Journal of the Korea Society of Mathematical Education Series D:
Research in Mathematical Education
Vol. 4, No. 2, November 2000, 79-93

韓國數學教育學會誌 시리즈 D:
<數學教育硏究>
제 4 권 제 2 호 2000. 11., 79-93

Mathematics Education for Gifted Students in Korea

Shin, Hyunyong
Department of Mathematics Education, Korea National University of Education,
Cheongweon-gun, Chungbuk 363-791, Korea; Email: shin@cc.knue.ac.kr

Han, Inki
Department of Mathematics Education, Gyeongsang National University,
Jinju, Gyeongnam 660-701, Korea; Email: inkiski@nongae.gsnu.ac.kr

(Received July 31, 2000, and in revised form October 31, 2000)

The purpose of this article is to introduce the gifted education of mathematics in Korea. We first discuss what is going on in Korea for mathematics education for gifted students. The curriculums for the institutes for gifted education are mentioned. Some focus of this article is on proposing some teaching materials that are actively utilizing many basic concepts of cryptography and super-string theory, along with careful use of calculators and computers. Many of the materials have been designed with problem-posing approach or through invoking the cognitive conflict.

I. PREFACE

Throughout the history, Korea has paid a great attention toward education, particularly as means to cultivate high-caliber talents needed to run the nation. When the modern school system was first introduced in the waning days of the Empire of Dae Han, number of schools and the capacity thereof were tailored to the students of selected few elite and of exceptional talents. Hence no discernable problems existed with regards to the educational venues for the gifted students.

However, a need for the educated in the Korean society rose sharply beginning the late '40s and, accordingly, the pace of school education took a quantum leap as the number of schools began to rise. As the results of the quantitative growth, fueled by the quest for learning among the populace across the nation, the standardization has taken in effect among the nation's middle school system in 1968, followed by the high school system in 1974.

The standardization has resulted in classes of 50~60 students of varying mathematical aptitude, knowledge and ability levels in a single classroom, skewing toward the students with average level of mathematics skills, thus depriving each student of attentive care for individual student's mathematical talent, interest and his future goal.

Such reality in the Korea's educational system was criticized for stagnating the quality of education, and spurred numerous discussions of developing the teaching venues for gifted students. In 1978 as an outgrowth of the research entitled, "An Outlook and Task for Educational Development" by Korea Education Development Institute (KEDI), the establishment of a science institute for gifted students in the high school level was proposed.

Originally this article has been prepared for a regular talk at ICME-9. The main purpose of the talk was to introduce the gifted education of mathematics in Korea to the foreign mathematicians who were interested in the topic. In this article we first discuss what is going on in Korea for mathematics education for gifted students and introduce some national institutes for gifted education including the National Academy for Gifted Students that will be established soon. The curriculums for the institutes are also discussed.

Some focus of this article is on the report of a project for expanding creative mind in gifted education. The teaching materials developed in the project are actively utilizing many basic concepts of cryptography and super-string theory, along with careful use of calculators and computers. Many of the materials have been designed with problem-posing approach or for invoking the cognitive conflict. We believe that our approach is quite novel and effective.

Finally we discuss the technology in mathematics education. It is very possible for the computers or calculators to be used for worse. We propose some teaching models using technology that is believed to be used for better. We conclude with some suggestions for more effective and desirable gifted education of mathematics in Korea.

II. THE SCIENCE HIGH SCHOOLS

In accordance with the KEDI's proposal, an experimental teaching program for gifted students was initiated in 1979. Gumi High School, for example, began a special class for gifted students, whereas, Kyonggi High School and Inchon Girls' High School experimented with the concept of stratified classes according to the proficiency levels. Furthermore, in 1981, the Board of Education of Kyonggi Province held the Summer Science Camp at the Kyonggi Student Science Center, and held mathematics classes for gifted students. The Student Science Center of the Kangwon Province opened up the Saturday School for the same purpose. Various experimental studies on the curriculum for gifted students followed.

In 1983, Kyonggi Science High School, nation's first and foremost science high school, was established under the government's authorization. Currently, there is one science high school per each province and metropolitan city[1], 15 schools in total, where the high school students with exceptional proficiencies in science are being taught. The curriculum provided at the science high school, however, differ very little from those of ordinary high schools. The most prevailing reason for the similarity is the fact that no special privileges are given to the science school graduates in the college entrance examination. The students of the science high schools, therefore, must prepare for the college entrance examination just as any other high school students would.

III. EDUCATION CENTERS FOR GIFTED STUDENTS IN SCIENCE

One of the important characteristics relating to teaching mathematics to the gifted students in Korea in recent years has been the expansion of the research and experiment on special program for the gifted students to include elementary and middle school levels. It is unanimous belief among Koreans that the education opportunity befitting to every student's ability and interest should be provided to the students of all levels. It seems to be desirable, according to the public perception, to develop the mathematics skills by providing appropriate educational venues to the students of exceptional talent and aptitude from as early as the primary school and the middle school levels.

However, neither the teaching program nor the facilities for accommodating gifted students in either the primary or the middle schools have yet to be adequate. One of the solutions by the Ministry of Science and Technology to such problem has been to select one university per each province and metropolitan city, to fund the research activities, and to establish the education center for gifted students science. Accordingly, "Education Centers for Gifted Students Science" were established at nine universities in 1998[2], three in 1999[3] and one in 2000[4] for the total of 13 universities.

Aforementioned science centers provide special mathematics, information technology studies to the gifted students who are attending the ordinary primary and middle schools.

---

1 The Seoul Metropolitan City has two science high schools, whereas the Ulsan Metropolitan City and the Jeju Province do not have any science high school.
The Minjok Leadership Academy is yet another high school for gifted students. Founded in 1995, the academy's objective is to cultivate true national leaders of tomorrow through solid national cadet spirit and special learning program for the gifted. The academy has opted for a unique entrance examination process under which all the applicants are billeted together for the duration of a complex series of entrance examinations, covering personal character, compatibility, intelligence, and scholastic ability.

2 Kyungnam University, Kyungpook National University, Seoul National University, Ajou University, University of Inchon, Chonnam National University, Chonbuk National University, Chongju National University of Education, and Korea Advanced Institute of Science and Technology (KAIST).

3 Kangwon National University, Pusan National University and Yonsei University.

4 Cheju National University.

In addition to the Education Centers for Gifted Students in Science, as stated in this article, the Center at KAIST has been conducting feasibility study on special education for the gifted in the fields of mathematics, information, and technology through *internet* since 1998. The experiment is to continue temporarily while the effects are being tested. [5]

1. A Case Study

KEDI (1999b) analyzed the teaching and study materials of each center for gifted student in 1999, and filed a report. The activities of one of the centers are as follows:

- First of all, teaching gifted students at this particular center is being carried out under the organic interactions with the appropriate city/county education agencies within the province.
- Furthermore, there is much of very active participation by the in-service teachers in developing the teaching programs, fine-tuning the degree of difficulty to the proficiency level of the students.

Some characteristics of the teaching materials of the center are:

- Encouraging students' interests and the activity-oriented studies through playing puzzle games and studying geometrical properties playing with square color paper (as known as Origami paper),
- Providing ample opportunities of mathematics-related activities with ample study materials with various degrees of difficulty corresponding to the primary and the middle school curriculum.

The mathematics curriculum includes function theory, number theory, combinatorial mathematics, problem-solving strategy, project study, and mathematical puzzles. The information technology includes programming, algorithm, algorithm design, topic-oriented studies, information puzzles, internet classes, etc.

Procedures for scouting and teaching gifted students are as follows:

- Gifted students are selected in March of each year, within budget, by city/county board of education, and the chosen candidates are being taught via correspondence courses, utilizing the text materials compiled by the active teachers and the supervising professors, until July of the same year. The correspondence courses are held for 15 weeks, two to four hours per week, and provide the basic fundamental study, conducive to developing and nurturing the talent potentials. At the end of the correspondence courses, the education agencies of each city/county screen out the students to be accepted at the camp for gifted students.
- The chosen students attend the camp in July for the duration of four nights/five days, four hours of class activities daily. Upon the completion of the camp program, the final group of students will be selected.
- The finalists then continue the study with a set of correspondence materials compiled and issued by the center for a 14-week period, from September to December and 2 to 4 hours of

---

[5] For more detailed information, you may visit the web site: <http://gifted.kaist.ac.kr:7777/html/main2.html>

study per week. For the purpose of monitoring the study progress, group lessons, and evaluations, the students are gathered together for a four-hour session, once or twice, on weekends during the mid semester.

- Lastly, four-hour daily classes would be held for two weeks in January. The class topics would include mathematics and information technology. The classes are grouped according to the primary, middle and high school proficiency levels, consisting of 20 to 30 students in a class. The purpose of the classes is to bring out the potential learning capacity of each student to the fullest limit, as well as to promote synergy through the group interaction. The project terminates at the completion of the winter session, and repeats anew with a new batch of students in March of the following year.

Problems and difficulties, however, are numerous in the learning centers for gifted students, the aforementioned center included. There are many difficulties in developing the curriculum and the study materials.

Furthermore, many centers tend to deviate from the original mission of the center by becoming quickie mathematics cramming venues to supplement the higher school mathematics curriculum. Worse yet is the teaching methodology that is heavily centered on lecture, thus forsaking creativity, perceptivity and initiatives on the part of the learners, critical to the development of characters. The curriculum and teaching materials of physics, chemistry, etc. are esteemed to be com-paratively better than those of mathematics are.

2. *Tentative Plan for the Curriculum for the Gifted Students*

One of the issues arising from managing the center is to come up with the curriculum, that is, the question of what to teach at the center. In an effort to develop a systematic curriculum for a center for the gifted, a team of experts, under the auspices of KEDI (1999b), has recently drafted a set of curriculum. The proposal calls for offering a series of intensive study-oriented program geared for the gifted students who are in the top 1% of the classes in the 4^{th} to 6^{th}-graders in primary schools and 7^{th} to 9^{th}-graders in middle schools.

The basic thrust of the proposed mathematics curriculum is centered on enrichment of the topics by combining problem solving and the in-depth study. Questing for mathematics not only heightens the interest in mathematics, but also tends to bring out student's initiative in his approach to the study. Whereas, the in-depth study of topics leads the student to look up numerous references in order to compile the data, culminating to the research papers and reports.

Under the tentative proposal, several unique characteristics in the mathematics curriculum can be highlighted as follows:

- The new proposal brings out the creative problem solving ability of the student to its fullest capacity.

- The proposed enrichment program concept would facilitate the student, centering on big ideas, to sharpen the thinking process logically and analytically, as well as to expand the scope of thinking through learning the concept in-depth and at a high level. In an ordinary curriculum, various concepts are taught little by little throughout several grades. By contrast, in the center curriculum for the gifted, comprehending a key concept is the center of topics, along with several other related concepts and facts, as well as the correlation between them. Students are encouraged to carry out a project by utilizing frequently the functions and abilities required in the mathematical studies. By doing so, the students would develop the creative problem-solving ability and would experience the role of creating knowledge.
- The key aspect of the proposed curriculum centers on activity-oriented, course-oriented, and an open-end approach that provides the student an ample opportunity for self-motivated studies and research activities.
- For each topic of studies, its objectives, key concepts and functions, unfolding study activities, the study output, and the standard of evaluation could be delineated so clearly. Hence this would make it easy for the teachers at the university affiliated Education Centers for Gifted Students in Science to grasp the procedures to unfold the study activities.

The following emphasis are incorporated into the teaching-learning approach in the curriculum designed at the Education Centers for Gifted Students in Science:

- To facilitate students' comprehension, various sources and method would be used in explaining the mathematics context. Questions are formulated in such a way to elicit creative answers from the students.
- In order to lead the students to the solution to a problem, the curriculum encourages the students to exercise initiatives toward solving the problems in real life situations, and in a cooperative and creative class environment.
- To facilitate participation of all students, implement the learning configurations that would accommodate students' varying proficiency levels.
- Encourage the students to recognize mathematics as an integral part of the nature and the every day life by showing its scope of application, inter-relationship with other fields, and a proper understanding of its value.
- Make use of calculators and computers to the fullest whenever deemed proper to do so, both in the context and in the procedure of teaching and learning mathematics.
- Utilize many interesting data from other areas in order to build up the mathematics proficiency. Encourage the students to make mathematical analysis of numerous data that occur all around the every day life, and to classify, organize, and to arrange the data.
- Equip with and make a judicious use of tangible study-aids, which are conducive to effective teaching and learning of mathematics.

IV. PRELIMINARY DRAFT OF NEW CURRICULUM FOR GIFTED STUDENTS IN SCIENCE BY THE MINISTRY OF EDUCATION

With the passing of the bill, by the legislative body, promoting special education for gifted students, a national school for the gifted students will soon be established. Various researches on operational specifics are being conducted currently.

The mathematics curriculum for the gifted has been researched, as a leadoff, by mathematicians, experts on mathematics education for gifted students, and by the experts in teaching the gifted (cf. KEDI, 1999a). The results of the research arc as follows:

> The new curriculum by the Ministry of Education targets the top 0.01% of the class, currently being considered as gifted students, in comparison to the top 1% set forth by the existing Education Centers for Gifted Students in Science. There is also a difference between the two in the curriculum. For instance, the topics in the curriculum are different. Furthermore, the curriculum adopted by the Education Centers for Gifted Students in Science has been organized, based on the student activities. Whereas, the new curriculum by the Ministry of Education calls for not only for the activities, but also additionally, greater emphasis is given to the quest for mathematical principles inherent to the activities.

The new curriculum has its basis on the general curriculum, but its ultimate goal is toward the cultivating expert mathematicians, who would sustain the research in the mathematics field, by emphasizing enrichment over acceleration, and by reinforcing the power of mathematics by creating it, rather than merely solving it.

The new curriculum calls for organizing 4^{th} to 9^{th} grades into four levels.[6] In each level, the regular curriculum will be taught by compressing it 50%, followed by providing the in-depth and selective studies so that the students may exercise initiatives in their studies.

Identical to the curriculum of the Education Centers for Gifted Students in Science, the new curriculum orients toward the three objectives: problem-solving, mathematics experiment, and quest for the mathe-matics theory. The new curriculum's in-depth procedures and the selection processes have been patterned after the enrichment triad model suggested by Renzulli (1997).

V. RESEARCH AND EXPERIMENT ON EXPANDING CREATIVE MIND IN EDUCATION FOR THE GIFTED

In order for the new curriculum to be organized more efficiently and systematically, much broader research on special mathematics education for the gifted is needed in such areas as study on the characteristics of the gifted students, on the special mathematics education system, on preferred directions for the education to take, on developing study

[6] The first level is for grade 4 through the first semester of 5^{th} grade. The second level is from the second semester of 5^{th} grade to 6^{th} grade, the third level is 7^{th} grade to the first semester of 8^{th} grade and the fourth level is from the second semester of 8^{th} grade to 9^{th} grade. Hence each level is one and a half years from grade 4 through 9.

materials for educating the gifted, etc.

Under the auspices of the Ministry of Education, the first author participated, from December of 1997 to November of 1999, as the researcher-in-charge, and as a hands-on field experiment personnel, in developing a tangible study program that is pioneering and suitable to the special mathematics education program for the gifted students in Korea (cf. H. Shin, Han, Kim & I. Shin, 2000; Shin, Han & Lee, 2000). One unique characteristic in developing the teaching materials was actively utilizing many basic concepts of cryptology (cf. Fellows & Koblitz, 1998) and superstring theory (cf. Greene, 1999), along with careful use of calculators and computers. Researching through various bibliographic materials on the initiative factors has been productive in extracting many factors attributable to the formation of initiatives. Consequently, such findings have contributed positively in developing about 100 hours of study materials for the primary, middle, and high school levels that are vital to instill the sense of initiative among the students. The study materials, in turn, have been validated through the teaching and learning processes.

In this research, the following supportive issues were taken into consideration in developing the study materials:

1. The Study Topics That Would Inspire the Motivation to Solve the Problem

It is essential that the study topic should be developed to bring out the interest, attention, and desire in students. What kind of topics would draw interest among the students? It would be the topics that are curious, spontaneous, and that has a strong attention-holding power; something students may react with feeling and with activities that involve creating many works, games of puzzles, playing many different games, the problems relating to the everyday life, working with computers, etc. We may also pose a problem through the cognitive conflict.

Example:

① Present the Monty Hall dilemma (cf. Hoffman, 1998).
② What is the strategy to get a car?
③ Read Hoffman (1998).

2. The Study Topics That Are Conducive to Developing the Factors of Initiative

1. Sensitivity toward the Task

It refers to the ability to accept the task. It is also the ability to identify the task on hand, to delineate the shortfalls in the problem-solving task, and the ability to quickly grasp the problems that are overlooked by others. Comprehending the principles of games, mathematical writing skills, paradox, etc. may be introduced in the high school curriculum.

Example A:

Explain, in mathematical expression, the principle of ladder climbing game. (Note that this game is a source of many interesting mathematical problems.)

Example B:

Find a winning strategy for the following 2-person game:

> Each person can take up to three consecutive natural numbers. The first player starts with 1. They play alternately. Eventually they come up with 1, 2, 3, 4, 5, 6, 7, ⋯.
> The player who takes 30 will lose the game.

2. Fluency in Thinking

Fluency in thinking refers to thinking out as many and diverse ideas and reactions as possible. The fluency in thinking plays a critical role in developing diverse thinking process.

Example:

The 1998 Game:

① Use only the following four numbers: 1, 9, 9, 8.

② Four arithmetical operations, square root, square, factorial, and exponent may be used to produce the numbers between 1 to 100.

3. Flexibility in Thinking

Flexibility in thinking refers to the ability to switch from one series of thinking process to others. It implies the ability to perceive a problem from a different dimension. The flexibility prevents thinking inflexibly in solving problems, yet enables the information applications in various modes, and stimulates one type of idea to be sprung out from another.

Example A:

① Read Abbot (1991) and Greene (1999).

② Discuss the differences between two-, three-, and ten-dimensional spaces.

③ Imagine the spatial distance in a four dimensional space.

Example B:

From Pascal's Triangle, find number patterns as many as possible.

4. Originality of Thinking

Originality is the ability to make a new and unique idea. Unique idea generally is produced by combining several old ideas, yielding diverse ideas, as well as implying independent and unheard of, that is, a fresh and an original idea. The basic concepts in cryptography may be used here (Fellows, 1998).

Example A:

A probabilistic proof: (This is one of the main characteristics of zero-knowledge proof in modern cryptography.)

> A bag contains two pebbles. There are three possibilities: Two whites, one white and one black, or two blacks. I have a bag with two whites. How can I prove that my bag has two whites without showing the contents?

Example B:

① Read Feynman (1985).
② Discuss some properties of light.

5. Perseverance

To solve some problems, it is necessary to have the analytical power as well as to scrutinize the problem in detail. Also needed is the perseverance to discover the rules underlying in the problem. The space-filling curves of Peano and Hilbert may be used as an example.

Example A:

Draw the fourth picture after analyzing the pattern.

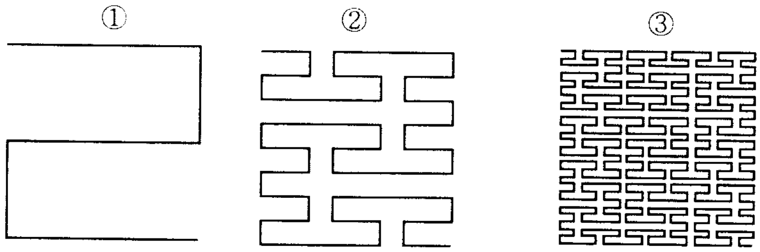

Figure 1. The space-filling curves

Example B:

Try to find a continuous curve filling in a box.

Example C:

At this point, it would be good to introduce the Koch curve and fractals.

3. Exercises for Self-motivated Study

An imaginative student is independent and possesses strong desire for self-expression. To achieve the self-realization of a mentally healthy person, interesting topics should be selected for the study in order to stimulate the inner urge of the student to lead the study on his own.

To create an initiative-driven study mode, the teacher should not only take charge of the preparation and execution of the study program, but also must create the environment under which a student may choose the study program that is compatible to his aptitude and ability.

On the other hand, the curriculum itself should be systematized for the presentation in order to carry out the initiative-driven study. At the outset of formulating the curriculum, such issues as student's proficiency and modularity of study programs are to be considered. Since the most basic study function takes place at this level, the study should be accomplished by means of manipulating shapes and colors or through physical activities in psychologically secure atmosphere, without feeling pressure.

In the expansion stage, the study should be capable of predicting causes and effects of various actions that incorporate both the existing knowledge and new ideas. In the consolidating stage, the study should include those tasks considered atypical, as well as those helpful to self-reflect and introspection on the initiative, and to refined it further.

Listed below are a few tasks relating to the systematized study program:

Example:

Find the counterfeit coin using the balance scale.

① Of the three coins, two are genuine and one is the counterfeit, which is lighter than the real coin, but is impossible to tell apart visually. Can you isolate the counterfeit coin, using the balance scale only once? What if there are 4, 9, 10, 27, 28 coins?

② What problem can you think of now?

③ There are three coins. One of the three is a counterfeit, and the only telling difference is its weight. Assuming using the balance scale, which does not use the counter weight, what is the minimum number of weighing to identify the counterfeit?

4. Diversification of Study Tools

Initiative can be nurtured through experiment and study. Teachers, therefore, should provide students various experiences to help the students studying and finding the mathematical ideas. To do so, students need the materials that they can manipulate and study.

This research has had extensive usage of such tools as computers and tangrams, and at the same time, independently made up and used other tools such as transparent cubes, etc.

Example A:

Lines were drawn with a marker on a transparent cube as illustrated below.

What does the line look like as you see the cube from the front, above, and from the left?

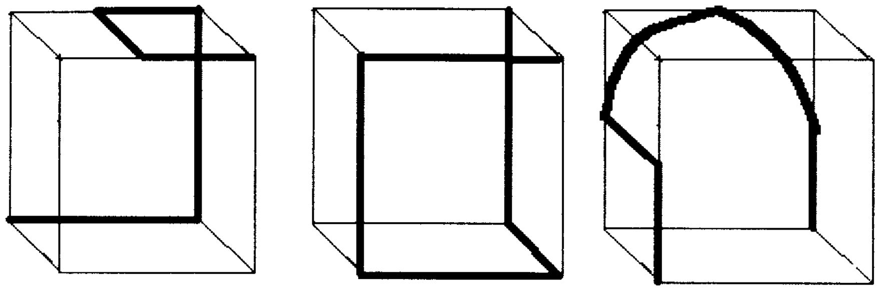

Figure 2. A transparent cube

Examples B:

- Write two programs (using BASIC or LOGO) for factoring and for expressing the input natural number in the binary system.
- Running above program, express $2^k - 1$, $1 \le k \le 10$, in binary system.
- Find a necessary condition for $2^k - 1$, $k \in N$, to be prime numbers.
- Test the primality for $2^3 - 1$, $2^5 - 1$, $2^7 - 1$, $2^{11} - 1$.
- Use MATHEMATICA or some other tool to test the primality of $2^{19} - 1$ and $2^{23} - 1$.
- Visit http://www.mersenne.org/primes.htm for Mersenne primes.
- Consider the similar problems for repunit numbers.

5. Study Tools to Stimulate Cooperation and Competition

The students in a small study group may exchange their views through discussion. It forms up friendly ties that are not common in the cognitive studies. The small study group is also helpful in synergistic group thinking where everyone participates and shares experiences. Furthermore, competitiveness in study subconsciously stimulates creative thinking and heightens the levels of study participation. Many topics in the program, therefore, have been designed to enable both the individual and the group activities to keep abreast of each other.

Example A:

At each dot given below, draw the human figure, and explain its shape.

This activity is to be carried by the small study group, and the team with the most solutions wins. The solutions generated by each team must be concurred by other teams on the soundness of logic.

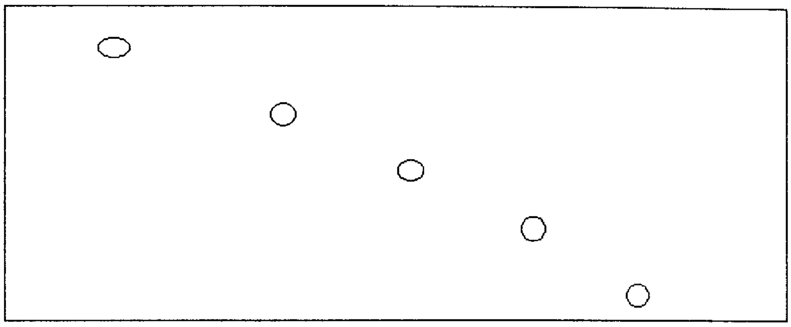

Figure 3. Draw the human figure

Example B:

In a HEX game (cf. Nasar, 1998)

① Explain why the game can't end in a draw.

② Try to get a better strategy for a win.

VI. CONCLUSION

The needs for the special mathematics program for the gifted students can be considered from two sides of perspective, i.e., the personal side and national side. On the personal side, it would be the satisfaction derived from developing individual's potentials and interest to the fullest. On the national side, developing the students with exceptional aptitude in mathematics by means of compatible curriculum would have a significant impact in the fields of mathematics and science and decisively contribute to the nation's competitive edge.

Recently, the issue relating to the special learning program for the gifted students has been gaining momentum in Korea. Consequently, interest and support by the government have been initiated[7]. Numerous researches on the theory and practice of the special eduation have been implemented at the elementary and middle school levels. Some teaching/learning materials have been developed with attention to the viewpoint of constructivism.

Recognizing the importance of university entrance examination system in Korea, extending many helpful considerations by major universities to the gifted students could be construed as a positive impact on the special education.

It is impossible to choose right or wrong between enrichment and acceleration in developing programs for the gifted. Both the mathematics curriculum for the Education

[7] Recently, a private institute has been established for education of gifted students in Korea. Also a private company has appeared to produce and supply the programs for gifted students.

Center for the Gifted Students in Science or the mathematics curriculum draft (see Chapter IV) by the Ministry of Education reveal greater emphasis on enrichment, albeit enrichment does have its basis on acceleration.

As for now, for the sake of more effective education for the gifted in Korea, the following few points need to be considered:

- Although both enrichment and acceleration in the mathematics context are important factors for the special education, it is also critical to activate the gifted students' creative and intellectual activities. In this vein, more of the teaching-learning materials for the gifted students of all grades should be developed further.
- The existing science high schools should become the schools for the gifted, both in name and in practice. To do so, the government needs to provide a substantial system supplementation. At the same time, more elite universities should offer special considerations to the gifted students of the science high school in the entrance examination procedures. We need to note that only 20 out of 90 senior (or grade 12) students are remaining at a science high school.
- The advent of computer and other technology could be of great advantages not only in enhancing the study effects and creativity, but in the constructive point of view as well. However, as Dong-A Ilbo (November 6, 1998), Gelernter (2000), and Healy (1998; also see Becker, 2000; Harvin, 1998) have pointed out, careless utilization of technology may result in a severe adverse impact. Tien (1998) has reported an experience that poorly designed use of technology could result in the lowering of the overall effectiveness both in thinking and learning. This implies that the role of the teachers in classrooms should be increased rather than reduced with the advances in technology. A careful study is mandatory in utilizing technology.
- Erdös (cf. Hoffman, 1998; Schechter, 1998) and Nash (cf. Nasar, 1998) have embodied the ideal image of gifted men who have contributed immensely to the 20^{th} century in mathematics. Both of them consciously refused to be ordinary persons, in thinking, and in their ways of family and social lives as well. Their views in life might have contributed in their efforts to sustain their unique creative talents. The unique ways of life of the creative need to be accepted and even encouraged fully by our society. It is desirable for them not to be in serious troubles in the society.
- It is easy for a mother to buy fast foods for her children. But, it will cost some time and effort for her to search for good food materials and cook them well for the children. It is certain that the latter food is good for her children's physical and emotional health. As everybody agrees, it is the teachers that play the most important role in education. It is also obviously true in the gifted education. Before we start to run a special program, the teachers who will participate in the program should be ready. Neither a fantastic program nor a sophisticated teaching environment will work if the teachers are not committed.
- As we have shown above, many areas of mathematics including mathematical physics and cryptology can supply useful and interesting ideas for the nice materials for gifted education. Such areas as well as games and puzzles deserve in-depth attention of teachers.

REFERENCES

Abbot, E. A. (1991). *Flatland.* Princeton University Press, Princeton.

Becker, J. (May 2, 2000). *Computers rot our children's brains.* Private communication by email.

Dong-A Ilbo (November 6, 1998). *Too Much Computer Spoils Kid's Math Grades.* Seoul: Dong-A Ilbo.

Fellows, M. R. & Koblitz, N. (1998). *Combinatorially based cryptography for children (and adults).* Pre-print through internet.

Feynman, R. P. (1985). *QED: The Strange Theory of Light and Matter.* Princeton: Princeton University Press.

Gelernter, D. (2000). *Put down that caculator, stupid!* Private communication with J. Becker, http://www.nypostonline.com/commentary/2735.htm.

Greene, B. (1999). *The elegant universe.* Superstrings, hidden dimensions, and the quest for the ultimate theory. W. W. Norton & Company, New York, London.

Harvin, S. B. (December 11, 1998). *Outsmarting Ourselves: How computers can fail children.* New York: New York Times.

Healy, J. M. (1998). *Failure to connect: How computers affect our children's mind — For better and worse.* New York: Simon & Schuster.

Hoffman, P. (1998). *The Man Who Loved Only Numbers.* The story of Paul Erdös and the search for mathematical truth. New York: Hyperion Books. [Korean translation: Hyunyong Shin. Seoul: Seung San Publishers, 1999.] MR **2001b:**01024

KEDI (1999a). *Development of Curriculum for the Gifted Children*, CR 99-20. Seoul: Seo-Bo Publishing Co.

KEDI (1999b). *Development Research on Science Education for Gifted Children*, CR 99-15. Seoul: Bong-Mun Publishing Co.

Nasar, S. (1998). *A Beautiful Mind.* New York: Simon & Schuster. MR **99j:**01021

Renzulli, J. S. (1997). *The enrichment triad model: A guide for developing defensible programs for the gifted and talented.* Mansfield Center, CN: Creative Learning Center.

Schechter, B. (1998). *My brain is open.* The mathematical journeys of Paul Erdös. New York: Simon & Schuster.

Shin, H.; Han, I.; Kim, W.-K. & Shin, I. (2000). Research on Revised Plan for Teaching Mathematics to the Gifted Children, *Journal of Korean Society of Mathematical Education, Series E: Communications on Mathematical Education* **10**, 325-342.

Shin, H.; Han, I. & Lee, C.-W. (2000). Program for Developing Creativity among Gifted Mathematics Students in Upper Classes of Elementary Schools. *Journal of Korean Society of Mathematical Education, Series E: Communications on Mathematical Education* **10**, 19-30.

Tien, D. (1998). *Using MATLAB in teaching advanced engineering mathematics.* Preprint. Submitted to but not presented at ICMI-EARCOME 1, 1998.