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AN ANALYSIS OF LEARNING ABILITY IN CALCULUS BASED ON THE SELECTION OF TEST AREAS IN THE COLLEGE SCHOLASTIC ABILITY TEST

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Abstract. This study analyses the cross-application system, one of the diversified college admission processes, based on the entrance examination system by the reorganization of the education curriculum. In addition, this study suggests an improvement direction of mathematics education for students who cross-apply by comparing and analysing academic results in Calculus for those students entering universities through the cross-application system.

1. Introduction and the study background

Korea's College Scholastic Ability Test, first introduced in 1994, has undergone several small and large changes. With these changes, each university has introduced a new entrance process, and as a result, even experts in entrance examinations and academic counsellors have difficulty understanding the whole system implemented by four-year universities in the country.

Most universities reflect scores for Korean B, Mathematics A, and social studies for students applying to liberal arts and social studies

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departments and scores for Korean A, Mathematics B, and sciences for students applying to natural science and engineering departments. However, for the purpose of normalizing education and its enrichment by securing qualified students, more and more universities have adopted the 'cross-application system', in which students can apply to natural science, engineering, and medical science departments with scores required for liberal arts and social studies departments. Universities have adopted this entrance process because they want to secure sufficient numbers of applicants, who are declining gradually due to reduction in number of students, and have introduced departments requiring no differentiation between the liberal arts and sciences because of the active convergence of study fields. We figured out that many universities in Seoul have permitted cross-application systems in departments such as construction engineering, clothing, and domestic science.

For example, S university in Seoul permitted a cross-application system for seven departments (statistics and actuarial science, industrial information systems engineering, architecture, computing, global school of media, software, and smart system software) for 2015 admissions, but for 2016 admissions, it plans to permit students in humanities course to cross-apply to eight departments by adding electric engineering (IT convergence) to the list.

In addition, in some medical colleges, including oriental medicine and dental colleges, which are typically part of natural sciences departments, humanities students can cross-apply to departments of medicine, oriental medicine, and dentistry. In 2016 admissions, eight departments in oriental medicine, two in medicine, and one in dentistry permitted humanities students' applications.

Another S university permitted humanities students to cross-apply to departments of architecture (architecture major), nursing science, and clothing, and K university allows it for departments of nursing science, home economics, and computer science. At D university and M university, humanities students are allowed to cross-apply to all departments in natural science. These universities allow students selecting Mathematics A and social studies to apply, while giving additional points to those students selecting Mathematics B and scientific studies. In addition, K university is expected to select half of all new students from humanities and social studies courses and the rest from natural science courses in home economics and computer science.

By contrast, a considerable number of universities allow students who select sciences in the College Scholastic Ability Test to apply to humanities and social studies. According to a survey, just 10 % of all four-year universities designate social studies as mandatory for humanities and social studies departments. That is, most universities allow students who select sciences to apply to humanities and social studies departments. However, in reflecting the student's file in humanities and social studies departments, many universities reflect social studies instead of sciences.

Because of this entrance examination system, students are forced to select subjects that provide them with an advantage in college admissions instead of considering their own talent, learning ability, and career interests. Given this, the implementation of the selective entrance examination system has reduced the academic achievement of high school students in mathematics, and students have tended to avoid science subjects. As a result, freshmen in natural science and engineering have faced some difficulty in adapting themselves to major subjects, and this has had a substantial impact on their majors. Accordingly, the entrance examination system is widely expected to have considerable influence on lectures in major subjects in natural science and engineering, weakening students' mathematics and science competitiveness and thus reducing the number of qualified science and engineering employees. In this context, this study analysis students' learning ability in Calculus by considering those students entering university through the cross-application system under the current entrance examination system and suggests some ways to develop suitable subjects for teaching mathematics.

2. Reorganization of the education curriculum and the current state of the college entrance examination system

The college admissions process used to reflect subjects selected by students in the College Scholastic Ability Test. In the 1996 university entrance examination, students who selected humanities courses could not apply to natural science departments or engineering colleges at 71 universities, and students who selected natural science courses could not apply to humanities departments. Only 13 universities permitted students' cross-application by subtracting some points in some scores(1∼5 % : 24. December. 1995. Dong-a daily newspaper). Since then, the cross-application system has expanded gradually, and it has become

more active since 2005, when the College Scholastic Ability Test was reorganized as a selective type. The 7th National Curriculum emphasizes the setting of a student-oriented educational curriculum that reflects students' diverse talent, aptitude, needs, and interests and allows students to select subjects suitable for their talent and aptitude for active and self-regulating learning.

Therefore, various subjects have been opened to reflect students' talent levels and differences in interests, and second and third-year high school students can select subjects suitable for their careers and talent levels (see [4]). In addition, under the 6th National Curriculum, the College Scholastic Ability Test could include questions from common mathematics learned by first-year high school students, whereas the 7th National Curriculum since 2005 could not.

	Korean		Mathematics		English	Segments		
	A-Type	B-Type	A-Type	B-Type		Soc.	Sci.	Voc.
choice	306,193 (47.9%)	333,472 (52.1%)	440,030 (73%)	162,993 (27%)	633,958 (99 %)	365,999 (58.6%)	245,762 (39.4%)	12,580 (2.0%)
	639,665(99.8%)		603,023(94.1%)			624,341(97.5%)		
unchoice	954(0.2%)		37,596(5.9%)		6,661(1%)	16,278(2.5%)		
640,619(100%)								

TABLE 1. The current state of selected subjects by 2015 applicants for the College Scholastic Ability Test (unit: person)

Further, humanities students used to learn basic calculus and probability and statistics, but since the 7th National Curriculum, Calculus, probability and statistics, and discrete mathematics have become selective subjects only for natural science students. As a result, the number of items from each unit of mathematics in the College Scholastic Ability Test has changed substantially from 2004 to 2005. This change in the educational curriculum has led to a large gap in the level of difficulty in the College Scholastic Ability Test as well as in the amount of learning in mathematics for both humanities courses and natural science courses (see [5]).

Because of this reorganization of the educational curriculum, many students have given up mathematics even when selecting science subjects, as demonstrated by the current state of selected subjects by 2015 applicants for the College Scholastic Ability Test <Table 1>. As shown in <Table 1>, 47.9 % and 52.1 % of all applicants selected Korean A and Korean B, respectively, whereas 73% and 27% selected Mathematics A and Mathematics B, respectively. The number of students selecting Korean A was nearly the same as that selecting Korean B, but the number of applicants for Mathematics A was about 2.7 times that for Mathematics B. In addition, 58.6% and 39.4% applied to social studies and sciences, respectively, indicating that the number of applicants to social studies was about 1.5 times that of applicants to sciences. This ratio shows that many students selected Mathematics A in the College Scholastic Ability Test, although they learned sciences through natural science courses in high school.

The reason for this may be due to the fact that the subject a student selects can make a difference in standardized scores. Indeed, the highest standardized scores by subject in sciences in the 2015 College Scholastic Ability Test were as follows: physics 1 (72), chemistry 1 (71), life science 1 (71), earth science 1 (69), physics 2 (67), chemistry 2 (68), life science 2 (73), and earth science (71), with scores ranging from 4 to 6 across various subjects.

Based on the 2009 revised Curriculum, the College Scholastic Ability Test has questions from three units only(mathematics II, Calculus I, and probability and statistics) for humanities course and three units only(Calculus II, geometry and vector, and probability and statistics) for natural science course (see <Table 2>). Given this big change, the Korea Institute for Curriculum and Evaluation examined the number of questions assigned to each unit suitable for characteristics of the College Scholastic Ability Test.

In addition, in September 2014, the Ministry of Education announced an integrated curriculum of liberal arts and natural sciences, is in progress to implement in 2015 revised curriculum and thus geometry likely to be classified as a selective subject, so it will be excluded from the College Scholastic Ability Test in the future. Accordingly, integration is expected regardless of humanities and natural science courses from the 2021 College Scholastic Ability Test, which will be taken by current first-year middle school students. This represents a huge change to the test (see [3]).

		∼ 2009	2009 ∼
Basic Subjects	Basic Course		Basic Statistics
General Subjects	1st grade	Mathematics	Math 1, Math 2
	Humanities Course	Mathematics 1, Calculus and Pre-statistics	Calculus 1, Probability and Statistics
	Natural Science Course	Mathematics 1, Mathematics 2 Integral Calculus and Statistics, Geometry and Vectors	Calculus 1, Calculus 2, Probability and Statistics, Geometry and Vectors
Advanced Subjects	Advanced Course		Advanced Mathematics 1, Advanced Mathematics 2

TABLE 2. The 2009 revised curriculum in mathematics

Those who support the integrated curriculum consider this integration a key point of 21th-century education, claiming that it may foster creative and talented students with humanistic imagination and scientific and technologic creativity by cultivating basic refinements in humanities, social studies, science, and technology and that, in particular, humanistic refinements may be more widely and deeply reflected in all students. Further, theoretical educationalists have suggested that in basic learning, such changes in the educational curriculum or the examination system may not have considerable influence on students regardless of humanities or natural science.

On the other hand, those who oppose the integrated process worry about a decrease in the overall level of education, insisting that the political integration of humanities and natural science would hinder Korea's efforts toward creative economic development based on mathematics and science, especially when many other countries are pursuing such development. Although they also agree with the theoretical necessity and importance of integrating liberal arts and natural science, they suggest that it may threaten the field of science and technology, especially because 70% of all high school students are focusing on humanities studies to avoid learning mathematics and science (see [3]).

Whenever the educational curriculum is organized, it causes confusion in the private education market as well as in the public education

environment, including elementary, middle and high schools, instead of providing a sustainable education policy by lacking consistency, thereby encouraging students to improve their advantages instead of studying. Such an idea motivates students to select those subjects advantageous to their test scores, even for just one more point, by combining subjects in a selective manner. This phenomenon not only influences the College Scholastic Ability Test but also changes the level and educational process of university education and increases the dropout rate among university students and changes in their majors.

3. A case analysis of learning ability in Calculus

For example, according to the results for a university located in the capital area and investigating a distribution chart of subject selection in the College Scholastic Ability Test of students pursuing natural science and computer engineering for the last three years, 48.1% of all students selected mathematics for humanities course and then entered natural science department[1] and computer engineering department[2] <Table 3>. In addition, 42.8% of all students in natural science and 63.5% in computer engineering selected mathematics for humanities course. According to the university's admissions criteria, it implemented a cross-application system in which students selecting mathematics for humanities course may apply to natural science and computer engineering departments while giving additional points for selecting mathematics for natural science course.

	math for natural science course		math for humanities course	
2012	math Ga-type	45.6 %	math Na-type	54.4 %
2013	math Ga-type	56.6 %	math Na-type	43.4 %
2014	math B	53.4 %	math A	46.6 %

TABLE 3. The current state of math-type in the College Scholastic Ability Test of students in the department of natural sciences and engineering

In the 2012 College Scholastic Ability Test, questions in Calculus and statistics were added to math Na-type, which was the subject most students in humanities course applied for, which extended the range of

[1]270 students
[2]90 students

questions. More specifically, the 6th National Curriculum focused on mathematics and problem-solving ability, but Mathematics I in the 7th National Curriculum emphasized students' interest in mathematics, confidence, and positive values. Accordingly, under the 6th National Curriculum, humanities students learned about basic calculus and probability and statistics, but the 7th National Curriculum changed those subjects such that Calculus, probability and statistics, and discrete mathematics were selective subjects only for natural science students, which forced business administration and economics students who had to study mathematics to attend outside learning center for mathematics. In addition, because some students in natural science course could apply to the college of natural science even when selecting mathematics for humanities course, which is typically easier than other subjects in the College Scholastic Ability Test, they did not even know the symbols of Calculus. Therefore, the 2007 revised Curriculum was reorganized and implemented in 2009 to make 'basic calculus and statistics' as a selective subject for humanities course. Accordingly, questions on Calculus and statistics were first presented in math Na-type for humanities students in the 2012 College Scholastic Ability Test, and all students who entered university in 2012 studied Calculus in high school.

The following table <Table 4> compares academic results for Calculus 1 for students of natural science and computer engineering departments, between group of students selecting mathematics for natural science course and group of students selecting it for humanities course in the College Scholastic Ability Test. Students selecting mathematics for natural science course were inversely proportional, focusing on grades 'A' and 'B' whereas those selecting it for humanities course focused on 'B' and 'C'. That is, it is shown that the result of students who selected mathematics for humanities course was relatively lower than that of students who selected mathematics for natural science course. This may be because mathematics for humanities course was a subject for students wishing to pursue humanities, business administration, and social studies and they selected only Mathematics I and basic calculus instead of Mathematics II. As a result, students seldom learned Calculus in high school, which is a useful foundation for social studies and natural science, and they had to study Calculus at a higher level with students in natural science and engineering. The concept of Calculus requires a substantial amount of basic knowledge, unlike in the case of

probability and statistics. Accordingly, students not selecting Calculus in high school or selecting mathematics for humanities course may have difficulty completing college-level Calculus (see [2]).

	Calculus 1					
	group of natural science course			group of humanities course		
	2012	2013	2014	2012	2013	2014
grade A	29.51	31.40	27.17	6.56	5.81	3.26
grade B	19.67	30.23	28.26	11.48	13.95	10.87
grade C	9.84	4.65	6.52	9.84	16.28	16.30
grade D	3.28	0.0	0.0	6.56	6.98	3.26
grade F	0.0	1.22	0.0	3.28	2.33	4.35

TABLE 4. The current state of academic results for Calculus 1 (unit : %)

The following table <Table 5> is a comparing academic results for Calculus 2 for students selecting different types of mathematics in the College Scholastic Ability Test, also, between group of students selecting mathematics for natural science course and group of students selecting it for humanities course in the College Scholastic Ability Test. As in the table for Calculus 1, students selecting mathematics for natural science course are focus on grades 'A' and 'B', whereas those selecting it for humanities course focus on grades 'B' and 'C'. Those students selecting mathematics for humanities course were outnumbered by those selecting it for natural science course.

	Calculus 2					
	group of natural science course			group of humanities course		
	2012	2013	2014	2012	2013	2014
grade A	30.26	27.96	15.24	3.57	3.23	4.37
grade B	19.64	29.03	28.67	7.14	6,35	11.74
grade C	5.36	10.75	15.33	23.21	11.83	9.32
grade D	5.36	3.23	5.41	1.79	4.30	7.74
grade F	0.0	1.08	0.0	3.57	2.15	2.11

TABLE 5. The current state of academic results for Calculus 2 (unit : %)

These results suggest that if prerequisite subjects in mathematics for humanities course are Mathematics I and basic calculus, then the current entrance examination system in which students can cross-apply to the college of natural science or engineering may make the reorganization of the college mathematics education process and the teaching and learning process relevant to Mathematics I in high school inevitable.

4. Conclusions and suggestions

This study presents a case in which 48.1% of all students who entered the college of natural science and computer engineering completed Mathematics I and the basic calculus(which are for students pursuing humanities, social studies, and business administration). This study also provides a case in which academic results for students cross-applying to natural science and computer engineering colleges were low. Most universities currently have lectures on Calculus. However, the level of such lectures generally targets students in the mathematics department or the college of natural science or engineering, causing some difficulty for students in humanities, business administration, and social studies.

The results have important practical implications. There is an urgent need to offer basic mathematics to students in humanities, business administration, and social studies. Universities should offer pre-calculus for students with no Calculus in high school. Concepts in Calculus form an important foundation in natural science and engineering and are critical to understanding and analysing social phenomena. Accordingly, basic knowledge of Calculus is inevitable concept for all educated people who learn in the university. From the perspective of Korea's position in the next few decades, this situation may be a serious problem that should not be ignored. Given that Korea's neglect of philosophy since three decades has led to various social problems today, the right combination of basic education is expected to lead to robust university education for a better educational climate at the national level. During this process, all university members should consider the necessity of mathematics education for the so-called 'humanities students'. It is time to address this issue from a political perspective to foster a social environment in which no student enter good universities while avoiding mathematics or not sufficiently learning it.

As mentioned earlier, unlike in the case of discrete mathematics or probability and statistics, the concepts of Calculus require a substantial amount of basic knowledge. Therefore, it is necessary to offer a prerequisite subject for students who do not select Calculus in high school or who select mathematics for humanities course and thus do not sufficiently learn mathematics but still enter natural science and computer engineering colleges, that is, cross-applying students.

In addition, offering basic mathematics subjects that can be learned by students with diverse majors, such as 'the World of Mathematics' and 'Mathematics in Daily Life', is expected to enable students to better understand the practical applicability of mathematics in real-world settings and cultivate new ways of thinking, thereby going beyond the simple idea that mathematics is just a calculation. From this perspective, various practical curricula based on mathematics can be developed (e.g., 'Financial Economy and Mathematics', 'Mathematics for Home Economics', 'Mathematics for Biotechnology', 'Mathematics for Humanities', 'Mathematics for Business Administration', and 'the World of Cryptology').

Future research should find ways to foster an educational climate in which students perceive mathematics as something enjoyable and useful, not a burden.

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