

# Education and Research of Science and Engineering in Korea

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## 1. Introduction

History of science and engineering education in Korea is about ninety years old. Ten engineering students in college level graduated in 1918 after three years study, and four students in mathematics and physics graduated in 1919 at Yonsei College in Seoul.<sup>1</sup>

The first university level graduates received bachelors degrees in 1943 ; one student in physics, four in mechanical engineering, two in metallurgical engineering, five in electrical engineering and two in chemical engineering.

Education in all levels were severely affected during the Korean War 1950-1953. Buildings and laboratories were damaged and destroyed. Many prominent professors were kidnapped to North Korea.

The economic progress in the sixties and seventies stimulated engineering and science education at universities.

We can proudly claim that engineering and science graduates from Korean universities have contributed tremendously in Korean economic developments in the last thirty years.

Korea is No.1 in shipbuilding, semiconductor memory and LCD display productions, No.5 in automobile manufacturing and No.6 in steel production in the world.

We now have nuclear reactors of our own design and a third generation 2 GeV synchrotron.

Recently, we produced supersonic jet fighter trainers too.

## 2. Growth in Science and Engineering Education and Research

Table 1 shows various university statistics for major countries in the world.<sup>2</sup> There are 158 junior colleges with 530,149 students in Korea. These figures are not included in the table.

Other than 52,328 full time faculty members, there are 67,548 part-time instructors in Korean universities. Due to financial difficulties, instructors are paid very low wages.

Out of 202 Korean universities, 44 are national universities supported by the Ministry of Education.

About 60% of their budget is directly provided by the Government. There are 158 private universities, and student tuition income amounts about 60-90% of their income.

Korea does not have the system of habilitation. Qualified young Ph.Ds are appointed instructors or assistant professors to be promoted to associate professor and full professor in about 10 to 15 years. About 9,000 new Ph.Ds are awarded yearly, but only 1,000-1,500 Ph.Ds are appointed junior faculty positions.

Table 2 shows the number of science graduates in Korea, Japan, United States, Germany and Great Britain.<sup>3</sup>

Table 3 shows the number of engineering graduates in Korea, Japan, United States, Germany and Great Britain.<sup>3</sup>

It is evident that Korea overproduce engineering and science graduates in bachelor level. Many Korean industries, however, complain the lack of qualified engineering graduates. Although there are 108 engineering schools in Korea, industries recruit from a few well-known engineering schools.

The Accreditation Board for Engineering Education of Korea (ABEEK) has accredited 19 universities for 130 programs since 2001.

### **3. Research Output in Korea**

In the year 2000, Korea published 12,471 Science Citation Index (SCI) papers, but it increased to 23,515 in 2005. Korea is one of the top three countries in SCI paper increasing rate. The world rank of Korea in SCI papers is No.12.<sup>4</sup> It is comparable to the Korean GDP rank in the world.

The increase in SCI papers is mainly due to the BK21 project initiated by the Ministry of Education.

The first phase of BK21 was from 1999 to 2006 supporting 200 billion won (\$ 182 million) per year to 14 major research universities and 38 other universities.

The second phase will be from 2006 to 2012 supporting 290 billion won (\$ 300 million) per year to 74 universities.

Up to 70% of BK21 funds are used to pay stipends to graduate students.

Before 1999 only KAIST (Korean Advanced Institute of Science and Technology) and Postech (Pohang University of Science and Technology) paid stipends to graduate students. Because of the BK21 project, most graduate students in research universities are supported.

Maximum stipend for master degree students are 1.2 million won per month and 1.5 million won for doctoral students.

Table 4 shows top ten universities in SCI paper publication in Korea and Germany.<sup>4</sup>

Table 4. SCI paper publication in Korean and German Universities

	SCI papers	Ph.D		SCI papers
Seoul N.U	3946	421	München	3047
Yonsei U	2025	211	Heidelberg	2703
Sungkyunkwan U	1568	82	TU München	2225
KAIST	1452	407	Tübingen	1975
Koera U	1441	175	Bonn	1954
Hanyang U	1274	212	Erlangen-Nürnberg	1867
Postech	880	123	Göttingen	1690
Kyungbuk N.U	862	128	Mainz	1676
Pusan N.U	827	160	Würzburg	1631
Ulsan U	799	17	Münster	1616

The number of Ph.D in the Table shows degrees in science and engineering awarded in 2004 at each university.

It should be noted that only KAIST and Postech have no medical schools in the above 20 universities.

It is interesting to compare two largest research universities in Korea and Germany.

	Seoul National University <sup>5</sup>	University of Munich <sup>6</sup>
Undergraduates	19,812	41,958
Graduate students	10,311	4,927
Total	30,123	46,885
Professors	1733	696
Academic Staff	1927	3072
no. of students per teaching staff	8.23	12...44
non-academic staff	991	5676
Ph.Ds awarded per year	974	1227
Masters awarded per year	2484	** 2469
Bachelors awarded per year	4161	81
State Exam	N/A	1257
Habilitation	N/A	148
Budget (excluding Hospitals)	* \$ 622 M	Euro 379.5M

\* Research grant \$122M included

\*\* Diplom and Magister

University of Munich has 60% more academic staff and 5.7 times more non-academic staff than Seoul National University. It means that wages and salaries at Munich is far more than SNU.

The Munich budget includes 76.8 Million Euro which is slightly less than SNU.

We understand that the University of Munich produced so many Nobel laureates in Physics in the first half of the 20<sup>th</sup> Century including Max Planck, Werner Heisenberg, Wolfgang Pauli, Max von Laue and Hans Bethe.

Three scientists from the University of Munich received Nobel Prize in Chemistry ; Adolf von Baeyer, Richard Willstätter and Heinrich Wieland.

Patent applications in Korea has increased dramatically in the past few years. The number in 1992 was 30,736, but it increased to 137,363 in 2004.

Table 5 shows the number of patent application in 2000-2004 by major universities in Korea.<sup>7</sup>

Table 5. Patent Applications 2000-2004

KAIST	981
Postech	510
Seoul National University	456
Kwangju Institute of Science & Technology	337
Inha University	257
Korea University	224
Hanyang University	253
Yonsei University	207
Sungkyunkwan University	180
Information and Communication University	174

Table 6 shows the patent applications to the United State Patent Office in 2005.

Table 6. Patent Applications to the U.S Patent Office

1. United States	221,922
2. Japan	65,025
3. Germany	18,245
4. Taiwan	16,865
5. Korea	15,200

Table 7. shows the similar data for the EU Patent Office.

Table 7. Patent Applications to the EU Patent Office

1.Germany	23,800
2.France	8,030
3.Netherlands	7,800
4.Switzerland	5,027
5.United Kingdom	4,649
6.Italy	4,200
7.Korea	3,850
8.Belgium	1,660

The Government research budget has increased greatly in the last few years. The 2007 research budget is 9 trillion 844 billion won (\$ 10 billion). Approximately \$ 2 billion will be allocated to universities.

#### **4. Korea Students in Foreign Countries**

Table 8 shows the number of Korea students studying abroad.<sup>8</sup> Because it takes 2-3 additional years to complete German diplom or magister degree for Korea students with bachelor degree, many Korean students prefer to study in the United States. If Germany adopts bachelor and master degree system, many Korean students could study in Germany.

Table 8. Korean Students Abroad

	Graduate Schools	Undergraduates	Total
United States	24,757	22,727	47,484
China	1,641	10,954	12,595
Japan	3,249	8,128	11,377
Germany		6,065	6,065
Australia		5,012	5,012
U.K.	1,800	1,300	3,100
France	1,600	1,400	3,000
Others	2,145	9,938	12,083
Total	35,192	65,524	100,716

Table 9. shows the number of doctorates received by professors in Korean universities reported to the Korean Research Foundation.

Table 9. Number of Foreign Doctorates

United States	17,819	56.6 %
Japan	5,193	16.5 %
Germany	2,522	8.0 %
France	1,407	4.5 %
United Kingdom	1,236	3.9 %
China	731	2.3 %
Russia	451	1.4 %
Taiwan	355	1.1 %
Canada	351	1.1 %
Others	1,417	4.5 %
Total	31,482	100 %

## 5. Korea-German Collaborations in Scientific Research

The collaboration between Ministerium für Wissenschaft und Forschung, Nordrhein-Westfalen Government and Pohang University of Science and Technology (Postech) began in

1995.

The German delegation visited Postech in April 1996 to participate in the Korean-German Forum on Innovative Technology.

The Korean delegations visited Germany in February 19-25, 1995 and September 7-13, 1997 to participate in the German-Korean Workshop. The first delegation consists of seven Postech professors and six industry executives. They visited Münster, Dortmund, TH Aachen and Duisburg. The 1997 workshop was held in the Rolduc Abbey in the Netherlands. We visited Siemens-Nixdorf and the University of Paderborn... The delegation included professors in Postech, KAIST and SNU as well as industry executives from Hyundai Motor Company, Korea Telecom, Samsung and LG Research Institute.

After these workshops, several students from RWTH Aachen came to Postech to work for their Diplom arbeit. Some Professors from Aachen had a collaboration project with Hyundai Motor Company.

The writer was invited by Mr.Hartmut Krebs, Deputy Minister, Nordrhine-Westphalia Ministry of Schools, Science and Research in October 2001 to consult on the German University Reforms.

President of Postech and DESY (Deutsche Synchrotron) Director General signed a cooperative agreement in 2005 for the 2 GeV Pohang Light Source.

## **6. Conclusions**

Education and research of science and engineering in Korea practically started in the 1960s. Due to the rapid industrial developments, many science and engineering graduates were required since 1970s. Currently, Korean universities overproduce graduates in all fields. Thanks to the BK21 projects since 1999, Korea is now No.12 in the publication of Science Citation Index papers.

Number of patent applications also increased greatly in the last several years.

Engineering graduates from Korean universities have contributed greatly in the rapid industrial growth. Korea is now No. 1 in shipbuilding, semiconductor memory and display manufacturing, No.5 in automobile productions and No. 6 in steel productions in the world.

We should emphasize quality than quantity in science and engineering education in Korea.

When Germany adopts the bachelor and master degree system, many more Korean students are expected to study in Germany.

## References

1. Sooyoung Chang, "Science and Engineering Education in Korea", Educating the Engineer for the 21<sup>st</sup> Century, Kluwer Academic Publishers, 2001, pp 91-96
2. Sooyoung Chang, "The Current Situation and Prospects for the Korean Higher Education," Lecture delivered at the Seoul National University of Education on October 21, 2006.
3. Sooyoung Chang, "The States and Prospects for Korean Engineering Education," Orbis Sapientiae to the published in November 2006
4. 2005 Science Citation Index CD-ROM DB
5. Statistical Almanac 2006, Seoul National University
6. [www.en.lmu.de](http://www.en.lmu.de)
7. [www.kipo.go.kr](http://www.kipo.go.kr)
8. Ministry of Education data



**Table 1. Higher Education in the World**

Countries	Institutions	No. of Students	Graduate Students	Annual Degrees Conferred			Faculty	Population	Students
				Bachelors	Masters	Doctors			Population
Korea	202	1,687,198	240,527	324,369	68,439	9,029	52,328	47,904,370	4.03%
Canada	121	919,659	98,575	143,977	29,018	3,861	32,739	32,805,041	3.38%
U.K	171	1,541,930	448,700	272,665	72,415	14,115	111,458	59,647,790	3.34%
U.S.A	2,272	6,960,470	2,072,275	1,184,406	430,164	** 46010	535,161	278,058,881	3.24%
Australia	48	468,624	116,772	98,520	30,865	1,848	33,659	18,077,000	3.24%
Sweden	73	253,650	16,150	-	31,255	2,245	20,000	8,861,000	3.04%
France	561	1,412,000	206,000	133,730	159,735	10,238	58,785	58,804,944	2.75%
Japan	702	2,509,374	230,844	544,894	67,412	14,512	156,000	126,771,662	2.20%
Germany *	350	1,798,517	-	70,126	99,287	24,545	156,763	83,029,536	2.17%
CIS	904	2,991,000	146,000	440,000	12,964	3,185	539,600	284,110,000	1.10%
China ***	1,552	11,736,900	651,300	1,877,500	92,300	18,800	1,452,600	1,274,915,000	0.92%

\* Statistisches Jahrbuch 2001, Universities 90, Fachhochschule 153, Music & Arts 49,

United Kingdom, Higher Education Statistics

Others 58

Professors 37,672 Out of 146, 371 teaching staff

Agency 2000/01

Graduates of Fachhochschule = Bachelors

undergraduates parttime 32.7%

Diplom, Magister = Masters

Graduate Students P/T 61.6%

\*\*Digest of Education Statistics 2000, professional degrees 78, 598 excluded

\*\*\* China Education Daily, May 27, 2004

Japan : 平成 15 年 學校基本調查報告書

Korea : Statistical Yearbook of Education 2005

CANADA : CAUT Almanac of Post-Secondary

Education in Canada 2006

Undergraduates Parttime 22%

**Table 2. Science graduates in Korea, Japan United State, Germany and United Kingdom**

	B.S					M.S					Ph.D.				
	Korea	Japan	USA	Germany	U.K	Korea	Japan	USA	Germany	U.K	Korea	Japan	USA	Germany	U.K
Mathematics	5,353	4,965	13,327	161	4,295	463	928	4,191	1,169	510	118	167	1,060	473	385
Statistics															
Physics	1,866	3,475	4,118	75	2,450	509	1,250	1,625	1,622	290	150	354	1,119	1,435	585
Chemistry	2,945	3,182	9,016	146	3,285	683	957	2,009	1,708	360	160	197	2,003	2,110	1,020
Life Sciences	7,036	1,731	104,974	242	18,890	1,546	692	10,022	2,691	3,040	366	298	7,696	1,803	2,130
Geology and Earth Science	671	764	3,312	17	1,175	152	406	1,389	763	410	21	175	463	375	130
Computer Science		N/A	59,488	2,792	12,825		N/A	20,143	2,527	4,670		N/A	909	470	385
Others	16,576	5,040		-	3,585	2,384	1,400		62	560	553	319		13	305
<b>Total</b>	<b>34,447</b>	<b>19,157</b>	<b>194,235</b>	<b>3,433</b>	<b>46,505</b>	<b>5,737</b>	<b>5,633</b>	<b>39,379</b>	<b>10,542</b>	<b>9,840</b>	<b>1,368</b>	<b>1,510</b>	<b>13,250</b>	<b>6,679</b>	<b>4,940</b>

Sources :

Korea : Statistical Yearbook of Education 2005

Japan : Report on Schools 2001, Ministry of Education

Computer Science included in electrical and Communication engineering

U S A : Digest of Education Statistics 2005.

Germany : Statistisches Jahrbuch 2003

Diplom Ingenieurs are included in M.S.

Graduates of Fachhochschule in B.S.

U.K : Higher Education Statistics Agency 2000/01

**Table 3. Engineering Graduates in Korea, Japan, USA, Germany and United Kingdom**

	B.S					M.S					Ph.D.				
	Korea	Japan	USA	Germany	U.K	Korea	Japan	USA	Germany	U.K	Korea	Japan	USA	Germany	U.K
Aeronautical	1,063	667	2,232		965	218	235	915		155	43	36	210		50
Agricultural			601					191					90		
Architecture	7,542		590	4,400	6,460	1,292		160	3,098	1,695	155		7	79	165
Biomedical			2,019		110			862		65			339		20
Chemical	3,671	10,548	4,801		1,050	790	2,638	1,321		270	156	332	655		205
Civil	6,121	20,044	8,142	4,085	2,640	1,586	3,662	3,745	2,614	975	231	312	644	223	250
Computer	9,051		9,156			1,520		5,797			266		494		
Electical	21,951	32,447	15,200	4,250	5,215	4,208	7,736	10,049	2,190	1,630	591	710	1,621	555	430
Environmental			576		2,640			579		830			124		140
Industrial	3,070	4,837	3,790		2,070	939	293	3,262		635	75	26	306		75
Materials Science	3,798	423	817	62	450	815	76	737	154	155	185	10	442	93	185
Ceramic	757				15	100				5	17				
Mechanical	6,984	19,600	14,182	7,770	3,650	1,107	4,263	4,461	2,994	700	243	201	855	1,253	310
Naval Architecture		221					27					10			
Mining		64	85		90		12	46		100		7	7		15
Nuclear		320	202				181	197				40	61		
Petroleum			233					233					28		
Others	5,411	14,342	10,267	1,827	4,310	895	7,834	7,282	574	1,530	176	1,364	721	96	465
<b>Total</b>	<b>69,419</b>	<b>103,513</b>	<b>72,893</b>	<b>22,394</b>	<b>29,665</b>	<b>13,470</b>	<b>26,957</b>	<b>39,837</b>	<b>11,624</b>	<b>8,745</b>	<b>2,138</b>	<b>3,048</b>	<b>6,604</b>	<b>2,299</b>	<b>2,310</b>

Sources : Same as Table 2 except

Japan : number of Ph.D. include only the new system, the old system without any course requirements produces approximately same number.

U.S.A. : Profiles of Engineering and ET Colleges, ASEE 2004 Edition

Korea : About 15,000 Engineering Technology (B.S...) graduates excluded