construction of the Institute;
b) Application of effective and modern administration techniques in implementation of the plans;
c) Cooperation in selecting Korean scientists and specialists in Korea and abroad;
d) On-the-job training necessary for contract-research projects for researchers and administration staffs;
e) Advice and cooperation in technology development and carrying out applied researches;
f) Advice on construction design;
g) Advice and cooperation on preparation of lists of research materials, facilities and other materials, design documents, bidding documents, as well as its selection, placing orders, installation, and operation; and
h) Support on establishing government agencies of science and technology as well as industrial economy

During the second phase, Battelle Memorial Research Institute supported specialists on specific research projects in industrial technology and economy, continued training for KIST's researchers, and supported analysis and application of foreign technologies while performing joint research projects with participation of specialists regarding the research tasks being carried out KIST.

Battelle Memorial Research Institute dispatched specialists to KIST on a permanent basis, and there were more than 60 specialists on non-permanent basis to support, human resource management, accounting and research fund execution, administration of laboratories, installation of research facilities, execution of research contract, construction design, purchase management, and research and development.

One of the most important functions of Battelle Memorial Research Institute was to recruit Korean scientists working abroad. While the final selection remained at the discretion of KIST's President, Battelle Memorial Research Institute was fully responsible for preparation of researcher selection and participated in interview with candidates. The participation of Battelle Memorial Research Institute in researcher recruitment was effective to reduce external pressures or disputes that might arise. However, one year after, from July 1967, appointment of staffs other than chief researchers was conducted independently by KIST without participation of Battelle Memorial Research Institute.

In addition, Battelle Memorial Research Institute supported various areas not only in establishment of the research institute from selection of site, construction design, organizational structure, and selection of research facilities and research scope, but also in research contract and operating management as well as establishment of research planning, during the early stage. However, the ideas developed by Battelle Memorial Research Institute were not simply applied to KIST, but through various adjustments considering the specificities of KIST.

Meanwhile, as KIST adopted the contract-based research system, which was not familiar in Korea, the research management trainings were implemented to researchers as well as administration staffs at Battelle Memorial Research Institute. Dispatched KIST staffs were trained during a period of six months to one year about the contract-based research system, including maintenance of relationship with the research requesters, preparation of contracts and final reports, as well as economic analysis of research cost and research plan.

3.4. Legislation of Act on Establishment and Fosterage

Ensuring active support from government was very important for KIST, being launched in a new form of research institute, until it becomes economically independent. Accordingly, a bill of fostering the institute including securing its financial stability was prepared by adding provisions for government's approval of business plan and audit to the initial bill submitted by Finance and Economy Committee of the National Assembly, and approved subsequently by the National Assembly. However, worrying voices were raised citing that the Act that reserves the grounds for government to intervene the operation of KIST might hinder the independence of KIST. Consequently, KIST submitted an amended Act including that KIST would neither be subject to audit nor government's approval of its business plan. Although it faced a lot of objections at Cabinet meeting, with help of the President's strong determination, the amended Act was approved in March 1967 during the special session of the National Assembly. KIST obtained undeniable legal grounds, thereby, that ensure its legal identity and financial stability.

The main provisions of "Act on Fosterage of Korea Institute of Science and Technology" enacted at that time are as follows:

a) Government funds in construction and operating costs as well as operating funds of the Institutes, and transfers or rents national properties that the Institute may require for free of charge[5];
b) Instead of obtaining approval of its business plan from government, the Institute report its annual business plan to the supervising Minister; and
c) Audit of the Institute will be substituted by financial statements reviewed by the Certified Public Accountant appointed by government.

Later in the 1970s, following the government's efforts to establish specialized research institutes in strategic technology areas, laws and regulations to foster these institutes were became necessary. Act on Fosterage of Specialized Research Institutions, enacted at the end of 1973, accordingly, adopted prescriptions of Act on Fosterage of Korea Institute of Science and Technology including payment of investment, free rent of national property, submission of business plan and audit by the Certified Public Accountant appointed by government. The Act was provided in order to reduce the inconveniences to prepare a separate act on fosterage for each establishment of new institution, such as KIST, Agency for Defense Development or KAIS. It served also as grounds for government's support for the newly established research institutes by adding the respective institute to the enforcement decree. Since Act on Fosterage of Specialized Research Institutions benchmarked Act on Fosterage of Korea Institute of Science and Technology, other research institutes were also established subsequently as foundations, entitled to receive government's financial support but to operate autonomously.

In addition, KIST amended Regulation of Tax Reduction and Exemption Act to exempt the institute's corporate income tax, registration tax, property tax, acquisition tax and excise tax, as well as to allow individuals or enterprises to deduct the total research cost paid to the institute based on the contract. And also, Customs Act was amended in order to exempt all materials used directly by the institute from custom duties.

5. The reason for using the term "investment", rather than "support" was to minimize government intervention in the operation of the Institute by avoiding applying "Act on the Budgeting and Management of Subsidies" which prescribes conditions such as approval of business plan and audit.

3.5. Recruitment of Scientists Abroad

In order to achieve its research scopes defined based on the survey on the actual industry status, it was important for KIST to secure key chief researchers with intensive experience in industrial research or with potentials to carry out industrial research by research area. However, at that time there was absolute lack of scientists with experience and competency in modern industrial research. Accordingly, it was decided to recruit Korean scientists and specialists working abroad, which also allow absorption of advanced scientific and technological knowledge, in the situation that brain-drain problem was serious in Korea due to backward economic conditions as well as weak science and technology environment.

In order to recruit outstanding manpower, KIST set a few principles as follows:

a) to ensure independence of research;
b) to ensure stability to continue research;
c) to provide appropriate research environment; and
d) to upgrade social acknowledgement and to provide financial stability to reward the work

In this regard, moving expenses including flight tickets, an apartment as well as medical insurance under contract with the United States that did not exist in Korea at that time were offered to the recruited scientists. Since many of scientists were recruited from the United States, salary levels were set at one fourth of that in the US, which was three times greater than the salary of a national university professor, thereby highly motivating KIST's scientists. Considering that 25 scientists with doctorate degree left Korea during the precedent three years due to underprivileged conditions which did not allow normal standard of living, it was important to ensure sufficient conditions to bring the drained brain back. Through this, KIST was able to recruit Korean scientists working abroad as key researchers and provided incomparable working conditions including sufficient salary, housing, and holidays so that the researchers may concentrate only on the researches.

KIST exerted active but prudent efforts in recruiting foreign scientists and adopted a strategy to recruit a selected few. With help of Battelle Memorial Research Institute, KIST prepared an introduction and distributed to foreign scientists and specialists working in approximately 800 organizations and institutions. In total, 500 applications were received, from which 150 candidates were screened, then conducted an interview for 78 candidates selected based on the priority in the candidate's country. For interview purpose, KIST required a research plan on the project selected by the candidate among the problems identified through the survey on the actual industry status. After reviewing the research plans with help of Battelle Memorial Research Institute's specialists in the respective area, 18 final candidates selected mostly in engineering sector were interviewed and recruited. The purpose of such a strict selection process was because, firstly, it was widely accepted that these first recruited chief researchers would influence the future of the institute as key manpower, and secondly, the strict screening would reduce possible drop-outs by reviewing intensively the conditions and competences of the returning researchers. Thanks to this prudent selection, there was rarely a case that the recruited researchers left again to foreign countries and even those could not adapt to the institute joined universities or enterprises, contributing to science and technology in Korea.

One of the difficulties that KIST faced in recruiting researchers during the early stage was that it was hard to find researchers specialized in machinery and metals that KIST required even abroad because while there were hundreds of scientists specialized in theoretical physics, only 20 scientists were specialized in related engineering. Also, foreign scientists' capacity to respond to diversified projects in Korea was poor since they have received education fitted environment in advanced countries and had experiences in specialized and specific areas. Moreover, even one or two outstanding scientists with remarkable achievements in a certain area had been recruited without detailed knowledge in the same area accompanied. It was difficult to expect the high utilization of such human resource. This problem became more serious in comprehensive research institute such as KIST because cooperation among various specialties was essential. In order to solve this problem, KIST first concentrated on organizing the best possible researcher groups by specialty. The vacant positions were filled by scientists with in-depth knowledge in basic science such as physics and chemistry and selected based on the acknowledged aptitude through re-training in machinery, metals and electronics.

Recruitment of scientists working abroad of KIST was introduced internationally as the first case to overcome the brain-drain that developing countries typically suffer from. The total number of chief scientists recruited by KIST reached 35 in 1967. Those scientists successfully settled down in Korea, and influenced other scientists to come back to the country, with impression of the high social treatment for the recruited scientists. Recruitment for temporary projects also increased. Through diversified recruitment activity, KIST succeeded to recruit hundreds of Korean scientists working abroad during 10 years.

It meant significant to the Korean government that KIST successfully recruited brains formerly drained to foreign advanced countries. The return of scientists to the home country was, most of all, an indicator showing the upgraded prestige of Korea. At the same time, it also helped the government ensure its justification based on its symbolic image as a modernized nation. During the early stages of KIST, various promotion materials such as film were produced. It became a must-visit place for foreign guest visiting Korea and symbolized a research institute equipped with the best facilities and researcher groups recruited abroad without direct intervention of government. The President showed personal interest for KIST's individual researchers, for example, by keeping a memo on a researcher in charge of steel for construction of comprehensive iron and steel plant construction that had been pursued since the early 1960s. In other words, KIST has been assigned to perform the function of a think-tank for national science and technology since its birth, rather than a simple research institute that develops technologies according to company requests based on contracts.

Subsequently, recruitment and use of foreign brain became more active as research competencies of government-funded research institutes strengthened with the establishments of specialized research institutes. The government started an inducement project targeting outstanding foreign brain in 1968. Through this program, those who wished to return to Korea were entitled to receive job proposals and to financial supports including moving and travel expenses. Based on this, KIST recruited 225 outstanding foreign scientists on a permanent basis and 229 on temporary basis during 1970s. Those scientists returned back to Korea at that time, and contributed significantly to the industrial development in Korea during 1970s and 1980s by forming the first generation of research and development and also to development of local advanced science and technology manpower.

4. Evaluation

4.1. Achievements

Firstly, KIST provided the fundamental for science and technology catch-up and self-reliance of technology through developing domestic R&D capabilities. KIST was established as the first modern comprehensive applied research institute in Korea. It served as the center of adoption, absorption, and assimilation of modern technology and derived improvement of imported technologies and self-reliance of technology development. In backward circumstances where research capacity of the university and the industry remained poor, KIST served as a focal institute for industrial technology development through problem-oriented research and development activities. KIST and other government-funded research institutes have contributed to improving overall standard of science and technology as well as to reducing gaps with advanced technologies and have improved self-reliance capacity of key technologies and high-technologies by playing the central role in national research and development projects since 1980s. As a contract research institute, on the one hand, they contributed to the improvement of industrial technology upon request from government or enterprises for projects required by the national industry. On the other hand, they helped develop capacity to derive self-developed technology and to assimilate and improve advanced technology. Examples of cases that research institute contributed to Korea's technological self-reliance are as follows:

(a) KIST mainly contributed to chemical and material technology areas through development of manufacturing technology of polyester film, development of semiconductor lead frame technology, etc. And also, KIST contributed greatly to technological self-reliance of computerizing technology with operation of its computer center.

(b) Korea Institute of Machinery and Materials contributed to self-reliance and advancement of machinery technology through development of automation system, development of software and design technology used for CAD/CAM, etc.

(c) Korea Chemical Technology Research Institute paved technological self-reliance base of fine chemical areas through development antibiotic substances, development of advanced chemical materials, etc.

(d) Electronics and Telecommunications Research Institute built up technological self-reliance base of information and telecommunication industry through development of domestic computers, development of 4M DRAM semiconductors, development of digital switching system called time-division exchange (TDX) series, etc.

(e) Korea Atomic Energy Research Institute advanced self-reliance of nuclear electric power technology through localization of nuclear fuel, development of the Korean nuclear reactor, etc.

Secondly, KIST supported industrialization and industrial development technologically. The functions and roles of KIST accompanied strategic areas of industrial development based on economic development plan. KIST also actively responded to demands for technologies of the industry with other specialized research institutes established in strategic industries during the 1970s as a part of the heavy-chemical industry promotion plan. Since 1980, the government has continued efforts to establish and develop government-funded research institutes in relation to the development of key industries, the high-tech. industries as well as next generation industries. These government's strategies to promote government-funded research institutes show that government-funded research institutes have taken the primary responsibility to meet the need for essential technology required by related industrial development. The existence of government-funded research institutes closely related to the strategic areas of industrial development increased the potentials and outcomes of establishing industry-university-institute research collaboration system for technology development in the respective area. The development of digital switching system called time-division exchange (TDX) series and high-density semiconductor that brought an important opportunity for the information and communication industry in Korea was realized by industry-university-institute research collaboration system with Electronics and Telecommunications Research Institute (ETRI), a government-funded research institute, taking a major role. Although government-funded research institutes such as KIST were established aiming at research and development and technological support, they carried out an essential role in localization and advancement of technologies in the course of formation and development of the industry in Korea.

Thirdly, KIST trained and provided human resources for development of science and technology. Researchers obtained knowledge and experiences in technology development area in KIST and other government-funded research institutes joined local companies, universities and research institutes and contributed significantly to the development of technology as well as science and engineering education. In case of KIST, in total of 4,397 employees were dispatched to other sectors as of July 2005. Among those, 1,892 persons remained in research sector; 606 of which were reachable and by sector, 332 persons (54.8%) found to have joined the university while 127 (21.0%) and 147 persons (24.2%) joined the industry and other research institutes, respectively. They all have carried out leading roles in science and technology development in respective areas. In establishment and development of research institutes owned by private companies, researchers of government-funded research institutes were recruited as a director or key researcher and made important contributions to the advancement of industrial technology in Korea and to expand R&D activities of enterprises. Besides, many researchers of government-funded research institutes joined the university and contributed to the development of science and engineering education directed toward solving problems. Today, Korea is named as one of the most developed IT countries in the world. This is also because professors from ETRI comprising more than 50% of total university professors in IT contributed to the development of high-quality human resources specialized in information technology. In addition, government-funded research institutes made a contribution to developing high-quality science and technology human resources driven toward problem-soling through on-the-job training system for graduate students specializing in science and technology, researcher program for graduate students implemented in 1980s, and university-institute collaborative master's and doctoral degree programs.

Fourthly, KIST provided a solution to the problem of brain-drain that most of developing countries suffer from. Establishment of KIST and other government-funded research institutes provided an opportunity to induce many Korean scientists and specialists staying abroad. They contributed to localization of advanced technologies and took a leading role in modern science and technology development in Korea. Successful settlement and high achievements of high-quality scientists recruited from abroad by KIST and other government-funded research institutes helped inducement of outstanding scientists working abroad by private sector in order to strengthen technology advancement and technological competitiveness.

Fifthly, KIST took a leading role in pursuit of national research and development projects and establishing industry-university-institute R&D collaboration. Based on their capacity to carry out organized R&D activities and adequate research funds and human resources, government-funded research institutes took a leading role in industry-university-institute R&D collaboration as the size of national research and development projects grew and development of complex technology system was under progress. In this aspect, national research and development projects opened a new page of industry-university-institute R&D collaboration to motivate private enterprises to invest in research and development activities. R&D investment made by private enterprises multiplied, accordingly, from 300 million won in 1966 to 12,000 million won in 1975.

Sixthly, KIST served as a think-tank for industrial development and technological advancement. KIST's researchers worked as a think-tank in economic development, development of strategic industries and technology self-reliance covering wide areas including development of key industries, establishment of fosterage strategies for the heavy-chemical industry, establishment of economic development plan, feasibility study for industrial development, and review of technology adoption. Other government-funded research institutes, assigned to a specific specialty through establishment of specialized research institutes and development of government-funded research institutes into specialized areas, have also been performing the function of a think-tank. In other words, in generating government policies on nuclear, such as development of the nuclear industry and enhancement of nuclear safety, Korea Atomic Energy Research Institute served as a think-tank.

Lastly, while KIST promoted the expansion and the development of research and development infrastructure, it also affected negatively the balanced development of research and development system. Based on the success of KIST, specialized research institutes were established during 1970s by benchmarking KIST model. Also, government-funded research institutes helped establish R&D system of private enterprises by providing research and development human resources and experiences. However, concentrating R&D investment and R&D activities on government-funded research institutes for a long time delayed improvement of research capacity of universities and caused their functions to be overlapped with those of private enterprises following improved R&D capacities of the industry which resulted in inefficiency of R&D investment. In other words, it is pointed that although the function of government-funded research institutes to link development of industrial technologies as defined in the past becomes ineffective, their new functions are not very clear. Moreover, today, the problem of relatively reduced efficiency of government-funded research institutes' R&D competencies is raised due to improved R&D competencies of the university and the industry.

4.2. Implications

Firstly, government-funded research institutes have made a demand-oriented role with linking its functions with industrialization strategy. They contributed to advancing technological self-reliance of the industry despite the situation of the lack of in-house R&D capacities, by making problem-solving roles to select appropriate technologies required for industrialization in strategic industries, to assimilate and absorb imported advanced technologies, and thereby to internalize advanced technologies into domestic technologies. In contrast to that, contributions of public research institutes to technological development of the industry are limited generally owing to biases to supply functions of scientific and technological knowledge caused by their impractical R&D perspective, government-funded research institutes in Korea built up demand-oriented research and development system through linking their research functions with technological needs of strategic industries, meeting technological demands of the industry by contract research system, performing proactive advising and training functions for technological problem-solving raised by the industry, etc. Government-funded research institutes that made main efforts on mediating roles for industrial technology development at their initial stages of establishments have moved toward contributing to technological advancement of the industry by precedent development of essential and core technologies needed by the industry in line with the upgrading of technology intensity of the industry.

Secondly, it is important to set a benchmark model for the development of institutes. KIST was established as a non-profit independent research institute in form of non-profit organization with ensured independency of research by adopting operating model of a research institute in advanced countries. To overcome problems of conventional national and public research institutes such as limited financial resources as well as inflexible and inefficient operation, its independence and financial stability were assured by related laws enacted for its establishment and promotion. It founded the grounds of long-term sustainable development of KIST and other government-funded research institutes and played a key role in achieving innovative results. In addition, KIST launched a contract-based research system and adopted independent research system by unit and independent accounting system. The contract-based research system strengthened the responsibility of researchers and improved responsiveness of research activities to demands for research. Also, the contract-based research system allowed autonomous control of purchasing unnecessary research facilities and increase or decrease research units according to demands for research. As the contract-based research system was unfamiliar in Korea, advices and supports of Battelle Memorial Research Institute in the United States that has been operating under the system helped the implementation.

Thirdly, ii is important to make continuous efforts to enhance operational efficiency of institutes in response to changing social-economic expectations. Considering that public research institutes tends to be inefficient generally compared to private research institutes, government-funded research institutes in Korea have made continuous efforts to enhance their operational efficiency while performing public role for research and development. Government-funded research institutes, as non-profit organizations, attempted to enhance operational efficiency through introduction of contract-based research system and responsible accounting system, etc. in order to avoid rigidities and inefficiencies frequently inherent to national and public research institutes at their initial stages of establishments. Afterwards, in 1990s when research and development capacities of the industry and universities expanded significantly government-funded research institutes attempted to enhance their operational efficiency through creation of competitive research environment by introduction of the project-based system(PBS) and institution evaluation system, preparation of development plans for their specialization, strengthening of demand-oriented contract researches under the research council system, enforcement of performance-based personnel appraisal system, etc. Nonetheless, it has been raised continuously that their performance is unsatisfactory compared to increasing investment insufficient it on the one hand as well as that too much research competition inhibits mid- and long-term research stability, Their development directions are still on the review.

Fourthly, it is important to manage development of government-funded research institutes with observing long-term co-evolution of nation's research and development system. By applying the experience from KIST in establishment of specialized research institutes, it was possible to successfully implement government-funded research institutes model. Since 1980s, research capacity of the university and the industry has been increased. Accordingly, it is inevitable to change the functions and roles of government-funded research institutes, functional distribution among institutes, governance system, and R&D collaboration system for national R&D development in mid to long term.

Fifthly, it showed a successful case of developing domestic research and development capabilities with development loan from an advanced country. KIST was the first research institute that the United States granted aids in large volume and systematically to an underdeveloped country. Unlike science and technology research institutes in other underdeveloped countries that failed to grow and to develop due to many limitations, KIST contributed importantly to science and technology as well as development of the industry. Thus, KIST has been considered as a typical benchmarking model to establish and develop a research institute in underdeveloped countries. As KIST represents a successful model of the first comprehensive modern contract research institute in developing countries, there are increasing demands to transfer experiences to establish similar research institutes from developing countries.

Sixthly, the willingness and interest of the top authority is important. In case of KIST, President Chung Hee Park placed research and development activities on the top priority of government policies as a founder, although often it may remain in the low priorities in national development of developing countries. The President's support helped KIST to grow in a short period of time with strong support of government. Also the government's active support and high level of working conditions provided to KIST researchers provided an opportunity that a scientist may realize his professional competencies and be recognized socially. President Park visited KIST even several times a year, listened at the construction and business site, and exchanged words with many researchers to motivate them. This special interest of the President founded a ground for researchers to get inspiration and motivation.

Lastly, the leadership of development of the institute holds an important role. Dr. Hyung Seob Choi showed an outstanding leadership in establishing the fundamentals of the new research institute as the first President of KIST for six years. He pursued establishment of principle operating system, enactment of special laws and regulations for promotion of KIST, recruitment of outstanding scientists, implementation of the contract-based research system, development into national think-tank, and creation of vital research atmosphere with firm belief and responsibility based on the President's strong confidence. The contribution of Dr. Hyung Seob Choi influenced significantly financial stability, independence of research, and contribution to the national development of science and technology that KIST and other government-funded research institutes enjoy today.

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Chapter 02-2

Establishment and Operation of the Daedeok Innopolis Special District

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<Summary>

Today's Daedeok Innopolis Special District is originated from the Plan for Construction of a Second Research Complex established in 1973. At that time, a new research complex was needed for construction to provide a location for newly establishing specialized research institutes for supporting strategic industries and for moving the number of national and public research institutes from Seoul.

Until early 1990s, with building up infrastructure focused of regional dispersion of government-funded research institutes until early 1990s, it was developed as a Science Park. With significant efforts to utilize research results for industrial purpose, from early 1990s to 2004, Daedeok district continued to grow into Technopolis. In September 2000, Daedeok District was proclaimed as Daedeok Valley and sought transformation into an innovation cluster. Though, since the "Law on Fostering Daedeok Innopolis Special District" was enacted in 2005, Daedeok Research Complex has tried another transformation into Daedeok Innopolis to support and promote research and development, business (R&DB) activities in relation to the nation's new growth strategy and regional innovation potentials. The designation of Daedeok Innopolis Special District in 2005 aimed at developing the science town as a world-class S&T-based innovation cluster.

The objective of policy in the first phase was to construct a research and university town that can generate the needed synergy to propel research activities and that can upgrade performance of dispersed and expanded research institutes in the nation. Another policy objective transforming Daedeok Valley to Daedeok Innopolis was to provide fertile ground for R&D and

to stake out ground in the world market by turning R&D results into commercial success. This orientation aimed at building Daedeok Innopolis as a global hub for S&T and as a super-regional innovation cluster that leads a various field of researches to successful commercialization of their results and that accelerates mutually cooperative R&D activities among industry, academia, and research institutes.

Tsukuba Science City in Japan was a role model for Daedeok Research and University Town at the initial stage. However, the designation of Daedeok Innopolis Special District for innovation cluster benchmarked the world development trends of innovation clusters such as Silicon Valley in U.S., Zhongguancun Science Park in China, Hsinchu Science-based Industrial Park in Taiwan, and Kista Science City in Sweden, have played leading roles in securing national competitiveness.

In order to effectively support the process of constructing Daedeok Science Town, the government steering entities, such as the Comprehensive Science and Technology Council, the Committee on Construction of Daedeok Science Town, and the Heavy-Chemical Industry Promotion Council, were involved or established. However, Daedeok Innopolis Special District has been developed with trials and errors from construction stage of the Research Complex centered on research institutes to pursue a stage for innovation cluster nowadays, in accordance with changing science and technology environment and its evolution.

Upon completion of construction of Daedeok Science Town in November 1992, the importance of effective Daedeok Science Town administration was addressed. In December 1993, the enactment of the “Daedeok Research Complex Administration Act” included planning for Research Town management, classification of land use, and approval and cancellation of occupancy. In August 1994, the administration headquarters for administration of Daedeok Specialized Research Complex were established.

This Act was amended at the end of 1996 by reflecting a growing trend of converting Daedeok Science Town into Technopolis and announced the technology commercialization zone allowing business incubators in research institutes. This Act was, however, regarded as a strict land use regulation act that had several limitations for innovation cluster. In December 2004, the “Law on Fostering Daedeok Innopolis Special District” was enacted as a substitute to the “Daedeok Science Town Administration Act.” This law included provisions allowing an establishment of Innopolis committee chaired by Deputy Prime Minister for Science and Technology as well as Daedeok Innopolis Support Headquarters, research institutes to create spin-offs, exemptions for high-tech. companies and foreign-invested enterprises, and implementation of Daedeok Innopolis R&D projects. Daedeok Innopolis Support Headquarters based on this act has provided various support services and benefits to newly relocated institutions to facilitate research spin-offs and venture businesses.

The major achievements from establishment and operation of Daedeok Innopolis Special District are as follows:

(1) Clustering a large-sized research and development zone served as a key point for science and technology knowledge.
(2) Daedeok Innopolis contributed to enhancing technology innovation competencies and served as a key point to organize innovation clusters.
(3) Openness of research and development activities related to the industry was insufficient.

The major implications from establishment and operation of Daedeok Innopolis Special District are as follows:

(1) It is important to establish and implement a flexible plan with a vision of long-term development.
(2) The development only focusing on research institutes is insufficient for fostering an open-type innovation cluster by connecting R&D activities and the industrial activities of private enterprises.

1. Background

1.1. Underlying Context

The idea on establishing a regional research complex in Korea to develop closer tie between academia and research institutes, aiming to share common research facilities and data, to maximize research efficiency through the exchange of scientific personnel and information, and to conduct collaborative research among fields of study, was brought up at the end of 1960s.

Since the establishment of Korea Institute of Science and Technology (KIST) located in Hongreung, Seoul in the 1966, Seoul Research and Development Complex was created?with the following formation of Korea Science and Technology Information Center, Agency for Defense Development (ADD), Korea Advanced Institute of Science (KAIS), Korea Development Institute (KDI), and Korea Atomic and Energy Research Institute (KAERI). Seoul Research and Development Complex, however, was not based upon precise long-term planning, but was instead built spontaneously by the formation of such institutes. In addition, Hongreung region in Seoul became inappropriate for a research environment due to the high rise of urban development and limited space available.

At that time, KIST played a bridging role for supporting the private sector in the technology development until early 1970s, but was not able to meet the rising demands of new technologies facilitated by the heavy-chemical industry promotion policy priority. In order to deal with this problem, the government recognized the need to establish specialized research institutes with special attention to technologies for strategic industries. In this context, the government took an initiative to transform five technology institutes into specialized research institutions by splitting research laboratories of KIST in the field of ships, ocean, mechanical engineering, petro-chemicals, and electronics from KIST. As a part of this initiative, in 1970, the government devised the plan to build a new research complex, which would host a number of specialized research institutes as well as approximately ten national and public testing research institutes apart from Seoul.

The initial plan for creating Daedeok Research Complex was initially based on the "Long-term Comprehensive Plan of Science and Technology Promotion (1968~1986)" that was initiated in 1968. This plan addressed the importance of establishing research infrastructure to conduct effective research and development activities and pursued the development of a research and academic town to gather research institutes and universities into a specific region. According to this plan, Ministry of Science and Technology (MOST) consigned a study called the "Establishment of a Master Plan for Construction of a Research and University Town" in October 1970 to the Council on Economy and Science. The study result, which included the concept and basic design of Daedeok Research Complex, was reported back to MOST in July 1971.

The establishment of a new research complex was facilitated once after Dr. Hyung Seop Choi, the first President of KIST, was appointed as Minister of MOST in June 1971. The "A Draft Plan for Construction of a Second Research Complex" was reported to the Council on Economy and Science by MOST, however, it did not attract much attention until January 1973. In its 1973 New Year's first report to the President, MOST stressed on the need of mediators in technology development in order to pursue science and technology development strategy in developing countries. In addition, MOST highlighted the urgency of the issue on a sequential establishment of research institutes in the field of strategic industrial technologies as well as relocation of national and public testing research institutes from Seoul. Particularly, MOST proposed again the draft plan for construction of a second research complex, emphasizing the importance of gathering such institutes together in one place in order to maximize their roles and functions. This proposal attracted much attention of President Chung Hee Park. As a result, Daedeok district was officially designated as a second research complex on May 1973, considering its relative advantages to connect research activities effectively over other candidate sites.

Since 1974, the "National Master Plan for Construction of Research and University Town" was implemented and accelerated the construction, and Deadeok Science Town now became a very center of S&T in Korea. The role and characteristics of Daedeok Science Town went through changes according to changing demands of technological innovation as well as national science and technology development. During the 1970s and 1980s, for instance, the construction on infrastructure and research institutes was carried out and, as a result, the government-sponsored Science Park was born. With significant efforts to utilize research results for industrial purpose, from early 1990s to 2004, Daedeok district continued to grow into Technopolis. In September 2000, Daedeok district was proclaimed as a Daedeok Valley and sought transformation into an innovation cluster. Though, since the "Law on Fostering Daedeok Innopolis Special District" was enacted in 2005, Daedeok Research Complex has tried an another transformation into Daedeok Innopolis to support and promote research and development, business (R&DB) activities in relation to the nation's new growth strategy and regional innovation potentials. The designation of Daedeok Innopolis Special District in 2005 aimed at developing the science town as a world-class S&T-based innovation cluster.

The pursuit to the change of Daedeok Research Complex into Daedeok Innopolis was emanated from the acknowledgement of the significance of S&T to the entry into developed countries. Development and commercialization of new technologies are expected to bring a new growth engine of the nation. In this context, the government recently has pursued policies promoting Daedeok District as a world-class regional innovation cluster to encompass the functions of R&D and production and to lead innovation-driven economic development.

1.2. Policy Objectives

Since the implementation of the "Plan for Construction of a Second Research Complex", Deadeok District has constantly expanded its policy objectives in order to respond to the changing demands and roles of S&T.

The objective of policy in the first phase was to construct a research and university town that can generate the needed synergy to propel research activities and that can upgrade performance of dispersed and expanded research institutes in the nation. According to the "Long-term Comprehensive Plan of Science and Technology Promotion" established in 1968, "…by gathering research institutes and universities together into a specific zone, R&D activities could be effectively connected, research facilities and equipment could be commonly utilized, linking research activities with university education could foster outstanding talents, convenient exchange of technological information and knowledge could be allowed, and research institutes possessing research capacities in various fields could be connected and performed joint research and development. … In a long term perspective, therefore, it is recommended to plan and construct a research and university town as a key milestone in Korea's scientific and technological advancement for the coming 1980s." This initiative shows deep insight and eager of MOST for catching up developed countries and to rebuild Korea driven by science, although the idea was mainly affected by the research and university town developed in Russia and Japan. The policy objective for building a research and university complex was laid on enabling efficient investment and effective activities for research and development by sharing technological knowledge, scientific personnel, research facilities, and equipment within a specific zone. In addition, this policy orientation aimed to disperse over population in Seoul metropolitan area as well as to build a world-class intelligent city leading S&T and economic growth for the future.

Another policy objective transforming Daedeok Valley to Daedeok Innopolis was to provide fertile ground for R&D and to stake out ground in the world market by turning R&D results into commercial success. This orientation aimed at building Daedeok Innopolis as a global hub for S&T and as a super-regional innovation cluster that leads a various field of researches to successful commercialization of their results and that accelerates mutually cooperative R&D activities among industry, academia, and research institutes. The aim of this policy met the national objective of becoming a developed country with realizing an innovation-driven economy by regarding the globally competitive innovation cluster as a driver for national development.

In this context, Daedeok Innopolis pursues a S&T-based innovation cluster generating, transferring, and utilizing S&T knowledge, which can incorporate the following: (a) providing common environment for sharing embodied knowledge among industry, academia, and institutes, (b) achieving cost savings in knowledge generation to commercialization by reducing the costs of knowledge sharing and communication, and (c) accelerating high speed innovation by cutting down the development time for new innovations as well as by raising the quality of innovation. Thereby, Daedeok Innopolis is trying to serve as a new growth engine for Korea by utilizing R&D capacities and technology commercialization, by enhancing industrial competitiveness through the convergence of traditional and emerging industries, and by building an industry cluster network within knowledge-based research fields.

2. Description of the Program

The promotion of Daedeok District has been processed through three phases as follows. The first phase is the development stage to create Daedeok Science Park from 1973 to 1992 mainly to provide a location for research institutes. The second phase from 1990 to 2004 is the development stage at which it had tried a transformation into Daedeok Technopolis with proclamation of the development toward Daedeok Valley in September 2000. The third phase is the development stage at which it has pursued the development toward Daedeok Innopolis since the enactment of the "Law on Fostering Daedeok Innopolis Special District" in December 2004.

2.1. Construction of Daedeok Science Park as a Research Complex

2.1.1. Building up Infrastructure

The construction of Daedeok Science Town in 1970s was initiated mainly to function as aggregation of research institutes that support technology development needed for heavy-chemical industries. It benchmarked particularly Tsukuba Science Town in Japan, developed in 1960s. According to the "Master Plan for Construction of a Second Research Complex", finalized in 1973, a research and university city was designed to host five newly established strategic industrial technology institutes, 12 relocated national laboratories, one science and engineering college either newly established or relocated, and public facilities and industrial institutes. The construction area is about 8.1 million pyeong and was supposed to be a self-contained city for 5,000 populations. Daedeok Science Town was initially designed as an independent city that has special research functions apart from Daejeon City. However, it was incorporated into Daejeon city in 1983 to be developed with a concept of a sub-center of Daejeon city.

It was a forward-looking policy to promote effective linkage of R&D activities by gathering research functions spatially. Since there had existed only industrial complexes until early 1970s, the idea of aggregating research institutes in a specific area was quite innovative. In addition, locating Chungnam National University and Korea Institute of Science and Technology (KAIST) inside of Daedeok Science Town was also an advanced idea.

The initial plan, which only concentrated on dispersed research institutes into the local area, however, was not taking into account for building physical and social infrastructures. In particular, as the relocation of government-funded research institutes was primary concern, isolated placement of research facilities as well as a lack of functional linkage between Daedeok Science Town and surrounding areas of Daejeon city caused many problems. Because of the problems, the development made slow progress until 1976. It was not until December 1977 when the Ministry of Construction announced Daedeok District as an industrial complex development site.

2.1.2. Expansion of Research Infrastructure

With the relocation of government-funded research institutes and the construction of residential district for researchers, the development of Daedeok Science Town began. As more research institutes had moved into Daedeok Science Town, the construction of residential district for researchers and schools for their children started. In addition, Daedeok Science Town Administration Center was established as an affiliated organization of MOST in 1979 for its effective management. Beginning with that Ssangyong Comprehensive Research Institute moved in March 1979, as for enterprise research laboratories, three more enterprise research laboratories moved in 1980s and many of them began to relocate in 1990s. After that Daedeok Science Town was incorporated into Daejeon city in 1983 and the construction became active.

However, the layout of Daedeok Science Town and amenities were not sufficient until mid 1980s. Only four government-funded research institutes, two enterprise research laboratories, and one university moved into Daedeok district (area of 8.4 million pyeong) by 1980. By 1983 education and research facilities (1.66 million pyeong), housing sites (180 thousand pyeong) and roads (18.7km) were developed. Especially as for public housing, only 336 out of 1,400 households (23%) were sold.

For this reason, the government revised the initial plan of building a self-contained town. Instead, it decided to move urban facilities like housing into the research areas by applying the concept of Technopolis annexed to Daejeon city. A concrete shape to the scheme which aims at converting Daedeok Science Town into sub-center of Daejeon city was given with the second revised plan of the “Master Plan for Construction of a Second Research Complex” completed in 1981. Residents of Daejeon city as well as researchers and their family members were invited to live in Daedeok Science Town. This change was made at the result of reflecting the intention to promote Daedeok Science Town into Technopolis, with learning together from Tsukuba Science City in Japan and Silicon Valley in the U.S.

With the third revised plan of the “Master Plan for Construction of a Second Research Complex” in 1984, the government changed main promoter of the project from Industrial Zone Development Corporation (currently, Korea Water Resources Corporation) to Korea Land Corporation, in order to invigorate the Daedeok Science Town project and to complete the construction early. Previously, while a part of the residential areas were developed by Korea Industrial Zone Development Corporation, 14 institutes which are going to be located in Daedeok Science Town including Korea Research Institute of Standards and Science adopted an in-house development approach. However, Korea Land Corporation adopted a new concept of research complex that regarded Daejeon city as the mother town. Accordingly, Daejeon city was able to make relationships with research institutes in Daedeok District, thereby a drastic revision was made to the prior plan under the aim of building up the town of Science, Technology, and Culture.

Since Daejeon City was selected as the host of 1993 EXPO in February 1989, this put spurs to early completion of the construction project. The construction for Daedeok Science Town was quite slowly progressed even in later 1980s as the development of urban infrastructure and the relocation of anticipated institutions were delayed. However, as the urban infrastructure such as roads was developed for successful hosting of the EXPO and as both private and public institutes increasingly moved into Daedeok District, Daedeok Science Town made a strong appearance as a research complex. Thanks to strong support from the government for its early completion, the completion ceremony was held in November 1992. Until then, three government organizations, 15 government-funded research institutes, four government enterprises, eight enterprise research laboratories, and three higher-education institutions moved into Daedeok Science Town.

In addition, the national R&D projects begun in early 1980s contributed largely to expanding the research capacities of Daedeok Science Town. The national R&D projects were initiated for the purpose of conducting research and development that the private sector found it difficult to carry out due to high risks of the development. The projects were regarded to provide opportunities to strengthen linkage among industry, academia, and research institutes.

2.2. Efforts for Transforming Science Town into Technopolis and Creation of Daedeok Valley

2.2.1. Transformation into Technopolis through Developing Industry-Academia-Research Linkages

Daedeok Science Town tried to transform into Technopolis though developing the industry-academia-research linkages upon the completion of its construction in November 1992. Thus, Daedeok Technopolis stepped forward actively responding to socio-economic paradigm in which knowledge, technology, and information are centered.

Since its inception, the number of enterprise research laboratories located in Daedeok Science Town further increased over the past eight years: back in 1990 there were about three enterprise research laboratories, compared with 23 enterprise research laboratories in 1998. At the same time, the government policy for promoting industry-academia-research linkages had been intensified. Particularly, with the 1994 enactment of the "Cooperative Research and Development Promotion Act", the government gave public investment priorities to collaborative R&D projects and promoted the transfer and commercialization of R&D results.

During the 1990s, the government focused on commercializing results of publicly funded research and on building industry-academia-research collaboration. For this purpose, the business incubation program for researchers was launched in September 1990 by MOST. In 1994, MOST supported the establishment of High-Tech Venture Center (HTVC) at KAIST to foster high-tech start-ups and innovation. The main function of HTVC was to provide venture firms business space on campus, managerial and fund information, and common equipment owned by KAIST laboratories and research institutes.

Additionally, the number of organizations supporting venture businesses flowed into Daedeok District as follows: Daedeok Valley Venture Association (former Daedeok 21st Century) in October 1996; Daejeon Software Support Center in November 1997; Daejeon Small and Medium Business Support Center in October 1998; and Dasan House for Venture Businesses within Daejeon Industrial Complex in December 1998.

Along with the vitalization of venture businesses in this region, Technological Business Incubator (TBI) had been established at government-funded research institutes in Daedeok District, with the sponsorship of Daejeon city. For instance, Electronics and Telecommunications Research Institute (ETRI) promoted commercialization of R&D results and supported creation of spin-offs based on its technologies.

All these efforts fostering venture businesses were mainly associated with the government's intention to expand existing businesses into knowledge or technology-intensive venture industries since 1997. Even though Daedeok District is a national industrial complex, it was hard to induce companies to move into Daedeok District due to strict land use regulations. By the end of 1996 the "Daedeok Research Complex Administration Act" was implemented, which announced technology commercialization zone allowing business incubators in research institutes.

Along with the above-mentioned supportive tasks, Daedeok District had been reborn as an innovation cluster achieving innovative accomplishments throughout an industry-academia-research linkage system.

2.2.2. Creation of Daedeok Valley for Innovation Cluster

Daedeok Research Complex had been managed by the special law, so the government played a critical role for evolving Daedeok District into innovation cluster. The 'separation of research and production', which was the major problem Daedeok District faced during the 1990s, was resolved by the amendment of the "Daedeok Research Complex Administration Act" in December 1999 and the Small and Medium Business Administration (SMBA)'s policy actions supporting construction cost of cooperation complex. By facilitating and supporting venture businesses and industry-academia-research collaboration in Daedeok District, regional network activities of industry-academia-research were further expanded.

In September 2000, the proclamation of Daedeok Valley was pronounced for the purpose of developing Daedeok District into the industry-academia-research complex. With the proclamation, Daedeok Valley, which comprised Daedeok Science Town, Daejeon Science Industrial Complex, Daejeon 3rd and 4th Industrial Complexes, Yuseong Special Tourism District, and Dunsan Administrative Town, became to be developed towards an innovation cluster where R&D, production, and commercialization were organically merged. By the end of 1999, 13 technological business incubators, three venture firm accumulation centers, three cooperation complexes, and about 300 venture businesses were located in 3rd and 4th Industrial Complexes close to Daedeok Science Town. Examples of successful regional innovation clusters, such as Silicon Valley in U.S., Hsinchu Science-based Industrial Park in Taiwan, Software Technology Parks in India, and Silicon Wadi in Israel, encouraged the government to build Daedeok Valley as the '2nd Silicon Valley' of Korea. As a result, IT venture businesses and new knowledge-based clusters were formed in Daedeok Valley where synergy effects among cooperative learning, technology innovation, and knowledge generation were realized.

The actual motive research-based Daedeok Valley region became the knowledge-intensive cluster was resulted from the financial crisis at the end of 1990s. During the crisis, restructuring research institutes had fostered that researchers were beginning to get the venture off the ground. For instance, 82.3% of IT ventures in Daedeok Valley were formed following the financial crisis.

The role played by the local government and the private sector in developing venture companies in Daedeok District was also significant. For instance, the city of Daejeon enacted the "Statute for the Promotion and Support of Venture Businesses" in September 2000 to increase support for venture companies. In the private sector, 'Daedeok 21st Century' was renamed 'Daedeok Valley Venture Association' in April 2004 and "Daedeok-Net" was established in November 2000 for the purpose of facilitating information exchange among institutes and businesses. Particularly, the Daejeon city had attempted to restructure industrial districts into high-tech centered manufacturing venture districts.

As an effort to activate the role of Daedeok District as an innovation cluster, the government and local authorities had provided support for venture businesses. For instance, the MOST and Daejeon city initiated a comprehensive development plan for developing Daedeok District as a technology-venture accumulation center, which comprises research institutes and universities in Daedeok Science Town, industrial complexes in Daejeon region, and Expo Science Park. In Addition, the Daejeon city drew the plan to promote 3,000 venture companies until 2005 and supported venture businesses by hosting the World Technopolis Association, the Technomart, and the Venture in Defense.

2.2.3. Features of Daedeok Valley

By transforming Daedeok District into Technopolis and forming Daedeok Valley, 74 institutes, 130 venture companies, six elementary schools, five middle schools, five high schools, and four universities (Chungnam National University, KAIST, Information and Communications University, and Daedeok University) were located in Daedeok District in 2003. In addition to such educational institutions, regional universities, such as Hannam University, Daejeon University, Mokwon Univeristy, Paichai University, and Hanbat University, made supportive environment for Daedeok District to build an industry-academia-research linkage system and to manage and foster outstanding human resources.

Research institutes in Daedeok District performed researches in a broad spectrum of fields, including information technology, bioscience, and advanced and polymer materials, etc. And, their innovation performance continued to strengthen the role of Daedeok District as the innovation cluster and to leverage nation's competitiveness.

2.3. Designation of Daedeok Innopolis Special District for Development as an Innovation City

2.3.1. Development of Innovation Cluster and Designation of Daedeok Innopolis Special District

The government designated Daedeok District as Daedeok Innopolis Special District in July 2005. Daedeok Innopolis is a concept of R&D-pull innovation cluster focusing on effective S&T knowledge generation, transfer, and utilization. With the celebration of 30th anniversary in 5 December 2003, a review on necessary legal and institutional measures designating Daedeok Science Town and its nearby area as Daedeok Innopolis Special District was made. The "Law on Fostering Daedeok Innopolis Special District" was enacted and implemented in January and July 2005 respectively, and the Vision for Daedeok Innopolis was declared in March 2005.

In order to develop a specification for the overall support systems of Daedeok Innopolis, committee, planning division, and support headquarters were established. In addition, legal and institutional support systems were developed to facilitate research spin-offs and venture businesses.

In October 2005, the "Master Plan for Development of Daedeok Innopolis Special District were established. This plan included a goal to upgrade Daedeok Innopolis into a world-class innovation cluster, by the year 2015, where research and business would converge as well as a virtuous cycle of R&D, technology commercialization, and reinvestment would be established.

In order to evolve into an advanced economy through S&T and technology innovation, during that time, the government implemented new national policy for innovation cluster where R&D, production, and commercialization are organically merged. For the purpose of spreading innovation results across the country by creating a world-class innovation cluster within 10 years, Daedeok Innopolis Special District developed a plan to combine R&D-based Daedeok Science Town with production capabilities as well as production-oriented industrial park with R&D capabilities. The plan for this phase was set as follows:

(a) Developing R&D business infrastructure (2006~2007): technology development, analysis and evaluation, expansion of basic infrastructure, and build-up of networks
(b) Creating and commercializing advanced technologies (2008~2010): creation of research spin-offs, training of commercialization specialists, and formation of business and residential environment
(c) Building global innovation cluster (2011~2015): promotion of global hub and ubiquitous environment, building of a Mecca of S&T and culture

In order to accelerate this plan, the following initiatives were implemented: (a) conducting R&D projects aimed at commercialization of technologies developed in Daedeok Innopolis, (b) building a venture ecosystem through research spin-off initiatives and technology financing, and (c) improving business environment for foreign invested companies and building global networks.

With the government taking strong initiatives to build innovation cluster, Daedeok District became home to more than 785 institutions, including 21 government-funded institutions, nine government enterprises, six universities, 13 public institutions, 13 support agencies, and 721 corporations by October 2006.

2.3.2. Features of Daedeok Innopolis Special District

Daedeok Innopolis Special District has a size of 70.4 Km^2, about 2.5 times the size of Daedeok Science Town, which was built beginning in 1978 (Daedeok Science Town 27.8 Km^2, Daedeok Techno Valley 4.3 Km^2, Daedeok Industrial Complex 3.2 Km^2, Agency for Defense Development 3 Km^2, Green Belt 31.2 Km^2, and Hanwha 0.9 Km^2, etc.). In addition, Daedeok Innopolis manages the area under five main zones to unleash the potential of the innovation cluster: Zone I for Daedeok Science Town, Zone II for Daedeok Techno Valley, Zone III for Daedeok Industrial Complex, Zone IV for Northern Green Belt and Zone V for Agency for Defence Development. In Zone I, industry-academia-research institutes, government and public institutions, and support agencies are located. In Zone II and III, industries and corporate R&D centers are located.

Daedeok Innopolis provides various supports for research-based spin-offs and highly advanced technologies. By the end of 2008, 12 research corporations and 61 high tech companies were assigned to receive the supports.

3. Pursuit of the Program

3.1. Benchmarking

3.1.1. Domestic Benchmark

The domestic benchmark models for academic-research complex were Suwon Education and Research Complex for Agricultural Technology and Hongreung Research Complex.

The nation's first research and education center was originated from an intellectual community organized by research institutes under Rural Development Administration in Suwon and the College of Agriculture (Suwon Campus), Seoul National University. Through outstanding research accomplishments based on collaborative efforts between researchers and professors, the nation's agricultural development was fostered. Particularly with collaboration between research institutes for applied technology development and university for basic research, an intellectual community was formed to organize cooperative research systems through technological information and human resources exchanges and sharing of research facilities. However, the roles played by such center were limited to the area of agriculture.

Seoul Research Complex, located in Hongreung, was developed with the establishment of KIST in 1966. Seoul Research Complex played a role as an engineering complex including Korea Advanced Institute of Science (KAIS), Korea Development Institute (KDI), Agency for Defense Development (ADD), and Korea Science and Technology Information Center (KORSTIC). Based on the philosophy of KIST, special laws were enacted by such institutions to ensure research autonomy and institutional stability. With excellent human resources and research atmosphere, Seoul Research Complex had grown into the core entity for developing science and technology in Korea. Through cooperative research activities, Seoul Research Complex performed leading roles of providing technological supports for the private industry, which had little awareness of technology development and was totally dependent on foreign technologies. In addition, Seoul Research Complex played a pivotal role in the development of industrial technologies by performing contract research projects from the industry and was in charge of training human resources, disseminating technical information, and turning the brain drain into a brain gain. Overseas Korean scientists and engineers who returned to Korea developed technologies across various fields and had contributed to carrying the national development strategy by engaging in industrial policy formulation.

Seoul Research Complex, however, was not based upon precise long-term planning, but was instead built accordingly for the formation of institutes located nearby Seoul.

3.2.2. Foreign Benchmark

Tsukuba Science City in Japan was a role model for Daedeok Research and University Town. During the process of turning Japan into a leading technology development nation, Tsukuba was designed as a new research and university city with the aim of decentralizing population, industrial facilities and researches, and science and technology away from the large cities like Tokyo. Tsukuba Science City was constructed to meet the needs of building technopolis surrounded by high-tech. industrial clusters, academia-research institutions, research laboratories, and attractive living environment. With the enactment of the "Tsukuba Science City Construction Act" in 1968, the Science City was constructed at the place 60km outside Tokyo with the size of 12 million pyeong consisting 36 public-funded research institutes including the Tokyo University of Education.

For scientific research and technology development, the research park development scheme in the world has changed with the times. In 1960s, the concept of building a collaborative research and academic city was adopted aiming at the promotion of R&D, training of scientific personnel, regional development, and population distribution. In 1970s, either directly or indirectly linked research and educational institutes and production facilities into a single regional sector had been developed. Through the acceptance of the pilot plant to achieve commercialization of research results and to conduct future technology development and research, the streamlined support was made for the strategic industries for export development as well as private institutions and the existing research groups. In 1980s, the development approach was changed to achieve comprehensive goals by creating a suitable environment where research and educational institutes, production facilities, and housing and culture were harmonized with each other. During this period, the concept of S&T-intensive industrial city was employed in the name of Technopolis in order to facilitate highly integrated urbanization, attainment of high culture & welfare society, coexistence of traditional and advanced culture, urbanization in nature, growth-based urban development, and research distribution and balanced regional development.

Daedeok Science Town, which was initially designed as a research and university city based on the Tsukuba Science City model, formulated a master plan oriented towards industrial development, urban development, and regional development since 1980s in line with world trends.

The designation of Daedeok Innopolis Special District for innovation cluster also apparently benchmarked the world development trends of innovation clusters in 2000s. Since 2000s, government-driven innovation clusters, such as Silicon Valley in U.S., Zhongguancun Science Park in China, Hsinchu Science-based Industrial Park in Taiwan, and Kista Science City in Sweden, have played leading roles in securing national competitiveness. The evidence of Medicon Valley cluster developed by Sweden and Denmark together or the construction of 2nd and 3rd Hsinchu Parks in Taiwan shows how government-initiated innovation clusters are used to develop the nation. Even Malaysia, Vietnam, and Algeria decided to develop science parks as innovation clusters.

In 2005, MOST conducted case studies of successful innovation clusters and regions and devised the "Mater Plan for Promotion of Daedeok Innopolis Special District (2006~2010)" to develop and promote Daedeok Innopolis. The findings are summarized as follows:

(a) Strong research capacity: excellent technology innovation capabilities in basic and applied research at institutes, enterprises, and universities within region.
(b) High-quality human resources: cost-effective human resources services for research, business/production activity, and management.
(c) Business-friendly atmosphere and infrastructure: effective hardware (transportation, communication, housing, and medical environment) and software (English language support) infrastructures within region.
(d) Sufficient investment funds: availability of funds to support research and business activity
(e) S&T-friendly culture and open environment: culture for innovation activities through formal & informal networks
(f) Transparent management/clear mission: organic management structures coupled with various supports and policies formulated and implemented by local and central governments and management entities.
(g) Globalization: participation in overseas innovation networks
(h) Institutional supports for ventures: technological business incubators and technological consultation and supports to achieve new venture creation.

3.2. Steering Entities

In order to effectively support the process of constructing Daedeok Science Town, the government steering entities, such as the Comprehensive Science and Technology Council, the Committee on Construction of Daedeok Science Town, and the Heavy-Chemical Industry Promotion Council, were involved or established.

The first meeting of the Comprehensive Science and Technology Council back in July 1973 went on to review the construction plan of Daedeok Science Town, which was signed into a national promotion program by the President, and to coordinate with related ministries in order to achieve the target and schedule of the plan. It appears that the Council was to have operated as a review board in relation to coordinating effectively important tasks and programs involving science and technology promotion. As a result of this meeting, the following recommendations were sent by the Prime Minister.

(a) In consultation with Ministry of Construction, MOST shall complete the establishment of a master plan for construction of a research and university town by the end of the year and incorporate action plans of prospective institutions for relocation into the master plan.
(b) In coordination with Ministry of Construction, the construction of a research and university town will be implemented gradually according to priorities of the master plan.
(c) The loan agreement of strategic industrial research institutes, which have plan to relocate to a research and university town, shall be submitted to the Economic Planning Board by the end of August.
(d) MOST shall review integration schemes for merging of prospective institutions for relocation that need to be in the future.

According to the confirmation of constructing Daedeok Science Town by the Comprehensive Science and Technology Council, the Construction Division was formed in MOST and the Committee on Construction of Daedeok Science Town was organized in September 1973. The purpose of organizing the Committee was to respond to inquiries of the MOST regarding the research and university town building. The Committee was organized by 16 members including Deputy Minister of MOST as a committee chair and Executive Director of Planning in MOST and Project Management Director in Ministry of Construction as vice chairs. The primary function of the Committee was to review (a) master plan for construction of a research and university town, (b) institutional relocation and new building plan, (c) institutional arrangements plan, and (d) plan for establishing and operating common infrastructure facilities. From October 1973 to February 1976, the Committee performed a role responding to inquiries of MOST regarding the construction plan. The Master Plan for Promotion of Daedeok Research and University Town was confirmed as a government policy in December 1973.

Since April 1976, the tasks of the Committee directed by MOST were transferred to the Heavy-Chemical Industry Promotion Council in order to efficiently construct Daedeok Science Town. According to the adjustments on the construction promotion system led by the Office of the President, the construction promotion system had been adjusted to the institutional system of comprehensive cooperation, in which MOST is only responsible for the overall planning and each division and department is responsible for carrying out its own activities under the project. In this context, the Heavy-Chemical Industry Promotion Council organized the working committee in May 1976 and amended the "Act on Fosterage of Specific Research Institutes" for the purpose of newly establishing government-funded research institutes in industrial parks located in Changwon and Gumi district.

Since October 1979, however, the Heavy-Chemical Industry Promotion Council was abolished under the economic condition of over investment in the heavy-chemical industry. Thus, the tasks for constructing Daedeok Research and University Town were mainly driven by MOST once again.

With the designation of Daedeok Innopolis Special District in 2005, the committee (the Prime Minister as a chair), planning division, and support headquarters were established in order to strengthen overall support systems for Daedeok Innopolis. In addition, legal and institutional support systems were developed to facilitate research spin-offs and venture businesses.

3.3. Establishment of Construction Plan and Its Coordination

3.3.1. Establishment of Construction Plan

The early initiative for planning the construction of Daedeok Science Town was taken after the release of the study, the "Master Plan for Construction of Research and University Town", which was consigned to the Consulting Committee for Economy and Science in October 1970 and reported back to MOST in July 1971. The purpose of this study was to examine cases of research and university cities in developed countries; the location and environment of domestic research institutes and academic institutions; the population and size of candidate sites; and the space configuration and arrangement of prospective institutions for relocation. In addition, the study included very comprehensive construction planning initiatives such as land use; transportation; water and sewer; parks and greenway; population distribution; land acquisition; construction regulations; construction cost estimation; and construction project plans and strategies. The results of this study supported the concept of Daedeok Science Town and framed its construction plan.

In 1973, based on this study, MOST prepared for the "Preliminary Plan for Construction of a 2nd Research Complex" that included philosophy and necessity of construction, institutional arrangement, construction area and period, and strategic plan.

The "Preliminary Plan for Construction of a 2nd Research Complex" attracted attention of the President. The key components of the plan included are as follows: (a) background information and necessity of research complex, (b) role and function of research complex, (c) five strategic industrial research institutes, (d) public-funded research institutions, universities, and private research institutes relocated to research complex, (d) cases of research and academic cities in overseas, (e) rationale for constructing research complex (f) type and size of research complex, (g) annual planning of constructing research complex, (h) site selection criteria, (i) status of candidate sites, (j) investment and financing, (k) principles and business strategy, and (l) suggestions.

In this plan, the function of research complex was summarized as follows: (a) mediator of technology development, (b) function for R&D and assimilation and absorption of imported technologies performing, (c) provision of technology training and information exchange, (d) technology guidance for private companies, and (e) technology adoption and distribution. According to these functions, the 2nd Research Complex was designed to promote efficient utilization of human resources and common facilities and to develop intellectual communities through the linkage of five newly established strategic industrial technology institutes, 12 relocated national laboratories, one science and engineering college either newly established or relocated, and public facilities and industrial institutes.

The research complex was also designed as an exemplary new town for research and education sitting on between 3.5 million and 5 million pyeong just outside urban area with less than 50,000 residents. The criteria for site selection were also given as follows: sufficient grounds for adjustments; low cost infrastructures (transportation, water, power); cheap land prices; and location of being in the heart of the country where universities and research institutions in Seoul will be linked to a regional heavy-chemical industrial base.

3.3.2. Revision and Adjustment of the Construction Plan

The “Plan for Construction of a 2nd Research Complex” was established by MOST in 1973 for the purpose of building a new town performing research and education. This construction plan included classified arrangements of institutions; common use of facilities; design of a pastoral urban environment; and construction of radial road systems, which passes through the center of Research Complex and the common service facility zone.

Although the construction of Daedeok Research and University Town was initiated in 1974, it was inevitable to shrink its plan size due to the 1st Oil Shock recession. In addition, the plan for constructing Daedeok Research and University Town had remained highly controversial since the Blue House took into consideration of Daedeok region as a candidate for relocating the capital city. In this context, in April 1976, the construction plan for Daedeok Research and University Town was revised and finally changed instead to construct Daedeok Specialized

Research Complex within the scope of the budget. Specific adjustments included are as follows: (a) Sequential and phased construction by taking into account of national economy and industrial needs, (b) minimum government investment, private participation, limited government fund for operating institutions, delayed payment of loans and debts, and independent operation of institutions with responsibility by including budget for each individual research project, (c) introduction of the concept of industrial complex, and government support for construction of facilities such as roads, water, and electricity, (d) problem solving for housing by building a number of apartments in Daejoen city, (e) relocation of public and private institutions, engineering colleges from the Chungnam National University, and graduate schools, and (f) responsibility of MOST only for the overall planning, and responsibility of each division and department for carrying out its own activities under the project.

Although the construction of Daedeok Science Town started in 1973, not much progress had been made due to continued adjustment of the plan. In August 1981, Ministry of Construction established and announced the master plan for developing Daedeok Industrial Zone based on the "Industrial Zone Development Promotion Act." The 2nd Amendment Plan in 1981 included the concept of defining Daedeok district as Technopolis annexed to Daejeon city. In this plan, the concept of industrial zone was introduced as an alternative to self-contained research city as a means to integrate urban activities like housing into research facility areas by building a road system which links Daedeok district with Daejeon city.

Under the fifth government of the Republic of Korea, MOST fully revised the construction plan again and reported the direction of Daedeok Science Town construction plan at the meeting of the 1st Technology Promotion Council in April 1984. For immediate measures, the formation of R&D environment with comfortable living conditions was highlighted. Mid- and long-term measures also were planned for the purpose of building and relocating research institutes, academic institutions, and culture and welfare facilities during the period of from 1984 to 1987, and of linking research institutes, universities, and brain-intensive high-tech industries during the years after 1988. In the 14th Council of Ministry of Economy, which was held in August 1984, the approach of site preparation was changed from the in-house development to the public development. In May 1985, Ministry of Construction announced Korea Land Corporation as a promoter for Daedeok Industrial Zone Development Project. Korea Land Corporation initiated the first phase of the project in November 1985 and the second phase in May 1987. During this process of constructing Daedeok Science Town, the master plan was revised a couple of times more to expand research and academic facilities, and the land transaction permit system was carried out for the first time in Korea.

In the 3rd Amendment Plan in 1984, the concept of industrial zone was changed to the concept of research complex as a means to account for its unique research function and capacity of Daedeok District. The key components of this revised plan included as follows: regional planning by function along with maintaining relation with Daejeon city as a mother town; maximizing the efficiency of land use based on the public concept of land; sharing common use facilities; and building inner-road network limiting traffic not necessarily related to the research activities as well as linking research facilities and the outer road around the Research Complex.

By hosting the 1993 EXPO in February 1989, the plan for Daedeok Science Town was expanded to increase its capacity. In November 1990, the number of institutions and population relocated to Daedeok Science Town was increased (from 50 to 60 institutions and from 50,000 to 70,000 populations), and the duration of development was also extended 3 more years from 1981~1990 to 1981~1993.

With the establishment of Daedeok Science Town, the government initiated the project of building Science, Industry, and Research Complex across nation's major regions in order to spread knowledge industries and to promote researches for advanced technologies. In this regard, the 1986 "Long-term Plan of Science and Technology Development for 2000s" suggested the establishment of nation-wide S&T city belt, and research for "National Techno-Belt" was also conducted in 1989. For instance, the project forming Gwangju High-Tech Science and Industrial Complex was strongly driven by the government since 1990 through feasibility study and basic plan in 1988 and 1989 respectively. In addition, a development program for science and industry research complex in region, such as Busan, Daegu, Jeonju, and Gangreung, was also initiated mainly by local governments with institutional support from the central government.

3.4. Enactment of Promotion Act

Upon the completion of construction of Daedeok Science Town in November 1992, the importance of effective Daedeok Science Town administration was addressed. Basically the construction of Daedeok Science Town was based on the "Act on Industrial Sites and Their Development", but the Act was not able to reflect the uniqueness of the Science Town. In December 1993, the enactment of the "Daedeok Research Complex Administration Act" included planning for Research Town management, classification of land use, and approval and cancellation of occupancy. In August 1994, the administration headquarters for administration of Daedeok Specialized Research Complex was established.

This Act was amended at the end of 1996 by reflecting a growing trend of converting Daedeok Science Town into Technopolis and announced the technology commercialization zone allowing business incubators in research institutes. The problem, 'separating research-production', Daedeok Science Town faced during the 1990s was resolved by the amendment of the "Daedeok Science Town Administration Act" in December 1999, which allows production activities within Daedeok Science Town, and by the Small and Medium Business Administration (SMBA)'s policy actions supporting construction cost of cooperation complex. By facilitating and supporting venture businesses and industry-academia-research collaboration in Daedeok Science Town, regional network activities of industry-academia-research were further expanded.

This Act was, however, regarded as a strict land use regulation act that had several limitations in itself as follows:

(a) The substantial benefits of Daedeok Science Town for regional innovation were not realized.
(b) There was no provision for the overall management of Daedeok Science Town as an innovation cluster, such as planning and implementation and management of research results and its commercialization.
(c) Daedeok Science Town was designed to perform as an industry-academia-research network for promoting R&D activities integrating various technological areas and its commercialization, but failed to support these R&D dynamics.

In December 2004, the "Law on Fostering Daedeok Innopolis Special District" was enacted as a substitute to the "Daedeok Science Town Administration Act." This special law was designed for the purpose of managing institutions, which moved into Daedeok Innopolis, in order to promote R&D and innovation based on outstanding human resources and R&D infrastructure in Daedeok Innopolis as well as to generate new growth engine for Korea through outstanding research accomplishments. This law included provisions allowing an establishment of Innopolis committee chaired by Deputy Prime Minister for Science and Technology as well as Daedeok Innopolis Support Headquarters, research institutes to create spin-offs, exemptions for high-tech companies and foreign-invested enterprises, and implementation of Daedeok Innopolis R&D projects. In this special law, the requirements for the designation of Daedeok Innopolis Special District were defined as follows:

(a) Industry-academia-research shall be directly inter-related for national R&D projects
(b) Adequate conditions shall be equipped to commercialize R&D accomplishments of industry-academia-research and to create venture businesses
(c) Contributions to S&T innovation shall be of far more consequence than any other region
(d) Adequate conditions shall be equipped to attract foreign universities, foreign research institutions, and foreign investment enterprises.

3.5. Operation of Daedeok District Administration Office and Supporting Systems

3.5.1. Evolution of Daedeok District Administration Office

The first Daedeok District Administration Office was set up in March 1979 by MOST in order to efficiently promote construction of Daedeok Research and University Town. The administration office had carried out following tasks, such as planning and coordinating construction activities of Daedeok Science Town, until February 1998:

(a) Establishing and implementing basic plan for administration of Daedeok District
(b) Establishing and implementing sector plan for land use and landscape
(c) Planning relocation and occupancy and providing construction support management
(d) Supporting constructions on infrastructure
(e) Promoting and supporting government-funded research institutes and relocated institutions
(f) Accelerating and supporting linkages between research institutes and the private sector
(g) Supporting technology development in the private sector
(h) Promoting collaborative projects among research institutions located in Daedeok District
(i) Introducing Daedeok Science Town and building cooperation with foreign research complex

Daedeok District Administration Office played a key role in completing and settling down Daedeok Science Town. In the early phase of the Town, the residential living environment for scientists who moved into the district was not yet perfectly suited. Thus, Daedeok District Administration Office provided shuttle and emergency services and carried out practical tasks assisting residents, such as supporting housing construction, attracting and establishing elementary, middle and high schools, post office and fire department, and opening welfare facilities in Deadeok Science Town.

Although the relocation of research institutions was delayed due to the sporadic construction of site development for research institutes, residential housing supply was also being raised as an urgent issue, once relocation of research institutes started in the near future. In order to overcome above-mentioned problems, the active plan to promote construction of Daedeok Science Town was designed in the early 1984 and reported to the Technology Promotion Council in April 1984, and the method of site preparation was changed to public development. Accordingly, Korea Land Corporation was announced as a promoter of the Daedeok construction project in May 1985 and completed the site preparation in November 1992, Daedeok District Administration Office performed overall coordinating tasks by maintaining collaborative relationships with construction agencies, such as Daejeon city, Korea Land

Corporation, Korea Electric Power Corporation, Korea Telecommunication Authority, and Korea Water Resources Corporation.

By the amendment of the "Daedeok Research Complex Administration Act" in January 1999, the administration headquarters for administrating Daedeok Specialized Research Complex was established to perform the management tasks, which was entrusted by Daedeok Specialized Research Complex Administration Office.

By the enactment of the "Law on Fostering Daedeok Innopolis Special District" in December 2004, Daedeok Innopolis Support Headquarters was established in 2005 under the Ministry of Knowledge Economy. The purpose of organizing this support headquarters was to promote national development of S&T as well as to support Daedeok district to grow into the world-class innovation cluster by providing physical environment in which new technology generation, transfer, and commercialization can be facilitated by the R&D activities of institutions and industries, by supporting efficient land use and management, and by maintaining and conserving a pleasant R&D and living environment.

The primary function of the Support Headquarters can be summarized as follows:

(a) To efficiently support commercialization of R&D results and venture businesses
(b) To build technology commercialization network and mutual exchange/cooperation
(c) To promote domestic and foreign investment and cooperation projects
(d) To procure, supply, and lease land, buildings, facilities, and equipment

The site management plans for education-research and business facilities designed by the Daedeok Innpolis Support Headquarters in 2008 can be summarized as follows:

(a) To maintain and manage a quiet and pleasant research environment in harmony with the surrounding environment
(b) To maintain the proper density for site development to preserve a pleasant research environment, and to limit the location of facilities causing pollution
(c) To design layout of facilities and buildings to harmonize the effective land use and a pleasant research environment
(d) To preserve the original land form to maintain a pleasant research environment, and if necessary, a prior approval of administrative authority is required to develop
(e) To provide relocation guidelines to prevent illegal monopoly of the land, the use of other purposes and long-term idle land.
(f) To enforce the relocation permit requirement by reviewing and assessing the business sector and the plans of institutions and enterprises

3.5.2. Supports from Daedeok Innopolis Support Headquarters

Daedeok Innopolis Support Headquarters has provided various support services and benefits to newly relocated institutions:

(a) Various service benefits as well as opportunities of participating in projects initiated by Daedeok Innopolis Support Headquarters, such as supporting companies commercializing technologies resulted from government-funded research institutions, providing knowledge-based services for spin-off creation and business growth, and supporting domestic and foreign investment and marketing
(b) Fee reductions for welfare facility (sports center and golf driving range, etc.) users such as institutions and enterprises relocated in Daedeok Innopolis
(c) National and local tax incentives for institutions and enterprises relocated to Daedeok Innopolis
(d) Benefits for using child care facilities when institutions and enterprises are relocated to Daedeok Innopolis

In addition, the Support Headquarters provides benefits to research spin-offs and advanced technology industries in Daedeok Innopolis based on the special law. Here the research spin-offs indicate companies established in Daedeok Innopolis by national and research institutions or government-funded research institutes, which invest higher than the ratio prescribed by Presidential Decree for the purpose of directly commercializing technologies owned by them. The Support Headquarters provides support services and tax incentives for research spin-offs, such as cost reduction of technology valuation; venture and management consulting; and income tax exemption (100% for first three years and 50% for next two years), acquisition tax and registration tax exemption, and property tax relief (100% for first seven years and 50% for next three years). The advanced technology industries here represent companies, which own domestic and foreign patents and use them to create or sell any products or services in high technology-intensive and fast technology innovation sectors such as information technology, biotechnology, and nanotechnology, etc., and inherited by the Minister of Knowledge Economy in accordance with the standards set by Presidential Decree. The Support Headquarters provides tax incentives for such advanced technology industries, such as income tax exemption (100% for first three years and 50% for next two years), acquisition tax and registration tax exemption, and property tax relief (100% for first seven years and 50% for next three years).

4. Evaluation

4.1. Achievements

Firstly, clustering a large-sized research and development zone served as a key point for science and technology knowledge. Daedeok District induced government-funded research institutes, private company-owned research institutes as well as universities involved in major science and technology areas into the zone, thereby functioned as a supplier of science and technology knowledge at the national level. In particular, Daedeok Innopolis has been contributing to the establishment of national fundamentals as well as to the development and the expansion of source technologies such as information technology and biotechnology, and in complex technologies including nuclear technology and aerospace technology for national industrial development. Daedeok Innopolis is also assigned to support science and technology related to the national competitiveness such as standards, measurement, major research facilities, technology and R&D information, etc. Clustering R&D institutes in various sectors in one site has provided complementing synergy effects to related technologies and increased development potentials of the conversion technologies.

Daedeok Innopolis supported private companies and universities to develop their R&D capacity by supplying related knowledge and human resources when the research and development competencies of private companies and universities remained insufficient. In addition, Daedeok Innopolis has formed an axis of national R&D networking where national R&D competencies to carry out national R&D projects are centralized. Approximately 80% of 674 researchers with a doctorate degree who changed jobs from government-funded research institutes from 1998 to 2001 joined universities (212 researchers, 31.5%), private companies (200 researchers, 29.6%), and other government-funded research institutes (116 researchers, 17.2%), expanding science and technology knowledge. Besides, Daedeok Innopolis has also been a pool of human resources that met the demands for high-caliber science and technology manpower of the Korean industry. 200 researchers with a doctorate degree moved from government-funded research institutes to the industry from 1998 to 2001 and fulfilled the needs for human resources by the industry. In addition, aside from direct job changes, Daedeok Innopolis has filled indirectly the needs of the industry for high caliber science and technology manpower through training and strengthening competencies of the partner in carrying out collaborative research projects.

Secondly, Daedeok Innopolis contributed to enhancing technology innovation competencies and served as a key point to organize innovation clusters. Daedeok Innopolis highly contributed to strengthening and progressing technology competencies of private companies in Korea through technology transfer, source and basic technology development based on research collaboration and support and transfer of operating know-how in case of establishing a new private company owned research institute. Daedeok Innopolis improved the utilization of research results derived by government-funded research institutes through promoting new venture businesses. Nowadays, the development of innovation cluster in Daedeok Innopolis is becoming the center of establishing innovation clusters nationwide in connection with the regional techno-park development.

Thirdly, openness of research and development activities related to the industry was insufficient. In the beginning, Daedeok Districts was constructed as a research and university town, showing characteristics of gathering research institutes in the District, with a high concentration of government-funded research institutes. At that time, research and development activities of the industry were inactive. Especially in Daejeon area, industries that require technologies were underdeveloped. However, Daedeok District faced problems such as insufficient utilization or commercialization of R&D results and separation from the regional development as a result of having focused on research and development activities in isolation from the industry for a long time. By transforming an innovation city from a technology city following its inauguration as Daedeok Innopolis Special District, efforts to resolve these problems were shown through the emphasis put on the development of an innovation cluster.

4.2. Implications

Firstly, it is important to establish and implement a flexible plan with a vision of long-term development. It takes more than 10 years, and, in certain cases, it may be extended up to 20 to 30 years to establish a large research and development zone or an innovation cluster. Therefore, without a long-term vision, it would be difficult to generate synergy effects related to the identity of the cluster. And establishment and implementation of a flexible plan is prerequisite to respond and adapt to changes in economic and social environment as well as in science and technology. Daedeok District was established based on the long-term vision to develop a research and university town, and further assigned to develop into an innovation cluster in response to the needs for expansion of innovation. The establishment of Daedeok Innopolis had faced several times problems caused by institutional conditions and environment. For this, Daedeok Innopolis identified the problems, revised the plan to pursue the initial vision and plan, and continued efforts to adjust functions of related bodies and to secure the force to realize the plan.

Secondly, the development only focusing on research institutes is insufficient. Initially established as a research and university town, Daedeok Innopolis achieved the objective to provide agreeable research and development environment. However, it soon faced concerns that

Daedeok District may become an isolated site of research institutes. Although it was meant to generate synergy effects of research and development activities by centralizing various research institutes, open collaborations and exchanges among institutes remained below expectations for a quite long time. Also, due to the prioritization on the establishment of research institutes, construction of the living environment was delayed and caused an interruption in activation of the complex for a significant period of time. In addition, lack of link with innovative actions of the industry such as industrial development in the region resulted in the low commercialization of research and development results, considering the volume of R&D investment involved. These problems have been raised and resolved; lately, the development into an open-type innovation cluster is pursued by connecting R&D activities and industrial activities of private enterprises.

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Chapter 03

Establishment of Technical High Schools and Junior Colleges

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Establishment of Technical High Schools and Junior Colleges

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<Summary>

In the period (1945-1962) after Korea's liberation in 1945, technical education offered an opportunity for a fresh start. 1st-line amendment to Education Law Section of the primary school system as enacted by the Technical High School was born. With the enactment of primary and secondary education courses in 1954 Technical High School education began to be settled, industrial high school in the early 1960s was enacted. During this period, unemployment, skills training plan based on five years of unemployment for the education industry, including the education of at least lay the groundwork for the material base was established. In addition, measures to improve secondary education was introduced in the comprehensive school system has been operating experimentally.

In development period (1962-1979), promoting economic development as an industry specific policies for promotion of education and for support of this investment has been fulfilled. This feature technology for economic development, workforce, responsible for supplying the Technical High School and Technology College has fulfilled the development. Technical High School-related policies include promotion of science and technology education being promoted by 5-year plan, regardless of the demand for manpower away from the workforce planning system, designed according to the Human Resource Development Program Technical High School by being groped, there was significant growth in quantity. Promotion of Industrial Education and Technology High School also instituted the policy leaders voluntarily High School in characterizing the attributes of the school alive by applying various operations to the development of industrial training was accomplished. Meanwhile, industry-related policies include specialized vocational high schools, including University College, established a

professional school after college reform launched by the foundation in mid-sized technology, manpower and time was chopped.

In transition period (1980-1998) is a labor-intensive and technology-intensive industrial structure, industrial structure, the industry turned into a sense there were many changes in education policy. This period compared to the generators of industrial education as the quantitative growth slowed, continuing education was expanded in the direction of the transition. Industry-related policies include high school vocational and technical education reform, expansion of business leaders voluntarily Technical High School and was pursuing substantial, notice the 2-1 systems, changes in the quality of the technical high school, and the scene was driven by increase adaptability. The Technical College System for the establishment of new education-related policies include education reform measures and the garden by liberalization measures and the quantitative growth of junior colleges was strengthened phase.

In leap period (1999), vocational education institutions since the mid-1990s to avoid Shortage, Technical High School and Technology College students entering the industry due to reduced conversion of the education policy was needed. Accordingly, vocational education system, school leaders voluntarily step of innovative measures of innovation and specialization in high school vocational education system focuses on the introduction and expansion was driven. Also hope to realize the diversification of vocational schools and 300 project development strategies, based on the technical high school education to foster Meister angry leader of the substance and competence of students in the various schools have been promoting a policy that allows you to choose. Meanwhile, colleges and industries not related to a comprehensive development plan for colleges, universities, based on the restructuring plan since 2000 due to a sharp decrease in enrollment Resource Technical College is committed to the existence of crisis is reached.

1. Introduction of Technical High Schools and Junior Colleges

1.1. Overview of Technical High Schools

1.1.1. Recent Policies

A wide range of polices on vocational education have been implemented for technical high schools in such as: ‘Reform of Vocational Education System (2005)’, ‘Dreams-Come-True Vocational High School Training Plan (2007)’, ‘300 Initiatives on High School Diversification (2008)’ and ‘Korean Meister High School Development Plan (2008)’.

A major policy on technical high schools is 'Advancement Plan for Vocational Education in High Schools (MEST, 2010)'. Indeed, the number of students in technical high schools has been declining. Furthermore, the increasing number of students enrolling in college has led to a shortage of skilled workers, making it difficult for small and medium-sized companies to find qualified skilled workers. The main objective of the policy is to restructure the system for technical high schools into a system of specialized vocational high schools and professional trade schools under the banner of 'work first, and study' in collaboration with industry and government. The restructuring is outlined below in Table 3-1.

Table 3-1 | Outline of 'Advancement Plan for Vocational Education in High Schools (2010)'s

System Restructuring	Support for System Restructuring
• Settlement of employment-leading model through meister high school - Expansion of meister high schools: engineering + agriculture, ocean, construction - Transfer of national meister high schools(3schools) to Small & Medium Business Administration	• Promotion of curriculum reflecting industry's demands - Adoption of basic vocation skills evaluation system - Promote industry-customized professional technology education
• Promotion and expansion of academic-industrial collaboration in specialized high school - Expansion of supporting ministries for government supported specialized high schools - Participation of regional administration and industries in Ministry of Education's specialized high school support	• Employment-first-study-later system - Establish a study-later system to work and learn at the same time - Reinforce job finding program in specialized high schools
• Transition of vocational high schools into general high schools. - Integration of small vocational high school - Transition of smaller vocational high school into general high school	• Preparation of financial support and evaluation control system

Source: Ministry of Education, Science and Technology. (2010). Advancement Plan for Vocational Education in High Schools.

1.1.2. Schools

The number of vocational high schools has been continuously declining after peaking at 764 schools in 2000, falling further to 691 schools in 2010. The increase in the number of vocational high school until the 1990's was led by the government, which sought to meet the demand for skilled workers. However, the decrease in number of vocational high schools since 2000 could also reflect the decreasing number of students in high school besides the general trend of students wanting to seek higher education thus not entering vocational high schools.

The vocational high school system is expected to be transformed to a meister and specialized high school system as part of the policy on ‘Advancement Plan for Vocational Education in High School (2010).’ As a result, the total number of vocational high schools is expected to be reduced as well. Currently, there are a total of 691 vocational high schools; 21 meister high schools; 40 specialty high schools; 168 specialized vocational high schools; 275 general vocational high schools; and 187 comprehensive high schools. The reform plan is expected to result in 50 meister high schools and 350 specialized high schools, reducing the total number of vocational high schools to 400 by 2015. As a result, many of the general vocational high schools and comprehensive high schools are expected to be switched to general high schools or merged.

As vocational schools are free to name themselves, going forward, the names of the schools are expected to be based on the industry or education field taught at the school. In the past, the names of vocational high schools were based on their field of study such as; ‘agricultural high school,’ `industrial high school,’ and ‘commercial high school.’ But recently, some of the names of vocational high schools reflect each school’s characteristics. For example, some names include; ‘Suwon Life Science High School,’ ‘Seonrin Internet High School,’ ‘Chungbuk Semiconductor High School,’ and ‘Daejeon Donga Meister High School’.

1.1.3. Curricula and Subjects

Vocational high schools must follow a basic framework for curriculum design that is determined at the national level, but the subjects taught and classroom hours are determined by each school. Since the First National Curriculum was formulated in 1955, it has undergone revisions. Current curriculum is based on The 2007 Revised Curriculum which was established in 2000.

The current curriculum for vocational high schools consists of general subjects, professional subjects, and extra-curricular subjects. Meanwhile, the national curriculum is expected to undergo many changes in 2011 as The 2009 Revised Curriculum is announced. Major changes include the reduction of academic units, more emphasis on professional subjects, which will emphasize filed practice on professional subjects, and on-the-job training or experienced based training is expected to increase.

This reflects the growing importance of professional trades, as vocational high schools emphasize industry-based curriculum and expansion of meister and specialized high schools. But still, school that have a curriculum for general subjects operate separately with schools on focus on professional subjects.

Table 3-2 | Curriculum Reform in Vocational High School

Items	Current(The Revised Curriculum 2007)	Future (The 2009 Revised Curriculum)	Note
General subjects	• 82 units and more - Includes common basic curriculum 56units	• 72 units and more - Required 72units for each curriculu	• 10 units decreased
Professional subjects	• 82 units and more - Required subjects by department - Elective subjects by department	• 80 units and more - Required subjects by department - Elective subjects by department ※ Includes field practice on education contents	• 2 units decreased • Focus on field practice
Extracurricular subjects	• Discretion activity (12units) ·Afterschool activity(8units)	• Creative experience activities(24units)	• Integration of discretion and afterschool activities • 4 units increased
total	216 units	204units	·12 units decreased

Notice: a) Applied from 2011 primary and secondary school curriculum
b) 1 class hour unit amounts to 1 hour of class per week, for 17 weeks (1 semester)

Source: Ministry of Education and Human Resource Development. (2007). The 2007 Revised National Curriculum.; Ministry of Education, Science and Technology. (2009a). The 2009 Revised National Curriculum.

However, there are also vocational high schools that do not follow the national level curriculum and use their own curriculum. They are newly established meister high schools, which are operated by some regional superintendent of education. These autonomous schools are not required to follow the national curriculum and are able to organize and operate their own curriculum within time limit (within 5years) based on the school's specialty. This could led to the autonomous schools that offer a subject specific curriculum by education division, which matches the demand from industry (Korean Ministry of Government Legislation, 2010).

1.1.4. Students

The decrease in school age population and social tendency for students to not consider vocational high schools result in reduced decrease in the number of students enrolling in vocational high schools. As the number of vocational high school shows a downward trend, the percentage of vocational high school students is also decreasing. The percentage of vocational high school students to total number of high school students has been falling steadily from 45.0 percent (764,000 students) in 1980 to 35.5 percent (810,51 students) in 1990, and to 24.5 percent (488,913 students) in 2009 (Center for Educational Statistics, 2009; Na, 2009).

As vocational high schools are not usually considered the first option for students, most students enroll into vocational high schools because of their low academic records, and except for a few specialized high schools and meister high schools, the level of learning of the students are very low. The results of Academic Performance Evaluation for vocational school students was 10 points lower than general high school students, and was persistently low in subjects of the curriculum (Park, Jo, Kim, Son, Song, & Kim, 2006; Jung, Choi, Kim, Kim, Yoo, et al., 2009).

The strong desire for higher education and increased enrollment capacity of colleges after the introduction of the University Establishment Regulations and Guideline in 1995, the percentage of students entering higher education institutions increased while employment rate decreased. Actually, the employment rate among vocational high school students was 76.6 percent (210,113 students) in 1990, but has gradually fallen to a very low 19.0 percent (30,036 students) in 2009 (Center for Educational Statistics, 2009). This could undermine purpose of vocational high schools. Moreover, it could result in a general decline in academic performance at junior colleges and universities as more students enroll even though they have low basic academic skills.

Meister and specialized high schools offer a way to enhance the general educational level of students, to nurture basic academic ability and to teach basic vocational skills, which could eventually raise the employment rate. At each school, different approaches are taken by schools and teachers to enhance employment opportunities and to promote academic-industrial collaboration. In some specialized high schools, the employment rate for students has increased but in most of the schools, there has not been a positive output so far.

1.1.5. Teachers

In 2000, there were 40,977 teachers in vocational high schools, but the number has consistently been declining along with the number of vocational high schools, resulting in 36,077 schools in 2009 (Center for Education Statistics, 2000, 2009). The percentage of general subject teachers and professional subject teachers show a similar pattern of 55.5 percent and 44.5 percent (Jyung, 2007).

A teaching license is given for 24 professional subjects when the training course is completed. Based on 2000 data, a total of 16,559 vocational high school teachers were trained in 1,389 subjects and majors. Different from training of general high school teachers, most of these teachers were trained at teacher training courses in general universities rather than at teacher colleges. Since vocational high school teachers know the theoretical and practical aspects of their specialty, continuous management and evaluation of teacher's qualification and ability is needed (Jyung, Lee, Kim, Na, & Seo, 2000).

Certain vocational high schools promote on-site or on-the-job education and training by teachers at the school and industry professionals brought in as Academic-Industrial Adjunct Teacher. Academic-Industrial Adjunct Teachers are hired on short-term contracts and must be professionals with more than three years of experience. There is a growing need to recruit more academic-industrial adjunct teachers as the vocational high school system is switched to meister and specialized high schools. As such, the importance of trade specific education is rising. Furthermore, diverse systems related to teachers are being adopted to promote professionalism and on-the-job training and education such as the Master Teacher System, the Teacher's Learning Sabbatical Year System and the Teacher's Skills Development & Evaluation System. It is necessary for vocational high schools to make use of these systems and enhance the quality of education.

1.1.6. Financial Supports

The budget support for vocational high schools was allocated by a central government branch of the Ministry of Education, Science and Technology until 2004. But from 2005, the administration of vocational high schools was transferred to the metropolitan & provincial office of education, resulting in different budgets being allocated by different offices. The total budget was KRW 97.2 billion in 1998, but decreased to KRW 28.8 billion in 2004. After 2005, the budget for each school was set differently depending on the metropolitan & province it was located in, but attention to vocational high schools has decreased generally, resulting in smaller budgets overall.

However, schools have been given financial support from governmental ministries other than MEST or the local governments in charge of education. This is part of numerous projects for vocational high schools being initiated by government ministries. This financially helps vocational high schools, but there are problems of inconsistency and inadequacy in providing deliberate and continuous investment (Na et al., 2007).

As the 'Advancement Plan for Vocational High Schools (MEST, 2010a)' was announced, financial support has been planned to restructure the vocational high school system into meister high and specialized high school. A total of KRW 72.5 billion is expected to be used for 168 specialized high schools in 2010. As the number of these high schools is expected to consistently grow, KRW 97.4 billion of funding is expected to be invested in 350 specialized high schools in 2015. Major categories for financial support include: formulation of curriculum, improvement of facilities and equipments, implementation of experience-based education in specialized field, recruitment of academic-industrial adjunct teachers, support for re-education of teachers, and so on. Moreover, specialized vocational high schools are expected to receive KRW 20 billion to support employment search system for graduates from 2009 to 2015. The financial support will based on each school's track record in employment of graduates while additional incentives will be given to schools with good performance (MEST, 2010a).

In the 71st 'National Economic Council' chaired by the President on September 16, 2010, the full-support of all vocational high school students from 2011 was one of the key policy tasks identified. To this end, students of vocational schools are expected to receive a KRW 1,200,000 exemption on admission fee and tuition fee. The government plans to invest KRW 315.9 billion in year 2011.

1.1.7. Major Challenges

There are four important challenges facing vocational high schools. First, vocational schools must address the falling number of enrollments which has caused the total number of vocational schools to decline.

Second, the idea of vocational schools being a possible alternative to college and universities must be promoted. The will require that graduates are ensured employment opportunities which will require improving the school's job search function.

Third, it is necessary to develop and operate a customized curriculum based on specific field or trade so that graduates are equipped with the necessary skills. This could be made possible by using NCS.

Fourth, the development of teachers is expected to be emphasis to actively cope with industrial and technological changes, along with adoption of Teacher's Skills Development & Evaluation System, Academic-Industrial Adjunct Teacher System and Master Teacher System.

1.2. Overview of Technical Junior Colleges

1.2.1. Recent Policies

Recent vocational education policies in junior colleges have been changed in a diverse way in response to changing times and social demands, with policies such as 'General Development Plan for Junior Colleges (2001),' 'College Structure Reformation (2004),' 'Vocational Education System Innovation Plan (2005)' and 'Junior College Education Competence Reinforcement Project (2008)'.

Major policies regarding recent vocational education in junior colleges are 'Junior College Specialization' and 'Promotion of Global-Level Higher Vocational Education Institution', suggested by MEST (2010d). These were implemented to address the decline state of vocational high schools, caused by falling enrollments at junior colleges and establishment of too many junior colleges. These policies are having a powerful impact, aided by 'Public Announcement Regulation for College Information,' which publically discloses key information such as employment rate and rate of teachers. The policies also focus on ensuring consumer's right of choice and competition between junior colleges. The main contents of junior college higher vocational education policies are as shown on Table 3-3.

Table 3-3 | Outline of Junior College Higher Vocational Education Policies (2010)

Policies	Main Contents
Specialization of junior colleges	• Reinforcement of selection system for supported junior colleges by formula index • Distribution of total financial support amount and maintaining school's free execution of budget. • Elaborate formula index for junior college's higher education competence reinforcement project • Promoting specialization of schools by focused support for leading junior colleges
Fostering at higher vocational education institution at a global level	• Choice and focus support for excellent junior colleges • Reinforcement by attracting foreign students to good junior colleges in the country • Promoting recruitment of graduates as leading professionals of Korean companies in overseas countries

Source: Ministry of Education, Science and Technology. (2010d). Major policies and plans for 2010.

1.2.2. Schools

Junior colleges seek to teach and educate students in professional knowledge and theory of each area of society and to foster professionals necessary for national and social development (Article 47, Higher Education Act). The junior college system was unified and the schools were changed to junior college in 1979.

The number of junior colleges has been increasing continuously, reaching 158 schools in 2005, before declining after. The 'University Establishment Regulation and Guideline' simplified college the requirements for establishing junior colleges, which led to an increase that created new 14 junior colleges (1 national, 5 public and 8 private) between 1996 and 2004. The over-expansion of junior colleges also brought a general decline in academic standards among higher education workers. The decrease in the number of junior colleges after 2005 was due to a decrease in number of applicants for junior colleges as well as efforts to restructure higher education institutions that were in excess supply. As a result, national and public universities were merged during this period, where 10 junior colleges were transformed into four-year universities between 2005 and 2007 (Korean Council for University College Education, 2009).

The number of junior colleges in Korea was 146 in 2009, which accounted for 35.9 percent of the total higher education institutions. Most of the junior colleges were private schools, as 10 were national or public (two national, eight public; 6.8 percent) schools and 136 were private (93.2 percent) schools. By region, a total of 43 (29.5 percent) junior colleges were located in metropolitan areas (Seoul, Gyeonggi), and rest were scattered throughout the country (Center for Education Statistics, 2009). Recently, junior colleges have been emphasizing lifelong education, as lifelong education centers are being founded within junior colleges with more expected to be opened. In fact, in 1997 there were 144 programs in 30 lifelong education centers, which has continued to increase, reaching 3,285 programs in 125 centers. This trend is expected to continue in relation to emphasis on lifelong vocational education in junior colleges.

1.2.3. Departments and Curricula

The number of departments in junior colleges has been increasing from 961 in 1980 to 6,775 in 2009, along with the expansion of junior colleges. This increase in the number of departments is due to changes in the structure of industry, job market and the increasing number of junior colleges. The junior college departments have been focusing on education toward a knowledge-based society since 2000. Certain departments were subdivided into particular areas while others were reorganized by combining two or three departments. In addition, an increasing number of special departments have been established in specific areas to accommodated growing demand(See Table 3-4). This trend indicates that the number of practical departments has grown consistently in response to educational needs of the public along with specialization of junior colleges and diverse promotion (Korean Council for University College Education, 2009; KRIVET, 1999; Lee, 2004; Na, 2009).

Table 3-4 | Diversification of Departments in Junior Colleges

Department Segmentation	Department Integration	Establishing Special Department
• Dept. of Business Administration ➔ Dept. of Service Management, Dept. of Business Foundation, Dept. of Product Quality, Dept. of Digital Marketing, etc.	• Dept. of Child Care + Dept. of Social Welfare ➔ Dept. of Child Care and Welfare	• Dept. of Kim chi Food Science, Dept. of Dietary Information Management, Dept. of Tire Engineering, Dept. of Cultural Assets, Dept. of Museum, Dept. of Shipping and Ocean System, etc.

The junior college curriculum includes: associate degree program, bachelor’s degree advanced course and irregular program. The associate’s degree program requires two or three years of study. The bachelor’s degree advanced course is a bachelor degree course one to two years to associate's degree holders, and 430 of these courses are approved and operated throughout Korea in 2010. The irregular program takes a lifelong education model, where the course credits are recorded in the credit bank system, and consists of special programs and part-time enrollment programs. Each junior college degree program and their required years are stated in Table 3-5.

Table 3-5 | Required Years and Credits by Degree Programs inJunior Colleges

Items	Associate's degree program		Bachelor's degree advanced course	Irregular program	
				Special program	Part-time enrollment
Years	2 years	3years	1~2years	No limitation	No limitation
Required credits	80 or more	120 or more	140 or more (including credits obtained in associate's degree)	Acknowledges credits obtained by credit bank Cannot receive degree	Acknowledges credits obtained by credit bank Can receive degree (provided in school regulation)

Source: Korean Council for University College Education. (2009). '30 Year History of Junior Colleges in South Korea (1979-2008).

Junior colleges are obligated to state credit requirements for graduation as well as requirements for completion of a major or discipline per in school regulations. However, due to the a lack of understanding of the curriculum structure and operation on the part of teachers, most cases are based on empirical data.

Thus, the degree programs and curriculum of junior colleges are diversifying, resulting in the following major trends: operation of bachelor's degree advanced course, increase in irregular lifelong education programs, and establishment of special courses to reflect the job market and industry's needs. This needs careful consideration because even though this may reflect the educational demands of students and vocations, it may blur the lines with general universities and also offer a secondary option for junior colleges that have difficulties in recruiting students.

1.2.4. Students

The number of junior college students has been gradually decreasing since 2000. In 2000, there were 913,273 junior college students (29.2 percent of total higher education institution), which has steadily fallen to 760,929 students (21.9 percent) in 2009, lower than a quarter of total students enrolled in higher education (Center for Education Statistics, 2009).

The employment rate for graduates was generally 80.4 percent in 2005. In terms of the employment rate by sector, the water & ocean sector had the highest rate of 85.3 percent, followed by health (82.2 percent), engineering (81.6 percent), humanities and society (81.1 percent), physical education (79.9 percent), and nursing (79.3 percent). Also, the enrollment rate of graduates seeking higher degrees was approximately 5.96 percent of total graduates (KCCE, 2005).

However, demographic of enrolling students is changing by age with the number of overseas students from different countries increasing. With the enrollment rate declining, junior colleges have taken a more open and diverse approach to admissions. This has contributed to more diversity in the age of students enrolling in junior colleges. Students in the age group of 19-25 accounted for 90.0 percent (290.981 out of 323,825) of the total students in 1990, but the rate has decreased to 66.8 percent (508,206 out of 760.929) in 2009. On the contrary, the number of students over the age of 26 has increased from 2.0 percent (6,381 students) in 1990 to 13.4 percent (101,407 students) in 2009 (KCCE, 2009). Also, the number of foreign students in junior colleges has been increasing, totaling 2,519 students in 2005, which increased to 5,552 students in 2009. In terms of nationality, 80 percent of these foreign students are Chinese or Korean-Chinese (KCCE, 2009).

Meanwhile, as lifelong education centers affiliated with junior college has expanded, the number of lifelong education programs and participants has also increased. In fact, the number of students and programs totaled 68,508 and 1,734 in 2006, respectively, which increased to 99,241 students and 3825 programs in 2008.

1.2.5. Faculties

Currently, there are a total of 12,451 teachers in junior colleges. The ratio of part-time teachers (part-time instructors, emeritus professors, adjunct professors, visiting professors, etc) has been increasing, going from 49.9 percent in 1990 to 73.2 percent in 2007. This is over 10 percent higher than that of universities, were the percentage is 60.9 percent. In case of junior colleges, it is necessary to staff the school with teachers that have diverse work and academic experiences, which results in a higher ratio of part-time instructors such as adjunct and visiting professors. However, it is also necessary to improve policies to increase the rate of full-time professors to promote education skills and consistent guidance for students (Center for Education Statistics, 2009; KEEC, 2009).

The ratio of students per full-time teacher in junior colleges steadily increased until 2005, and then decreased down to around a ratio of 42 registered students per full-time teacher in 2008. In case of private junior colleges, which make up most of junior college, they have a relatively higher ratio of students per one full-time teacher compared to national and public junior colleges. But the number of students per teacher is still higher compared to universities. Considering the vocational nature of junior colleges, it is necessary to improve the quality of courses by reducing the number of students per teacher.

However, the enrollment rate in some provincial colleges fails to meet the school's capacity. As such, junior college instructors visit high schools to promote their college and department. At some vocational high schools, junior college instructors perform promotion activities, showing the difficulties that provincial junior colleges experience.

Despite these difficulties, there are also some positive efforts being made to raise the status of junior colleges institutionally, such as enabling junior colleges to have a president instead of a dean from 2009.

1.2.6. Financial support

Raising efficiency of junior colleges through financial support has been promoted for past 10 years, based on the principle of 'choice and focus'. Also, autonomy at colleges has been increasing recently. Until 2008, budget support for junior colleges has been allocated through various forms of financial support that sought different objectives, selectively supporting certain colleges based on the goal of each project. From 2008, the Junior College Education Competence Reinforcement Project has sought to support top performing colleges selectively, and to improve autonomy by allocating the whole budget to colleges and giving colleges discretion over the budget.

Furthermore, as several financial support programs are integrated into 'Education Skills Reinforcement Project' based on a formulaic funding system, the goal of administering junior colleges on the principle of 'choice and focus' is emphasized even more. Formula-based funding system calculates a college's financial support based on its educational conditions and performances.

Financial support for junior colleges is mostly dependant on MEST, and the circumstance prevented the colleges from applying for other financial support programs in other ministries. Besides, the ratio of junior colleges that receive financial support from the general MEST budget for higher education has been decreasing, falling from 25.5 percent in 2001 to 17.7 percent in 2005. For this reason junior colleges suffer financial problems, which increasing the possibility that underperforming junior colleges may go out of business with the emphasis on 'choice and focus' principle.

In 2010, programs supported by MIES at junior colleges include 'Junior College Education Competence Reinforcement Project' and 'Global Hub Junior Colleges Project'(MEST, 2010f, 2010g). The number of projects supported and its budget amount are shown in Table 3-6.

Table 3-6 | Selected Schools and Support Budget Amount in Junior College Funding Projects (2010)

Items	Junior College Education Competence Reinforcement Project		Global Hub Junior Colleges Project
	Support for Junior Colleges with Excellent Education Competency	Support for Brand-Leading Junior College	
Subjects	• 78 junior colleges	• 80 junior colleges	• 5 junior colleges
Supported budget	• 176.2 billion KRW (2.26billion per school)	• 82.5 billion KRW (1.03billionper school)	• 3 billion KRW (0.6billion per school) • Additional support of 1billion for three consecutive years

Source: Ministry of Education, Science and Technology. (2010f). 2010 Selecting the excellent education competence junior colleges. Ministry of Education, Science and Technology. (2010g). 2010 Selecting the global hub junior college.

1.2.7. Major Issues

There are five key issues in vocational training in junior colleges. First, policy initiatives seek to emphasize competition among junior colleges with the goal of promoting choice and focus by allocating financial support to junior colleges using a performance-based system of calculating funding.

Second, specialization and diversification of individual junior colleges has been pursued in response to decreasing enrollment rates and increased competition from four-year universities and in efforts to increase the role of junior colleges in vocational education.

Third, the implementation of the 'Public Announcement Regulation for College Information' and diversification of the student body has resulted in increased demand. As such, there is a question of how to handle these demands.

Fourth, as the industrial sector advances and demand for skilled workers grows, linkages between junior colleges and vocational high schools are emphasized.

Fifth, even though the employment rate of junior college graduates is higher than university graduates, the salary scale of university graduates is 1.5 times higher. So it is necessary to raise quality of jobs junior college graduates can secure.

2. Technical High Schools and Technical Junior Colleges during 1945~62

2.1. Main Policies Related to Technical High Schools

2.1.1. 5-year Plan for Industrial and Technical Education (1958~62)

2.1.1.1. Background

After the Korean War, the Ministry of National Defense, then suffering from a lack of workers with technical skills, was in need of more engineers. As the number of engineering and manufacturing companies grew, Korea experienced a large demand for human resources ranging from engineers graduating from technical high schools to engineers with college education. The government's extensive efforts in strengthening the industrial and technical education system did not have the desired outcomes, in part because of the lack of training facilities and qualified instructors, and because of inadequate teaching skills. Also, there was the problem of technical high school education itself, whose education was not different from that of regular high schools. At the time, many students were trying to enter colleges in order to avoid mandatory military service, even when unable to financially afford it. These circumstances led the Ministry of Culture and Education to establish the 'Five-Year Plan for Industrial and Technical Education' in 1957, with a goal of enforcing more efficiently its policy to promote industrial and technical education.

2.1.1.2. Main content

The 'Five-Year Plan for Industrial and Technical Education' aimed to efficiently pursue the Ministry's policy to promote industrial and technical education. According to the plan, the purpose of industrial and technical education was not to teach theoretical knowledge, but to train and educate workers with the necessary know-how and skills in high demand. As means to achieve this goal, the plan proposed various detailed action plans such as strengthening administrative positions in charge of industrial and technical education, increasing the number of industrial and technical education facilities, enhancing teaching skills of instructors, and raising public awareness on the value of industrial and technical education.

Table 3-7 | Summary of Five-Year Plan for Industrial and Technical Education

1. Reinforce administration of industrial and technical education.
2. Decrease dependence on foreign support by expanding industrial and technical education facilities and by gradually enabling each school to meet facility standards with the national budget or government support.
3. Strengthen re-education program for industrial and technical teachers by providing training opportunities to all teachers and establishing overseas training plan by 1962.
4. Raise public awareness on the value of industrial and technical education through promotional events, publications, lecture tours, conferences with teachers and students, and exhibitions of products manufactured by students.

Also, of the five year plan sought to increase the supply of teachers, training facilities, and scholarships, as well as raise its social status. The plan pursued the following: ① Gradually increase the number of teachers for each industrial and technical school to meet the legal standard for school staffing. ② Provide funding for training facilities and equipment for public schools from the national budget. For public-private schools, 50% of expenses will be covered by the national budget. ③ Reinforce programs for overseas education, research conferences, and re-education seminars to enhance teaching skills of teachers and expand the number of teachers. ④ Proceed with various campaigns to raise awareness and social status of vocational schools among the public, which prefer human science education to industrial and technical education. ⑤ Students of industrial and technical schools were given priority over students of other schools in terms of scholarship programs.

2.1.1.3. Implication

Although five year was initiated address the problem with technical education at the time, its execution was met with many difficulties, including insufficient budget support, material support from the government, lack of qualified teachers, and lack of public acceptance on the value of technical education. For instance, it had been estimated that the budget required to fund the first year of the plan would be 6 hundred million won, but later it turned out that the actual amount used for the plan was only a sixth of the estimated amount. This was due to the poor fiscal state of Korea at the time, which shows that the plan failed to achieve the desired outcomes.

But the plan was the first documented effort of the Ministry of Culture and Education to fundamentally solve the problem of unemployment in a national scale, and laid the foundation for the legislation of the Industrial Education Promotion Act in 1963.

2.1.2. Introduction of Comprehensive High School

2.1.2.1. Background

The introduction of a 'comprehensive high school' in Korea stemmed from the fact that schools can be separated into academic and technical schools and boys and girls schools. It would have been ideal if everything could have been carried out in the same school, but schools were segregated between academic and technical based on past traditions and customs. As a result, technical schools in certain districts could not meet the demand for college education. To improve the situation, the Ministry of Culture and Education needed to reform the high-school education system. So the Ministry, as a means to improve the secondary education system, introduced the 'comprehensive high school' and tested its operation.

2.1.2.2. Main content

The 'Comprehensive high school' is a school which provides both academic courses (college preparation classes) and technical courses (technical classes). This type of school was introduced as an alternative to the existing model of secondary education, which had proved to be somewhat problematic.

In Europe, academic education and technical education are separated in secondary schools, without any linkages between the two areas. That is, the traditional education system of Europe was based on complete separation of technical and academic education, so that once a student begins a technical track, he or she cannot transfer to an academic one, and is denied a college education. This system was criticized for not being able to help resolve social class inequalities, because it re-creates the separation of physical labor and mental labor. Such social criticism led to the desegregation of different types of schools. As a result, the world witnessed the spread of universalities among secondary schools, which means each school set up its own college preparation courses so that the students could choose freely between different types of education.

The Ministry of Culture and Education designated the town of Pyung-Taek for the experimental school, and commissioned the Central Institute for Education Research to conduct a research study. The Institute proposed that Pyung-Taek High School be reformed as a comprehensive high school, for the purpose of meeting the local needs and realizing the principle of equal education. Finally, in 1957, the budget for Pyung-Taek high school was appropriated, and the first comprehensive high school in Korea began its operation.

Pyung-Taek Comprehensive High School, the first of its kind in Korea, was differentiated from other high schools in that each student could choose from various courses that suited their aptitude and career goals. Pyung-Taek High School provided courses in fields of study other than college preparation courses, such as agriculture courses, industrial courses and commercial courses, so that the students could enter the course that wanted. And the classes operated on a university-like credit system, and there were various optional classes. Such education programs tried to respect the aptitude and individuality of the students, and it was an effort to adopt the trend of developed countries, such as the United States. In later years, the Ministry of Culture and Education expanded the comprehensive high school system nation-wide.

2.1.2.3. Implication

After the establishment of the Pyung-Taek High School in 1957, 60 high schools (33 public schools, 27 private schools) became comprehensive high schools by July, 1968. But comprehensive high schools failed to be generalized, as many of the schools were changed back to academic high schools. The Ministry of Culture and Education concluded that the failure came from the fact that some comprehensive schools veered from its original purpose simply because it was more convenient, or even many of them misrecognized the comprehensive high school system itself. This proves that in this regard, the Ministry's initial purpose in introducing comprehensive high school system failed to achieve its desired outcomes. And comprehensive high schools showed problems in its operation, since many of the students in technical courses felt inferior to the students in academic courses. The comprehensive high school system, however, received constant support from many critiques, as a system with a possibility of further improvement, and the government recently proposed 'integrated high school' or 'integration of education courses' as a part of its vocational education reform program.

3. Technical High Schools and Technical Junior Colleges in the Period of Development Stage (1962~79)

3.1. Main Policies Related to Technical High Schools

3.1.1. Five-Year Plan for Industrial and Technical Education(1967~71)

3.1.1.1. Background

The 1960's in Korea was a period of time when full-scale economic development was initiated to escape poverty and to secure prosperity. The First Five Year Plan for Economic Development, initiated in 1962, was established for achieving economic development, by means of swift industrialization, export expansion, productivity increase, and employment expansion.

Implementation of this plan drastically increased Korea's GNP growth rate from 4.7% in 1960 to 12.4% in 1966, and 15.0% in 1969. For a country not endowed with natural resources for economic development, development of human resources was essential to the growth of the national economy. That was why a more powerful technical education policy was necessary. In this period, the government extensively reformed the industrial education policy in line with the Second Five Year Plan for Economic Development, and such an effort led to the Five Year Plan for Science and Technology Education.

3.1.1.2. Main content

The goals of Five Year Plan for Science and Technology Education included cultivation of scientific and creative mind, greater focus on the study of science, promotion of technological innovation and scientific invention, enhancement of qualities and abilities of technical workers. To this end, the plan include the following measures: increasing the number of students in natural science and engineering universities, expanding the number of engineering schools and classes, introduction of engineering courses to meet industrial needs, improvement of training institutes for teachers, reinforcement of academic-industrial cooperation, and reinforcement of investment.

Table 3-8 | Summary of Five-Year Plan for Science and Technology Education

1. To balance the supply of human resources in each industry field, expand the number of students in natural science and engineering universities and establish more industrial, fishery and marine universities and classes.
2. Introduce and gradually expand engineering departments that suits local industrial needs into agricultural schools within industrial complexes to support simultaneous promotion of agriculture and engineering
3. To secure enough number of practical education teachers and enhance their capabilities, improve operation of training institutes for teachers, reinforce instructor training and provide improved benefits for teachers.
4. Renovate and develop education courses and contents to follow the industrial development of today, and publish practical education textbooks that are currently in need.
5. Promote and develop audiovisual education center for innovative teaching methods.
6. Enact decrees for engineering lab training, and reinforce industry-academy cooperation for more efficient investments in facilities.
7. Gradually increase budgetary support for engineering lab equipments to cover 50% of the expenses, and provide financial support for private industrial schools as well.
8. Gradually increase the amount of student loans, for wider range of recipients.

In the plan, the goal of increasing focus on the study of engineering was to contribute to supply of human resources needed to make Korea an industrial country, by expanding the facilities and labs of engineering schools and training skilled engineers. Details of the plan are as the following. ① Improve the operation of training facilities for teachers, reinforce instructor training, and provide improved benefits for the teachers, to secure enough number of practical education teachers and engineering teachers, and to enhance their capabilities. ② Renovate and develop education courses and contents to follow the industrial development of today, and publish practical education textbooks that are currently in need. ③ Enact decrees for engineering lab training, and reinforce industry-academy cooperation for more efficient investments in facilities. ④ Gradually increase budgetary support for engineering lab equipments to cover 50% of the expenses, and provide financial support for private industrial schools as well. ⑤ Gradually increase the amount of student loans, for wider range of recipients.

3.1.1.3. Implication

The five year plan is considered to have been the foundation for the development of the study of engineering in the 1970's. Especially, the plan was the first comprehensive effort that sought to upgrade the manpower without putting focus only human resource demands. And after the implementation of the plan, engineering actually became much more dynamic, showing great development both in its quantity and quality.

3.1.2. Enactment of Vocational Education Promotion act

3.1.2.1. Background

As the country's need for more and better human resources rendered the dated industrial education policies of the past, the Vocational Education Promotion Act was enacted in 1963 to facilitate the training of skilled engineers who would contribute to the independence of the nation's economy.

3.1.2.2. Main content

The Act established a legal basis for innovative promotion of industrial education, and was enacted and declared on September 19th, 1963. But its inception can be traced back as early as 1959. The Ministry of Culture and Education was proceeding with the Five-Year Plan for Industrial and Technical Education, and the Ministry's bill for Vocational Education Promotion Act passed the Central Education Committee. It was not enacted at the time, but this bill eventually led to the enactment of the Vocational Education Promotion Act in 1963.

The Act sought to recognize the importance of industrial education and promote its development on that basis. And it promoted support from the central government, local government and schools. To be more specific, this act provided various support including securing of engineering labs and equipment, providing benefits to practical education teachers and practical education students. The presidential decree for this act was declared on June 8th, 1965, with the following action plans: ① focusing on specialized subjects, ② expanding and maintaining engineering labs and equipment, ③ training and developing teachers, ④ reinforcing local relations for field studies and on-site training, ⑤ training engineering workers to run small-sized self-employed business, ⑥ systematic follow-up for the graduates.

And on February 22th, 1973, the national assembly revised the Vocational Education Promotion Act, adding clauses to reinforce industry-academy cooperation. According to the second clause of the 3rd article, students of schools with industrial education courses were required to attend field practices for a set period of time. The Minister of Culture and Education was allowed to request that certain companies be designated for field studies. Once such a request was made, the organization had to select and notify the designated companies and notify the Minister of Culture and Education. Companies were required to actively participate in field study programs. The decree for this act specified the cooperation of the companies, and suggested the total amount of time of each field study.

3.1.2.3. Implication

To propel the enforcement of industry-academy cooperation policy, the government established Industry-Academy Cooperation Section within the organization. The function of this section was transferred to another section in 1975, but this section was a testament to the will of the government in promoting industry-academy cooperation, and made actual contribution in that regard.

3.1.3. Policy of Specialized Technical High School

3.1.3.1. Background

In 1970's, the government shifted focus of its industry policy from light industry to heavy chemical industry. The reason for this shift was that the light industry-centered policy in the 1960's proved to be insufficient to expand export. Such policy change brought about the need for more engineers in the field of heavy chemical industry, but the level of engineering education at the time limited the supply of quality human resources. Also, as enormous amount of budget and time was needed to simultaneously enhance the level of engineering high schools around the nation, the government decided to select engineering high schools as models in the field of engineering, dividing those schools in four categories and concentrating its investment into those categories, to ensure higher level of efficiency. In 1973, as the government declared its industrial policy of promoting the steel, shipbuilding, machine, and petrochemical industries, a new plan for upgrading the level of engineering education was implemented, whose purpose was to train students to be highly trained engineers for its industrial policy. For this purpose, the policy of specialized technical high school was put forward.

3.1.3.2. Main content

Policy of specialized technical high school sought to categorize technical high schools into four types: machinery schools, model schools, specialized schools, and general schools. The policy pursued concentrated investment according to the types, thus training skilled industrial engineers. In 1973, the policy was initiated with the establishment of the machinery high school, an experimental school for training engineers for precision processing. Then, in 1976, divided total of 83 engineering high schools in the nation were divided into four types: 19 machinery schools, 10 specialized schools, 11 model schools, and 55 general schools. Each school was set up differently, with specialized goals and courses for each types. This system peaked in 1979.

Table 3-9 | Goal and Number of Specialized Technical High Schools

Type	Goal	Number of Schools (%)	Year of Establishment
Machinery School	Training precision processing engineers for defense industry and machinery industry	19(20%)	1973
Model School	Meeting the non-regular need for special human resources such as overseas engineers, and establishing exemplary model for technical high school operation	11(12%)	1976
Specialized School	Training skilled engineers for specialized industrial field such as electronics, chemical, construction, steel, railway.	10(10%)	1977
General School	Training engineers for general industrial field.	55(58%)	

Among of the four types of schools, machinery high schools were established to meet the human resource needs of the defense industry, as it was suffering from a lack of machineries. The machinery industry itself was showing astonishing development in the 1970's. In 1973, four engineering schools were designated as experimental schools for training precision processing engineers, and their names were changed to 'machinery high schools.' By the year

1978, 19 schools were designated as machinery high schools, which accounted for 20% of the total number of engineering high schools. Specialization of machinery school was supported by bold fiscal investment. From 1973 to 1978, more than 12 billion won was invested in engineering labs and equipments. And in 1976, the electricity supply regulation was revised and 'contract for general public electricity utility' was renewed as 'contract for industrial electricity utility', so that engineering labs and equipments could be operated 24 hours a day, thus enabling each school to save about 2 million won's worth of education expenses a month.

Establishment of model schools began when the government selected 11 engineering high schools around the nation based on the quality of their facilities, and designated them as model schools in March, 1976. Those schools included Kyung-Nam Technical High School, An-Yang Technical High School, Yeong-Wol Technical High School, Ok-Cheon Technical High School, Cheon-Ahn Technical High School, I-Ri Technical High School, Sun-Cheon Technical High School, Tae-Ku Technical High School, Ul-San Technical High School, and Han-Lim Technical High School. Model Schools were required to have courses on machinery, electronics, architecture and construction. In 1976, six types of specialized textbooks were published for each field such as machine assembly, metal plate, welding, plumbing, electronics, together with the Ministry of Culture and Education, Korean Center for International Vocational Training Competition, representatives from Dae-Lim Industry and Hyun-Dai Construction, and teachers from technical high schools. This policy functioned as a catalyst to invigorate technical education, and in 1976, a total of 2,140 students trained through this policy were all employed.

As for specialized schools, three schools in 1977 and five schools in 1978 were designated as specialized schools for various industrial fields such as electricity, chemical, construction, steel, railway, electronics, and metal. And in 1979, two schools were added to the list. In detail, those schools included Railway High School, Su-Do Electricity, Pu-San Electronics, Gu-Mi Electron, Jeon-Ju Construction, Gim-Hae Construction, Keum-Pa Chemical, POSCO, Dae-Jung Metal, and Keum-Oh Technical High School. Education courses of specialized schools were based on that of machinery schools, but each school was required to teach main subjects for each field, and each subject had different objectives for its education. In 1979, textbooks for 15 subjects were developed and distributed, as an effort to advance the quality of education.

3.1.3.3. Implication

This policy of establishing specialized technical high school is thought to have brought about substantive developments in the short-term, specialized education in technical high schools, through exercises focusing on the major, and intensive training focusing on practical skills. And it transformed the unilateral model education of the past to include diversified operation method according to the specialty of each school, thus furthering the development of technical education itself. But at the same time the policy was met with criticism for insufficient general education program, lack of adaptation to changes in technologies.

3.2. Main Policies Related to Technical Junior Colleges

3.2.1. Establishment of Specialized Vocational High Schools

3.2.1.1. Background

In the early 1960's, there was a nation-wide demand for skilled technical engineers while elementary colleges were criticized for having lost their identity. Such demands and criticisms were based on the social recognition that training of skilled engineers was necessary for successful economic development. This led to the establishment of specialized vocational high schools in the education system in 1963.

3.2.1.2. Main content

Specialized vocational schools sought to contribute in the nation's modernization and industrial development, the government's key policy task under Park Chung Hee Regime. According to the 128th article of the revised Education Act, the purpose of these schools was to teach and study industrial knowledge and theories, to refine industrial technologies and to train skilled industrial engineers. The program required five years of schooling for graduation; the admission was limited to students with a middle school education or equivalent education level. And graduates of these specialized vocational high schools were provided opportunities to pursue higher education by entering college.

In 1963, 41 majors were established in 9 universities as specialized vocational high schools. In 1963, these schools admitted students for 1st grade and 4th grade. For the 1st grade, competition for admissions was very high as many students from the entire nation applied, but application for the 4th grade was fairly low. Which forced the school to admit 3rd grade students. At first, there were many difficulties in terms of facilities, professors, education courses and budget, because they were operated side by side with existing high schools. But specialized vocational high schools gradually secured their place in the education system due to the high demand for skilled industrial professionals. Also, the school admission system was designed to balance the number of admitted students from each province.

3.2.1.3. Implication

Specialized vocational high schools constantly grew in size until they were reformed as two-year specialized schools. But its initial limitations shown from the very beginning prevented them from adapting to changes in the education system and the society itself. As in the previous case of elementary colleges, the specialized vocational high school system was dismantled due to the introduction of new vocational school system,

3.2.2. Reorganization of Vocational College

3.2.2.1. Background

As admissions to specialized vocational high schools were limited to middle-school graduates, it was difficult for them to find new recruits among students who did not pass the preliminary college entrance examination, which began in 1969. And those schools were criticized for failing to adapt to changes in labor demand caused by changes industrial structure and by rapid economic development. The rapid economic development in the late 1960's brought about increased demand for industrial professionals, which in turn necessitated more vocational schools in the short-term. In addition to those trends, International Development Association (IDA) requested the establishment of a two-year short-term higher education school. Due to these factors, specialized vocational high schools were reorganized as two-year 'vocational schools'.

3.2.2.2. Main content

Vocational schools were introduced to address the issues caused by specialized vocational high schools, and to give students who failed to enter college an opportunity to receive a vocational technical education. Vocational schools were introduced when the Education Act was revised on January 1st, 1970, which proposed the establishment of two-year special schools, in addition to the five-year vocational schools. By 1976, specialized vocational high schools were turned into vocational schools. The two-year vocational schools grew in quantity for nine years along with elementary colleges, nursing college, and specialized vocational high schools.

Vocational schools aimed to teach and promote the study professional knowledge on each field within society, and to refine technologies and training skilled professionals. There purpose is similar to that of specialized vocational high schools, which were also in existence. This implies that the nature of vocational schools were the same as specialized vocational high schools in their founding principles and purpose. The difference was the amount of years required by each school for graduation, which was reduced to two or three years. The number of vocational schools grew from four in 1970 to 112 in 1978. This increase was a result of the rapid conversion of specialized vocational high schools into vocational schools.

3.2.2.3. Implication

The vocational school system is recognized for reflecting the nation's desire for skilled technical professionals and support for higher education in vocational schools. Despite the importance and effort placed on the development of vocational schools, the system never took hold due to limitations caused by society's negative attitude toward vocational education and preference for four-year universities. As four-year universities became more sought out after, vocational schools failed to establish identities of their own. Also they did not make sufficient efforts to establish themselves as short-term higher education institutions specializing in vocational education, especially when they were co-existing with specialized vocational schools. The negative perception toward vocational education and the underdeveloped support systems contributed to its lack of acceptance.

3.2.3. Establishment of Junior Colleges

3.2.3.1. Background

The mid-1970's witnessed drastic change in the industrial structure. As the Fourth Five Year Plan for Economic Development went on successfully, there was increased demand for more mid-level engineers and for professional development. In response, specialized vocational high schools, the forerunner of vocational schools, were introduced as five year schools for technical training in 1964. But it was met with skepticism, as the 5 year program requirement was deemed excessively long and many students dropped out because many of the graduates had difficulty in entering colleges or finding employment. In response to this, the government reformed the system of specialized vocational high schools into vocational schools, which was similar to junior college. Newly organized vocational schools showed great quantitative growth, as the number of schools grew from 26 to 112 by 1978, but the system still had many problems in terms of quality of education. The quality of students was fairly low as many of the students did not pass the preliminary university entrance examination, In other words, 'repeat test takers' were admitted, and the quality of education itself was not up to initial expectations. The government tried to make improvements and address the problem of students that were not able to pass the college entrance examinations. This resulted in the establishment of junior colleges in 1979, through which the government unified existing elementary colleges and vocational schools.

3.2.3.2. Main content

One of the goals of establishing junior colleges was to solve the problem posed by the increasing number of students retaking the entrance exam. This led to drastic increase in the number of junior college students, which grew from 59,165 in 1978 to 121,539 in 1982. But in the course of this quantitative growth, other problems emerged, such as the lowering of academic standards and low employment rate of graduates. Responding to these problems, the government came up with new measures to improve the junior college system. As a result, two strands of policies emerged. First, the government decided to reduce the number of colleges, majors and students to discourage competition between colleges for recruits, and encourage each college to focus on a specific field of study. Second, certain colleges and departments were exempted from downsizing including: colleges with a sound track record such as healthcare colleges, nursing colleges, agricultural and fishery colleges and marine colleges; junior colleges founded and operated by industry training engineers; departments of majors that were in great demand, such as data processing training, education for children and girls, and tourism. As a result, the number of junior colleges decreased from 132 in 1981, to 120 in 1985, then to 117 in 1990. The total number of students also decreased from 105,830 in 1982 to 97,090 in 1985 then to 96,930 in 1987.

3.2.3.3. Implication

Although the initial development of junior colleges was hampered by many difficulties such as lack of public acceptance and inadequate educational environment, they gradually grew to secure themselves as short-term specialized vocational schools training in the late 1980's. This development was made possible by the great demand for mid-level industrial professionals driven by Korea's rapid industrialization and economic growth which began in the late 1970's. Of course, the efforts of junior colleges themselves played an important part in their rapid development, which included the development of courses which reflected the industrial demands, improvement of teaching-learning methods, enhancement of teaching qualities, and reinforcement of industrial-academic cooperation.

4. Technical High Schools and Technical Junior Colleges during 1980~98

4.1. Main Policies Related to Technical High Schools

4.1.1. Plan for Reforming Vocational & Technical High School System

4.1.1.1. Background

As Korea entered a period of economic prosperity with the help of low fuel prices, low interest rates and low currency exchange rates, the wage costs of major companies increased rapidly, which led to increased demand for workers from labor-intensive manufacturers. On the other hand, in the same period, there was a growing shortage of manufacturing professionals. Meanwhile, there was increasing pressure for high schools to be more academically oriented, as education in Korea became more heavily centered on obtaining a college education while the importance and weight of vocational education kept decreasing. As a result, a sizable amount of the youth population was dropping out of the education system, as they failed to enter college. At the same time, college graduates were having difficulty getting employment, worsening the labor imbalance or shortage of workers. The growing disparity between the number of high school and college students in each department and increased demand for qualified workers became a grave social concern. As a solution to this problem, the government initiated the 'plan for reforming vocational and technical high school system' to enhance vocational education in high schools and to improve the quality of education.

4.1.1.2. Main content

The plan was mainly concerned with addressing education and labor, that is, it aimed to stabilize education and labor. To this end, the plan implemented several measures such as increasing the percentage of industrial and engineering high school students, enhancing educational quality in industrial high schools and vocational schools for students unable to enter college. Details of the government's execution of the policy are as follows. First, to increase the capacity of industrial high schools focused on engineering, the government adjusted the ratio of industrial high school students to academic school students to 50:50 by 1995, and increased the rate of engineering high school students in industrial high schools to 45% by 1995. This deadline was adjusted to 1998 later. Second, the government decided to improve the educational environment to improve the quality of education at industrial high schools. Third, the government tried to vitalize vocational training for students who didn't enter academic high schools. Fourth, while the study of engineering was focused on expanding capacity at schools, the fields of agriculture and commercial business were focused on diversifying their courses.

4.1.1.3. Implication

The reform plan being implemented in vocational and technical high schools is considered to be a comprehensive solution to solve the 'bottle neck' caused by the failure of more than half of high school graduates to enter into colleges and the huge lack of qualified engineers in the labor market. During implementation, several problems emerged such as ① unsure in the possibility of achievement its goals, ② level of consideration for ensuring educational quality, ③ follow-up management for trained workers, ④ effectiveness of 'vocational courses' in general high schools.

In particular, the plan to expand the number of industrial high school students and engineering high schools was hindered by many obstacles. When the government initiated the plan in 1990, the ratio of academic high schools to industrial high schools reached its peak at 68.6 : 31.4. But execution of the plan reduced the ratio of academic high school students and increased the number of industrial high school students, increasing the rate to 62.6 : 37.4 in 1996. The percentage of engineering high school students in the total number of industrial high school students grew from 28% in 1990 to 40% in 1996. While the government's effort brought about great changes, the initial goal of the plan to increase the ratio of academic and industrial high school students to 50 : 50 by 1998 and the percentage of engineering high school students to 45% is expected to face many obstacles. In the course of the plan's execution, many obstacles emerged, such as ① insufficient budget, ② insufficient number of high schools that want to be reformed, ③ opposition from parents and alumni, and local residents, of the schools targeted for reform, ④ opposition from teachers concerned with an oversupply of teachers due to reforms.

4.1.2. Technical High School 2+1 System

4.1.2.1. Background

As global competition has grown more intense with the emergence of WTO system, the government has determined that the only way of sustaining economic development is to train highly-skilled professionals to secure competitive advantage. This realization led to the implementation of the 'Five Year Plan for New Economy' (1993-1997). This plan proposed a comprehensive reform of the high school vocational education system. Also, major policies regarding engineering high school education were proposed in 'human resources development.' This plan suggested many courses of action such as 'expansion of engineering high schools and industrial on-the-job training', 'vitalization and diversification of post-high school vocational education', 'adjustment of public training center and reinforcement of incentives for education and training'. Based on the direction of the policy and reform plan, the government established the 2+1 system for technical high schools in order to ensure that engineering high school students adapt to the field.

4.1.2.2. Main content

Under this system, each school is required to provide a two-year program consisting of cultural and basic major education, and one-year on-the-job training, in order for the schools and the companies to cooperatively share their role in the development of engineering high schools. That is, each school would provide basic technical and theoretical education for the first two years, and the companies would provide joint practical training and on-the-job training, thus shifting the focus of education from theories and concepts to practical techniques.

With the lack of qualified professionals in engineering and the low level of students adapting to the field, the 2+1 technical high school system was introduced to expand engineering high schools and institute on-the-job training under the 'Five Year Plan for New Economy.' Although the initial time table suggested that the system be introduced as one type of regular high school by 1998, a four year pilot program planned from 1994 to 1997 was extended by another year to 1998, due to incompleteness of related systems, lack of educational environment in the field.

Table 3-10 | Technical High School 2+1 System Test Operation

- 1992. 7~12 : Origination of technical high school 2+1 system
- 1993. 7 : Confirmed by 'Five Year Plan for New Economy'
- 1994. 6 : Joint inspection and review report
- 1994~1997 : Pilot program of technical high school 2+1 system
- 1997. 3 : Confirmed extension of pilot program to 1998
- 1997. 4~8 : Comprehensive evaluation of technical high school 2+1 system

4.1.2.3. Implication

The plan was expected to improve engineering high school education so that it could adapt more actively to changes in the labor market and education environment, thus, helping to satisfy the growing demand for qualified engineers. The results of the pilot program for 2+1 technical high schools showed the following. First, it highlighted the importance of on-the-job training in terms of improving the quality of vocational training. Second, it resulted in 49,416 students being educated and trained to meet the worker demands of companies during its test period of five years. And this effort laid the foundation for the students to become skilled technical professionals in the future. Third, it led to the institution of on-the-job training and improvement of its environment. Fourth, it contributed to helping students adapt better to the field by developing modulated, work and technique-centered teaching materials through work analysis with the participation of industrial representatives.

But the following were raised as limitations. ① There is insufficient amount of research on the generalization of this program in the Korean environment ② The system began its operation without detailed plans③ Students, parents and teachers are skeptical about the feasibility of this system.

4.1.3. New vocational Education System Reform Plan (1996)

4.1.3.1. Background

Recently, many developed countries are reforming their vocational education system, acknowledging that the current system cannot cope with today's 'infinite competition without border'. Korea, in line with this international trend, has put the development of 'human ware' as one of its main national tasks. In light of this objective, the education reform committee proposed a plan to establish a new vocational education system.

4.1.3.2. Main content

The new vocational education system reform plan was a multi-lateral and comprehensive plan for enhancement of vocational training, which aims to establish life-long vocational education system. It suggested shifting focus of vocational education from quantitative growth to quality enhancement. The committee declared that it will establish a life-long vocational system to realize recipient-centered education and an opened life-long education society by laying out seven reform goals for vocational education.

In regards to vocational education in middle and high schools, the plan proposed diversifying the high school vocational education system. To this end, the establishment of specialized high schools was proposed to offer new opportunities for students to decide their career paths according to their aptitude and capabilities in various professionals (e.g., information high school, design high school, electronics and communication high schools, applied music high schools). And the plan also proposed consolidating academic and industrial courses so that students in the 2nd and 3rd grade can choose various electives regardless of their departments. Also, it proposed reinforcing the linkage between industrial high schools and junior colleges. In addition, the following was proposed as courses of action to securing skilled teachers for industrial high schools. ① Employing skilled industrial instructors with certain educational and work experience (e.g., mid-level technical professionals who retired early can qualify as high school teachers through after a certain period of training), ② Utilizing skilled technical professionals or managers as part-time teachers, circulation teacher, teaching professionals, on-the-job training instructor, ③ Dispatching technical teachers to the field so as to improve their teaching skills and their career development (e.g., introduction of 'training semester' for the field work).

4.1.3.3. Implication

The new vocational education system reform plan is considered to have contributed to shifting focus in vocational education from middle and high school level to college level. It brought about meaningful change, as industrial high schools aimed to achieve 'ongoing education' rather than 'completion education'. Other achievements of the plan include reinforcement of basic vocational education in high schools, expanding the range of choices for vocational education by diversifying high school-level vocational education, and granting high-level vocational education for students who finish high-school vocational education.

4.2. Main Policies Related to Technical Junior Colleges

4.2.1. Introduction of Graduation Quota System

4.2.1.1. Background

In the 1970's, as the government's control on society intensified, short-term higher education was encouraged through the establishment of vocational schools and specialized vocational high schools. Also, the government suppressed expansion of high school education so as to ensure educational quality. These circumstances led to the inflation of social demand for higher education, which resulted in increasing educational expenses in the civil sector and growing number of students unable to obtain admission to college. To solve this problem and to normalize high school education and to satisfy Korea's demand for skilled workers, the government announced the 7.30 education reform plans in 1981, the core of which was the introduction of the graduation quota system.

4.2.1.2. Main content

At the time of its announcement, the system required each college to give a failing grades to 30% of the enrolling students (15% for junior colleges) in order to foster a learning environment and absorb students unable to gain admission to college. It also sought to alleviate the over-heated private education sector and competition for college admissions. But the graduation quota system ran into problems including the self-contradiction in dealing with the drop outs. After several revisions, the system became nominal after the liberalization of college admissions in 1984, and was virtually abolished, becoming the 'admission quota system' in 1988. After this, phased liberalization of student quota was accelerated concentrating on industrial departments.

4.2.1.3. Implication

While the graduation quota system had a positive impact on meeting the social demand for college education and expanding educational opportunities, it was criticized for not being the ultimate solution. Indeed, it encouraged colleges to inflate their admission numbers, so the reduction in the number of students not admitted to college was only temporary. After the introduction of the system, the rate of college admissions went up drastically resulting in the lowering of academic standards and greater unemployment among graduates. Also, as the number of students in four-year colleges increased, many students decided to enter four-year colleges rather than junior colleges, making it difficult for junior colleges to enroll students. As a result, many junior colleges suffered a shortage of applicants.

4.2.2. New Education Reform Plan (1996)

4.2.2.1. Background

The 1990's saw the transformation of Korean society and industrial structure, with unemployment and under-education emerging as important issues of the time. To improve Korea's national competitiveness, it needed to improve its industrial structure and train skilled professionals. To meet this social demand by developing human resources with competitiveness of international level, the government focused on the need for a new vocational education system. With this in mind, the government established 5.31 educational reform plans in 1995, which aimed to establish a new education system that would take the lead in this era of globalization and information (I). Also the government proposed 2.9 educational reform plans in 1996, for establishment of a new education system.

4.2.2.2. Main content

According to the new educational reform plan, the focus of vocational education was shifted to higher education. And it laid out detailed plans such as upgrading the status of junior colleges, open colleges and technical colleges, and linking high school education with junior colleges to train professionals needed in small and medium businesses, organizing junior colleges into central institutions for vocational education that provide continual vocational education of higher education level, and founding specialized junior colleges.

In particular, the second educational reform plan focused on establishing a vocational education system, upgrading the level of vocational, professional education through junior colleges and open universities. To induce systematical changes in the vocational education system, it proposed vitalization of vocational education in junior colleges and open universities, establishment of technical colleges to diversify the vocational education system, reflecting the needs and circumstances of students. In line with this reform plan, junior colleges implemented various changes by adopting diverse education systems. Those changes included introduction of industrial commissioned education, introduction of exchange program between industrial high schools and junior colleges following the example of Tech-Prep system, expansion of special admissions criteria to provide industrial high school graduates with more opportunities to enter colleges.

4.2.2.3. Implication

Liberalization measures such as the introduction of normative system in college foundation and liberalization of student quotas, was considered to have resulted in the diversification of colleges and their quantitative expansion. After the plan was enacted, the number of public junior colleges decreased significantly since 1990, while the number of private junior colleges grew. Just as the expansion of four-year colleges did in the 1908's, this increase in the number of private junior colleges caused a shortage of applicants in junior colleges, even threatening the very survival of local colleges.

5. Technical High Schools and Technical Junior Colleges during 1999~Present

5.1. Main Policies Related to Technical High Schools

5.1.1. Plan for Reforming the Vocational Education System (2005)

5.1.1.1. Background

After the mid-1990's, a growing number of students avoided vocational education institutions. As such, the quality of education declined at vocational schools, increasing the number of drop outs. And the number of enrollments at industrial high schools fell after 1997, which had been steadily increasing before. While small and medium companies suffered from a lack of workers, students were not interested in finding employment in the so-called 3-D industries, exacerbating the imbalance in the labor market. On the other hand, in terms of the education system itself, other problems emerged such as: discontinuation of vocational education courses that did not meet the needs of students; failure of educational courses to meet the need of students, companies and local communities; rigidity in the supply of teachers; insufficient linkages between mid-level and high-level vocational educations; insufficient linkages between vocational education and vocational training; and lack of public investment in industrial high schools and junior colleges. These problems compelled the education innovation committee to announce the plan for reforming the vocational education system in May, 2005.

5.1.1.2. Main content

The plan integrated various national education policies regarding specialized schools, and aimed to 'synthesize work-learning-living into one,' through vocational education for all, work-oriented / open vocational education system and seamless transition from school to workplace, and from work to school. for engineering high schools, this plan proposed ① reform of vocational education in high schools ② ensuring education quality through industrial-academic cooperation ③ reinforcement of career counseling ④ promotion of educational equality and welfare.

The most distinctive feature of the plan was 'innovation of vocational education in high schools,' the purpose of which was to encourage reform of the current specialized high school system in consideration of industrial demands and social changes. To this end, the plan sought to reform the school system to 'improve and expand specialized high schools'. The objective was to increase the number of specialized high schools to 200 by 2010, which accounts for 10% of the total number of high schools. To accomplish this, three courses of action were suggested: specialization of industrial high schools by local governments, specialization of industrial high schools by industrial companies and vocational organizations, and specialization of industrial high schools by each government bodies. And each school was required to support those changes and reforms by actively employing school consulting, and adopting and operating CEO courses for vocational education. Each local office is required to transform specialized high schools into academic schools and institute cultural education in high schools to meet the industrial demand of local communities and labor market. In addition, the plan proposed that specialized schools import courses of general high schools to ensure quality of basic vocational education, and also suggested introduction of integrated high schools.

5.1.1.3. Implication

The plan for reforming the vocational education system is recognized for its comprehensive integration of educational policies regarding specialized high schools. Also, the plan holds great significance in that it established a comprehensive course of action to overcome the limitations of the vocational education system of the past, which focused on quantitative expansion of educational institutions rather than educational quality in terms of its contents and methods, which can accommodate social changes and various demands from students and their parents.

5.1.2. Strategic Plan for Cultivating Vocational High Schools (2007)

5.1.2.1. Background

After 2000, the perception among Koreans that colleges were the only way grew worse. This phenomenon has led to a waste of labor power. This can be seen by the increasing disparity between wages of high school graduates and college graduates. High school graduates found it hard to transition into the labor market, and companies avoided hiring high school graduates who didn't finish their military services as much as possible. In addition, vocational high schools were viewed with deepening misunderstanding and prejudice, and the special college admissions system for applicants with same majors was considered to be nothing more than a more convenient way to enter college. Facing this problem, the Ministry of Education and Human Resources announced 'strategic plan for cultivation of vocational high schools for realization of hope' in February, 2007, a plan designed for training core technical professionals equipped with practical experience as well as theoretical knowledge.

5.1.2.2. Main content

The strategic plan for cultivation of vocational high schools seeks to foster technical high schools by reforming them as specialized schools and by implementing a pre-employment contract system for industrial-academic cooperation. This plan aims to change the perception of

Table 3-11 | Summary of Strategic Plan for Cultivation Vocational High School

Task	Course of action
Execute specialization of technical high schools with participation of each government body, local government, business company	• Train core technical professionals in each industrial field by establishing network connecting industrial demand with government bodies, local governments and business companies and participating in supporting and encouraging specialization • From 2007, improve specialized high schools by providing commission and support from the government • From 2009, establish 100 new specialized high schools operated in collaboration of local governments and business companies
Establish feasible life courses from high school graduation to employment or college graduation	• Vitalize pre-employment contract (majors related to industrial cooperation) and industrial-academic cooperation • Grant priority in employment to technical high school graduateso • Encourage the early employed to apply for junior colleges • Introduce advanced courses (bachelor's degree) in junior colleges as the final stage of continuant vocational education of technical high school graduates • Vitalize industry-commissioned education
Expand self - development opportunities through coalition of learning and working	• Vitalize part-time student system • Reinforce on-the-job learning • Vitalize colleges in work place for acquisition of degrees
Improve professionalism of technical high school teachers	• Mandatory field adaptation training for teachers • Reinforce vocational training for teachers in joint training centers • Encourage teachers' innovation through innovation training for vocational education
Innovate vocational education courses and guarantee of its operational quality	• Innovate education courses in technical high schools • Reinforce vocational education and career advice • Increase rate of scholarship recipient and reduce number of students per class

technical high schools and to encourage smooth transition of high school graduates into the job market, by creating 500 technical high schools specialized in each industrial field by 2020. Detailed courses of action include ① establish specialized technical high schools with cooperation from each government body, local governments, and businesses ② establish feasible life courses from high school graduation to employment or college graduation ③ expand self-development opportunities through learning and working ④ improve quality of teachers at technical high schools ⑤ innovate vocational education courses and ensure their educational quality.

5.1.2.3. Implication

The strategic plan for cultivation of vocational high schools has succeeded in expanding the specialized high school system. Especially, the plan took considerable effort to encourage participation of various parties in the expansion of the specialized high school system, by introducing government-supported specialized high schools and local/business-supported specialized high schools.

5.1.3. High School Diversification 300 Project

5.1.3.1. Background

In 2008, the president-elect committee announced a 'task report'. This report presented a development strategy and five major directions through 21 strategies and 192 tasks. Included in the five directions, 'a nation with vast pool of human resources,' and this is specified by 3 strategies, 18 tasks (5 core tasks, 5 central tasks, 8 regular tasks). Establishment of Meister high school is included in the 'high school diversification 300 project,' a part of five central tasks. The government announced its high school diversification policy to take initiative in ensuring educational quality in schools and provide students with opportunities to make educational choices according to their aptitude by diversifying school systems, under the name of 'high school diversification 300 project'.

5.1.3.2. Main content

The project focused on accelerating the diversification, specialization and liberalization of high school education. It aimed to solve the problem of unilateral regulation of the education system, which has been criticized for stifling creativity in the education system, while maintain basic frame of high school equalization system.

The high school diversification 300 project proposed detailed courses of action as the following: establishment of 100 liberal private schools, that are granted autonomy over its operation in terms of education courses, personnel, administration, and are monitored by students and their parents; designation of 150 boarding public schools in under-developed rural areas, local cities and major cities that will provide local students with priority in admission and can accommodate 80% of the students in the dormitories; intense fostering of 50 Meister high schools in each vocational field that nurture student's characteristics and opportunities.

Table 3-12 | Summary of High School Diversification 300 Project

Task	Course of action
150 boarding public high schools	• Provide selective support including dormitories to high schools located in rural areas and under-developed areas, based on their contribution to local education • Provide support for establishment and expansion of dormitories, renovation of libraries, language labs, multi-purpose classrooms for improved educational environment, and operation of various programs including foreign language courses with native speakers
100 liberal private high schools	• Select schools with sound financial record and sufficient budget for its operation, who base their education on clear visions and are capable of operating various courses, and grant them freedom of operation • Sign MOU's regarding educational operation with each school to liberalize its operation • Each school is granted with freedom in terms of student selection, but use of written tests made by the school is prohibited. • Detailed plan for the operation will be discussed in the future.
50 Meister high schools	• Business companies or local governments can found Meister high schools under regulation of related foundation procedure. And select 50 schools among existing specialized schools to reorganize them into Meister high schools after certification process. • Sign MOU's regarding educational operation with each school to liberalize its operation and increase flexibility of teacher qualification and wage system so that Meister in each field are eligible for positions such as teacher or principal.

5.1.3.3. Implication

It may be somewhat early to evaluate the effectiveness of the high school diversification 300 projects as it is still running, but it is expected to show the following outcomes. First, it is expected to induce profound changes in the structure of Korean society and to reduce domestic spending in private education. Second, through this project, skilled professionals with practical techniques and theoretical knowledge can be acquired in advance by locating students with aptitude and capabilities needed to change industrial structure in each field. Third, overall physiology of each industry businesses, including small and medium companies, can be improved through customized specialization of professional training and support. Fourth, establishment of nation-wide vocational training system is expected to help the emergence of new educational track with vision. Fifth, constant improvement of national competitiveness is expected to be accomplished through preservation of traditional technologies and establishment of preservation system for industrial technologies. Sixth, presentation of clear vision for stable career can lead to changes in people's attitude toward vocational education. Seventh, the project is expected to expand opportunities for employment and on-going education, contributing to overcoming of social bi-polarization and establishment of educational safety net.

5.2. Main Policies Related to Technical Junior Colleges

5.2.1. Junior college development plan (2001)

5.2.1.1. Background

The Ministry of Education and Human Resources announced its 'junior college development plan,' whose purpose is to prepare the Korean society for reforming the vocational education system to meet the demands of information-based society, and to ensure financial soundness of schools and quality of education of junior colleges, brought on by the rapidly decreasing number of applicants. The plan to develop junior colleges aims to make junior colleges a central educational institution for training technical professionals, through restructuring of the overall junior college education system.

5.2.1.2. Main content

The plan was designed to develop junior colleges as the center of education for training technical professionals by encouraging the specialization of junior colleges through restructuring of the overall junior college education system. This plan stipulated the following courses of action. ① Restructuring of overall junior college education system to counteract reduction in number of applicants ② Reinforcement of lifelong vocational education for efficient training of national human resource ③ Vitalization of liberal and flexible vocational education ④ Promotion of vitality of minor junior colleges in local district.

Table 3-13 | Summary of Junior College Development Plan

Course of Action	Details
Restructuring of overall system of junior college education to counteract reduction in number of applicants	• Set up stricter standard for self-regulated admission system for specialization of junior colleges through restructuring of junior college education • Ensure sound operation of private junior colleges • Establish annual goals for improving of educational environment
Reinforcement of lifelong vocational education for efficient training of national human resource	• Establish network system of education adaptable to changes in vocational market • Develop and operate various vocational education program to create demand for new vocational education
Vitalization of liberal and flexible vocational education	• Flexible administration of school years • Vitalize multi-semester system and training-semester system
Promotion of vitality of minor junior colleges in local district	• Create demand for new vocational education to counteract decrease in number of applicants • Jointly enforce policies aimed at encouraging self-regulated reduction of admission quota in preparation for decrease in number of applicants

5.2.1.3. Implication

The junior college development plan is considered to have historical significance, as it is the first policy designed for junior colleges since their establishment in 1979. It proposes policies such as improvement of the professor-student ratio, reinforcement of competitiveness of college education and research, establishment of flexible education system reflecting social demand for human resources, reinforcement of financial support for development of competitive human resources.

5.2.2. Policy of Restructuring Junior College (2004)

5.2.2.1. Background

After 2000, the very survival of junior colleges fell into great peril. This crisis was caused by the number of college applicants exceeding that the number of high school graduates, as a new flow of students increased. After liberalization of college admission in 1995, each college dramatically increased its admission quota, above the number of applicants. And colleges often failed to fill their admission quota after 2003. The Ministry of Education sought to solve this problem by announcing a plan to restructure junior college in 2004, on the ground that ① Quantitative growth of higher education institutions was not matched by development of its quality ② Each college's role and character was obscured by plans to seek university status ③ Junior colleges are expected to face greater peril, such as increasing shortage of applicants, ④ The importance of local college's role in local innovation will increase, ⑤ Request of information disclosure from students, parents, local community, business sector is expected to increase.

5.2.2.2. Main content

The policy of restructuring junior colleges proposed revising the Higher Education Act to introduce 'information disclosure' on the educational environment and operation status, and to gradually improve the educational environment of public and private colleges. To achieve this goal, it suggested increasing the number of professors by 50% and reducing the college admission quota by 15%. And it also presented yearly expense target for school facilities, school buildings and basic property. If a college fails to reach the target, it would face stricter administrative restrictions including reduction of admission quota and suspension of financial support. Support for college specialization would be differentiated depending on purpose of establishment and level of human resources training goal, and it would encourage each college to set its own development direction reflecting its purpose of establishment and operation, and to initiate self-regulated restructuring accordingly. Accordingly, the level of each college's conformity would determine its level of financial support.

Restructuring for inter-college merger was also considered. This merger targeted private schools as well as public schools, and various plans were suggested such as inter-colleges, inter-junior colleges, college-junior colleges integration followed by reorganization into a four-year colleges, integration of four-year colleges, and junior colleges run by the same corporation. Additionally, the 'Special Act on Restructuring' was also considered to shut down some colleges and set stricter standards for establishing colleges, to induce restructuring through financial aid, and to establish Higher Education Review Agency.

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