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AN ANALYSIS OF KOREAN STUDENTS' RESULTS IN PISA'2012

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The paper considers Korean PISA' 2012 results via the Korean educational system in Mathematics. It contains an analysis of PISA scores, Korean students' general methods of studying Mathematics, Korean school system, timetable of Korean high schools, teaching styles of public school Math teachers in Korea, private education in Korea, necessary changes in Korean Mathematics education, explanation of the Math scores importance in Korea, some changes in Korea's education policy together with the Korean Government – Ministry of education's effort in improvement of the educational system and some conclusions.

Introduction. In 2012 PISA, Korean students achieved excellent scores. Among the 34 participating OECD countries, Korea was the first in Mathematics, $1\sim2^{\text{nd}}$ in Reading and $2\sim4^{\text{th}}$ in Science. This result can be seen as extremely high grades. A comparison of all participating nations' grades reveals that Korea follows Shanghai-China, Singapore, Hong Kong-China, and Taiwan as 5^{th} in Mathematics. Furthermore, the changes along the PISA research period illustrate that Korea has been consistently maintaining good grades. This article will concentrate on Korean students' mathematical ability for extensive analysis. A notable point is that most Koreans surveyed and interviewed for the sake of this article did not offer positive comments regarding the strengths of Korean Mathematics education system. However, unlike the perspectives of most Koreans, many foreign nations seem to be curious about how Korean students can constantly receive high PISA results. Actually, this article began from that very curiosity. The questions below are the origins of this article.

1. How were Korean students able to receive high scores in PISA, especially in the Mathematics area?
2. What influences did the originalities of Korea's Math education have on the PISA results?
3. What are the worries that Korean students and educators have regarding Korea's Mathematics education?

Unfortunately, this article does not start from the vague hope that Korea's distinct education method has led to good PISA results. On the other hand, it analyzes official statistics presented by the Korean government as well as the interviews with various people including but not limited to students, teachers, and educators in order to objectively view the status quo and review the possibility of development Korean Mathematics education can bring.

1. Analysis of PISA Scores. The first step would be analyzing the PISA results of Korean students. As mentioned in the introduction, Korean students attained high scores in areas of Mathematics and reading. The rankings were similar to those of 2009 results. Korea has been maintaining one of the highest levels in terms of achievement since the study in 2006. The following shows the scores Korean students received each year.

Recent PISA rankings of Korean students
(Source: Korean Institute for Curriculum and Evaluation press release)

Research Period (Number of Participating Nations)			PISA 2000 (41)	PISA 2003 (40)	PISA 2006 (57)	PISA 2009 (75)	PISA 2012 (65)
Math	Average		547	542	547	546	554
	Rank	OECD	2	2	1∼2	1∼2	1
		All	3	3	1∼4	3∼6	3∼5
Reading	Average		525	534	556	539	536
	Rank	OECD	6	2	1	1∼2	1∼2
		All	7	2	1	2∼4	3∼5
Science	Average		552	538	522	538	538
	Rank	OECD	1	3	5∼9	2∼4	2∼4
		All	1	4	7∼113	4∼7	5∼8

The Korean government analyzes the reasons for Korean students' high PISA scores as below. The Korean government has been considering consistently promoting education policies accommodated for the passage of time as its goal. It also has been procuring a pool of skilled teachers through policies to improve the quality of school courses. It views the PISA results as the corollaries of these measures. Specifically, the reasons are:

1) The introduction and implementation of academic achievement evaluation policies

2) The invigoration of participation in education activities outside regular curricula

3) The improvement of curricula and teaching methods for the benefit of female students

4) The implementations of policies to strengthen science education

In fact, since 2009 PISA, Korea's Ministry of education has been striving to raise talented people evenly possessing creativity and an upright personality. The results have influenced the 2012 PISA results positively. However, high Mathematics scores are just one side of a coin. Although Korean students received high Math scores, many of them are not interested in Mathematics and do not believe math will be useful in their later

lives. Their confidences in their Mathematics abilities are especially low. According to studies, their self-efficiency and their self-conception are among the lowest. This result sharply contrasted with the fact that the students of most OECD nations whose average Math scores ranked 10^{th} or higher had average or higher self-efficiency and self-conception. In other words, even though Math scores of Korean students are high, many Korean students receive much stress from Math, are not likely to pursue a career in relation to the area, and do not feel happy when studying the subject. Still, the same students who are greatly stressed about Mathematics study Math outside regular classes and participate in Math competitions, leading to high participation rates in Mathematics pertinent activities.

Definitive indexes in studying mathematics – PISA 2012
Each index is standard scores (average 0, standard deviation 1)
High index indicates high anxiety in math.
(Source: Korean Institute for Curriculum and Evaluation)

Classification		Republic of Korea			OECD Average		
		All	Male Students	Female Students	All	Male Students	Female Students
Academic Motivation	Internal Motivation	−0.20	−0.12	−0.30	0.00	0.10	−0.11
	Instrumental Motivation	−0.39	−0.31	−0.48	0.00	0.09	−0.10
Self-Conviction	Self-Efficiency	−0.36	−0.22	−0.52	0.00	0.17	−0.16
	Self-Conception	−0.38	−0.25	−0.54	0.00	0.17	−0.17
	Math-related Anxiety	0.31	0.20	0.42	0.00	−0.15	0.14
	Participation in Math Activities	0.17	0.28	0.05	0.00	0.13	−0.13
	Plans to Study Mathematics	−0.21	−0.16	−0.28	0.00	0.17	−0.16
	Perception of Mathematics of Important People	−0.21	−0.13	−0.29	0.00	0.06	−0.06

What is the background of such a twofold situation? To understand the answer, there is a need to take a look at Korea's Math education.

2. Korean Students' General Methods of Studying Mathematics.

A. Korea's School System. The following shows the average time Korean students spend studying at school. Refer to the Korea's school education table shown below for better understanding.

<table>
<tr><td>School level</td><td>Age</td><td colspan="3">School Year</td></tr>
<tr><td rowspan="4">Graduate school</td><td>25</td><td rowspan="2" colspan="2">Doctoral</td><td>Doctoral</td></tr>
<tr><td>24</td><td rowspan="2">Master/MBA</td></tr>
<tr><td>23</td><td rowspan="2" colspan="2">Master/MBA</td></tr>
<tr><td>22</td><td rowspan="4">University/College</td></tr>
<tr><td rowspan="4">University/College</td><td>21</td><td rowspan="4" colspan="2">University/College</td></tr>
<tr><td>20</td></tr>
<tr><td>19</td></tr>
<tr><td>18</td><td rowspan="2">High School
(10∼12)</td></tr>
<tr><td rowspan="7">Secondary School</td><td>17</td><td rowspan="4">High School
(9–12)</td><td rowspan="4">High School
(9–12)</td></tr>
<tr><td>16</td></tr>
<tr><td>15</td><td rowspan="2">Middle
School(7–9)</td></tr>
<tr><td>14</td></tr>
<tr><td>13</td><td rowspan="3">Middle
School(6–8)</td><td rowspan="6">Elementary
School(1–8)</td><td rowspan="5">Elementary
School(1–6)</td></tr>
<tr><td>12</td></tr>
<tr><td>11</td></tr>
<tr><td rowspan="5">Primary School</td><td>10</td><td rowspan="5">Elementary
School(1–5)</td></tr>
<tr><td>9</td></tr>
<tr><td>8</td></tr>
<tr><td>7</td></tr>
<tr><td>6</td><td rowspan="2">Kindergarten
Pre-school</td></tr>
<tr><td rowspan="2">Pre-school</td><td>5</td><td>Kindergarten</td><td>Kindergarten</td></tr>
<tr><td>4</td><td>Pre-school</td><td>Pre-school</td></tr>
<tr><td colspan="2">System</td><td>5–3–4 System</td><td>6–6 System</td><td>6–3–3 System</td></tr>
<tr><td colspan="2">Countries</td><td colspan="2">America</td><td>Korea</td></tr>
</table>

In Korea, students aged 7–12 attend elementary school, students aged 13–15 attend middle school, and students aged 16–18 attend high school. All school years start in March. Students attend college for two years and university for four years. The time needed to acquire Doctoral/Master degree is about 1–2 years. Korea's school system follows the 6–3–3 system while Bulgaria's school system follows the 4–4–4 system. Moreover, new school years begin in March, and high schools are divided into liberal arts and natural science. The following table shows the Math courses that Korean middle school students, who are the actual subjects of PISA, learn at school.

Data for math course of Korean middle school students

School Level	Middle School		
Grade Domain	1st grade	2nd grade	3rd grade
Number and Operation	set Prime factorization Greatest Common Factor, Least Common multiple Decimal System and Binary System Concept, operation and order relation for integer, Concept, operation and order relation for rational number	Meaning of circulating decimals Relation between circulating decimals and rational number Approximation and error Expression methods for approximation	Meaning of Square root Meaning of irrational number Order relation of real number Operation of expression
Equation and Expression	Use of letter Value of expression Addition and subtraction of first order Expression First order equation Properties of equation	Addition and subtraction of second order Expression Exponential Law Product formula for a polynomial expression Division of polynomial expression Modification of equation First order equation with 2 unknown quantity Simultaneous first order equation Value and properties of inequality First order inequality Simultaneous first order inequality	Factorization of polynomial expression Second order equation Application of second order equation
Function	Concept of Function Ordered pair and coordinate Application of function	Meaning and graph of linear function Relation between linear function and first order equation Application of linear function	Meaning of quadratic function Properties of graph of quadratic function

Probability and statistics	Frequency table, histogram, frequency polygon Average in the frequency table Relative frequency distribution and cumulative frequency distribution	Number of cases Meaning and properties of probability Calculation of probability	Mean, mode, median Variation, standard deviation
Geometry	dot, line, face, angle Relation between dot, line and face Properties of parallel line Simple construction SSS,SAS, ASA, Properties of polygon, interior angle and exterior angle Relation between central angle of fanlike shape and arc Area of fanlike shape and length of arc Location relation between circle and line, 2 circles	Meaning of proposition and proof Properties of triangle and square Similarity of figure Properties of similar figures Similarity condition for triangle Ratio between two segment in parallel line Double point theorem in triangle Area and volume of similar figures	Pythagorean Theorem Triangle ratio Properties of chord and tangent line in circle Properties of the angle at the circumference Properties of inscribed square Properties of circle and Proportion

Based on this table, Korean education system intends to cultivate skills in all areas. Unlike the curriculum which teaches each domain of Math separately, such as in the order of Algebra, Geometry, Pre-calculus, Calculus, and then Differential Equations, Korean Math education hopes to have students learn all areas together little by little so that they can use integrate all areas naturally. This method helps students solve problems more efficiently when learning a new area in any domain. In other words, it can be said that the blueprint of mathematical curricula is well designed. This can be confirmed by the 2012 PISA results in Mathematics, which show that Korean students performed well in the areas such as 'space and shape' and 'formalizing,' which require relatively more mathematical sense than other areas. These points can be said to be some of the factors leading to Korean students' high Math scores.

B. Timetable of Korean High Schools. The next point to observe is how much portion Mathematics takes in an average Korean high school timetable. Generally, middle schools and high schools hold 4 hours of Mathematics courses a week. The following timetable is the timetable for 10^{th} graders of high schools that do not separate natural science course and liberal arts course.

Schools are given certain amounts of time they can use to hold discretion classes. Schools can assign these periods the appropriate courses on their discretion. In the timetable shown above, the discretion classes have been assigned as Mathematics courses

10^{th} grade timetable of public school in Seoul

Time table	Monday	Tuesday	Wednesday	Thursday	Friday
1	History	English	**Math**	P.E	Korean
2	**Math**	Home Economics	Religion	English	Social Studies
3	Science	Science	English	**Math**	History
4	Korean	English	Technology	Music	English
5	Social Studies	**Math**	History	Career	Science
6	P.E	Korean	Korean	Career	Art
7	Science	Social Studies	Religion	Autonomy	**Math**

and English courses. The third period of Thursday is one of these periods. Some other schools use these hours for Korean courses, P.E courses or art courses. Furthermore, there are 'after school activities' held after 7^{th} period. These classes are selective. Among the held classes, students generally choose Korean, English and Math, which are the subjects most directly related to the College Scholastic Ability Test. Usually, the Math class is the one with the most students. The timetable changes into one of the following timetables when students become 11^{th} graders, the year in which schools begin to divide natural science courses and liberal arts courses. In liberal arts courses, there are three hours of Calculus and Statistics and an hour of Math course held on discretion each week, which amounts to four hours of math a week.

Liberal arts Time table

Time table	Monday	Tuesday	Wednesday	Thursday	Friday
1	Calculus and basis of statistics	English	Literature	Discretion Math	Literature
2	English	Economics	Calculus and basis of statistics	Literature	Economics
3	English	Literature	Chinese Character	Calculus and basis of statistics	Social Studies
4	Literature	P.E	Speaking	Reading	English
5	Career	Calculus and basis of statistics	English	Religion	Chinese Character
6	P.E	Social Studies	Economics	Autonomy	Korean
7	Social Studies	Reading	Religion	Career	P.E

Natural Science time table

Time table	Monday	Tuesday	Wednesday	Thursday	Friday
1	Science	Biology	Literature	English	Reading
2	P.E	Math	Religion	Literature	Science
3	Literature	Reading	English	Career	Math
4	Math	Geometry and Vector	P.E	Earth Science	Literature
5	Earth Science	Chemistry	Math	Biology	Literature
6	English	English	Science	Autonomy	Chemistry
7	Geometry and Vector	English	Religion	Career	Health

Natural Science courses hold four hours of Math as well as two hours of Geometry and Vector each week, which amounts to six hours of Math every week. As we can see in the timetables, most schools imbue Math and English courses with great importance. Furthermore, many schools in Korea use an education method known as the divided class system. The divided class system is controversial. People who agree with this system assert that by running this system, teachers can provide the appropriate level of education for their students. On the other hand, people who disagree argue that this system's advantage is limited to only a certain number of students. In fact, it is hard to expect students in middle and low level classes to have positive attitude. These students often collide with their teachers, preventing efficient procession. This could be said to be a side effect of the divided class system that is different from its original purpose.

C. Teaching Styles of Public School Math Teachers. Generally, classes are based on two different kinds of textbooks – the book containing basic concepts and the book containing practice problems. The objectives of each chapter are set beforehand and announced at the start of each chapter, but teachers mostly do not pay attention to these goals. They decide how to lead the class and which teaching aids to use. Usually, official courses use standard textbooks. Furthermore, there are discretion Math hours in which teachers do not use a previously decided textbook but rather use the books made by Math teachers in their own schools.

In the case of midterm and final exams, teachers announce the test range at the beginning of each semester and teach the test material using the textbooks. However, in the case of afterschool classes, all aspects of the courses are up to the teachers, so they are free to teach a specific part of Mathematics, provide make-up courses for middle school materials, et cetera. Since teachers are the ones who decide on their teaching methods, they can choose to investigate the textbooks or make their teaching aids in their free time. These teaching aids made by teachers are sometimes shared on the Internet for free. Teachers can also choose to buy books made by academies from website where they have to pay. Most teachers prefer to make their own teaching aids that suit their teaching styles.

D. Private Education in Korea. Private education at institutes cannot be omitted when discussing Korean Math education. Students go to private institutes after 6 pm

when public schools end. Different institutes have different class hours, but most of them hold five days of courses, teaching for 1.5∼3 hours on each day with ten minutes of break time in between. When the exam period approaches, many institutes hold classes only on Saturdays with the classes being mostly two hours of supplementary sessions. One public school teacher who was interviewed during the process of writing this article analyzed the reasons Korean students go to private academies. "At school, students find it difficult to ask questions and concentrate in the class because they are overly conscious of their classmates. This is probably why they depend on private institutes. Almost 80% of the students rely on private institutes more than schools."

What would be the actual percentage and efficiency of Korea's private education?

It is difficult to define how to evaluate the efficiency of academic achievement, but under the assumption that time spent studying is usually proportional to academic achievement, it is hard to say that Korean students' Math scores are very satisfactory. Korea ranks first place in the whole world in terms of education expenses.

GDP to Public education Payment ratio(2010)									
Division	Total			Elementary/middle Education			High Education		
	Total	Government payment	Individual payment	Total	Government payment	Individual payment	Total	Government payment	Individual payment
Korea	7.6	4.8	2.8	4.2	3.4	0.9	2.6	0.7	1.9
OECD	6.3	5.4	0.9	4	3.7	0.3	1.7	1.1	0.5

*Source 2013 OECD Education at Glance

Private Education Expenses and Participation rate						
Division	Total Private education expenses (Trillion)		Monthly average private education expenses per student		Participation rate	
	2011	2012	2011	2012	2011	2012
Total	20.1	19	$222	$218	71.7%	69.4%
Elementary	9	7.7	$223	$202	84.6%	80.9%
Middle	6	6.1	$242	$255	71%	70.6%
High	5	5.1	$201	$207	51.6%	50.7%

*Source 2012 Survey for private education expenses

In 2012, Korea's total private education expenses were about 19 billion won while monthly average private education expenses per student were about 240,000 won. Rate of those involved in the private education market was almost 70%. Furthermore, when private education participation rate is considered, average private education expenses per student goes up to 340,000 won. According to 2013 OECD Education at Glance, Korea's ratio between GDP to public education expenses is 7.6%, a number far higher than the average of OECD countries' (6.3%). The portion that individuals pay is estimated to be 2.8%, a value 3 times higher than the OECD average (0.9%) and actually the highest.

These data indicate that people spend great amounts of education expenses, but the education infrastructure is not quite as good. If the private education expenses, which are omitted from the official statistics, are included, the amount of education expenses per person will be more than five times higher than the OECD average.

Students do not go to private institutes only for Math, but since this article is intended to analyze Mathematics studies, it will not discuss other subjects. Even a crude estimate shows that many of Korea's middle and high school students spend almost all day long studying. Unfortunately, although it may seem like they receive well structured public education and spend a large amount of time studying Mathematics, there are many Korean students who choose to give up on Math. We are left with a question. "Why?"

3. Necessity for Change in Korean Mathematics Education. A look at how Korean students consider Korea's Math education reveals the problems of Korean education and the direction it should follow. "Korea's evaluation system does not grant pass or fail from an objective standard. Rather, it ranks the students from first to last according to how well they do compared to each other, discouraging the overall improvement of all students. Thus, Korea's evaluation system should change to absolute evaluation from relative evaluation. I believe that the change will gradually occur. If being compared with others is the objective of studying, as soon as one person stops moving, everyone will stop moving. Instead, if the competition gets overly fierce, other problems come into the picture. Thus, relative evaluation is one of Korea's Math education." Firstly, there are not any factors that can help students become interested in Mathematics. Students mostly meet Math in uninteresting school textbooks, and only the students who are comparatively talented in Mathematics study Math more in depth at private institutes, studying for Olympiad and competitions. However, in the process, no one provides answers to questions such as "why do we need to study Math?" and "what else is there to gain from studying Mathematics except good grades?", and nothing actually helps students realize the answers. In addition, when students begin to fall behind in Math compared to their peers, there is no way to catch up except for private education."

"In our nation, the main way to have one's Math abilities recognized is winning awards at competitions. However, that process is a lonely one in which one has to struggle through by himself and get his individual abilities evaluated. Thus, except for the students who are exceptionally talented, it is hard to get a special motivation to study math, interest in math, or a goal pertinent to Mathematics."

"Many students stop trying because they do not realize why they have to solve these problems."

Likewise, Korean students find it hard to enjoy Math amid the harsh reality in which they are compared to others according to their Math abilities. They eventually consider Math as a subject they have to study so that they do not fall behind. It is indeed difficult to know why one has to study Math in the austerity of Korea's relative evaluation and lonely competitions. Then, in which direction should Math develop toward, according to the above students?

"Students would become interested in Mathematics and strive to develop their aptitude if they realize that Math is not a subject for individuals but an area they can collaborate in and exhibit their leadership through constant participation in Mathematics related activities and group projects. An environment in which students can realize

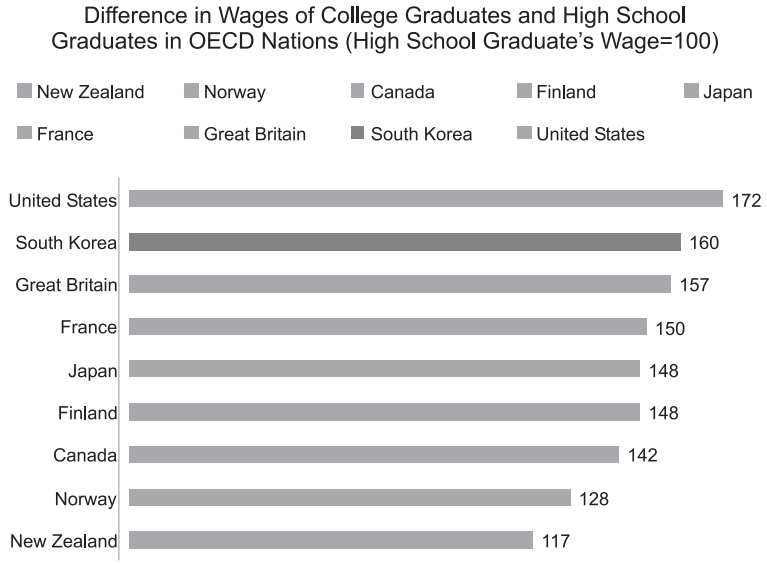
the applications of Mathematics without complaining, 'Where math can be used?' should be formed."

"For the development of Korea's Math education, there has to be ways to culminate internal motivation to study Mathematics. Instead of tests to foster a race against all other people, there has to be cooperation-oriented contests to promote interest in Mathematics and raise students' Math prowess as well as opportunities for students to investigate Math and realize that Math is not just a difficult subject in the process."

"For Korea's Mathematics to develop, the primary necessity is collaboration. Mathematics that students study for to reach a particular level, rather than Mathematics that students study for to win, would be able to edify students about the true meaning behind the study of math."

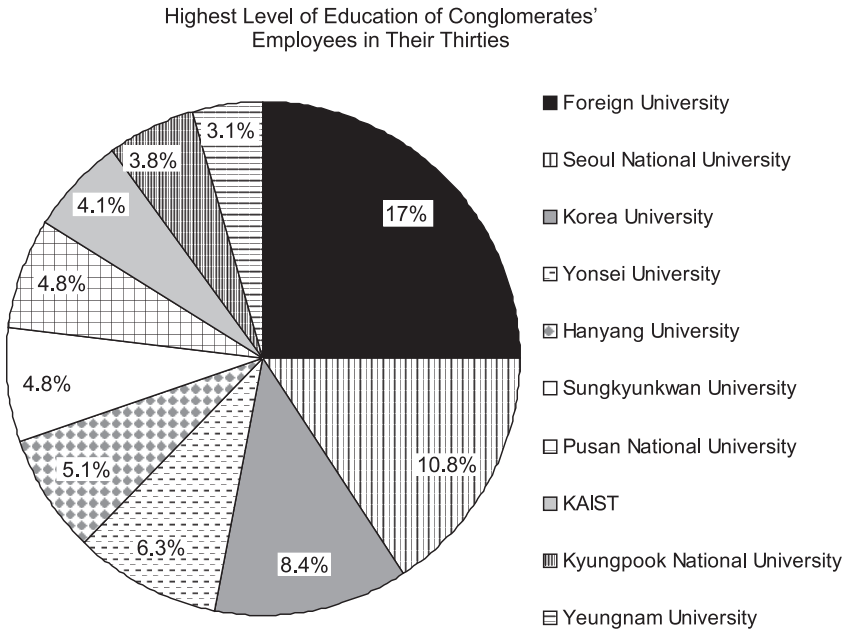
After knowing about these background stories, it is hard not to feel bad for the Korean students who do not feel interested in Math or find the subject too perplexing. Now, it is time to investigate why Korea's Mathematics became an onerous burden to Korean students instead of the subject they wanted it to be.

4. Why Math Scores are Important In Korea. The most certain answer lies in university admission. It is easy to note that the disparity of wage between college graduates and high school graduates is quite large. Even among college graduates, where one graduated from has a great influence on wage.



This data represents the highest level of education that employees in their thirties who work at conglomerates had received, as presented by a site for job searching and training. The percentage of such employees who graduated from foreign universities or the so-called SKY universities – Seoul National University, Korea University, and Yonsei University – amount to 62%.

Which students get admitted into SKY universities? In Korea, although the number of universities has increased, the quota has decreased, making it harder to get admitted



into prestigious universities. The most widely used data for estimating high school students' academic achievement level are the grades they receive on the College Scholastic Ability Test, which range from grade 1 to grade 9. The number of students who receive grade 1 is just 4% of the 700 000 students who take the test every year. The quota of SKY universities amount to about 1.5%. This means that receiving a grade 1 does not guarantee acceptance into SKY universities. In addition, there is another variable that affects the situation; it is the college entrance rate of students who hold themselves back one year after receiving dissatisfactory college admission results. As a result, high school students aim for colleges lower than those that their college entrance mock test scores indicate. To get accepted into universities one wants to go to in Korea, high scores in reading, Math, and English areas are essential. Especially since most students think of Math as difficult, one has an advantage when applying to universities that weighs math more than other universities if he has exceptionally high math grades. Moreover, all prestigious universities consider Math highly, so students have no choice but to study math.

5. Changes in Korea's Education Policy. Historically, studying has been crucial in Korea in order to overcome discrimination by their rank determined at birth. Also, after the Korean War, the government has fostered high fervor for education at a nationwide level in order to produce a large quantity of human resources to reestablish and lead the devastated nation. In the process, the ambience of fierce studying competition was formed. In addition, the widespread belief that universities are necessary in order to achieve success came into existence. In countries like Korea, where natural

resources are scarce, interest and investment in human resources is inevitable. These all suggest how much importance education assumes in Korea. Government policies that are closely related to education have changed dramatically over time. From an optimistic perspective, the Korean government has constantly strived to raise talented human resources. On the other hand, it has changed university administration policies way too often. Korea's College Scholastic Ability Test, which is similar to the United States' SAT, was first implemented in 1993. During the next 20 years, there has been 16 policy changes regarding the test, and the test will soon meet its 17th change. Korea's education evaluation standard has changed from the original achievement tests of the memorization era to the current period of College Scholastic Ability Test and essays – which require understanding, inference, and demonstration abilities – and school grades. Among school grades, a high math grade can greatly influence university administration.

Korea's college acceptance rate is 80% according to 2011 statistics. Korea ranks first place in terms of number of colleges per person as well as first place among OECD nations in terms of percentage of college graduates among people in their twenties or thirties. It has also ranked first in the whole world in terms of high school students' university acceptance rate for ten years. One fact to note is that the actual admission rate is falling every year because of the decrease in the teenage population, which correlates with the admission rate.

Korean students' university admission rate according to year

Year	University Admission Rate
1990	27.1%
2000	62%
2005	73.4%
2009	77.8%
2010	75.4%
2011	72.5%
2012	71.3%
2013	70.7%

Among Korean students born in 2002, who would become 6th graders in 2014, 430 000 are expected to graduate from high school six years later. If about 80% move on to college, there would be 350 000 college students among them. Assuming that the current quota of universities is 560 000, this would mean that Korean colleges have a loss of 200 000 potential students. Among other countries of similar economic scale, Korea is one of the few nations without a Nobel laureate in the basic science field. Korea's only Nobel laureate is Kim Dae-jung, the 8th President who received the Nobel Peace Prize. Korea has been drinking bitter cup of defeat in Nobel Prize for Literature. Another statistics reveal the actual successful graduation rate of students studying in the United States. Among Korean students accepted into prestigious American universities, the dropout rate is 44% (while the average dropout rate in the United States is 34%), which is greatly larger than the dropout rates of Jewish, Indian, and Chinese international students (12.5∼25%). With these points in mind, many Koreans do not consider 2012 PISA results as totally optimistic. If so, what are the Korean government and the

education world preparing regarding this reality, and what measures can change the high fervor for education into qualitative development of human resources? The efforts of the Korean government and the thoughts of the writers have been added to answer these questions.

6. The Korean Government – Ministry of Education's Effort. Most Koreans already know how uninteresting Korean students find studying to be as well as how hard it is to meet students who study to pursue their academic interest. The changes in education policies mentioned above have been based on diverse trial and error processes to break free from memorization-oriented education. The educational world has prepared "advanced Mathematics measures" which would foster interest in Mathematics and promote motivation to study through the so-called "storytelling Mathematics" and "integrated curriculum Mathematics" that would meet the original purpose of Mathematics – improving thinking abilities – so that students would not grow up to be mere mechanical problem-solvers. Integrated curriculum Mathematics strives to make students find and understand the mathematical concepts and principles hidden in textbooks while raising thinking abilities and accentuating how math is useful in everyday life. It is intended to show how math can be used in music, art, and everyday life to emphasize the close relationship between academic studies and lives. Storytelling Mathematics textbooks are self-directed learning materials that present textbook math concepts in a storytelling manner. The biggest trait of these textbooks is that they offer problem approaching methods that help widen thinking abilities. Students can learn to solve problems of varying difficulties creatively through the three steps of "understanding the problem," "creating a strategy," and "finding the answer." Also, the provided video lecture, which is intertwined with the learning content, helps to improve mathematical thinking abilities and self-directed learning abilities as well as to overcome anxieties regarding math.

In 2009, a creative 3rd grade problem was introduced in the College Scholastic Ability Test. It was a path-finding problem that involved a circle unlike previous path-finding problems, which composed of straight lines. The problem surprised many test takers. When a similar version was uploaded into a third-grade textbook, it became a hot issue. The problem could actually be solved by third graders with a slight change of conception.

College Scholastic Ability Test Type 'B' Question 25
25. There are trails inside a rectangular grass field. These trails are composed of eight circles of the same radius that are tangent to each other in a 2*4 arrangement. Staring from Point A, find the number of shortest ways to reach Point B at the other side of the field along the trail. (The marked points indicate tangential points between either two circles or a circle and the rectangle.)
Creative Textbook Soma Elementary 3rd Grade Math Textbook Question
Find the number of shortest paths an ant can walk along to reach the strawberry cake, and discuss the solution. (A picture shows nine circles that are tangent to each other in a 3*3 arrangement, and an ant and a strawberry cake are located on opposite vertices.)

Also, the education world introduced STEAM, which aims to raise well-rounded talented students who can find the optimal solutions to numerous conundrums that might occur in the future.

<table>
<tr><td colspan="5">Actual STEAM Implementation Instances</td></tr>
<tr><td colspan="5">Interesting Plant Stories</td></tr>
<tr><td rowspan="2">Research Institute</td><td rowspan="2">Chungbuk Wonbong Elementary School</td><td rowspan="2">Course Outline</td><td colspan="2">Class type
Subject integrated type (science, engineering, mathematics)</td></tr>
<tr><td>Trial
10^{th} trial</td><td>Subject
5^{th} graders</td></tr>
<tr><td>Main Content</td><td colspan="4">On the topic of “interesting plant stories,” connected elements of math and engineering within science textbooks to observe water relocation within stems, extract pigmentation of leaves using chromatography, and observe pollen, done in the manner of storytelling about traveling within a plant</td></tr>
<tr><td>STEAM Elements</td><td colspan="4">Science (knowing plant’s structures and functions) + Engineering (creating models of phyllotaxis) + Mathematics (Finding patterns of phyllotaxis, Fibonacci sequence)</td></tr>
<tr><td colspan="5">Using Self-Made Scales to Measure Weights</td></tr>
<tr><td rowspan="2">Research Institute</td><td rowspan="2">Daejeon Yongsan Elementary School</td><td rowspan="2">Course Outline</td><td colspan="2">Class type
Subject + creative experiential activity type</td></tr>
<tr><td>Trial
11^{th} trial</td><td>Subject
4^{th} graders</td></tr>
<tr><td>Main Content</td><td colspan="4">On the topic of “using self-made scales to measure weights,” tried to have students understand the properties of scales and designed, created simple scales with beautiful colors using complementary and contrasting colors</td></tr>
<tr><td>STEAM Elements</td><td colspan="4">Science (Understanding weight, equilibrium, and properties of scales) + Art (Complementary and contrasting colors) + Mathematics (Understanding fractions and proper fractions) + Creative Experiential Activity (Visiting Korea Research Institute of Standards and Science site: standard experience)</td></tr>
</table>

The Korean government is making efforts to help Korean students recognize Math as a subject needed in reality rather than an uninteresting subject, and it is trying to find the fundamental approach to enhance Korean students' mathematical creativity within promoting motivation. Look at the example below. This data has been gathered from Korean students with high scores on the AMC, which has been offered in Korea since 2006.

The statistics show the 2011 AIME scores and 2012 AIME scores of ten randomly selected students who took the AIME for two consecutive years in their 9^{th} and 10^{th} grade. The strange trait of Korean students taking the AMC is that students with relatively greater Math abilities exhibit a clear drop in math scores after their 9^{th} grade year while there is no notable change in the score distribution according to age. The most basic reason behind this phenomenon lies in motivation to study Mathematics. Korean students who are good in Mathematics often have many chances to participate in competitions and study math intensively before their 9^{th} grade. After they become 10^{th} graders, many students study Math because it is mandatory, not because they are

AIME scores of students who took AIME for two consecutive years in their $9 \sim 10^{\text{th}}$ grades

	2011 AIME Score / 9^{th} grade	2012 AIME Score / 10^{th} grade
1	50 Points	20 Points
2	80 Points	40 Points
3	90 Points	50 Points
4	40 Points	0 Points
5	70 Points	60 Points
6	**40 Points**	**70 Points**
7	**40 Points**	**60 Points**
8	**60 Points**	**70 Points**
9	80 Points	20 Points
10	**70 Points**	**100 Points**
Average	62 Points	49 Points

interested in it. The statistics show the results of declining Math abilities after 9^{th} grade or age 15. 2012 PISA results do not show the statistics of students older than 15. If PISA is extended to students of age eighteen or younger, the high scores of Korean students cannot be guaranteed to appear. AMC scores were used to show the result of education without motivation.

Conclusion. The most fundamental and yet the most difficult approach yet remains. It is "How to motivate students to study." Korean students' PISA results to this day show that there are actually more than enough reasons Korean students can motivate themselves to study, including the cultural background. If they can recognize these reasons and gain creative thinking abilities, the future of Korean education will be optimistic.

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АНАЛИЗ НА РЕЗУЛТАТИТЕ НА КОРЕЙСКИТЕ УЧЕНИЦИ ОТ PISA' 2012

Патрик Юу, Инси Парк, Едуард Чанг, Дахий Чънг

В статията се разглеждат корейските резултати от PISA' 2012 от гледна точка на Корейската образователна система по математика. Тя съдържа анализ на точкуванията от PISA, общите методи за изучаване на математика от корейските ученици, Корейската училищна система, разпределение на часовете в горен курс на корейските училища, стила на преподаване на учителите по математика в държавните училища на Корея, частното образование в Корея, необходимите промени в корейското образование по математика, обяснение за важността на оценяването по математика в Корея, някои промени в корейската образователна политика заедно с усилията на корейското правителство и Министерството на образованието на Корея за подобряване на образователната система, както и някои изводи.