Chapter 1
Mathematics Education in Korea after TIMSS

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I. Introduction
In the Third International Mathematics and Science Study (TIMSS) with over 40 countries around the world, Korea ranked all others except Singapore by getting scores of 607 and 611 in the 8th grade and the 4th grade respectively (Beaton, et al. 1996; Mullis, et al., 1997). Korea also has attained similar good results in the other large scale international competitions such as IAEP I, II administrated in the last two decades (Im & Kim, 1995; ETS, 1989). Korean students' high achievement internationally recognized very well encourages many mathematics educators who believe that their students' mathematical potentiality is very important to accelerate the nation's economic development and to strengthen competitive power in the international market place.

The international tests like TIMSS have provided Korean mathematics educators with a matchless opportunity to reflect on their educational environment on the whole. Particularly, TIMSS permitting fine exploration of the observed differences through multivariate analysis tied to teachers, institutions as well as students showed that Korean mathematics education has many serious weak points, despite of students' very proud achievement.

TIMSS exerted a deep impact on the 7th national curriculum revised in 1998. The 6th curriculum, issued in 1993 was designed for mathematical literacy education for all people to cope with very rapid social change of the 21st century by emphasizing mathematical problem solving ability and application of mathematics. Computer and calculator as an instructional tool, and various teaching and evaluation methods were supposed. But, there was few educational effort to support successful realization of the slogan. Different with general remark, the approach of textbook and contents were not different with the past and in classes verbal method without any technological support continued and evaluation measured to measure how many pieces of knowledge. As a result, students could not attain goals the curriculum pursued in mathematics.

The 7th curriculum, reflecting the movement of mathematics education throughout the

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1) Korea did not participate in the population 3.
worlds, particularly of USA, is very different with the previous one. Focusing on the improvement of thinking, the change comes with the shift of teaching methods and contents from skill to thinking, from pieces of knowledge to connection, from teachers’ explanation to students’ spontaneous construction, from aversion to interest, from knowing that to knowing how and why, and from concept to application.

This chapter will introduce Korean mathematics educators’ efforts trying to improve students' mathematical abilities after TIMSS where their students have attained an excellent success. After introducing some lessons learned from TIMSS, this article provides the new goals in mathematics education manifested in the 7th curriculum revision, and various efforts of mathematics community to remodel mathematics classes before or after the new curriculum.

II. Some Lessons from TIMSS

Korean mathematics educators take precious lessons from TIMSS for improving their current situation. TIMSS reports indicate a serious defect hidden in the plausible external success in achievement scores.

First, Korean students’ affective characteristics was not friendly to mathematics compared with other countries. In the case of the 8th grade, Korea was one of the lowest countries with Japan and Lituania in the confidentiality and interest levels. 62% of the students disagreed about doing well in mathematics and 42% of them disliked mathematics. As well, students’ overall negative attitudes towards mathematics were 50%. What is more serious is that this phenomenon becomes worse as students' grade is up. In the case of the 4th grade, the corresponding rates about interest, and attitudes were 27% and 28%. And, 53% of Korean students disagreed that the reason why they need to do well in mathematics is for getting desired job. TIMSS shows that Korea school system needs to develop a particular program for nurturing students' affective disposition very urgently.

Second, there was a significant difference in the achievement level between male and female, and city and rural area (Kim, et al, 1996) The result raises a serious problem with respect to an equal opportunity in mathematics education. Man-centered traditional custom usually guides girls, even though mathematically talented, to choose the college departments unrelated with mathematical fields. Parents and even teachers do not expect generally girls learn mathematics better than boys. And, generally rural area, compared with city area, has an educationally inferior environment in aspects of teachers' teaching competency and parents'
Educational expectation and educational information etc. Although this tendency is reported as similar in other countries, in my opinion, the case of Korea is more acute. Any informational society cannot endure this kind of difference in that mathematics counts for all social groups for developing their society up.

Third, the national study of TIMSS (Kim, et al, 1996) shows that in its mathematics scores, the effect of private programs so called "Goawe", an extra program after school, is very strong which implies that the high achievement of TIMSS came from not a good public education but the technical skills learned and a time spent in such a program. In Korea, the private program has raised a serious social problem in the sense that it not only exerts a stronger influence on schooling than a normal school system itself, but also goes to ruin the public education. Unsatisfied with the public school system, parents, despite of their economic burden, urges their students to participate in the program for at least 3-4 hours a day in mathematics and English which are given much weight in the college entrance examination. In some sense, rather than cultivating mathematical ability, they learn technical skills and knowledge for improving achievement scores in school and eventually preparing for the college entrance examination.

Fourth, TIMSS result shows that in Korea, whole class activities with teachers' control is the first consideration in the style of organizing classes. In the case of the 8th grade, during mathematics lesson, 89%, the largest rate among TIMSS countries, of students worked together as a class with teacher teaching the whole class and only 12%, one of the lowest rate, of students worked in pairs or small groups with assistance from teachers. Whole class lesson inevitably more relying on the verbal explanation of teachers rather than students' spontaneous construction should be changed.

Fifth, according to TIMSS reports, Korean math teachers were the most conservative in using technology like computer and calculator. The rate teachers and students use calculators and computers in their classes and problem solving process were the lowest among countries participating in TIMSS. In the case of the 8th grade(4th grade), 76% (86%) of teachers and 93%(93%) of students never used calculators in their classes. And, 93%(96%) of teachers and 96%(92%) of students never used computers in their math classes. This phenomena was very unexpected because at the time of TIMSS survey every elementary and secondary school had already over 50 computers and Korea was one of the top five computer manufacturing countries. Basically, one of the reasons was that math teachers had have no good software different with a "page turner" style. Some teachers still have a belief that technology has no more positive effect
on mathematics education than a traditional paper-and-pencil circumstance, now, most of all math teachers agree that technology is an inevitable tool every student has to use in the huge stream of the current information society.

Sixth, TIMSS result shows that many math teachers do not consider mathematical application in daily life and reasoning ability to support logical conclusion as important goals for students to be learned. Korea belonged to countries whose rate was very low. This implies that teachers do not understand well the reason why problem solving is emphasized in the current curriculum. Although the rate considering memorization of formula and procedure as important is lower than other countries, application of mathematics and reasoning should be more emphasized.

Seventh, ironically, the good result in TIMSS made Korean mathematics educators reconsider their evaluation system. Except of a small portion of subjective items with a short answer, most of TIMSS items were objective with 5 choices. So, critics have been proposed that the objective items might give a better chance for Korean students to get higher scores than European students because Korean students were familiar with an objective test. An alternative performance assessment like project and open-ended items might have given worse results than the objective item centered TIMSS. TIMSS gave a moment to introduce the performance assessment system to make up for weak points of the traditional paper-and-pencil test in order to measure students' mathematical power more correctly.

III. TIMSS and the 7th National Curriculum

This TIMSS results impact to the 7th national curriculum revision issued in 1998. This change comes from the reflection of teaching method and content as follows: First, the focus on mathematics education in school is only concept and skills. School education presupposes the proper use of mathematics if necessary. But, there is a few case to use mathematics in the society and if the case occurred, skills and knowledge is not enough. In the everyday life, what is more important is thinking. Second, school education cannot connect various knowledge and skills learned in school. We have to make an environment to summing up known knowledge rather than many pieces of knowledge. Third, The content of school mathematics is not attractive. we can change a negative attitude in mathematics by raising challenging circumstances interesting rather than the direct and easy application of knowledge and skill through investigative activities for improving thinking.
The rationale for the new curriculum has three strands, which are interrelated. The first is a reflection from the mathematics education community that the curriculum should support Korea's national goals practically, which is to construct an advanced civilized society, with rapid circulation of information, highly developed technology, and openness to other cultures. This society is expected to be dedicated to the welfare of mankind, a traditional dream of Korean people throughout their history.

Secondly, compared to that of thirty years ago, the current curriculum shows few changes either in content or in methods of teaching and evaluation. It is a skill-orientated curriculum relying on the expository method to transfer fragmentary pieces of knowledge. In the opinion of the designers of the new curriculum this orientation has led students to learn mathematics meaninglessly and as a result mathematics education in Korea is in total crisis.

Thirdly, the current curriculum leaves no room for considering individual differences in the abilities, needs, and interests of students. The majority of mathematics educators in Korea want a curriculum which is structured to maximize the potential for growth in each individual student - in short, a level-based, differentiated curriculum.

IV. The Nature of the 7th National Curriculum

The ultimate goal of the 7th mathematics curriculum is to cultivate students with a creative and autonomous mind by achieving the following three main aims: First, to understand basic mathematical concepts and principles through the concrete experiences with various manipulative materials and the use of daily life phenomena related with mathematics; second, to foster mathematical modeling abilities through solving various problems posed within and without mathematics; Third, to keep a positive attitude about mathematics and mathematics learning through emphasizing a connection between mathematics and the real world ..

The new curriculum emphasizing basic mathematical knowledge and application of mathematics in the aspect of practical mathematics contrasts sharply with the 3rd curriculum, which emphasized "mathematical structure" in the aspect of theoretical mathematics. The 4th curriculum issued in 1980 revised the 3rd curriculum where strongly accepted the philosophy of "New Math" which was designed for reflecting the pure mathematics rapidly developed in the 20th century. For about 20 years since 1980, a basic position of mathematics education has slowly changed from the theoretical aspect to the practical aspect such as problem solving, application and the use of technology.
In the 7th mathematics curriculum, students are expected to be able to organize real world phenomena mathematically, to determine mathematical relations of concepts and principles by the process of abstraction based on their own concrete operations, to promote mathematical reasoning abilities through solving various problems by using mathematical knowledge and skills they have already acquired, and finally to acquire the positive attitude toward mathematics.

Traditionally, the most serious problem in Korean mathematics education is that mathematics is considered just as a tool subject for students to prepare for college entrance examination in which theoretical mathematics focusing on mathematical knowledge is emphasized more than practical mathematics focusing on its utility. The emphasis on the examination without internal motivation for learning has made it difficult for students to have real understanding and to develop reasonable and productive thinking abilities. It demands students to accept mechanically undigested content organized around topics frequently appearing in the examination. As a result, it becomes almost impossible for students to nurture an investigative attitude and a desirable mental habit.

Korea has a long history of emphasizing theoretical mathematics for a selective examination (See Fig.1). In 958AD the "Koryeo" Kingdom (918-1392AD) introduced mathematics into its examination system to select government officials (Needham, 1954, p.139). Whoever wanted to become a government official ought to have learned many Chinese mathematical classics including "Chui-chang Suan Shu"(nine Chapters on the mathematical Art) for 7-9 years in the national schools. This tradition of mathematics education had continued during the period of the Koryeo Kingdom and "Chosun" Kingdom (1392 - 1910AD).

![Figure 1. History of mathematics curriculum of Korea](image-url)
IV. Instruction and Evaluation in the 7th curriculum

The 7th curriculum emphasizes various types of instruction to improve efficiency and significance of students' mathematical learning. It recommends that students should be able to experience the joy of discovery and maintain their interest in mathematics by pursuing the following instructional methods in their classrooms: to emphasize concrete operational activities in order to help students to discover principles and rules and solve problems embedded in such a discovery; to have students practice basic skills to help students be familiar with them and problem-solving abilities in order to use mathematics in their everyday life; to present concepts and principles in the direction from the concrete to the abstract in order to activate self-discovery and creative thinking; to induce students to recognize and formulate problems from situations both within and outside mathematics; to select appropriate questions and subsequently provide feedback in a constructive way in order to consider the stages of students' cognitive development and experiences; to use open-ended questions in order to stimulate students' creativity and divergent thinking; to value the application of mathematics in order to foster a positive attitude toward mathematics; to help students understand the problem-solving process and use basic problem-solving strategies in order to enhance students' problem-solving abilities.

The 7th curriculum encourages that mathematical power should be evaluated by realizing the following evaluation methods in their classrooms: to emphasize processes more than products in order to foster students' thinking abilities; to focus on students' understanding of a problem and the problem-solving process as well as its results in order to evaluate students' problem-solving abilities; to focus on students' interests, curiosity and attitudes toward mathematics in order to evaluate students' mathematical aptitudes; to focus on student's abilities to think and solve problems in a flexible, diverse and creative fashion in order to evaluate mathematical learning; to use a variety of evaluation techniques such as extended-response questions, observations, interviews as well as multiple-choices in order to evaluate students' mathematical learning.

V. Efforts for Remodeling Mathematics Classes

In the late 1990s, there were three kinds of instructional movements to remodel the mathematics classes: Open education, use of technology, and performance assessment. Although these movements encountered resistance due to various barriers of human resources
and environmental factors, they have contributed critically to the development of instructional methods. As well, they had an effect on the development of the 7th national curriculum.

“Open” education

It has been criticized that the teacher-centered whole class lesson is a serious barrier hindering students' thinking abilities and attitudes toward mathematics learning. It is identified as the main culprit of the "total crisis" in mathematics education. For several years in the late of 1990s, the Korean mathematics education community was filled with debate of "open education movement" to improve students' thinking and communication abilities and to provide them with the joy of doing mathematics. It was a spontaneous movement of teachers for remodeling math classes against a "closed" school system to erase students' creativity and autonomy by preparing only for college entrance examination. Teachers provide various materials including investigation tasks, discussion topics, strategy games and projects and adopt a small group cooperative learning to cultivate cooperative spirit and to induce discussion between peers.

This movement has faced many barriers such as teachers' instructional competency, cultural conflicts with a large number of "traditional" teachers, an absence of the appropriate teaching model, a shortage of good materials, class size of over 40, and a conventional school system. However, it has contributed to change dramatically the instructional methods of most of all teachers.

Technology

Recently, the Korean mathematics education community has been encouraged by the instructional potentiality of various computer software, such as LOGO, designed to explore mathematics in a micro-world, LiveMath (CAS) with excellent symbolic manipulative functions, GSP and Cabri for easy construction and dynamic transformation of geometric figures, and EXCEL as a tool for various numerical problem solving. Because the computer can provide concrete method to represent abstract and formal mathematics and particularly because its operation is under students' own control, if proper software is used, students can reflect on their own mathematical and cognitive activities and strengthen mathematical communication among students and teachers by representing their concrete operational activities through mathematical language.
Performance assessment

Recently, in Korea, the evaluation system of mathematics has been changed rapidly focusing on how to apply knowledge to a situation, how to communicate a given situation and ideas concisely by using proper mathematical language, how to select and integrate information rather than on how much information students have. Under this direction, performance assessment has been introduced in order to evaluate what cannot be tested by the traditional paper-and-pencil test. Performance assessment is a test to evaluate an ability to set up an assumption, to check the assumption through practical or mental operations in various problem settings and an ability to communicate with other people in order to evaluate students' mathematical power rather than their memory of pieces of knowledge.

VI. Closing Remarks

Everywhere students dislike mathematics and are afraid of applying mathematics. It is a serious problem to keep mathematics at a distance and to consider mathematics in appropriate in the 21st century when mathematics is more important than in previous period. If the number of people working mathematics related field is insufficient, serious labor problem will be occurred in high technological society. Despite that mathematics spread out our society and there is no field not to use mathematics from daily life to rocket manufacturing industry, members of our society are not shameful about their absence of mathematical literacy. This society with false dichotomy cannot develop further more.

More students have to leave school absorbing mathematics and having confidence. Until now, school mathematics is considered as only a subject for college entrance examination. Thus many students think that the continual learning of mathematics is meaningless and the elementary mathematics is enough. We have to stop this consideration from now. Korea has a long history of false mathematics education. It is very difficult to restore this phenomenon. But, many Korean mathematics teachers and educators are trying to re-modeling math classes though it is a rugged way very difficult.

This article has summarized their effort made in Korea after TIMSS. The main focus is on the development of mathematical thinking abilities. This is related to the national strategy to construct a highly developed country in the near future and is based on the belief that mathematics provides tools for propelling the development of science and for solving quantitative and qualitative problems faced by people in their lives. To use these tools properly
in appropriate situations, fragmentary knowledge and skills are not enough. We have set ourselves the specific educational objective of providing the mathematical thinking experiences which students need in order to synthesis their knowledge and skills.

In the following 9 chapters, more detail description of the process to pursue the education objective in Korean mathematics education will be provided in terms of curriculum, textbooks, gifted education, classroom culture, teacher education and evaluation.

References