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Convergence in Education and Employment of Engineering Students: Korean Evidence

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The convergence of science, technology, the humanities, and the social sciences is an irreversible general trend. As a result, it will be important to foster employability counseling of engineering students leading to an understanding of why broad knowledge will help their employability. This study measures the effects of the convergence concept on students' employability by calculating the proportion of major classes taken in the humanities and social sciences among all college classes taken. This study analyzed the impact of convergence education as well as academic performance such as grades and study abroad experience on employability using employability-course matched data on graduates from a college of engineering from 2008 to 2015. The results showed that the higher percentage of classes taken in business administration or economics, as well as the total GPA and participation in study abroad programs, the more positive the effect on getting a job. This result reflects the reality that companies that value professional engineers are beginning to prefer that they have not only a business-oriented mindset but knowledge about other fields so that they can deal with the complexities and rapid changes in modern society. Accordingly, fostering corporate human resources philosophies that advocate for broad education will not only increase productivity in the labor market but make a great contribution to the development of colleges.

Keywords: *Convergence in Education; Employability-Course Matched Data; College of Engineering Graduate Employability; Academic Performance; School-To-Work Transition.*

Introduction

We are living in an era in which knowledge is increasing explosively and the lifecycle of technology is becoming shorter. This is too much to handle using knowledge from a single field of study. Accordingly, convergence of fields is a new paradigm that is sweeping through the academic world.

Convergence in education, in which information from two or more fields of study is combined in various ways, is aimed at developing multidisciplinary thinking ability in students (Kim & Lee, 2012). The early concept of convergence started with majors in engineering fields, and now, as knowledge of the humanities and social sciences by engineers is being emphasized more, convergence is spreading to fields beyond engineering (Ministry of Education, 2012). In this respect, the need for convergence in education is suggested as an alternative to education based on only a single subject area (Petrie, 1992; Fiscella & Kimmel, 1999; Loepp, 1999; Goodlad *et al*., 2000; Akins & Akerson, 2002).

Learning other areas of knowledge besides one's major enables students to accumulate more understanding of the human experience, which will increase their wages because they will be better able to contribute to productivity. Particularly, as the demand for highly skilled labor in the limited engineering labor pool rises because of the constant growth of cutting-edge technology, students will need to know about many fields that were once considered to be entirely separate engineering, technology, the humanities, and the social sciences in order to remain competitive in the labor market.

Corporations also prefer human resources departments that advocate broad education that covers the humanities and social sciences and creates a business-oriented mindset along with technological expertise (Mignogna, 2002). Especially, thanks to the recent development of the service sciences, the importance of combining creative classes in the humanities and social sciences with engineering is being emphasized. However, it remains unclear whether those who received multidisciplinary education fare better in the labor market than those who studied only their majors (Del Rossi & Hersch, 2008).

To date, the convergence approach in education has mainly been based on the experience of individual teachers or schools that present only its advantages or disadvantages (Applebee *et al*., 2007). We approach this study with the understanding that employability and effective learning are closely linked and relate closely with the qualities rated highly by employers (Yorke & Knight, 2006). One approach to effective education is convergence education. This study empirically analyzes the need for convergence in education as a way to deal with both a lack of students who want to major in engineering and the increase in the demand for broadly educated employees to fill science-related positions. We measure the effects of the convergence concept on students' employability by calculating the proportion of major classes taken in the humanities and social sciences

among all college classes taken. Therefore, this study empirically analyzes the impact of convergence education as well as academic performance such as grades and study abroad experiences on students' employability. For this study, we used Employability-Course matched data from Sungkyunkwan University, a famous private university in Seoul, in order to look at the impact of convergence in education on getting a job. In other words, we were asking whether the social demand for convergence in education meets the demands of enterprise for broadly educated graduates. Thus, our study provides basic information on the value of convergence in engineering education.

Theoretical Background

Many studies have addressed the importance of convergence, as well as specific goals and the implementation strategies needed to reach those goals, in order to cultivate talented people with creative problem-solving abilities. When students engage in courses that require them to use concepts to describe, manipulate, and explain phenomena, their conceptual knowledge is gradually elaborated (Van Boxtel *et al*., 2000; Lemke, 2001; Oliveira & Sadler, 2008), and several studies have focused on facilitating interest in and pursuit of science courses and employability by engaging in convergence learning (Tytler *et al*, 2008; Harackiewicz *et al*., 2012).

A good example of this is the introduction of STEM (Science, Technology, Engineering, Mathematics), which started in the US in 2003. With the growing interest in promoting student engagement in the sciences, STEM education is becoming integrated with other areas, because these fields are deeply intertwined in the real world and in how students can learn more effectively (Carnevale *et al*., 2011; Sinatra *et al*., 2015). The Ministry of Education in Korea introduced STEAM (Science, Technology, Engineering, Arts, Mathematics), which is convergence human resources education in the liberal arts, including economics, politics, law, social science, philosophy, psychology, and the arts. However, even though convergence in higher education is more active in engineering than in any other academic field, there has been little empirical research on how convergence in education affects job prospects for graduates with engineering degrees. Existing studies only describe programs of convergence between engineering, business administration, the humanities, and social sciences (Yun *et al*., 2011; Shin, 2012).

How the term *convergence* is defined depends on the scholars who used it or the fields in which it is used (Frodeman, 2010). Nissan and Niroomand (2006) stated that convergence is to put together more than two majors or subjects, and Hong (2012) defined convergence as an act that creates something new by interaction among studies. In this regard, convergence education is not the combining of two or more subjects so that there is less of one and more of another. It means the creation of a new concept of curriculum by the fusion of two or more subjects based on a common principle, issue, or interest among the subjects. Therefore, this study, in light of the concepts of convergence defined by previous research, defines convergence as "knowledge that is learned beyond the borders of conventional academic majors." This means approaching convergence in a multidisciplinary manner in the quest for learning (Petrie, 1992; Klein, 2006), and such an approach has something in common with the parameterized concept of convergence in this study by keeping the details of majors as originally intended and making students realize that there are other subjects involved.

Figure 1 shows the concepts of engineering education and convergence with the four majors that were measured as variables in this study, which looks at how convergence in education affects the likelihood of students getting hired. We measure majors in the fields of business administration, economics, the humanities, and social sciences (which, from here on will be collectively called "convergence courses") that have a definite academic boundary with engineering, but we also consider academic performance variables, such as grades and participation in study abroad programs, that are relevant for employability (Lassibille *et al*., 2001; Jung & Lee, 2005; Williams, 2005; Lee & Youn, 2012). Generally, grades and study abroad programs, which mean academic performance, are most important factors in employability. According to Di Pietro (2015), three years after graduation, study abroad experiences still have shown statistically significant results on the probability of securing employment. This effect is mainly driven by the impact that study abroad programs have on the employment prospects of graduates from disadvantaged (but not very disadvantaged) backgrounds, though positive but imprecise effects are also found for graduates from advantaged backgrounds. In an Australian qualitative study of employers, scholars, and students' perceptions of international experience and employability of graduates, Crossman & Clarke (2010) suggests that graduates need to experience culturally diverse situations as globalization and internationalization evolve. The current study confirmed that all stakeholders are aware of the importance of international experience, networks, experiential learning, language acquisition, and cultural understanding. In terms of employers and companies, they prefer highly competent people with global competitiveness (Cranmer, 2006), which means that international experience, such as study abroad experience, is more advantageous for employability of graduates.

GPA had become the key to getting a good job (Lassibille *et al*., 2001; Jung & Lee, 2005), but some studies that analyzed the determining factors for becoming employed in terms of their majors reported that more humanities and social science course, as well as study abroad experience, rather than only engineering courses, seemed to make the difference for graduates when they entered the labor market (Lee & Youn, 2012).

In addition, we consider employability in terms of several criteria, such as being employed or not, employment by large corporations, and average annual wages, which reflect students' perceptions of the quality of jobs (Baek & Cho, 2015), and thus, average annual wages can be used as a proxy variable for employment prestige in this study. According to the human capital theory, convergence education and academic performance have an effect on the accumulation of human capital as an indicator of having achieved the desired outcome in college, and influencing employability (Schultz, 1961; Becker, 1975). Also, from the viewpoint of signal theory, these experiences of graduates will have a positive effect on employment as an indicator of their ability and integrity (Arrow, 1973; Stiglitz, 1975; Spence, 1978).

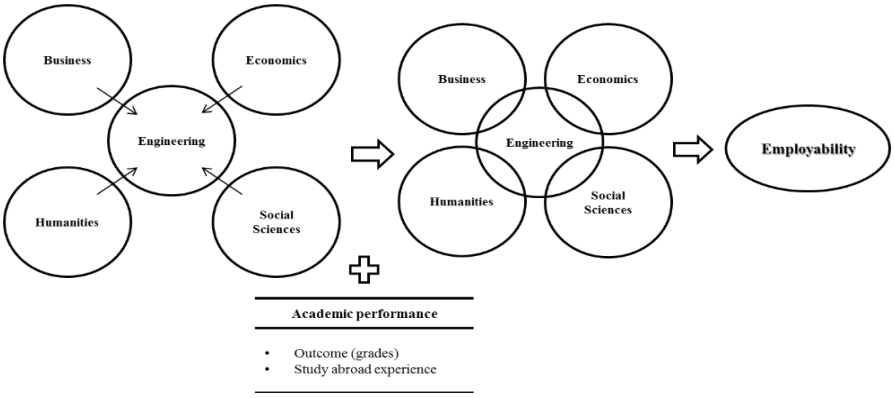

Figure 1. Convergence in Engineering Education

Description of the Data

We used course, grade, and employability data for classes taken by graduates from 2008 to 2015 to determine the effect of convergence in education on employability. Convergence was identified by the ratio of convergence courses in the fields of business administration, economics, the humanities, and the social sciences to major courses taken by engineering graduates. The graduates were 6,083 from six departments in the college of engineering at Sungkyunkwan University. In this paper, the corporate information database of the South Korean Data Analysis, Retrieval and Transfer System (DART) of the Financial Supervisory Service was used to measure employment prestige. Corporate data include information on financial status, including sales and net profits. We used average annual wages as a proxy variable for employment prestige. As dependent variables, which reflect employability, we used being employed or not, employment by large corporations, and employment prestige based on average annual wages.

The independent variables included the ratio of convergence classes taken by graduates, academic performance, graduates' background, major, and year of graduation. Course and grade data covered all courses that the graduates took during their college years, as well as their grades. To measure convergence in the education of engineering graduates, we used the ratio of convergence courses to major courses as a variable for the degree of convergence. For example, a proportion of business courses of 0.02 means that two percent of all major courses taken were in business administration.

Figure 2 shows the graphs for the rates of convergence courses that employed graduates took during their college years. Although the proportion of major classes in business administration is relatively high, and the annual trend depends on the subjects, there was an overall increase in the total proportion of convergence courses taken by graduates that got hired. This tells us that the interest of engineering students in convergence subjects is growing and has an effect on employment.

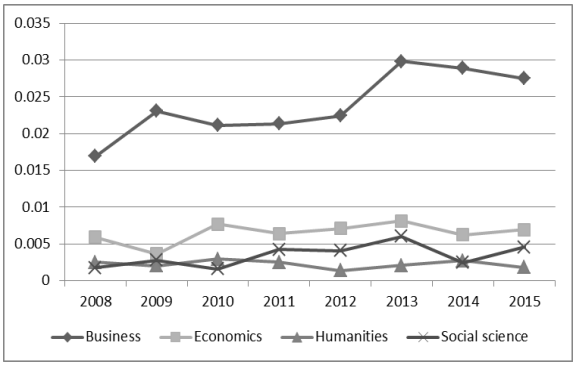

Figure 2. The Annual Change in the Ratio of Convergence Classes Taken by Employed Graduates

Empirical Specification

This study uses the Logit and Multinomial Logit Model using Stata to examine the effect on employability of convergence in engineering education. As dependent variables, we used Model 1, being employed or not, and Model 2, employment by large corporations, among those employed by companies (excluding public organizations). The formula for the Logit Model is as follows:

$$L_i=\ln(\frac{P_i}{1-P_i})=\alpha+X_i\beta+S_i\gamma+D_i\delta+K_i\chi+u_i\ ,$$

where X_i is the vector expected to have an effect on the ratio of convergence classes taken by i, an engineering school graduate, on employability; S_i is a vector that includes indices on academic performance, such as the dummy variable of the GPA and whether or not the graduate studied abroad; D_i is a vector of the personal characteristics of graduate i and of the index on the characteristics before entering the university, including where i came from, the high school, and the admission type; K_i represents the dummy variables of the graduation year and the six specific majors of the engineering school, while u_i is an error term.

In Model 3, using the Multinomial Logit Model, we were classified into four groups according to their importance based on average annual wages. We analyzed the impact of this

classification on employment prestige. The formula for the Multinomial Logit model is as follows, and the non-employed group was chosen as the baseline category:

$$P(Y_i = j) = \frac{e^{\beta_j' X_i}}{\sum_{k=0}^{4} e^{\beta_k' X_i}}, \quad j = 0, 1, 2, 3, 4 .$$

In this equation, X_i is the vector of all the indices included in the Logit Model analysis, such as the proportion of convergence courses, academic performance, and personal characteristics; β_i indicates the selection probability of j (=1,2,3,4) to zero, the standard of independent variables; however, it does not show the marginal effects on each selection of independent variables. Therefore, the coefficient values that show the marginal effects of independent variables can be obtained by substituting different independent variables in the formula above to observe their marginal effects on the selection of each category:

$$\delta_j = \frac{\partial P_j}{\partial x_i} = P_j[\beta_j - \sum_{k=0}^{3} P_k \beta_k] = P_j[\beta_j - \bar{\beta}] .$$

Table 1 summarizes the statistics of the independent variables between employed and unemployed groups. The proportion of business and economics classes taken by engineering graduates was higher for employed graduates. We use the total GPA with a scale from 0 to 4.5 in order to measure academic performance; about 48.4 % of the employed graduates had a GPA between 3.0 and 3.5. Study abroad is a variable that include language study abroad and exchange student experience. Employed graduates ranked higher on this measure than unemployed graduates. We set metropolitan areas based on where the students came from before entering the university. In the category for specialized high schools, we included elite schools, such as foreign-language high schools and science high schools. Sungkyunkwan University selects special admission students based on superior grades, essay writing, and language skills. The rates of employed graduates from metropolitan areas with special admissions are higher than those of unemployed graduates.

Table 1

Summary Statistics

Independent variable	Employed	Unemployed
The proportion of convergence classes taken by graduates		
Business	0.026	0.019
	(0.060)	(0.041)
Economics	0.006	0.003
	(0.046)	(0.031)
Humanities	0.002	0.002
	(0.022)	(0.019)
Social sciences	0.004	0.004
	(0.032)	(0.030)
Academic performance		
Total GPA≥4.0	0.045	0.113
	(0.208)	(0.316)
3.5≤Total GPA <4.0	0.388	0.378
	(0.487)	(0.485)
3.0≤Total GPA <3.5	0.484	0.370
	(0.500)	(0.483)
Total GPA <3.0	0.083	0.139
	(0.275)	(0.346)
Study abroad experience	0.051	0.017
	(0.220)	(0.127)
Graduates' background		
Metropolitan area	0.621	0.528
	(0.485)	(0.484)
Elite high school graduation	0.018	0.039
	(0.133)	(0.194)
Special admission	0.152	0.101
	(0.359)	(0.348)
Graduates' characteristics		
Female student	0.170	0.202
	(0.376)	(0.402)
Student's age	25.865	25.607
	(1.866)	(2.099)
Major		
Mechanical Engineering	0.305	0.243
	(0.460)	(0.429)
Systems Management Engineering	0.163	0.091
	(0.369)	(0.288)
Advanced Materials Science and Engineering	0.177	0.222
	(0.381)	(0.416)
Landscape Architecture	0.025	0.035
	(0.155)	(0.184)
Civil and Architectural Engineering	0.100	0.158
	(0.300)	(0.365)
Chemical Engineering	0.231	0.251
	(0.421)	(0.434)
Observations	4,023	2,060

Main Results

Table 2 shows the results of Logit analysis with dependent variables for employment and employment by large enterprises. According to the findings, the higher the ratio of classes in business administration and economics, the more positive the effect on employment and on employment by large corporations. However, coursework in the humanities had a negative impact on employment and on employment by big businesses. Hence, convergence between the humanities and engineering is not yet valued by businesses, and this affects the labor market negatively.

A high total GPA had a significantly positive effect on employment for college graduates. Graduates with GPAs between 3.0 and 4.0 were compared to those with GPAs lower than 3.0 in Model 1. Those with GPAs above 4.0 had a significantly greater likelihood of being hired by large companies. Also, study abroad experience had a positive effect on employability.

The graduates' background had a significant effect on employability. Graduating from elite high schools had a negative impact on employment; however, people who were admitted to college via special admission were more likely to be hired. Age had a positive effect on employment overall but a negative impact on employment by big companies. In terms of gender being a woman also had a negative impact on employment by big businesses.

Table 2

Logit Estimates of Employment

	Model 1 (Employed = 1)	**Model 2 (Large corporations = 1)**
The proportion of convergence classes taken by graduates		
Business	0.406***	0.087**
	(0.043)	(0.024)
Economics	0.323**	0.050**
	(0.068)	(0.049)
Humanities	-0.030***	-0.513***
	(0.080)	(0.024)
Social sciences	-0.061	-0.472
	(0.187)	(0.366)
Academic performance		
Total GPA≥4.0	-0.033	0.170***
	(0.029)	(0.035)
3.5≤Total GPA <4.0	0.149***	0.314***
	(0.020)	(0.026)
3.0≤Total GPA <3.5	0.184***	0.296***
	(0.019)	(0.025)
Study abroad experience	0.219***	0.160***
	(0.040)	(0.033)
Graduates' background		
Metropolitan area	-0.014	-0.013
	(0.012)	(0.013)
Elite high school graduation	-0.130***	-0.164***
	(0.035)	(0.041)
Special admission	0.044**	0.017
	(0.017)	(0.017)
Graduates' characteristics		
Female student	-0.008	-0.104***
	(0.017)	(0.018)
Student's age	0.020***	-0.016***
	(0.004)	(0.004)
Major		
Mechanical Engineering	0.046**	0.053**
	(0.017)	(0.017)
Systems Management Engineering	0.076***	0.072***
	(0.023)	(0.021)
Advanced Materials Science and Engineering	-0.050**	0.014
	(0.017)	(0.018)
Landscape Architecture	-0.102**	-0.537***
	(0.036)	(0.073)
Civil and Architectural Engineering	-0.139***	-0.194***
	(0.020)	(0.023)
Year of graduation	Yes	Yes
Observations	6,083	6,083
Pseudo R^2	0.063	0.074

Source: The Employability-Course of graduates matched data from Sungkyunkwan University in South Korea.

*Notes: 1. ***p<0.001, **p<0.05, *p<0.1.*

2. Standard errors in parentheses.

3. The reference group had GPAs of less than 3.0, and the reference group for the field of study consists of graduates with a chemical engineering major.

Table 3 shows how employment prestige, classified by annual wages and compared with the unemployed through Multinomial Logit, affects employment probability. The results show that people were hired by different types of companies depending on the ratio of convergence classes to engineering classes. Graduates with a higher percentage of

business and economics classes were more likely to be hired by the top five firms and to have high annual salaries. A high ratio of social science courses to engineering courses had a significantly positive effect on employment by upper-middle corporations. However, a high ratio of humanities courses to engineering courses had a negative impact on the probability of being hired by companies in the top group, which was similar to the probability of employment by large corporations.

As these statistics show, a high GPA increased the probability of being employed by large corporations and companies with better wage conditions; however, for engineering graduates, a GPA of 4.0 or higher did not have an effect on whether or not a graduate was able to secure employment. Foreign-language study abroad, one of the major factors for employment, increased the probability of being employed by top 5 and upper-middle rank companies.

Table 3

Multinomial Logit Estimates of Employment Prestige

	Model 3			
	Top 5 firms	**Upper-middle**	**Middle-low**	**Low rank**
The proportion of convergence classes taken by graduates				
Business	0.250***	-0.066	-0.027	0.212***
	(0.079)	(0.128)	(0.055)	(0.079)
Economics	0.205**	0.245**	0.052	0.186*
	(0.042)	(0.039)	(0.046)	(0.098)
Humanities	-0.384**	-0.156**	-0.177	0.264
	(0.099)	(0.025)	(0.254)	(0.182)
Social sciences	-0.095	0.273**	0.055	0.130
	(0.175)	(0.013)	(0.060)	(0.136)
Academic performance				
Total GPA≥4.0				
	0.064**	0.015	-0.006	-0.076
	(0.027)	(0.037)	(0.015)	(0.025)
3.5≤Total GPA <4.0	0.067***	0.188***	0.004	-0.073***
	(0.020)	(0.026)	(0.010)	(0.016)
3.0≤Total GPA <3.5	0.040**	0.208***	0.020**	-0.050***
	(0.019)	(0.025)	(0.009)	(0.015)
Study abroad experience	0.085***	0.093***	0.012	0.038
	(0.022)	(0.030)	(0.011)	(0.024)
Observations		5,896		
Pseudo R^2		0.084		

Source: The Employability-Course of graduates matched data from Sungkyunkwan University in South Korea.

*Notes: 1. ***p<0.001, **p<0.05, *p<0.1.*

2. Standard errors in parentheses.

3. The reference group for the total GPA had less than 3.0, and the reference group for the field of study consists of graduates with a chemical engineering major.

4. Graduates' background (dummy variables of metropolitan area, elite high school graduation, and special admission), graduates' characteristics, including gender (female=1), age, major, and graduation year are included in the analysis, but not reported.

Table 4 shows the results of Logit analysis, which used employment status as the dependent variable with regard to six majors in the college of engineering to evaluate the effects of the subjects studied on employment. The higher the ratio of courses in business administration, the more positive was the impact on employment for those who majored in mechanical engineering and systems management engineering. The school of mechanical engineering is aimed at cultivating engineering designers who can meet global standards. Therefore, on-the-job training programs, including internships through ABEEK (Accreditation Board for Engineering Education of Korea), have been offered since 2005. Washington Accord is the basis of ABEEK, and six developed countries, the US, UK, Australia, Canada, New Zealand, and Ireland, certify engineering education through the program, which demonstrates that the convergence of mechanical engineering and business administration has a positive effect on employability. Systems management engineering graduates were also more likely to be employed with higher ratios of courses in business administration. Unlike other engineering majors, those who majored in systems management focused on studying systems. The analysis results indicate that new disciplines, such as financial engineering and management innovation, which were derived from systems management engineering, also converged with business administration to improve employability. Graduates with degrees in advanced material engineering and chemical engineering were more likely to be employed if they had higher ratios of economics courses. These latter two majors require students to be able to conduct scientific analysis in order to develop new materials or raw chemical materials and reactions. When viewed from this perspective, it can be said that economics, which requires precise analysis, greatly improved employability for these two majors. As observed in the above results, taking courses in the humanities had a negative impact on employability for mechanical engineering, systems management engineering, and advanced materials engineering graduates.

As an indicator of academic performance, GPAs of 4.0 or higher did not have a significant effect on employment. For advanced materials engineering graduates, a GPA of 4.0 or higher had a negative impact on employment. Study abroad experience affected employability, except in the cases of graduates in systems management engineering, landscape engineering, and civil architecture engineering. This result indicates that learning foreign languages is also important even for engineering graduates, who, in the past,

were only required to have expertise in their major fields in order to be employed.

Table 4

Logit Estimates of Employment for 6 Groups of Engineering Majors

	Model 4					
	Mechanical	**Systems Management**	**Advanced Materials**	**Landscape Architecture**	**Civil and Architectural**	**Chemical**
The proportion of convergence classes taken by graduates						
Business	0.677*	0.501**	0.184	-1.097	-0.019	0.230
	(0.401)	(0.203)	(0.892)	(0.868)	(0.327)	(0.360)
Economics	-0.160	0.139	1.020**	1.645	-0.511	1.505**
	(0.424)	(0.211)	(0.498)	(1.042)	(0.438)	(0.071)
Humanities	-2.194**	-0.249**	-1.208**	2.329	0.501	0.321
	(1.013)	(0.057)	(0.569)	(3.496)	(0.692)	(0.657)
Social sciences	-0.541	1.146	0.183	-1.062	1.999	0.493
	(0.599)	(0.754)	(0.407)	(1.287)	(1.425)	(1.085)
Academic performance						
Total GPA ≥4.0	-0.047	0.025	-0.222**	0.263	-0.034	0.055
	(0.050)	(0.076)	(0.073)	(0.181)	(0.105)	(0.057)
3.5≤Total GPA <4.0	0.136***	0.182***	0.096**	0.008	0.118*	0.226***
	(0.036)	(0.053)	(0.045)	(0.109)	(0.061)	(0.046)
3.0≤Total GPA <3.5	0.232***	0.117**	0.169***	-0.103	0.144**	0.247***
	(0.034)	(0.050)	(0.042)	(0.104)	(0.060)	(0.044)
Study abroad experience	0.217**	0.041	0.277**	0.060	0.127	0.356***
	(0.077)	(0.073)	(0.099)	(0.023)	(0.100)	(0.102)
Observations	1,727	844	1,168	169	728	1,445
Pseudo R2	0.085	0.063	0.073	0.120	0.059	0.062

Source: The Employability-Course of graduates matched data from Sungkyunkwan University in South Korea.

*Notes: 1. ***p<0.001, **p<0.05, *p<0.1.*

2. Standard errors in parentheses.

3. The reference group for the total GPA had less than 3.0.

4. Graduates' background (dummy variables of metropolitan area, elite high school graduation, and special admission), graduates' characteristics of student's gender (female=1), age, major, and graduation year are included in the analysis, but not reported.

Discussion

The National Academy of Engineering in the United States has pointed out that interactions between various fields are required in the process of addressing the problems of the real world, and it is helpful for undergraduate students to have the opportunity to learn about such interactions, even though curricula to help them do so is not well developed yet (Phase, 2005).

For convergence courses, the higher the proportion of courses in business administration and economics, the more positive the effect was on employment. These results show that companies that consider engineers' expertise to be their most important quality, prefer employability counseling that advocates broad education with a business-oriented mindset and knowledge about the humanities and society. Del Rossi and Hersch (2008) explained that majors that combining business and science have more than 50% greater returns than major that do not. The analysis reflects the trend of diversification by students taking classes according to the needs of companies, which are gradually changing. Taking economics courses has a positive effect on getting a job because economics not only reflects a vocational interest by graduates but is very compatible with engineering, due to its scientific basis (Kasper, 2008). On the other hand, even though the importance of the humanities has been increasing, taking classes in the humanities has had a negative effect on employment.

In addition, the total GPA, which reflects academic performance in college (Cho *et al*., 2015), plays a key role in determining success in the labor market. The findings suggest that somewhat high GPAs have a very significant positive effect on the probability of employment by large companies; however, GPAs above 4.0 did not have an effect on employment in Model 1, because graduates with engineering majors are highly in demand even with a lower total GPA (Baek & Cho, 2015). In particular, the existing studies analyzing the determinants of the labor market performance of college graduates explains that the humanities and social sciences are a kind of differentiation strategy and are more active in study abroad than engineering students (Lee & Youn, 2012). However this study's findings suggested that study abroad experience is also becoming a crucial factor in success in the labor market among graduates in engineering fields.

The results of the special admissions variable indicated that engineering graduates' route to entering college was more closely related to their employability than was their place of birth, which are directly or indirectly relevant to family background. Also, many Korean companies set age limits for employment, and men account for a relatively higher percentage of employees in large corporations (Cho *et al*, 2013; Cho & Cho, 2015; Cho & Lee, 2015). In this regard, Roksa (2005) argued that women were more likely to be employed by public or non-profit businesses, which indicated that their qualitative performance in the labor market was better.

In terms of employment prestige, the results indicate that more engineering graduates are going into non-engineering fields, because many non-engineering companies, particularly banks, provide higher annual salaries; therefore, having knowledge about the humanities and

social sciences is becoming more important. According to Graham and Smith (2005), if graduates with engineering degrees had jobs in non-engineering fields, their expected incomes were higher. North (1995) also argued that more engineering graduates entered other fields because engineering professions paid less than those related to other majors, such as law or business administration. The results of this study empirically support these previous studies.

Conclusion

This study reports the effects of academic performance and convergence education on the employability of engineering graduates. We calculated the proportion of convergence courses, which could measure the degree of convergence in engineering education in a situation where a convergence education system is not yet established. However, this approach does have limitations in that it could not measure convergence courses themselves. Our results serve as a guideline for convergence in education by providing basic information about employability; it can also be applied to convergence for other majors. Companies are gradually demanding not only expertise in their major knowledge but comprehensive skills that graduates have not learned properly in their fields of study. This means that colleges need convergence education curricula, and it is strongly aligned with employability.

Colleges need to determine whether convergence is possible and discuss its feasibility. They also need to provide education that can connect engineering or technology with the humanities or social sciences in order to meet the demands of the labor market. Particularly, the study of the humanities needs to be combined with engineering by emphasizing the training they offer in creative problem-solving in order to attract engineering. Furthermore, cultivating convergence human resources by interacting with leading world universities and institutions will significantly contribute to the development of universities and the improvement of the labor market.

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