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Leadership and Autonomy Driving Mathematics Teacher Education in South Korea

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ABSTRACT This paper provides the findings of the pilot study and the current status of the initial training of mathematics teachers at both elementary and secondary level and in-service teacher training in South Korea. The pilot was conducted among teachers, administrators and facilitators of Mathematics Continuous Professional Development (MCPD) programs. The findings showed that the majority of Korean mathematics teachers took with high regard MCPD programs and wanted them to be part of their professional and personal development rather than pursuing their personal benefit like higher certificate or economic gains.The paper also outlines the commitment of administrators to implement MCPD programs and identifies the challenges of facilitators in the field. It is concluded that various incentives given to teachers are a stimulant to effective implementation of mathematics professional development programmes in the country and possibly a contribution to Korean students' good achievement in PISA and TIMSS mathematics performance.

INTRODUCTION

Education is a key factor in understanding the Korean society. The Korean society has a substantial interest in their children's education and Korean parents and government make great investments into their children's education with prospects of providing their children with a better life. Most Korean parents believe that their children's education is valuable enough for them to overcome realistic hardships.According to Korean government Survey (Statistics Korea 2012) fairly many parents in Korea are using more than 10% of their income on their children's out-of-school tutoring fees.

The Korean society has had a long tradition of holding teachers in high regard. It might be an impact of Confucius Heritage which emphasizes loyalty to a nation, education by teacher, and devotion to a family. The departments of teacher training are at the top level in almost all universities in Korea which means that undoubtedly, students enrolled in schools of education and teacher training programs tend to display a considerably high achievement level compared-to their peers in high school. As a result, teacher quality seems to be a very strong variable in the Korean educational society (Park 2004). Teachers are believed to be well-equipped with pedagogical and subject content knowledge of subject matters under the philosophy that the quality of education cannot exceed the quality of teachers.

Such keen interest in education and the quality of teachers are observed to serve as one of the main reasons why Korean students fare so well in such international comparative studies as TIMMS, TIMMS-R or PISA (Park 2004). But, the Ministry of Education (MOE) announced a policy on advanced mathematics education on January in 2012 (MEST 2012). This is because Korean students had a low interest, value and confidence in mathematics even though ranking the highest grades at international mathematics tests (Mullis et al. 2012). Korean government believes that it seems to come from traditional teaching ways, such as memorizing and solving problems without understanding of mathematical concepts. MOE emphasizes the fact that mathematics education should change to become more productive and future-oriented in order to promote an interest and understanding of mathematics as well as to develop integrated thinking ability and problem solving skills in students.

According to the new policy and the philosophy that the quality of education cannot exceed the quality of teachers, MOE has been carrying out various programs and policies to improve the quality and capability of teachersand provided various incentive such as a sabbatical year and a master teacher who is treated

as a vice-principal level leader of teacher learning in school (Cho and Choe 2012).This paper is to show the current status of the initial training of mathematics teachers and in-service teacher training and propose the challenges for professional development of Mathematics teachers.

Current Status of Initial Training of Mathematics Teachers

Elementary School Teachers

Elementary school teachers are trained at 13 universities including 11 National Universities of Education to train only elementary school teachers and the Korea National University of Education and Ehwa Women's University which are comprehensive universities to train both of elementary school teachers and secondary school teachers. All of them run 4 year educational qualification as initial elementary teacher training courses. Their curricula consist of a general education course work and a course work in one's specific major. Students are required to take at least 145 credits up to 162 credits to graduate (Pang 2009).

In Korea, although elementary teachers teach all subjects including Korean, English, Science, Social Study, Music and Art etc., in order to get elementary school teacher certificates in mathematics education as the declared major, students need to take at least 21 credits for subject matter knowledge and pedagogical knowledge of mathematics (Cho and Choe 2012). The proportions of courses for subject matter knowledge and pedagogy knowledge are well balanced as shown in Table 1 which is the case Korea National University of Education.

Secondary School Mathematics Teachers

Secondary school mathematics teachers are trained at the department of mathematics education of colleges of education and the department of mathematics of general colleges in the comprehensive universities, and graduate schools of education. In general, for all prospective secondary teachers, the curriculum of the colleges of education sets the graduation credit requirements in a range of 130 to 150 credits, of which the credits for liberal arts courses take 20 percent of the total credits, those for major courses take 60 percent, and those for electives take 20 percent (Cho and Choe 2012). The major field includes the study of curriculum, pedagogy of subjects, general pedagogy and practice teaching.

In comparison with the curricula of pre-service elementary teacher education programs, subject matter knowledge is much more emphasized in the curricular of secondary mathematics teacher education programs. In the case of secondary mathematics teachers, there is technically no curricular difference of content knowledge between the department of mathematics and the department of mathematics education. This means that most of the educational institutions attempt to maintain the high level of future teacher's knowledge in mathematics. Ultimately, it provides evidence that Korean secondary mathematics teachers are expected to possess strong mathematical knowledge. However, there have been recent reforms in the curricular of pre-service teacher institutions enhancing the correlation between teachers' subject matter knowledge of school mathematics and how to teach it. Table 2 shows curriculum of Korea National University of Education for pre-secondary mathematics teachers.

Many universities also offer extra programs to develop teaching competencies of pre-service teachers such as teaching workshops, competitive exhibition of teaching, mentoring for students, teaching behavior analysis lab, teaching clinics, special lectures on leadership development, peer tutor system, debating contest on

Table 1: Curriculum for elementary mathematics education

Content knowledge subject	*Pedagogy knowledge subject*
Elementary algebra	Teaching materials of elementary mathematics
Foundation of elementary mathematics	Instructional media in elementary mathematics education
Elementary geometry	Method and practice of elementary mathematics education
Elementary analysis	Psychology of learning mathematics
Elementary discrete mathematics	Understanding of elementary mathematics class
Elementary statistics	History of mathematics and mathematics education

The number of credit hours of all subjects is 3

educational issues, competitive exhibition of lesson plans, lectures on teaching, etc. (Kim et al. 2010). In addition, they make connections between theories and school practices. Through these connections, pre-service teachers can develop their expertise in implementing curriculum by applying and integrating the core structure of their subject matter knowledge to school curriculum.

Teacher Employment Test

Completing the four-year teacher education does not in itself guarantee teaching position in public schools. Upon their graduation from the college of education, teacher candidates are conferred the "second-level teacher", which makes them eligible to apply for the national teacher employment test called the Teacher Employment Test (TET). The graduates are awarded a secondary teacher certificate which enables them to only be eligible for teaching in secondary schools. City or provincial superintendents select teachers from those who hold teacher's certificates through open competition, and if teacher candidates want to teach in a public school, they must pass a highly competitive national examination. In the case of private schools, the institution itself makes the selections of teachers.

The TET for being a public school teacher has had a great influence on the teacher quality as well as the curriculum of teacher education programs. The first open competition exam for the selection of secondary public school teachers was conducted in November, 1991. The metropolitan/provincial Offices of Education forms 'the committee for teacher recruitment' and entrusts a research institute such as Korea Institute of Curriculum and Evaluation (KICE) to develop and score the TET questions. Each metropolitan/provincial Office of Education uses the exam to hire teachers in their local public schools. Table 3 shows Structure of the current TET for elementary and secondary school teachers.

In-Service Teacher Professional Development

There are strong demands for teachers to continuously update their knowledge and skills

Table 2. Curriculum for secondary mathematics education

Content knowledge subject	*Pedagogy knowledge subject*
Advanced Calculus 1, Advanced Calculus 2, Complex Variables Analysis, Functions of Several Variables, Linear Algebra 1, Linear Algebra 2, Number Theory, Modern Algebra 1, Modern Algebra, Geometry, Introduction to Differential Geometry, Topology 1, Topology 2, Numerical Analysis, Introduction to Differential Equations, Discrete Mathematics, Mathematical Statistics	Teaching Secondary School Mathematic, Educational Technology in Mathematics, Materials and Methods in Teaching of Mathematics, History of Mathematics and Mathematics Education, Mathematical Logic and Writing

Table 3: Structure of the current TET for elementary and secondary school teachers

Phase	*Applicants*	*Test*	*Test contents*	*Examination type*	*Secondary*	*Elementary*
Phase 1	All applicants	Pedagogy	Pedagogy	Essay Type	60 min	60 min
		Major A	Pedagogical content knowledge (25~35%)	Short Answer Type	90min	70min
		Major B	Subject matter knowledge (65~75%)	Sentence Completion Type Descriptive Type	90 min	70 min
		History of Korea	Substitution by Korean History Ability Test			
Phase 1	Successful Candidates of Phase 1	In-depth Interview of PCK			10min	60min
		Making a Teaching Plan			60min	20min
		Teaching Demonstration			20min	10min
		English Interview				10min
		English Teaching Demonstration				10min

due to the introduction of new curriculum (Lew et al. 2012), changes in the characteristics and learning needs of students (MEST 2012), new research on teaching and learning like Story telling or STEAM (Kwon et al. 2012). In addition, from 2013, the 17 metropolitan/provincial Offices of Education implement annually teachers' teaching ability test called TAT in order to improve the quality of education and enhance the educational responsibility of teachers in each school through professional judgment about their schooling activities (MOE 2013). Table 4 shows the framework for TAT test for secondary mathematics teachers.

Therefore teachers are required to take training courses with 60~80 hours every year to supplement their weak points based on the teacher evaluation. The metropolitan/provincial Offices of Education and teacher communities develop and offer various in-service teacher training courses including both off-line training and online training.

In Korea, there are four types of in-service teacher training which consist of Beginning Teacher program, First level Teacher Program, Autonomous Training Program, Special Training (Cho and Choe 2012). This section gives an explanation of each type of training and provides contents of first level teacher program and autonomous training program as typical professional development program together with examples.

Beginning Teacher Program

All teachers begins the second level teachers after passing Teacher Employment Test. Local government teacher training centers give them three kinds of in-service programs. Pre-employment training program of two weeks Follow-up program of one week after one semester or one year Mentor-mentee program: Well-qualified teacher is assigned as mentor for each beginning teacher

First Level Teacher Program

First, this qualification training is for teachers who want to acquire an advanced certificate of first-level teacher. After three years of teaching having completed180 hours of training, novice teachers are awarded an advanced first level teacher certificate. Table 5 shows courses offered for the secondary mathematics teachers in the first-level teacher training of the Seoul metropolitan office of education in 2011(Seoul Education Training Institute 2011). Major courses in the first-level teacher training for the elementary school teachers are fewer than those for the secondary school teachers since elementary school teachers are teaching all subjects. It is

Table 5: Courses offered in the first-level teacher training of the Seoul metropolitan office of education in 2011

Classification	*Courses*	*Credit hour*
Elementary	General courses	28
	Teacher education courses	34
	Major courses	110
Secondary	General courses	20
	Teacher education courses	28
	Major courses	128

Table 4: Framework for TAT test for secondary mathematics teachers

Areas of evaluation	*Elements of evaluation*	*Indicators of evaluation*
Teaching and Learning	Preparation for class	Understanding the curriculum, effort of improvement for teaching and learning, Analysis oflearner's characteristics and mathematical content, Establishment of strategy forteaching and learning
	Carrying out class	Introduction of class, questioning, Behavior of teacher, Interaction between teacher and student, Application of learning materials, Progress of class, Finishing of class
	Evaluation and its application	Content and method of evaluation, application of evaluation results
Education for Living	Guide for personal life	Understanding personal matters, guide of student's creativity and personality, Guide connected with students' home, Guide for student's career direction, specialty and aptitude
	Guide for social life	Guide for basic daily habits, Guide for adaptation to school, Training of democratic citizenship

hard to deal with mathematics-related integrated perspectives and teaching strategies in the first-grade teacher training for the elementary school teachers.

There is little difference of training courses given by the 16 metropolitan/provincial offices of education since MOE determines the 'Standard curriculum for teacher qualification training' for the first level teachers. In-service teacher training courses, however, vary across the metropolitan/provincial offices of education since each metropolitan/provincial office of education designs various courses to meet the needs in the local contexts. Table 6 shows the MOE standard curriculum for the first level mathematics teacher training revised in 2009 (MEST 2009).

Table 6: MOE standard curriculum for the first level mathematics teacher training

Course	*Subject*	*Time (hour) operation*	*Method of*
Theory and Curriculum	♦ Theory of mathematics education and its recent trend ♦ Theory of mathematics education and its recent trend ♦ Practice of school management of mathematics curriculum ♦ Curriculum management fitted with student's leve ♦ History of mathematics curriculum	12~16	
Subject Content Education	♦ Advanced learning about main areas of mathematics curriculum: Algebra, Geometry, Statistics and Probability, Discrete Mathematics, Analysis, Applied Mathematics	28~34	
Methods of Teaching and Learning	♦ Theory of teaching and learning in mathematics ♦ Teaching and learning models in mathematics ♦ Class analysis methods in mathematics ♦ Making teaching and learning material in mathematics ♦ Case study of high level classroom instruction in mathematics ♦ Theory and practice of cyber learning in mathematics ♦ Theory and practice of project learning in mathematics ♦ Analysis and application of student reference books in mathematics	14~22	Discussion Practice Lecture
Evaluation of Teaching and Learning	♦ Theory and practice of evaluation in mathematics Evaluation methodology and grade management in mathematics ♦ Practice of evaluation item analysis and item construction in mathematicsË% Evaluation of mathematicalactivities at student's discretion	6~10	
Extra-curriculum	♦ Management and evaluation of extra curriculum activity in mathematics (student club, adaptation, service in society, school event etc.) ♦ Theory and practice of field-experience learning in mathematics	6~8	
After School Activity	♦ Lifelong education related with mathematics ♦ Management of specialty andaptitude education activity related with mathematics ♦ Management of differentiated supplementary classes in mathematics	6~8	Discussion Field-practice Lecture
Education Research and Educational Technology	♦ Theory and practice of educational research in mathematics ♦ Educational technology and instructional design for mathematics classes ♦ Application of educational technology in for each type of learning model in mathematics	8~10	Discussion Practice Lecture
Understanding of School Practice	♦ Conversation with senior mathematics teacher ♦ Visiting high level schools in mathematics ♦ Cross-curriculum activities like STEAM ♦ Theory and practice of school research in mathematics	18~22	Practice Discussion Field-practice Lecture
Evaluation	♦ Evaluation	4~6	
Elective Subject	♦ Free electives of training institution	6~8	
Total		108~144	

Autonomous Training Program

On-the-job training is targeted at developing abilities and quality of teachers in relation to the performance of their duties and adaptation to school practice, and it used to be the most popular training for teachers. This training is implemented at the institutes approved by MOE or metropolitan/provincial Offices of Education. These institutes offer various customized in-service training courses such as 'Prosumer training' and 'school-based training' that are tailored to meet teachers' needs. For example, the Korean Society of Teachers of Mathematics (KSTM) hosts a training called 'Math Festival', which are responded well from teachers, for four days and three nights during the winter vacation every year. Those who will benefit have to bear the cost of training, and they can get two credits from the course. In addition, they can choose sessions and workshops among various units of the training based on their preferences or concerns. As most instructors are in-service teachers, they share and present what they had direct experience of or created.

Special Training

Many teachers attend master degree program at the graduate level with the purpose on enhancing advanced expertise of teachers. Special case is Korean National University of Education (KNUE) program in which selected teachers by a special selection test are dispatched to KNUE as a full time students with all their tuitions and salary for two years supported from government. special training has purpose on enhancing advanced expertise of teachers. For example, selected teachers by a selection test are dispatched to KNUE or Seoul National University for two years in order to studying for a master's degree.

General Training

General training aims to enhance general knowledge of education theory and method, so thereare various training courses arranged for developing teachers' problem solving abilities of educational practice and for leading participation and professional development.

Lesson Study (Research Lesson)

Korea also has a history of Lesson Study which is called **"**Research Lesson".Teacher invites principal, colleagues, sometimes, even parents to give advice on teaching.This tradition might not be effective in the sense that teachers used it just as an annual event to show up their classrooms.Nowadays, young teachers use it as a tool for improving their teaching skills through peer evaluation before and after classrooms.

OBSERVATIONS AND DISCUSSION

Pilot Test on in-Service Education

To understand the status of Korean in-service program for mathematics teachers, 6 kinds of questionnaires were used for each of School District Officials, Teacher, Providers, School Principals, School Subject Advisor, Facilitators, and-MOE Officials. They were developed in the first preparatory meeting for this project but were slightly modified to be applied at the local level.

Target subjects were 61 teachers from the first level mathematics teacher certificate program, the second level mathematics teacher certificate program,two school district officials, one providers, two high school principals, one high school subject advisor, and one MOE official.Among 61 teachers, 23 (37.7%) were male and 38 (62.3%) were female. 23 (37.7%) come from mathematics, 21 (35 %) from computer and 11 (27.3%) from others from Technology and Science. Among them 29 (47.5%) were junior high teachers and 32 (52.4%) were senior high teachers.

Teachers

While 89% of teachers described MCPDas "professional development as math teachers" or "self-development as teaching experts in math" or "easy adaptation to rapid change in theoretical development in mathematics education", or "connection of various subjects", only 11 % of teachers described it as getting the "higher level of certificate" or "double certificate". And 76% of teachers and 16% of teachers thought that they had participated MCPD for "personal fulfillment" and "for career progression" respectively. This is far higher than "economic gains" (1.3%) and the others (6.5%).This means that a majority of Korean mathematics teachers want that MCPD should be an arena for their professional and personal development

as a teaching expert rather than pursuingtheir personal benefit like higher certificate or economic gains.

MCPD in Korea is being promoted relatively well and Korean teachers have participated in the various autonomous MCPD programmes. While 80.3% of teachers thought that their schools had a policy to support their MCPD activities, 19.7 % had not. A total of 71 programmes were mentioned and they can be categorized as follows: Advanced pure mathematics training (5.6%), Advanced secondary school training (8.5%), Math festival (7.0%), Workshops for talented students (16.9%), Research Club for theory of mathematics education (8.5%), Instructional design and teaching methodology (15.5%), Management of mathematics laboratory (18.3%), Development of mathematical consulting skills (12.7%), Management of mathematics curriculum (7.0%).

In Korea,the majority of MCPD was provided by Provincial Office of Education. MCPD service providers identified by the respondents were NGOs/ Private sectors (4.3%), Provincial Office of Education (78.3%), Higher Education Institutions (2.9%), Public/Private partnerships (4.3%), Professional Learner Community studies (2.9%),Others like schools and teacher's self-studying groups (7.2%).

The programmes of MCPD emphasized various areas like: Content knowledge (for for examle algebra, numbers, measurement, etc.) (22.0%), Pedagogical content knowledge (21.0%), Curriculum interpretation and implementation (21.0%), Classroom management and organization (14.5%), Mathematics knowledge for teaching (21.0%). As a result, most of all teachers (96.7%) considered these activities relevant to your classroom practice. And, the activities used in the programmes used various activities like: Introducing current teaching models in mathematics (24%). Connecting pure mathematics and school mathematics (20%),Introducing current theory of mathematics education (27%), Introducing current mathematics curriculum (17%), Analyzing of current textbooks (5%), Using computer technology (3%), Introducing current philosophy of mathematics education (2%). This implies that MCPD in Korea focuses on practical and pending aspects rather than theoretical and future aspects. For example, computer and textbook might be matter of less concern of teachers in that they believe themselves as an expert of textbook and computer is not a practical matter in current mathematics education

Teachers interviewed mentioned that MCPD influenced their professional practice by:Getting new certificate (19%), Learning current teaching and learning methodology (51%), Learning advanced knowledge of mathematics (4%), Reflection on classrooms (15%), Learning advanced theory of mathematics education (13%). Here, this continuously implies that the concern of Korean mathematics teachers are interesting in practical and pending aspects of MCPD.

76.3 % of teachers interviewedparticipated "once a year", 10.2% of teachers "twice a year" and 13.6% "three times a year". And, 86.9% of teachers answered "Holidays" as the time of MCPD conducted,6.6% of teachers "during teaching sessions", 4.9% of teachers "weekends", 1.6% of teachers "after teaching hours." Most of teachers participated MCPD once a year during holidays. The MCPD venues was "inaccessible" for 45.9% of teachers , "easily accessible" for 26.2% of teachers and "far away" for 27.9% of teachers. This implies that frequency of MCPD and accessibility to the venue need to be improved.

About the motivation to participate in the programme (s), teachers indicated as follows:, Policy requirement 40 (57.1%), Certification or improving/upgrading qualification 21 (30.0%), Economic gains such as salary increase 7 (10.0%) and Part of holiday 1 (1.4%). This implies that policy and system for upgrading of certificate are main motivation for teachers to participate MCPD.

Ninety percent of teachers answered their school districts as a supporting organization and 7% of teachers answered their schoolsand 4 % answered "personal." 75% of teachers received registration fee only, 15% of teachers received registration and lodging, 2% received transportation fee only and 10% got information and taking care of absence. Eighty-two percent of teachers thought the support is enough, 9% of teachers very enough, 7% not enough and 2% relatively enough. This means that MCPD in Korea are relatively well supported by the Provincial District Office financially.

All teachers answered that they were aware of the objectives of the MCPD programme (s) they attended. Based on this awareness, teachers interviewed chose the weaknesses of the MCPD programme(s) they attended as follows:

Training period is short (47%), Training period is too long (6%), Lecture style of training (9%), Providing too many information (not concentration, diffuseness) (21%), Shortage of reality5 (11%), Shortage of professionalism of lecturer (2%). This means that teaching style need to be systematized and trainee-friendly and training period need to be re-arranged properly

Similarly, teachers interviewed chose the strength of the MCPD programmes as follows:High level lecturers (13%), Getting of certificates (4%), Fullness of lectures (4%), High concentration of lectures (9%),Various advanced level of lecture contents (33%), Fitness to field adaptation (27%), Network of teachers (9%). This implies that the most important point of MCPD is to invite lectures to provide high level teaching methodology for classroom management and field adaptation.

The MCPD programme(s) were evaluated with various methods: Various Evaluation methods (38%), Objective and subjective tests (29%), performance assessment (12%), Discussion and presentation (15%), On-line examination (3%), Tasks at home (3%).

After attending the MCPD programme (s), teachers interviewed considered to be successful in their classroom practice in the following aspects: Professional Development of teachers (13%), Good mathematics contents knowledge (15%), Students centered instruction (18%), Research on teaching methodology (43%), Development of good learning materials (6%), Induction of learning motivation (6%).

Teachers interviewed indicated their challenges to be faced in implementing MCPD initiatives after attending these programmes as follows: Relation with colleagues (19%), New adaptation of new knowledge (4%), Difficulty of adaptation in real instruction (Students levels, teaching methodologies etc.) (48%), Specialty on teaching (7%), Support of schools (15%), Disconnection of reality and theory (7%).

They suggested some points to improve MCPD programme (s) as follows: Extension of training days (24%), Reduction of training days (2%), Systematic training (4%), Continuity of training (16%), Relevance of training period (16%), Discussion and self-study with colleagues (20%), Providing practical classroom material (14%), Improvement of some training environment (6%).

Facilitators

In the lesson by the facilitator, learning objectives for the in-service teachers were given verbally and written, and the objectives were discussed at the end of session. Facilitator used power point material mainly and hand-outs occasionally. The participants seemed to be interested and enthusiastic in the lecture because the facilitator used humor and rapport appropriately and allowed the participative atmosphere of the classroom. And, the opening mention gained the sessions' attention in that the opening outlined the topic and purpose of the presentation clearly. The facilitator showed evidence of preparation of the session, and asked teachers' prior-knowledge in the content presented. The facilitator used various activities of explanation, showing examples, asking, commenting during the lesson, and emphasized key points very well. Particularly, the facilitator offered "real world" examples frequently.

However, the facilitator did not involve teachers in deciding what issues to discuss and did not induce trainees' questions.The facilitators did not give assignment or suggest an idea to consider before the next session andthere was no the session stimulating and thought provoking.The facilitator did not encourage teachers to summarize the work done in the sessionand the participation of all the teachers, and to mention problems/concerns with the session. Furthermore the facilitator did not prompt awareness of teachers' prior learning and experiencesand did not pay attention to clue of boredom and confusion.

Administrators

According to administrators at MOE and District Office, in Korea, there was a general policy on Continuous Professional Development (CPD) for teachers, which is formulated by MOE and School Districts. The policy has influenced to the curriculum formation for CPD programmes, Policies on teacher's status change and various incentives to facilitate the effective implementation of CPD of which mission is to improve teaching quality through teachers' professional development and eventually supporting high quality learning of students.

The administrators showed various types of MCPD programmes for teachers to cope with

rapidly changing mathematics education theories such as Instructional consulting for mathematics teaching, Contest of mathematics teaching, Management of subject matters council in each school, Seminar for mathematics teachers, Lesson study, Workshop for mathematics materials, Mathematics Festival, Mathematics Clinic for mathematics teachers, Contest of Mathematics teaching, Management of mathematics teacher's council in each school, Seminar for developing creativity and humanity through mathematics. Mathematical computer software workshop, Cooperative learning workshop, level fitted instruction workshop, Creativity and humanity instruction competition. The main focus/emphasis of the programmes was to improve basic knowledge of mathematics teachers for strengthening teaching ability and professionalism. The programmes were conducted through face-to-face teaching usually and on-line sometimes.

They have selected the providers of the MCPD programmes which could provide various good programme to coincide with government policy and advanced policy of mathematics education based on the formal guideline designed by MOE. They have encouraged mathematics teachers to form research groups or mathematics teacher's council for investigating the current issues in mathematics education and manage "Open Classroom" for lesson study in each school as a platform to apply what they have learned at the training center and to communicate information related with classroom implementation to sustain teacher's professional development suitable to school based situation.

They chose the limitation of budget," Shortage of experienced lecturers in mathematics area", "shortage of awareness of teachers on professional development", "Difficulty of replacement for teachers on in-service education" as aspects to hinder the effective implementation of MCPD in the district.

Most MCPD programmes lead to some form of certification issued by Director of the training center and were Supported by MOE and District Office financially. Trainees evaluate the whole management of providers after the course through a questionnaire and providers evaluated the facilitators of MCPD programmes through interviewing with trainees.Cyber study and training, activation of consulting committee,

They chose forming of research groups of teachers as strategies to use to sustain the programs in schools They suggested continuous-periodic qualifying training (at least once every five years rather than only one qualifying training in life time) after becoming teachers, cyber study and training, finding good lecturers, anddesigning the good curriculumto improve teachers' spontaneous participation extending teacher sabbatical for more teachers to attend 1 year professional development programme for the improvement of the MCPD programmes

Challenges of Professional Development

In this section, some challenging points are proposed based on the current situation of initial teacher education and in-service education in mathematics, and the above described pilot test on MCPD

Pre-service Training

By reviewing pre-service teacher education, teacher employment test, and ways to develop teacher professionalism in Korea, we can conclude as follows: First, the results from the analyses of the realities of pre-service teacher education and teacher education programs imply that Korean teacher education programs should be more aligned with the school curriculum. Teacher education systems in Korea do not update their curriculum timely. In addition, little differences are found between teacher education programs in mathematics and general college programs in mathematics. We need, therefore, to find ways to enhance school adaptability of pre-service teachers and their mathematics teaching competencies.

Teachers' instructional competencies can be determined by the kind of education they had experienced in the teacher preparation program. We should, therefore, train more competent teachers by reforming the curriculum of the teacher education program. Various strategies can be implemented within the existing system and framework of teacher education programs. First, we should develop the curriculum of teacher education programs to meet the practical needs in schools. Rather than developing theory-oriented curriculum, we need to develop field-oriented curriculum for prospective mathematics teachers based on the analysis of school mathematics and pre-service teachers' understanding of school practices through video anal-

ysis of mathematics classroom, relationship between college courses and teaching internships, and so on. Second, pre-service teachers need to participate in the various programs for underachieving students, education for the gifted, after-school classes as well as regular classes and so on to get familiar with the school field, enhance their understanding of students, and improve their teaching professionalism. It is important to conduct mentoring systems between pre-service and in-service teachers, and online and offline teacher networks throughout these experiences. Third, we need to revise the curriculum of the teacher education program towards more future-oriented and classroom-friendly to keep pace with the times and rapid changes. Mathematics education should incorporate interdisciplinary integration, teaching using smart phone, and so on.

Teacher Education and Training (TET)

Considering high competition to be a teacher in a public or private school (for example the competition rate for national and public elementary school teacher employment test is up to 3:1 and over 10:1 for that of secondary school teachers), it would be difficult to maintain the specific characteristics of teacher education programs. This will in turn cause difficulties in controlling teacher quality. By improving the teacher employment test system, we can select more competent teachers and contribute to the normalization of the teacher education program. We can validate pre-service teachers' teaching competencies by examining pre-service teachers' portfolios that contain extracurricular activities, service activities, teaching practices, etc. Teacher portfolios have been introduced in America since the early 1990s to train and evaluate teachers. Teacher education programs validate pre-service teachers' teaching competencies based on the portfolios and then this accreditation credit is used in the TET.

In-service Training

There have been various measures and systems to improve teacher professionalism including on-site teacher training programs and teacher training programs that are tailored closely to the needs of individual schools and teachers. In particular, the MOE has been implementing new policies and systems to increase teacher professional knowledge and skills including teaching consulting, outstanding teachers' research leave, master teacher system, and so on. The MOE has explored various ways to develop teacher professionalism since the implementation of the Teacher Ability Test.

Various strategies are required to utilize current teacher development programs. First, we need to conduct more research on diversifying the content and format of teacher development programs. The content and implementation methods of the teacher development program need to be detailed to the needs and levels of the trainees. We need, therefore, an in-depth research to devise the content and the format of the teacher development program. Second, we need to reinforce the reflective teacher education model. The essence of the reflective teacher education model is a cyclic approach that consists of planning, preparation, data collection, data analysis, evaluation and reflection, planning of the next stage, and so on. This model requires the teacher's will to develop her professionalism as a prerequisite. Third, we should activate teachers' learning communities. Compared with the teachers who are not collaborating, the teachers who collaborate with colleagues to prepare teaching materials resulted in higher students' achievement scores at a statistically significant level (Lee and Chung 2011), which shows that teachers' collaboration efforts have a significant impact on their professional development. Korean mathematics teachers have already operated various teacher learning communities such as teacher research meetings, subject teacher conventions, etc. We need, therefore, to figure out the realities of these teacher learning communities and investigate ways to activate them. Fourth, teachers should collaborate with their colleagues to increase lesson study opportunities focused on practical knowledgein their classrooms. Teachers should develop their teaching skills to enrich their 21st century competencies and their expertise.

CONCLUSION

In the researcher's opinion, we have many driving forces for teachers to attend actively an in-service education: Promotion to a school supervisor, Honor to be a master teacher, Good scores on Mandatory Evaluation of teachers,

Inner confidence as an expert, various incentive such as research funding and sabbatical year. Teacher education has been designed by government efficiently and been implemented by teachers autonomously. Korean students' good achievement in PISA and TIMSS comes through a high quality of Korean teachers well trained on the tradition that teachers are highly regarded. A leadership by a government and autonomy in a teacher society are key elements of good professional development.

RECOMMENDATIONS

As previously mentioned, this research is based on the pilot test with a limited number of samples. The further research needs to be conducted with more numerous data for getting persuasive ideas to upgrade mathematics teachers' professional development. Autonomy in a teachers' society can be kept by reflecting opinions and expectation on teacher development of society members. Moreover, this research needs to be extended to the international comparison study for getting new ideas used in other countries. A leadership by a government can be strengthened by providing teachers with more efficient and more productive way for their professionalism.

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