

South Korea: A Success Story in Mathematics Education

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Introduction

South Korea has experienced enormous economic growth over the last 50 years and now has the 13th largest economy in the world (World Bank, 2012). During the period 1961–2011, per capita gross domestic product increased from \$155 to \$22,424. Much of South Korea's economic development has been attributed to improvements in its public education system. South Korean students consistently perform in the top rankings among countries according to international studies such as Trends in International Mathematics and Science Study (TIMSS), and the Program for International Student Assessment (PISA, 2010).

This article summarizes some of the highlights of the author's learning experiences during her recent trip to South Korea. The author attended The 12th International Congress of Mathematical Education (ICME12) held July 8-15, 2012, in Seoul, South Korea. She visited the Department of Education at Ewha Womans University in Seoul, a highly rated female educational institute in South Korea. There, she met with Noh Sun-Sook, Dean of the College of Education, and discussed the teacher-preparation programs for elementary, secondary, and special education teaching.

The author's experiences led her to the conclusion that the principal factors responsible for Korea's success in education included equity in educational opportunity for all students regardless of their socioeconomic background and extremely active parental involvement. There is high academic rigor in Korean teacher-training programs followed by continuous teacher support and professional development and a research-based pedagogy that utilizes the best teaching practices. However, the intensity of the education including after-school programs referred to as "*hagwons*" has pitfalls as it leaves little time for personal life outside of school for students or teachers.

This article is based on readings, classroom visits, and interviews with Korean public school teachers, and the national presentation on Korean education system during ICME12. In this article, the author shares her experiences and presents the mathematics content of the primary and secondary schools of the most recent curriculum revision that will be implemented in 2013.

Korea's Primary and Secondary Education System

Public School Education

The overwhelming majority of Korean students attend public primary and secondary schools with publically supported education beginning at ages 6 or 7. The Korean school year includes 2 semesters. The first semester starts in early March and extends to mid-July and second semester runs from late August to mid-February. Class periods are typically 45 minutes in length followed by a 10 minute break. At least 4 lesson periods per week are designated to mathematics instruction. Education is compulsory through the 9th grade and is fully funded by the government. Students who do not perform at their grade level will not have to repeat a grade and they will not be transferred to other schools because of deficiencies. Teachers work with them as much as possible to ensure that these students will move up with their classmates.

Students have to apply for their high schools. Better students will be admitted to gifted high schools while some will go to vocational schools. Statistics from the 2010 PISA study showed that "Korea is one of the top performers in terms of the proportion of successful school leavers with 94% obtaining a high school diploma." (Organization for Economic Cooperation and Development [OECD], 2011). All 6th, 9th, and 11th grade Korean students take a national test each year and the results of these national tests are used for evaluating the performance of schools. Schools that show deficiencies receive additional support and training from the government.

After-School Programs and Education Fever

Many experts believe that much of Korea's economic growth can in part be attributed to its education system. Korean parents are considered as the major driver of Korean's economic growth through their continual support of education programs and efforts for educating their children. Korea is well known for its after-school programs called "*hagwon*," which extend the school day. A majority of students engage in these after-school programs for several hours and some through midnight. Due to the high costs of private tutoring, the government created

affordable after-school programs at the public schools using public school teachers. These programs run for a minimum of 2 hours per day for elementary school students and more hours for the middle and high school students. Despite this effort, many parents are still not satisfied with their children's achievements because of the stiff competition associated with university entrance examinations.

The biggest challenge in the secondary mathematics education is getting students ready for the university entry exam, which is called the College Scholastic Ability Test (CSAT). A large portion of many family budgets is spent on providing private tutoring for the children in preparation for the CSAT. More recently, Korea has been experiencing an increase in teenage suicides and violence among students. Korean officials believe that these problems are the side effects of the phenomena referred to as "Education Fever." The government is taking steps to cool down the education fever a bit. Recently, the government imposed a curfew of 10 pm for *hagwons*, but as one teacher I interviewed revealed, "[The curfew] is only on paper." Many students even buy online lessons for after school and after *hagwon* hours at home.

Teacher Preparation and Professional Development

Teacher Training

Admission to Korean teacher-training programs is highly competitive. The Korean Ministry of Education, Science, and Technology (MEST) reported that only the top 5% of high school graduates were accepted in the university education programs (MEST, 2010). All teachers, including part-time teachers, must complete a teacher certificate training program at a nationally accredited institution with a grade average of at least 75%. Quotas are set by MEST for student admissions to teacher training institutions based on the national demand for teachers. In spite of this, the total MEST quotas have not been changed for several years, which has led to an oversupply of teachers.

Teacher-training institutions set the curricula for secondary school teacher preparation. Typically, a total of 130–150 credit hours are needed by students in teacher certificate training program. The program requirements vary by institution. For example, the College of Education of Ehwa Womans University requires a total of 135 credit hours, which includes a minimum of 51 credit hours of content in a student's major and 14 credit hours in teaching pedagogy and methodology.

At the end of their university-training program, new teachers seeking employment in public schools must take the Teacher Employment Test (TET) (Kwon & Ju, 2012). Teacher vacancies in public schools are filled by students with the highest scores. Private schools have their own procedures for teacher

selection that vary by institution. The TET for mathematics teachers consists of three areas: general education, mathematics education, and mathematics content knowledge. The TET is given in three stages including a written test, an essay, and a teaching demonstration and interview. Only 4.4% and 4.1% of the students taking the TET were hired as public school teachers in 2010 and 2011, respectively. This illustrates the intense competition and rigor required in the Korean teaching profession. Students, who initially do not do well enough on the TET to obtain employment, either continue with their studies (often in *hagwons*) to retake the test the following year or alternatively, enroll in a graduate program.

Teacher Interviews and Experiences

In part, going back to its Confucian heritage, teachers have always been highly regarded in Korean culture and school teachers are respected professionals in Korean society. The teaching profession is a highly sought-after career path because teachers are relatively well paid, have excellent job security and pension benefits, and have more flexibility in work hours leave time. Generally, women are paid less than men for the same job in Korea. However, in education female and male teachers are paid the same making this profession attractive for women.

Most teachers are required to do administrative work and engage in after-school programs. This is a major drawback for teachers. In my interviews of 16 teachers in Korea, when asked if they would opt for a teaching career again if given the opportunity to start over, only 3 of 16 responded favorably. This group included the two master teachers who responded positively. The other 13 teachers who professed dissatisfaction with their teaching careers complained about administrative workloads, the large classes (they cited an average 40 students; there were 36 in the two classes I observed) and work in after-school programs that was expected of them. Some teachers explained that they had to work as long as 15 hours daily, leaving little time for a personal life. While this group represented only a small and admittedly nonrandom sample, their responses were an indicator of some of the serious problems that Korean teachers are facing.

Korea offers a master teacher program, which is a promotion program for an ordinary teacher. Master teachers receive a higher salary, often teach only two classes per day, and are not responsible for administrative and after-school work. Rather, their role is to oversee and provide training for other teachers within a school. Consistent with Korean culture, most master teachers are men (< 90%); only a few female teachers have been promoted to master teachers. This is a point of contention among women teachers.

In Korea, school teachers are required to participate in professional-development activities each year. The government fully

supports a minimum of 20 hours of annual professional development for each teacher. However, most teachers attend 40 to 60 hours of professional-development activities to keep up with the new developments in their fields of expertise. Korean teachers share ideas and help each other. Experienced teachers work together and provide lesson plans and classroom activities for younger teachers every week. The lesson plans and classroom activities, including worksheets and technology based activities, are posted on a special website each week, and they are made available for all teachers. Teacher guide books are provided in addition to the standard instructor textbooks for teachers. The guide books provide valuable resources for teachers and consist of lesson plans, suggestions for group activities and point-by-point guidelines for teaching curriculum objectives. Typically, teachers do not stay in the same school during their career. Rather, they are rotated between schools every five years. This helps to provide equity in educational opportunities for both students and teachers regardless of the socioeconomic status of the community being served by a school.

Classroom Observations

During my visit, I had the opportunity to observe a mathematics class at a public elementary school (4th grade) and a middle school (8th grade). I found that all Korean classrooms were equipped with the state-of-the-art technology regardless of the location and socioeconomic status of the school. Cooperative learning was effectively utilized in all classes. Students worked

in groups of four, and the classrooms were equipped with small desks that easily allow for rearrangement of seats to facilitate group learning. Students were actively engaged during the entire class period and a variety of activity-based learning tools for promoting a student-centered learning pedagogy were used. In elementary school, various group activities including songs, games, and manipulatives were used. Teachers are instructed to incorporate activity-based learning before introducing a new topic. For example, before introducing the properties of isosceles triangles, groups of students will be asked to explore similarities of triangles using manipulatives and then the teacher will present a formal definition.

Class activities and lessons were organized for optimal use of time. Table 1 illustrates a lesson plan that was presented by Hyokchon Kwon, a Master Teacher with Seongsan Middle School in Seoul. The lesson began with a short video clip of the curvilinear flight path of a Shenzou 9 Chinese rocket launch, which illustrated a real-world quadratic function and the role of minimums and maximums. An example of the type of work produced by students is shown in Figure 1 where students used a “mind-mapping” strategy to summarize what they had learned from quadratic functions. These activities were supported by textbooks and workbooks that are designed for both group and individual work.

Geometer’s Sketchpad and GeoGebra programs are the two most popular computer programs used in the secondary

Table 1. Sample Lesson Plan for One Class Period of 45 Minutes (8th grade)

Lesson	Maximum and Minimum Values of Quadratic Functions
Teacher	Greetings and humor: Power Point Slides.
Teacher	Short video clip about of the Shenzhou-9 China spacecraft rocket.
Class Discussion	What is the relation between quadratic function and the spacecraft rocket launch? What is the role of maximum/minimum in a rocket launch?
Group Work	Worksheet 1 1. Estimate the values of y for given values of x from graph. 2. Find the exact value of y using the equation of quadratic function. 3. Find the maximum or minimum of a linear function if they exist from graph. State the reason if they do not exist.
Teacher	Introduce the definition of maximum and minimum of functions. Introduce the vertex.
Group Work	Worksheet 2 Investigate the relationship between equations, graphs, shape and maximum/minimum.
Class Discussion	Shape, maximum/minimum, and vertex of quadratic functions.
Individual Work	Each student is asked to create three examples of different forms of quadratic functions and find the maximum/minimum of their examples. A group of students will present an example on the board.
Group Work	Worksheet 3 Application problem from business: modeling using a quadratic function and finding max./min. profit
Homework Assignment	Summarize what you have learned from quadratic functions. Provide examples.

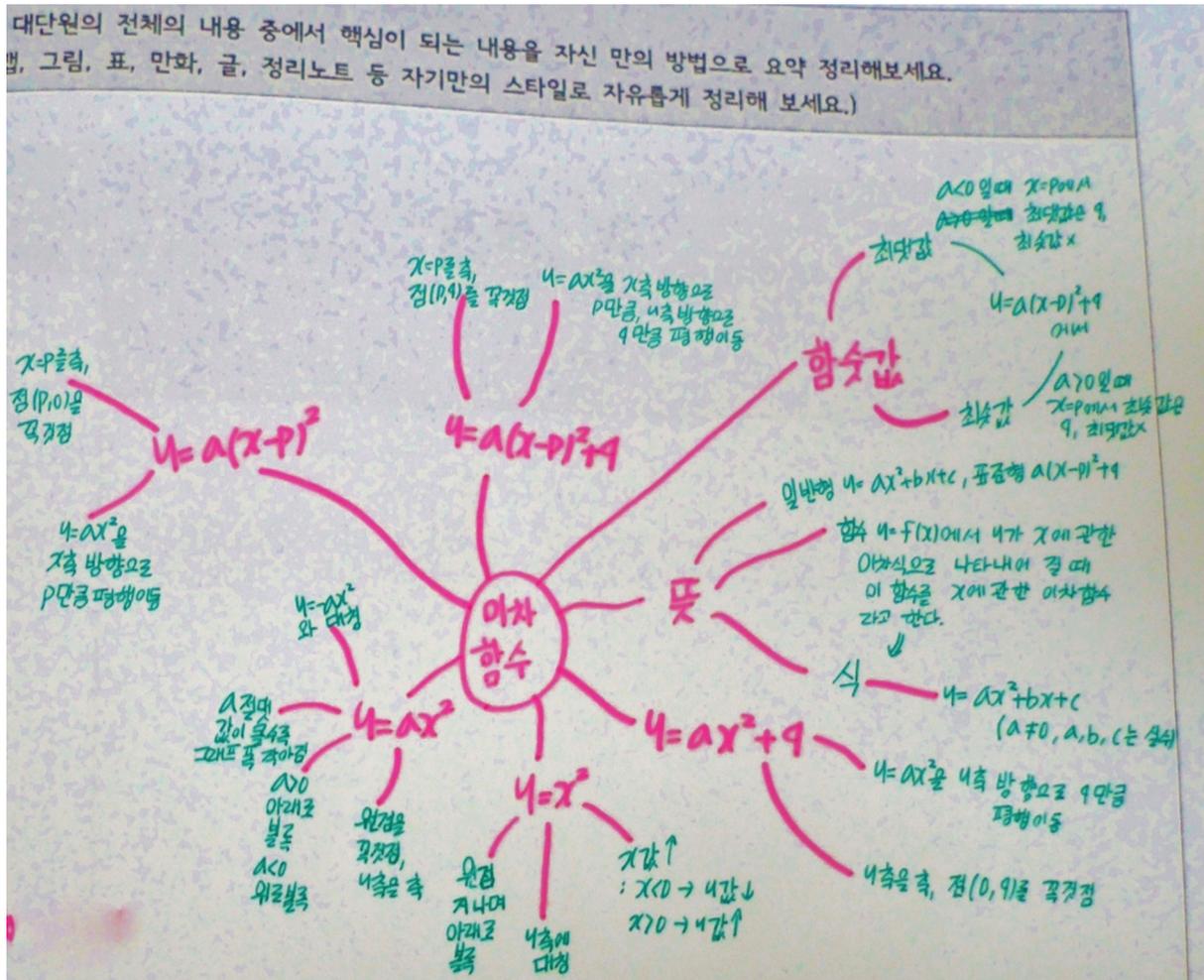


Figure 1. Example of student work using “mind mapping” strategy to summarize what he/she has learned from quadratic functions.

mathematics classrooms. The use of a graphing calculator is basically for computations and their use was at the instructor’s discretion.

The 2011 Mathematics Curriculum Revision

The Korean education system has been revised and modified every 5 to 10 years since the mid-1940s. The most recent revision of the public school mathematics program started in 2011 and will be implemented in 2013. One of the main goals of the recent revision is to address the needs of the growing economy and the extensive needs of skilled workers in Science, Technology, Engineering, and Mathematics (STEM) fields. Teaching and learning mathematics, the backbone of the STEM fields, has become the center of attention for Korean education for the 21st century.

The 2011 revision is intended to enhance mathematical problem solving, mathematical creativity and mathematical communication skills. The main feature of this revision is the creation of five grade bands to allow flexibility in the organization of topics covered. Grade bands include grades 1-2, 3-4, 5-6, middle school, and high school. The emphasis areas for

mathematic concepts and subject areas for elementary, middle, and high school in the 2011 curriculum revision are shown in Tables 2–5.

South Korea is moving away from its current centralized system to a more decentralized education system, giving local schools more flexibility on implementation of education programs. The middle schools and high schools will be able to choose from the government authorized textbooks as opposed to being restricted government-only copyrighted textbooks. Electronic books (e-books) in support of the curriculum are being developed and the use of technology will be emphasized. Curriculum components are being added to enhance a positive attitude toward mathematics and mathematical creativity.

Surprisingly, curriculum content is being reduced by 20% to allow more time for student-centered activities and conceptual understanding of topics covered as well as decreasing the student’s workload. Components like “character building” will also be added to develop a better-rounded student. The reduction of the curriculum content and emphasis on character building are ultimately intended as remedies for dealing with the side

effects of the current “education fever” that some believe has had negative effects on Korean society.

Conclusion

I was impressed with both the rigor and efficiency of the Korean public school system. Their students’ success is a result of continuous monitoring, reform, revision, and modification based on societal needs. I was intrigued with the heavy use of educational research and the results of peer-reviewed studies of different teaching pedagogies, much of it developed in the U.S., in the development and revisions of the South Korean curriculum and teaching pedagogy. Certainly, parental involvement plays a key role in the success of Korean students, perhaps to the point where both students and teachers feel that there is too much interest. Still, enough cannot be said about the emphasis that Korean society places on the quality of its teachers. As stated by Emma Kim, the founder of Ewha Womans University, “The quality of an education system cannot exceed the quality of its teachers.”

Government support for education reflects the societal interest. The South Korean government provides a high degree of financial and educational support for its teachers and schools, providing excellent teaching guides and training for its teachers and encouraging teacher collaboration and sharing of materials. Regardless of socioeconomic background of the students within a school, there were always excellent facilities, textbooks, and workbooks, and availability of technology. When coupled with teacher rotation among schools, frequent curriculum revision, and the high degree of subject matter training required by its teachers, there appeared to be true equity in educational opportunity for all students regardless of their socioeconomic background.

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Table 2. Korean Elementary School Mathematics: Grades 1–6 (2011 Revision)

Numbers and Operations	<ul style="list-style-type: none"> • Natural numbers, fractions, and decimals • Order of operations
Figures	<ul style="list-style-type: none"> • Plane figures and their properties • Solid figures and their properties • Congruence and symmetry
Measures	<ul style="list-style-type: none"> • Angle, hour and time, length, capacity, and weight • Circumference, area, volume, and surface area • Estimation and rounding
Probability and Statistics	<ul style="list-style-type: none"> • Organizing data including bar graph, simple pictograph, line graph, stem-and-leaf diagram, and rate graph • Averages • Cases and probability
Pattern and Problem solving	<ul style="list-style-type: none"> • Finding patterns • Problem-solving methods • Equations, proportions, direct and inverse proportions

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Table 3. Middle School Mathematics: Grades 1–3 (2011 Revision)

Numbers and Operations	<ul style="list-style-type: none"> • Fractions, greatest common divisor, least common multiple, prime factorization, decimal system, integers, and rational numbers • Repeating decimals, approximation, and exact value • Square roots and irrational numbers • Calculation of numerical expressions containing square roots
Variables and Expressions	<ul style="list-style-type: none"> • Expressions containing letters; calculation of expressions • Linear equations and quadratic equations • Operations of expressions (addition/subtraction and multiplication of quadratic expressions) • Simultaneous linear equations with 2 unknowns • Linear inequalities and simultaneous linear inequalities • Factorization of polynomial
Functions	<ul style="list-style-type: none"> • Concept of function and their graphs • Linear functions and their graphs • Relationship between linear functions and linear equations • Quadratic functions and their graphs
Probability and Statistics	<ul style="list-style-type: none"> • Frequency table, histogram, frequency distribution polygon, means, and distributions • Number of cases, probability, and calculating simple probabilities • Median, mode, variance, and standard deviation
Geometry	<ul style="list-style-type: none"> • Properties of basic figures, properties of triangles, construction and congruence conditions of triangles, sectors, properties of plane figures and solids of revolution • Proportions and proofs, proofs of the properties of triangles and rectangles, similarities of figures • Pythagorean theorem, trigonometric ratios, cords and tangent segments of circles, inscribed angles, and circle theorems

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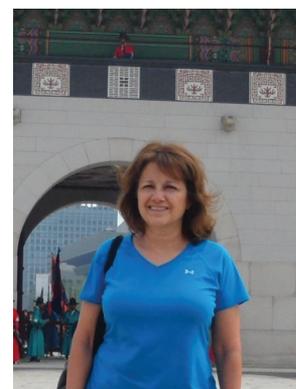


Table 4. High School Mathematics: Grade 1 (2011 Revision)

Numbers and Operations	<ul style="list-style-type: none"> • Converse, inverse and contraposition of propositions, necessary conditions, and sufficient conditions • Sets and their operations • Real numbers and complex numbers
Variables and Expressions	<ul style="list-style-type: none"> • Polynomials, factorization of polynomials, divisors and multiples, identical equations, and remainder theorem • Rational expressions and irrational expressions • Discriminant of quadratic equations, relations between solutions and coefficients of a quadratic equation • Simple cubic equations, simple quadratic equations, and simultaneous equations • Properties and applications of inequalities, absolute inequalities, and quadratic inequalities, simultaneous inequalities
Functions	<ul style="list-style-type: none"> • Functions and graphs, composite functions, and inverse functions • Quadratic functions, rational functions, and irrational functions, • General angle and circular measurements; trigonometry • The law of sines and cosines, trigonometric equations, and trigonometric inequalities
Probability and Statistics	<ul style="list-style-type: none"> • Counting techniques, sum rule, product rule, permutation and combination
Geometry	<ul style="list-style-type: none"> • Distance between 2 points; internal/external division of a segment • Equation of lines and equation of circles • Regions of inequalities, translations, and symmetric transpositions

**Table 5. High School: Elective Curriculum—
Grades 2–3 (2011 Revision)**

Mathematics I	<ul style="list-style-type: none"> • Matrix and Graphs • Exponential functions and logarithmic functions • Sequences • Limit of sequence
Mathematics II	<ul style="list-style-type: none"> • Equations and Inequalities • Trigonometric functions • Limit of function and continuity • Differentiation
Calculus and Statistics (Basic)	<ul style="list-style-type: none"> • Limit of functions and continuity • Differentiation of polynomial functions • Probability • Statistics
Integrals and Statistics	<ul style="list-style-type: none"> • Integration • Permutation and combination • Probability • Statistics
Geometry and Vectors	<ul style="list-style-type: none"> • Linear transformation and matrix • Quadratic curves • Spatial figures and coordinates • Vectors
Application of Mathematics	<ul style="list-style-type: none"> • Propositions and logic • Exponents and logarithms • Sequences and series • Geometry

**Table 6. Management of Elective Subjects for
High School: Grades 2–3 (2011 Revision)**

Track 1	<ul style="list-style-type: none"> • Mathematics I • Calculus and Statistics (basic)
Track 2	<ul style="list-style-type: none"> • Mathematics I • Mathematics II • Integrals and statistics • Geometry and vectors
Track 3*	<ul style="list-style-type: none"> • Application of mathematics

***Track 3 is intended for students whose career goals are social sciences and liberal arts.**