Int. J. Engng Ed. Vol. 26, No. 1, pp. 205–217, 2010
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Perceptions of Engineering Among Korean Youth*

SO YOUNG SOHN, YONG HAN JU
Dept. of Information and Industrial Engineering, Yonsei University, Seoul, Korea.
E-mail: sohns@yonsei.ac.kr juyonghan@yonsei.ac.kr

A lack of enthusiasm for engineering as a career choice is prevalent among young students in Korea, which may have negative effects on national competitiveness. As understanding students' perceptions of engineering is a first step toward designing strategies to boost interest in this area, we surveyed secondary school students to gauge their general knowledge about several engineering areas, their knowledge about application domains of various engineering fields, their thoughts about the status of engineers, the types of courses they prefer, the time of life during which they are likely to decide on future careers, persons/media affecting their career decisions, and other factors. We found significant differences in perceptions about engineering in different age and gender groups. Insights gained from the results of our study will be used to establish a youth engineering adventure program in Korea.

Keywords: K-12; engineering education; engineering perception; youth engineering adventure program

1. INTRODUCTION

ENGINEERS MUST BE PREPARED to fulfil key roles across a broad variety of enterprises in an international context, and to recognize how engineering can be deployed to help steward the world's diminishing resources. It is important, too, to ensure a sustainable future for the practice of engineering in the world, to in turn ensure the future success and profitability of industry and business [1].

However, the current environment for engineering is not very favorable, and young people's avoidance of engineering is prevalent worldwide. The importance of K-12 or pre-college engineering education has increased more than ever before. Student perceptions and attitudes about educational experiences have been found to make an important contribution to the retention of students in science, math, engineering, and technology (SMET) programs [2].

Many studies investigating perceptions of engineering as a career choice and of K-12 education have been conducted [3]. Besterfield et al. [4] investigated student attitudes and self-assessment differences among the freshman classes of 17 US engineering schools. These analyses provided important perspectives on the characteristics of freshman engineering students, as measured by the choices of institutions they attended and their attitudes. Koehn [5] studied student perceptions of accreditation criteria employed by the Accreditation Board for Engineering and Technology (ABET), and noted that undergraduate and graduate engineering students, as well as practitioners, consider three of the 11 attributes to be particularly important. These attributes are 'an ability to apply knowledge of mathematics, science, and engineering,' 'an ability to design and conduct experiments,' and 'an ability to identify, formulate, and solve engineering problems.' Shivy & Sullivan [6] studied engineering students' perceptions of engineering specialties and used analysis of variance procedures to examine differences in perceptions of engineering specialties by gender, ethnicity, commitment to career choice, and career decision-making self-efficacy. Bardsley [7] studied the importance of effective secondary education for all children as Australian society embraces globalization. Forcada et al. [8] investigated students' perception and performance with traditional against mixture learning methods in an industrial plants course.

A number of K-12 support programs related to engineering have been implemented in different countries. The National Science Foundation (NSF) of the USA has been employing support programs for science and engineering education, from pre-K through graduate school and beyond [9]. The NSF's DR-K12 (Discovery Research K-12) program seeks to enable significant advances in K-12 students' and teachers' learning of the Science Technology Engineering and Mathematics (STEM) disciplines through development, implementation, and policy-making. The GK-12 (Graduate Teaching fellows in K-12 education) program provides funding for graduate students in NSF-supported STEM disciplines to acquire additional skills that will broadly prepare them for professional and scientific careers in the 21st century.

* Accepted 12 October 2009.

Through interactions with teachers and students in K-12 schools and with other graduate fellows and faculty from STEM disciplines, graduate students can improve communication, teaching, collaboration, and team-building skills while enriching STEM learning and instruction in K-12 schools. The Royal Academy of Engineering (RAENG) of the UK supports programs such as Young Engineers, the Smallpiece Trust Engineering Courses, and the Engineering Education Scheme. These programs promote a number of schemes at pre-university level to encourage young people to consider professional engineering as a career [10]. In Korea there are a number of extracurricular engineering education programs such as Women into Science & Engineering (WISE), Junior Engineering Classroom, and Industrial Camp. Most of these programs exist to complement regular education courses in schools that have insufficient engineering contexts. In Korea, the high school curriculum does not accommodate a separate curriculum of engineering. This lack of contact with engineering in secondary education may be responsible for a widespread engineering avoidance phenomenon. Of the university applicants matriculating in Korea in 2003, only 32% applied to programs in the natural sciences and engineering, while 45% applied to programs in the humanities and social sciences (Education Statistic Annual Report in Korea). This discrepancy is due to several factors including the burden for studying science, a decline of interest in science, universities' cross-application permission, loss of opportunities to find employment in engineering and low salaries for engineers [11] [12].

In order to attract young students to engineering, first we need to understand what they know about engineering and how they perceive it. This understanding can be used to create a strategic component of student recruitment. Many such studies have been performed in different countries at the national level: Relevance of Science Education [13], of Norway, Science and Engineering Indicators [14], of the USA, and Public Attitudes to and Perceptions of Engineering and Engineers [15] of the UK. However, engineering perception studies for youth have not been implemented widely in Korea, although general surveys on perceptions of science and technology are available.

We investigated perceptions of engineering among Korean secondary school students. We examined student preferences regarding academic subjects, general perceptions about engineering, and factors related to choice of major at college. We tested whether there are significant differences in perceptions of engineering by gender or age. The results of this study are expected to be used to present suitable strategies to enhance the engineering perceptions of each group.

The organization of this paper is as follows: in Section 2 we summarize previous research; in Section 3 we present the results of a survey we used to investigate secondary students' perceptions of engineering in Korea; and in Section 4 we discuss our findings.

2. RELATED STUDIES

Science and Engineering Indicators developed by the National Science Board (NSB) of the USA draws on a variety of quantitative data "to examine US students' mathematics and science achievement, to compare it with that of their international peers, and to highlight developments, trends, and conditions influencing the quality of US elementary and secondary mathematics and science education" [14]. SEI shows that:

> . . . many factors influence student performance, either directly or indirectly. Access to challenging courses, qualified and experienced teachers, school environments that support learning and teaching, and opportunities for using computers and the internet are all important factors. Educational policies on curriculum standards, testing, and accountability, as well as instructional material, also help define the broad learning context, while their practical effects on curriculum, teaching methods, and learning materials all shape the experiences of teachers and students. Looking at these and other factors affecting education provides a context for the student achievement results reported

In addition, SEI documented that a recent increase in Science and Engineering (S&E) graduate enrolment occurred across all major demographic groups: women, minorities, white men, and foreign students. Primary mechanisms of support differ widely by S&E field of study [14].

The ROSE [16] project is an international comparative project designed to identify factors that influence the effectiveness of science and technology education across approximately 60 countries [17]. Key international research institutions and individuals worked jointly on the development of theoretical perspectives, research instruments, data collection and analysis. The target population consisted of students nearing the end of secondary school (age 15) who completed a standardized questionnaire allowing for the comparison of responses from large groups across widely different cultures. The ROSE project explored how students are engaged with and related to science & technology (S&T) in school and in everyday life. The results of the ROSE project revealed generally positive views of S&T among secondary school students, and that belief in the benefits of S&T is much stronger in the less developed EU countries than in the wealthier and more developed countries.

The Royal Academy of Engineering and the Engineering and Technology Board of the UK jointly commissioned BMRB (British Market Research Bureau) Social Research and BMRB stakeholders to conduct research exploring public attitudes to and perceptions of engineering and engineers [15]. This project aimed to provide a baseline measurement of public knowledge and understanding of engineering that could be taken forward and used to inform action plans and to build engagement. The research comprised two strategies: a quantitative survey and a qualitative workshop. The quantitative survey findings showed that people's immediate mental associations with the word 'engineer' vary widely. The most frequently mentioned associations are related to construction and mechanics. In the qualitative workshop, attitudes towards engineering were more mixed: views were found to relate to the perceived benefits of engineering, either personally or for society more broadly.

Changing the Conversation, a publication of the Committee on Public Understanding of Engineering Messages, (an initiative of the National Academy of Engineering, USA), details the results of a project undertaken to enhance public understanding of engineering [18]. The goal of this project was to encourage coordinated, consistent, effective communication by the engineering community to a variety of audiences, including school children, their parents, teachers, and counselors, about the roles, importance, and career potential of engineering. The study used both qualitative and quantitative approaches including in-depth interviews and an online survey. The results of the study showed that engineers do not have major image problems and less than 15 percent of the public associated the words "boring" or "nerdy" with engineering. In fact, most adults and teens respect engineers and consider engineers' work rewarding and important; but perhaps not enough to inspire them to become engineers.

Studies exploring perceptions of engineering among young Korean students have not been conducted frequently in Korea. The Korea Foundation for the Advancement of Science & Creativity (KOFAC) recently conducted surveys to investigate public interest, knowledge and attitudes about science and technology [19]. The respondent groups included adults, secondary school students, and a group of science and technology experts. The results suggest that youths are more interested in science than adults, that attitudes about science and technology are generally positive, that scientists are considered to be important for societal development but that their societal status does not reflect this importance; and that youths desire science culture activities that they can experience directly. However, perceptions of engineering among youth were not specifically investigated.

Our goal was to conduct a study investigating perceptions of engineering among youth in Korea. Secondary school is divided into middle school (ages 13–15) and high school (ages 16–18) in Korea. A relatively small number of female students choose engineering as their college major. Gender and age differences in perceptions of engineering and other related issues have been widely dealt with in the literature.

Osgood et al. [20] studied gender issues in work experience placement. Scantlebury et al. [21] found that females prefer biology and males prefer physical sciences. They also found that females strongly disagreed that females did not have the ability, confidence, or interest to do science or that there were structural barriers to their participation in science. Callender [22] shows that the university students attended, their qualifications on entry to higher education, their gender, the subject they studied, and their age on entry, all had an effect on achievement. Ding and Hall [23] studied gender, ethnicity, and grade differences in perceptions of school experiences among adolescents. They found that male students tended to have more negative attitudes than female students, and the results indicated that older students tended to feel more negative about their educational experience than younger students. Dabaj and Basak [24] investigated the role of gender and age on students' perceptions towards online education. Regarding gender, the results showed that female students have a better perception of online education. Regarding age, the results showed that the older the students are, the greater is their preference towards attending face-to-face classes. Agogino et al. [25] studied difference in gender about perception of the design process. Bagilhole et al. [26] studied a woman engineer's experience of British industrial sectors.

Based on preceding research, we set up the following hypotheses to investigate young students' engineering perceptions in Korea:

Hypothesis 1: Engineering perceptions would differ according to the ages of young students in Korea.

Hypothesis 2: Engineering perceptions would differ according to the gender of young students in Korea.

3. ANALYSIS OF ENGINEERING PERCEPTION

3.1 Survey framework

In order to test our hypotheses, we needed to design the perception survey. First, we categorized related question items used in the previous studies as shown in Table 1. In addition, we added our survey questions in Table 1 such as preferred academic subject, curiosity about engineering, engineering utility, engineers' employment field, higher education plans, etc.

In order to investigate young students' engineering perceptions in Korea, we created survey categories based on preceding projects. Categories were composed as follows. First, we surveyed preferences of academic subjects in secondary school. Through this category, we wanted to obtain information about the preference level of science and mathematics, which can be related to

Table 1. Classification of survey category of existing studies

Study (research institute) / Categories	SEI (part of elementary and secondary education) (NSB, 2006)	The Relevance of Science Education (Dep. Of Teacher Education and School Development, University of Oslo, 2004)	Public Attitudes to and Perception of Engineering and Engineers (RAENG, ETB, 2007)	Changing the Conversation (NAE, 2008)	People understanding investigation about science and technology. (KOFAC, 2008)	Our engineering perception studies
Engineering & Technology Interest	N/A	My science classes	Confidence in knowledge and understanding	N/A	Interest and knowledge about science and technology	preferred curriculum/ curiosity about engineering
Engineering & Technology Utility	N/A	My future job/ The environmental challenges and me	Attitude towards engineering	Engineers are creative problem-solvers/ Engineers help shape the future/ Engineers make a world of difference/ Engineering is essential to our health, happiness, and safety/ Engineers connect science to the real world	Science technology and national development	Engineering's utility/ Engineer's employment field
Engineering & Technology Experience	Student course-taking in Mathematics and Science	My out-of-school experiences	Sources of awareness and knowledge/	N/A	Attitudes about science and technology	Person or media affecting career decision
Engineering & Technology Learning	Student learning in Mathematics and Science	What I want to learn about	Knowledge and understanding of engineering	N/A	N/A	Higher education plan
Engineering & Technology Connection (Information, opinion)	Information Technology in Education	My opinions about science and technology	Hooks and drivers to engagement with engineering	N/A	Science and Technology-related information resources	Engineers' social position/ Income
Others	Transition to Higher Education/ Mathematics and Science Teachers	Myself as a scientist/ How many books are there in your home	N/A	N/A	Attitudes about scientists	Relation of mathematics or science/ Engineering college education level in comparison to an advanced country/ Time for deciding on a future career

engineering. Second, we investigated general perceptions about engineering such as curiosity, relationship to mathematics/science, difficulty, utility, social position, income, and engineering college education levels in comparison to those in an advanced country. These factors can be used to show the degree of perception about engineering. In addition, we surveyed the factors related to students' decisions about their college majors. These factors included higher education plan, time during which students decide on a future career, people/media affecting career decisions and engineer's employment fields. Finally, we surveyed the preference of engineering majors along with the perceptions of the utility of each major.

For these analyses, we conducted a survey of 1038 students from more than 40 schools in a metropolitan area of Korea during January— September, 2008. Out of these 1038 students, 52% were male and 48% female; 35% were middle school students and 65% high school students.

3.2 Result of survey

This paper's survey category is divided into three dimensions. The first dimension consists of subject preferences among Korean language, English, Mathematics, Science, and Social Studies. Students answered the preferred ranking for each subject on a 5 point Likert scale, with higher scores representing higher degrees of preference. Second,

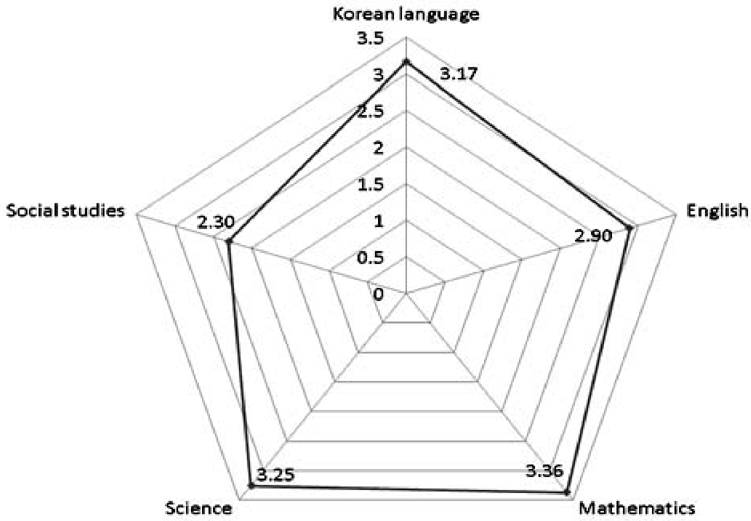

Fig. 1. Preference of academic subject.

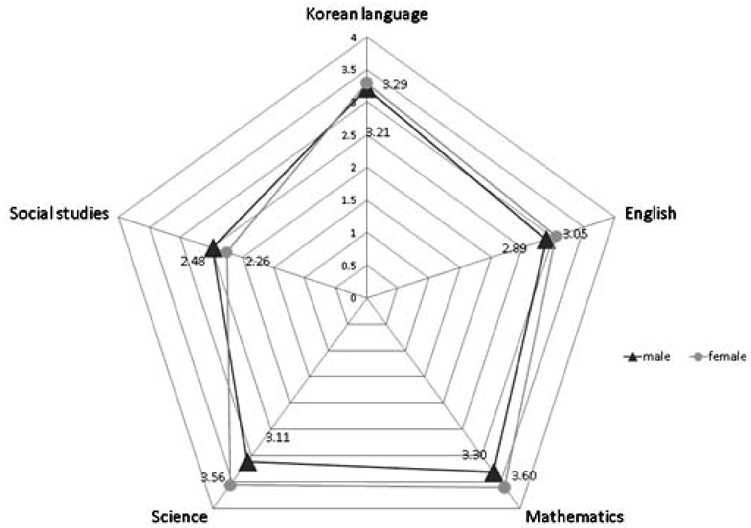

Fig. 2. Academic subject preference by gender.

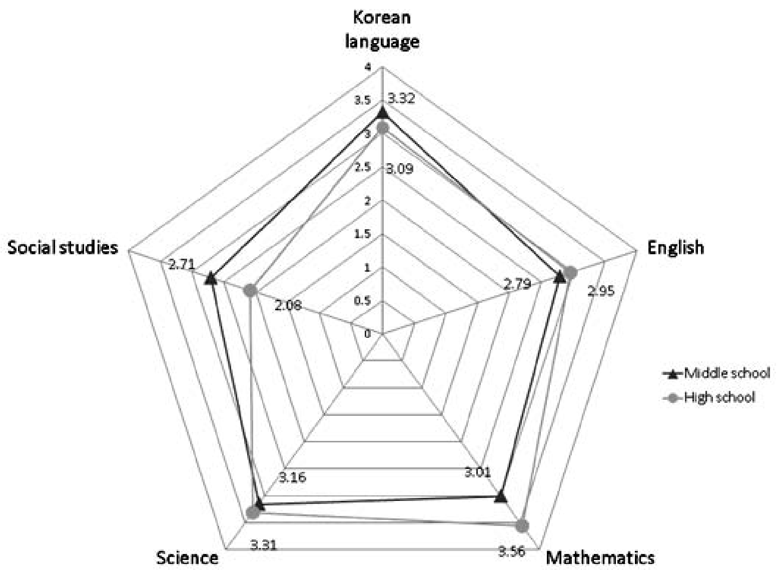

Fig. 3. Academic subject preference by age.

Table 2. Analysis of engineering perception by gender

Category	Score	Gender		Observation
		Male Students	Female Students	
Curiosity	Less than 3 points	301 (61.18%)	335 (62.27%)	Low on average
	More than 4 points	191 (38.82%)	203 (37.73%)	
Relation to mathematics/ science	Less than 3 points	153 (31.10%)	154 (28.47%)	Perceived to be high on average
	More than 4 points	339 (68.90%)	387 (71.53%)	
Difficulty**	Less than 3 points	429 (87.02%)	505 (93.17%)	More female students think Engineering is difficult
	More than 4 points	64 (12.98%)	37 (6.83%)	
Utility	Less than 3 points	169 (34.35%)	187 (34.50%)	Perceived to be high on average
	More than 4 points	323 (65.65%)	355 (65.50%)	
Social position*	Less than 3 points	292 (59.23%)	289 (53.32%)	More male students consider it lower
	More than 4 points	201 (40.77%)	253 (46.68%)	
Income	Less than 3 points	269 (54.79%)	287 (53.05%)	Perceived to be low in general
	More than 4 points	222 (45.21%)	254 (46.95%)	
Engineering college education level in comparison to that of an advanced country**	Less than 3 points	419 (84.99%)	421 (77.68%)	More male students think that the level is low
	More than 4 points	74 (15.01%)	121 (22.32%)	

(Unit: persons)

**p value < 0.05; *p value < 0.10.

we investigated in terms of a 5 point Likert scale the degree of general engineering perception; while questions related to the decision of college majors were adjusted to fit the scale as features. Third, we surveyed the preference order for nine engineering majors, giving 9 points for the most highly preferred field.

Figure 1 shows the distribution of preferred subjects of secondary school students in Korea. They mostly preferred mathematics and science; fewer preferred social studies. Also, we compared difference patterns with respect to gender and age as displayed in Figures 2 and 3.

Figure 2 shows that male students mostly preferred mathematics, followed by Korean language. In comparison to male students, female students turn out to prefer mathematics and science, in that order. Also, a very different preference pattern by age was observed in Figure 3.

Middle school students mostly prefer Korean language, while high school students liked mathematics and science the most. Apparently, high school students' preference for social studies is very low. In view of the positive effect of science and mathematics subjects on engineering, it appears that some schemes are necessary to boost interests of both male students and middle school students in science and mathematics.

We analyzed engineering perception by gender and age. First stage components consisted of seven questions: curiosity, relationship to mathematics and science, difficulty, utility, social position, income, and engineering college education level in comparison with that in advanced countries. Responses for these components were recorded in a 5 point Likert scale where larger point is the better. In contrast to other questions, difficulty of engineering was rated so that smaller point represents more difficult situation. In order to test gender and age effects, we used a χ^2 test. For this, we arranged responses into two groups: one for "less than 3 points" the other for "more than 4 points" The analysis result is displayed in Table 2.

In summary, Table 2 shows that there are some significant gender effects at 10% level in terms of the perceived difficulty of engineering, social position of engineers, and engineering college and education level in comparison to that of an advanced country. These results reflect the difference by gender in engineering perceptions. In particular, it is observed that male students' perceptions of these areas are more negative. This information indicates the importance of policy to improve male students' engineering perceptions.

Next, we analyze engineering perception by age.

In summary, Table 3 shows that there are some significant age effects at 5% level in terms of curiosity, relationship to mathematics and science, utility, social position, and income. These results show that engineering perceptions differ by age. In particular, it is observed that engineering percep-

Table 3. Analysis of engineering perception by age

Category	Score	School type		Observation
		Middle school	High school	
Curiosity**	Less than 3 points	289 (80.06%)	348 (51.94%)	More middle school students have low level of curiosity
	More than 4 points	72 (19.94%)	322 (48.06%)	
Relation to mathematics/ science**	Less than 3 points	154 (42.42%)	154 (22.95%)	More high school students think engineering is related to mathematics/ science
	More than 4 points	209 (57.58%)	517 (77.05%)	
Difficulty	Less than 3 points	322 (88.71%)	614 (91.23%)	Low on average (most student think Engineering is difficult)
	More than 4 points	41 (11.29%)	59 (8.77%)	
Utility**	Less than 3 points	145 (40.06%)	212 (31.50%)	More middle school students consider it lower
	More than 4 points	217 (59.94%)	461 (68.50%)	
Social position**	Less than 3 points	237 (65.29%)	345 (51.26%)	More middle school students consider it lower
	More than 4 points	126 (34.71%)	328 (48.74%)	
Income**	Less than 3 points	229 (63.26%)	328 (48.88%)	More middle school students consider it lower
	More than 4 points	133 (36.74%)	343 (51.12%)	
Engineering college education level in comparison to that of an advanced country	Less than 3 points	290 (79.89%)	551 (81.87%)	Perceived to be low in general
	More than 4 points	73 (20.11%)	122 (18.13%)	

**p value < 0.05; *p value < 0.10.

tion is improved for high school students. This information indicates the importance of policy to improve middle school students' perceptions of engineering. Next, we analyze decisions about college majors.

In summary, Table 4 shows that there are some significant gender effects at 5% level in terms of higher education plans and employment fields. Also, we confirmed that there are some significant age effects at 5% level in terms of higher education plans, time at which students decide on a future career, people and media affecting career decisions, and employment fields. These results imply that youth engineering adventure programs to promote the perception of engineering must be designed differently according to age group and gender.

Along with these categories, we also surveyed preferences of engineering fields among the following nine fields: Architectural Engineering, Computer Science, Mechanical Engineering, Industrial Engineering, Biotechnology, Electrical & Electronic Engineering, Materials Engineering, Civil & Environmental Engineering, and Chemical Engineering.

Figure 4 shows the distribution of preferred engineering majors of secondary school students in Korea. They mostly preferred Biotechnology; Civil and Environmental Engineering was the least popular field. Also, we compared difference patterns with respect to gender and age as displayed in Figures 5 and 6, respectively.

In Figure 5, it is shown that male students primarily preferred Computer Science, followed by Architectural Engineering. In comparison to male students, female students turned out to prefer Bio Engineering. In addition, male and female students preferred Civil & Environmental Engineering the least. Also, a difference in preference pattern by age was observed in Figure 6. Middle school students preferred Computer Science the most, as did high school students.

In engineering field preferences, we found that preferences for Civil & Environmental Engineering as well as for Material Engineering are considerably low. Compared with this, Architectural, Computer, and BioEngineering preferences are high. These results indicate that students' engineering major preference is biased. Non-preferred majors need to make an effort to recruit competent students.

Next, we investigated how each engineering major is perceived. For this, we created questions

Table 4. Analysis of engineering perception: decision of college majors

Gender	Higher education plan**						Total	Observation
	Engineering	Science	Medical	Business and Economics	Literature	etc.		
Male Students	163	96	45	59	61	65	489	More female students consider medical
Female Students	122	107	89	42	87	89	536	
Total	285	203	134	101	148	154	1025	

School type	Higher education plan**						Total	Observation
	Engineering	Science	Medical	Business and Economics	Literature	etc.		
Middle school	65	81	43	18	71	83	361	More high school students consider selecting engineering
High school	221	123	91	83	77	70	665	
Total	286	204	134	101	148	153	1026	

Gender	Decision time for future career					Total	Observation
	Ages 10-11	Ages 12-13	Ages 14-16	Ages 17-19	etc.		
Male Students	28	48	209	183	23	491	Decide mostly in the secondary school
Female Students	24	40	250	209	19	542	
Total	52	88	459	392	42	1033	

School type	Decision time for future career**					Total	Observation
	Ages 10-11	Ages 12-13	Ages 14-16	Ages 17-19	etc.		
Middle school	26	57	241	20	19	363	They tend to decide career during high school days.
High school	26	32	219	371	23	671	
Total	52	89	460	391	42	1034	

Gender	Person affecting career decision					Total	Observation
	Parents	Teacher	Friends	Myself	etc.		
Male Students	95	38	25	305	27	490	Both genders decide by themselves
Female Students	111	41	34	336	13	535	
Total	206	79	59	641	40	1025	

School type	Person affecting career decision **					Total	Observation
	Parents	Teacher	Friends	Myself	etc.		
Middle school	102	25	26	200	8	361	More high school students decide by themselves
High school	104	54	32	444	32	666	
Total	206	79	58	644	40	1027	

Gender	Media affecting decision career						Total	Observation
	Books and magazines	Internet	TV	Newspaper	Radio	etc.		
Male Students	63	232	84	32	4	75	490	Internet affects decision the most.
Female Students	87	249	101	40	4	58	539	
Total	150	481	185	72	8	133	1029	

School type	Media affecting career decision**						Total	Observation
	Books and magazines	Internet	TV	Newspaper	Radio	etc.		
Middle school	37	179	88	19	2	37	362	Middle school students are secondarily affected by TV. High school students are secondarily affected by books and magazines.
High school	114	302	97	53	6	96	668	
Total	151	481	185	72	8	133	1030	

Gender	Engineer's employment field**						Total	Observation
	General-employee	Researcher	Public service personnel	Faculty	Self-employed	Venture business		
Male Students	92	237	51	26	29	52	487	More female students want to be researchers
Female Students	65	324	39	30	27	46	531	
Total	157	561	90	56	56	98	1018	

School type	Engineer's employment field**						Total	Observation
	General-employee	Researcher	Public service personnel	Faculty	Self-employed	Venture business		
Middle school	55	143	61	25	34	42	360	More high school students would prefer to be researchers
High school	103	419	29	30	22	56	659	
Total	158	562	90	55	56	98	1019	

(Unit: persons)

**p value < 0.05; *p value < 0.10.

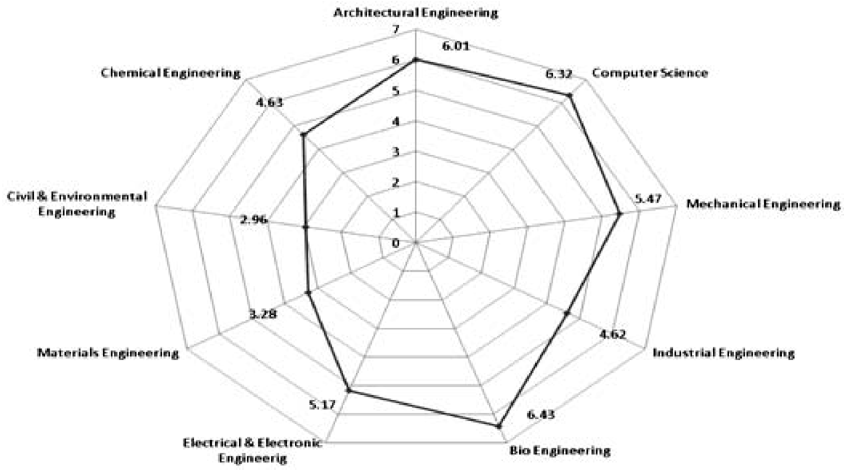

Fig. 4. Preferred engineering field.

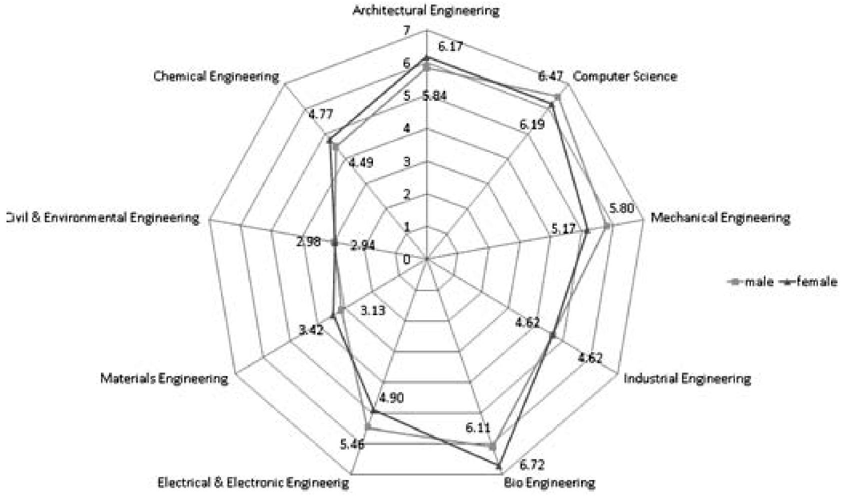

Fig. 5. Preferred engineering field by gender.

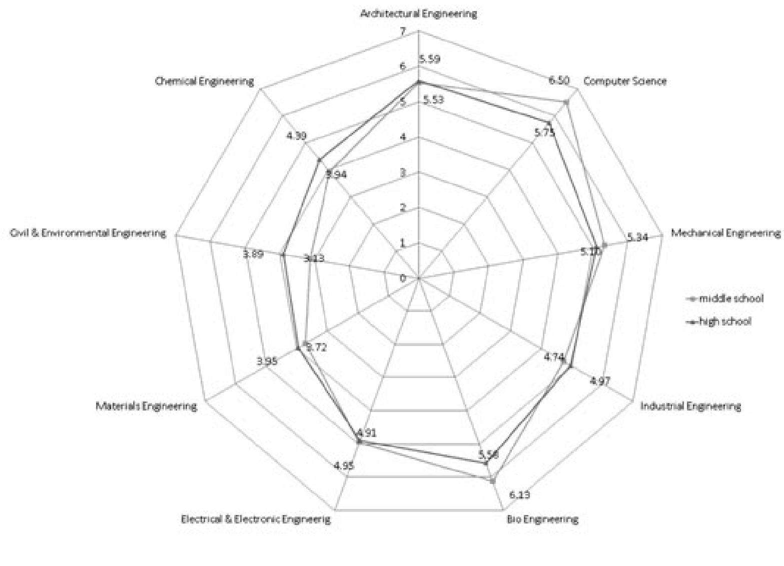

Fig. 6. Preferred engineerig field by age.

Table 5. Relevancy questions

Initial	Questions
A	This Engineering major is unrelated to mathematics.
B	This Engineering major is related to finance.
C	This Engineering major is related to semiconductor production.
D	This Engineering major is related to NASA.
E	This Engineering major is related to weapons production.
F	This Engineering major is related to apartment design & construction.
G	This Engineering major is related to perfume production.
H	This Engineering major is related to natural energy.
I	This Engineering major is related to inventing robots.
J	This Engineering major is related to LCD television production.

Table 6. Frequency of perceived relevance to each engineering major

	A	B	C	D	E	F	G	H	I	J
Architectural Engineering	102 (5.9%)	130 (9.5%)	29 (1.5%)	75 (4.1%)	60 (2.9%)	908 (43.4%)	8 (0.5%)	141 (7.9%)	54 (2.7%)	33 (1.7%)
Mechanical Engineering	80 (4.6%)	104 (7.6%)	551 (27.8%)	451 (24.9%)	552 (26.5%)	99 (4.7%)	32 (2.0%)	142 (8.0%)	785 (39.6%)	619 (31.7%)
Chemical Engineering	169 (9.8)	52 (3.8%)	136 (6.9%)	208 (11.5%)	487 (23.4%)	74 (3.5%)	677 (43.1%)	296 (16.6%)	71 (3.6%)	110 (5.6%)
Industrial Engineering	152 (8.8%)	709 (51.6%)	351 (17.7%)	274 (15.1%)	203 (9.8%)	174 (8.3%)	95 (6.0%)	328 (18.4%)	276 (13.9%)	296 (15.2%)
Bio Engineering	334 (19.3%)	73 (5.3%)	35 (1.8%)	255 (14.1%)	139 (6.7%)	34 (1.6%)	199 (12.7%)	155 (8.7%)	153 (7.7%)	20 (1.0%)
Electrical & Electronic Engineering	88 (5.1%)	151 (11.0%)	641 (32.3%)	307 (17.0%)	186 (8.9%)	66 (3.2%)	17 (1.1%)	162 (9.1%)	429 (21.6%)	604 (30.9%)
Materials Engineering	383 (22.2%)	99 (7.2%)	226 (11.4%)	181 (10.0%)	395 (19.0%)	282 (13.5%)	502 (32.0%)	173 (9.7%)	194 (9.8%)	250 (12.8%)
Civil & Environmental Engineering	420 (24.3%)	56 (4.1%)	13 (0.7%)	59 (3.3%)	59 (2.8%)	455 (21.7%)	41 (13.5%)	383 (21.5%)	22 (1.1%)	20 (1.0%)

(Unit: persons)

displayed in Table 5. Students were asked to select engineering fields related to individual questions. Multiple selections were allowed.

In Table 6, we found important points. First, students tended to select specific engineering fields in response to question A. All engineering disciplines are related to mathematics, but students do not think so. For question B, most students selected industrial engineering (IE). This means that students recognize the scope of IE relatively well. In response to question C, most of the students selected Electrical & Electronic Engineering and Mechanical Engineering. Although Materials Engineering is also heavily related to semiconductor production, students' selection ratio of the field was low. In question D, the selection ratios of Architectural Engineering and of Civil and Environmental Engineering were very low compared with other majors. Students thought that these fields are not related to NASA's research. In question E, most students selected Mechanical Engineering, Chemical Engineering, and Materials Engineering. Students thought that these engineering majors are related to weapons development. In question F, they mostly selected Architectural Engineering, but the relationship of Civil and Environmental Engineering to apartment design was not well-recognized. Also, in question G, most students chose both Chemical Engineering and Materials Engineering. This reflects students' relatively accurate recognition of the Chemical Engineering and Materials Engineering research fields. In question H, students' selection was equal for each major. In question I, over half of all students selected Mechanical Engineering and Electrical & Electronic Engineering. Students overlooked other engineering majors in this area. In question J, the majority of students selected Mechanical Engineering and Electrical & Electronic Engineering. A particular point is that students selected Industrial Engineering as a third choice.

These observations reflect distorted perceptions. For most relevancy questions, students selected two or three engineering majors, although they can be related to many other majors. These situations show that those students' perceptions about engineering application domains need to be improved.

4. CONCLUSIONS

The phenomenon of avoidance of engineering has been prevalent among young students in Korea. Many overseas countries have conducted studies about young students' perceptions of science and engineering. Based on previous studies, we created survey questions to understand students' perceptions about engineering in Korea and ultimately used the resulting observations to improve students' perceptions and to overcome the engineering avoidance phenomenon in Korea.

Compared with previous studies, we focused on engineering fields and analyzed perceptions of engineering by gender and age groups of students. We conducted a perception survey based on a designed questionnaire which consists of areas of three dimensions such as academic subject preference, general engineering perception, and understanding of nine engineering majors.

In academic subject preferences, it was observed that students recognize the relevancy of science and mathematics to engineering. In general engineering perception, different patterns were found by age and gender in terms of students' perceptions of the difficulty, curiosity, and utility of engineering; engineers' social positions; etc. This implies that we need different approaches for each group to improve their perceptions of engineering. Also, we observed which are the less-preferred engineering fields. We found that preference for chemical, civil and environmental engineering fields is relatively high. However, there are still less preferred engineering majors that should put their efforts into contact with students.

It turns out that students decide their higher education plan during high school. Therefore, an introduction to the engineering field is important at this time. We need to derive some approaches that make male students, who showed higher avoidance rates, think seriously about engineering fields, and we need to inform them about the positive sides of the engineering majors. The reason for male students' engineering avoidance is that they have a low preference for mathematics and science compared with female students. Also, we found that as students grow older, their perception of engineering is improved. In other words, middle school students' engineering perception level is lower due to less exposure to engineering.

Therefore, we should focus on developing the engineering adventure program by aiming it at middle school students. When developing the engineering adventure program, we need contents to improve male middle school students' perceptions about the difficulty, curiosity, utility, social position, and income related to engineering.

Through engineering major relevancy questions, we found that students' perceptions are skewed about the engineering major. For high school students who are at the stage of deciding on their majors for college, effective introduction of specific engineering fields is necessary. These results are important information to set up the youth engineering adventure program, which is designed to offer learning experiences about engineering to the youth in Korea.

We conducted a general analysis about perceptions of engineering, which suggests the development of a youth engineering adventure program that can accommodate different age groups of Korean students.

Designing such a program and analyzing changing perceptions of engineering through the experience of this program are left as areas for further study.

Acknowledgment—This research was financially supported by the Ministry of Knowledge Economy (MKE) and Korea Institute for Advances in Technology (KIAT) through the Human Resource Training Project for Strategic Technology. S. K. Kim participated in this work as research assistant.

REFERENCES

1. The Royal Academy of Engineering, Strategic Plan 2005–2010, 2007.
2. The Foundation Coalition, http://www.foundationcoalition.org, 2009.
3. P. Wankat, Survey of K-12 Engineering-oriented Student Competitions. *Int. J. Eng. Educ.* **23**(1), 2007, pp. 73–83.
4. M. Besterfield M. Mareno L. J. Shuman and C. J. Atman, *Comparing Entering Freshman Engineers: Institutional Differences in Student Attitudes*, American Society of Engineering Education Conference Proceedings, Charlotte, NC, June (1999).
5. E. Koehn, Engineering perception of ABET accreditation criteria. *J.Professional Issues in Eng. Educ. and Practice,* **123**(2), 1997, pp. 66–70.
6. V. A. Shivy and T. N. Sullivan, Engineering students' perceptions of engineering specialties. *J. Vocational Behavior*, **67**(1), 2005, pp. 87–101.
7. D. K. Bardsley, Education for all in a global era? The social justice of Australian secondary school education in a risk society. *J. Educ. Policy*, **22**(5), 2007, pp. 493–508.
8. N. Forcada M. Casalas and X. Roca, Students' Perceptions and Performance with Traditional vs. Blended learning Methods in an Industrial Plants Course. *Int. J. Eng. Educ.* **23**(6), 2007, pp. 1199–1209.
9. National Science Foundation (NSF), http://www.nsf.gov, 2009.
10. The Royal Academy of Engineering (RAENG), http://www.raeng.org.uk, 2009.
11. Y. R. Lee J. K. Park B. W. Lee and I. O. Han, Analysis and Evaluation of the Content Relevance in the 7th National Primary Science Curriculum. *J. Korean Primary Science Educ.*, **24**(3), 2005, pp. 214–225.
12. Y. P. Park, Science and engineering avoidance phenomenon and required change. *J. Korean Eng. Educ.* **11**(4), 2004, pp. 108–114.
13. S. Sjoberg and C. Schreiner, How do learners in different cultures relate to science and technology? Results and perspectives from the project ROSE (the Relevance of Science Education). *Asia-Pacific Forum on Science Learning and Teaching,* **7**(1), Foreword, 2006.

14. National Science Board., *Science and Engineering Indicators 2006*. Two volumes. Arlington, VA: National Science Foundation, volume 1, NSB 06-01; volume 2, NSB 06-01A, 2006.
15. H. Marshall L. McClymont and L. Joyce*, Public Attitudes to and Perception of Engineering and Engineers 2007*, The Royal Academy of Engineering & the Engineering and Technology Board, UK, 2007.
16. S. Sjoberg, and C. Schreiner, *Young people and science: attitudes, values and priorities: evidence from the ROSE project.* Keynote presentation at the European Union Science and Society Forum, Brussels, March 2005. Also available at http://www.ils.uio.no/forskning/rose
17. S. Camilla and S. Sjøberg, *The Relevance of Science Education,* Department of Teacher Education and School Development, University of OSLO, 2004.
18. The National Academies, *Changing the Conversation: Messages for Improving Public Understanding of Engineering*, The National Academies Press, 2008.
19. Korea Gallup., The public understanding of science and technology report. Korea Foundation for Advancement of Science & Technology, 2006.
20. J. Osgood B. Francis and A. Louise, Gender identities and work placement: why don't boys care? *J. Educ. Policy*, **21**(3), 2006, pp. 305–321.
21. K. Scantlebury D. Baker A. Sugi A. Yoshida and S. Uysal, Avoiding issue of Gender in Japanese Science Education. *Int. J. Science and Mathematics Educ*., **5**(3), 2007, pp. 415–438.
22. C. Callender, The impact of term-time employment on higher education students' academic attainment and achievement. *J. Educ. Policy*, **23**(4), 2008, pp. 359–377.
23. C. Ding and A. Hall, Gender, ethnicity, and grade differences in perceptions of school experiences among adolescents. *Studies in Educational Evaluation,* **33**(2), 2007, pp. 159–174.
24. F. Dabaj and H. Basak, *The Role of Gender and Age on Students' Perceptions towards Online Education,* Case Study: Sakarya University, Vocational High School. World Academy of Science, Engineering and Technology, 2008, pp. 441–444.
25. A. M. Agogino C. Newman and M. Bauer, Perceptions of the Design Process: An Examination of Gendered Aspects of New Product Development. *Int. J. Eng. Educ.* **20**(3), 2004, pp. 1199–1209.
26. B. M. Bagihole A. R. J. Dainty and R. H. Neale, A Woman Engineer's Experiences of Working on British Construction Sites. *Int. J. Eng. Educ*. **26**(9), 2002, pp. 422–429.

APPENDIX A

Part of survey questions

1. Write the preferred rank about subject and major

Subject	**Rank**
Korean language	
English	
Mathematics	
Science	
Social studies	
Major	**Rank**
Architectural Engineering	
Computer Science	
Mechanical Engineering	
Industrial Engineering	
Bio Engineering	
Electrical & Electronic Engineering	
Materials Engineering	
Civil& Environmental Engineering	
Chemical Engineering	

2. First stage questions

General questions	**Answers**				
	Very low		**Normal**		**Very high**
What degree of curiosity do you have in engineering field?	1	2	3	4	5
What do you think about the relationship between mathematics/science and engineering?	1	2	3	4	5
How difficult do you think engineering is?	1 (very difficult)	2	3	4	5 (very easy)
What do you think about the utility of engineering?	1	2	3	4	5
What do you think about engineer's social position?	1	2	3	4	5
What do you think about engineer's income?	1	2	3	4	5
What do you think about engineering college education level in comparison to that of an advanced country?	1	2	3	4	5

So Young Sohn is a Professor of Industrial Engineering at Yonsei University in Korea. Her research areas include engineering education, technology management, marketing, quality and reliability engineering. Detailed information about her teaching and research areas can be found at http://isl.yonsei.ac.kr

Yong Han Ju is a graduate student at the Department of Information and Industrial Engineering, Yonsei University. His research area is engineering education, IP management, quality engineering and customer relation management.