

## Korean Primary School Teachers' Conceptions of Foundations and Creativity in Mathematics

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### I. Introduction

Mathematics is unique in that mathematical concepts require learners to understand their abstractness. Even though teachers use concrete manipulatives for introducing mathematical concepts, they eventually need to 'teach' intangible mathematical concepts to students. Thus, the teaching methods vary from teacher to teacher and teachers' teaching practices are also affected by their conceptions of mathematics (Andrews & Hatch 1999, 2000; Beswick, 2004; Diakidoy & Kanari, 1999; Hong & Kang, 2010; Hoz & Weizman, 2008).

Foundations of mathematics have long been the subject of debate in the history of mathematics (e.g., Chaitin, 2000; Marek & Mycielski, 2001). Foundations of mathematics have been recognized in various manners (Shapiro, 2004). The detailed philosophical definition of foundations of mathematics is beyond the scope of this study and the definition of it is added in the next section. In this study, I regarded the foundations of mathematics as essential and important mathematical components—concepts and skills—that students should learn. Foundations of mathematics are emphasized in the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathe-

tics, 2000) as contents standards such as number and operations, algebra, measurement, and data analysis, and as process standards such as problem solving, reasoning and proof, communication, connections, and representation. The recently revised Korean mathematics curriculum (Ministry of Education & Human Resources Development [MOE & HRD], 2011b) also emphasizes foundations of mathematics as basic skills, concepts, principles, and patterns (p.3).

Contrasting to the long-debated issue of foundations of mathematics, researchers recently drew attention to creativity in mathematics. Regardless of slight differences, creativity has been emphasized in every field of contemporary society. We often use the terms like 'creative thinking,' 'creative management,' 'creative man or woman,' 'creative problem solving,' and so forth. Creativity in mathematics is also appreciated in most mathematics curricula (e.g., National Council of Teachers of Mathematics [NCTM], 1989, 2000) and the revised Korean mathematics curriculum (Ministry of Education & Human Resources Development [MOE & HRD], 2011b). The Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) recommends teachers include "open-ended (problems) with no right answer" (p.6). The Learning Principle in the book (NCTM, 2000) emphasizes the need to go beyond rote memorization and basics saying, "students need to learn a new set of mathematics basics that enable them to compute fluently and to solve problems creatively and resourcefully" (p.1) and "students must learn mathematics with understanding, actively

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building new knowledge from experience and prior knowledge" (p.20).

The Korean mathematics curriculum (MOE & HRD, 2011b) emphasizes creativity in mathematics as "producing new ideas and challenges" (p.1) to make an ideal human. It also includes "creative problem solving" (p.3) as a goal, and "creative thinking ability based on mathematical knowledge and skills" (p.131) in the teaching, learning, and evaluation requirements. International studies, including Trends in International Mathematics and Science [TIMSS] (National Center for Educational Statistics, 2011) and the Program in International Student Assessment [PISA] (OECD, 2010) also include creative ideas in their test items.

Mathematics has been considered as a subject with which students can foster logical thinking (Whitehead & Russell, 1910) which has different brain functions compared to creative thinking (Carter, 2009). With this view, foundation building and fostering creativity are the main interests for mathematics educators although both topics are not given much attention at the same time. There have been several studies on conceptions of mathematics and creativity related to mathematics, respectively (e.g., Hoz & Weizman, 2008; Laborde, 2007; Marek & Mycielski, 2001). Hoz and Weizman (2008) investigated official conceptions of mathematics concerning the nature of mathematics. They assembled the ideas about mathematics and about its teaching mathematics. Concerning creativity in mathematics, there have been several studies (e.g., Aljughaiman & Mowrer-Reynolds, 2005; Bolden, Harris, & Newton, 2010; Silver, 1997). Bolden, Harris, and Newton (2010) analyzed pre-service primary teachers' conceptions of creativity in mathematics in the United Kingdom. Silver (1997) suggested fostering creativity strategies through instruction enrich mathematical problem solving and problem posing. He argued that mathematics educators should view creativity not as the domain of only a few exceptional individuals but

rather as an orientation or disposition toward mathematical activity that can be fostered broadly in the general school students.

Korean students have routinely scored high at the TIMSS (National Center for Educational Statistics, 2011) and PISA (OECD, 2011). However, Korean students spend almost double the amount of time studying compared to the time spent by other OECD students. In addition, their attitude toward mathematics is quite negative among participating students (National Center for Educational Statistics, 2011). Being aware of this problem, the Korean government emphasizes creativity in the mathematics curriculum and in the process of teaching and learning mathematics (MOE & HRD, 2011b).

Recently, the Korean government suggested that teachers should encourage students to use the 'STEAM (Science, Technology, Engineering, Arts, and Mathematics)' model as an integrated approach to enhance students' creativity in instruction (MOE & HRD, 2011a). Teachers' conceptions of foundations and creativity in mathematics can significantly affect their teaching methods when they help students foster the foundations and creativity of mathematics (Brunkalla, 2009). However, few related research has investigated in subject areas and teachers have limited understanding of creativity. For instance, Hong and Kang (2009) argued that Korean science teachers had narrow conceptions of creativity.

Some found that there could be a closer relationship between conceptions and teaching (e.g. Beswick, 2004; Strauss, 1993), and teachers' beliefs about the nature of knowledge would impact their teaching plans and practices (Hofer & Pintrich, 1997; Lerman, 1990; Thompson, 1984). Studies on foundations and creativity in mathematics have been conducted in many countries (e.g., Aljughaiman & Mowrer-Reynolds, 2005; Andrews & Hatch, 1999; Fryer & Collings, 1991; Kamylyis, Berki, &

Saariluoma, 2009; Wong (2007). In this study, I took the position that teachers' conceptions of mathematics would influence their teaching practices in the classroom. However, the establishing the correlation between teachers' conceptions and their teaching practices was not focus of this study.

The focus of this study is to identify the conceptions what the Korean teachers have about foundations and creativity. Despite the importance of foundations and creativity in mathematics, they have rarely been discussed. Thus, it is meaningful to investigate the conceptions of foundations and creativity in mathematics of Korean primary school teachers.

For the purpose of the study, I posed the research questions as follows:

1. What conceptions of foundations of mathematics do the teachers have?
2. What conceptions of creativity in mathematics do the teachers have?

## II. Related Literature

### 1. Foundations and Creativity in Mathematics

The word 'foundations' may have many different meanings. Shapiro (2004) argued that 'foundations' of mathematics have multiple meanings by explaining metaphysical, epistemic, and mathematical, with subcases of each. From the first position, a foundation provides the ultimate ontology for mathematics, stating what mathematics is about, the second, the proposed foundation provides the ultimate justification for each founded branch of mathematics, and the third, the proposed foundation provides a lucid articulation of a theory into which all mathematical theories can be translated. Marek and Mycielski (2001) stated logics and foundations are a domain of mathematics concerned with basic mathematical structures and mathematical reasoning and

computations. They argued that mathematics is the art of deduction rather than the science of a list of facts. They argued that "the study of nature often suggests new mathematical conjectures and sometimes even their proofs, and from time to time it suggests new fundamental axioms that yield interesting theories. In particular, logic is a study of ways in which nature has prepared us to describe reality, a study of natural intelligence" (p.466). From their point of view, mathematics is not from human imagination alone, but from humans' generations by contacting with nature.

Moore (1903) argued that students should have opportunities to observe the connections between mathematical concepts and other subjects by enriching and vitalizing the materials and methods (p. 414). He emphasized that the grade teachers must make wiser use of the foundations furnished by the kindergarten. By posing elaborated questions, teachers should give opportunities to their students to observe connections of mathematics. For instance, questions in the drawing and the paper folding activities must lead on directly to systematic study of intuitional geometry. Simpson (2011) defined mathematics as 'the science of quantity.' He interpreted quantity broadly as numbers and higher quantities (e.g., matrices, etc.) and geometrical figures (e.g., triangles, manifolds, etc.). He stated that 'foundations of mathematics' mean 'the study of basic mathematical concepts.'(p.2) He also argued that all human knowledge is contextual and hierarchical. In this study, I took the position of Simpson to consider foundations in mathematics.

The existence of creativity outside the arts and, in particular, the many ways of being creative in mathematics did not attract much attention until more recent times (Treffinger et al., 2002). Like foundations of mathematics, creativity has been widely described in various ways from being considered as an indefinable concept (Bohm, 1998, Craft, 2003;

Shaughnessy, 1998) to definable concept (Sriraman, 2009). Even though most researchers did not provide explicit definitions of creativity, they often considered creativity as the similar notions such as producing an appropriate new idea or object of value (Csikszentmihalyi, 1996; Hatcher, 2008; Haylock, 1987; NACCCE, 1999; Sriraman, 2009).

Focusing on divergent thinking, Kwon, Park and Park (2006) defined creativity as a high-dimensional human activity or skill to think up something new. Some researchers even included ethical (Cropley, 2001) and autonomical (Hodges, 2005; Sawyer, 2004) issues in creativity. Also, conceptions of creativity reflect cultural values, which may affect a person's experience of creativity and his or her ability to manifest it (Craft, 2003; Csikszentmihalyi, 1996; Sawyer, 2004; Sternberg, 2007). Mann (2006) argued that the essence of mathematics should be creativity. He tried to measure mathematical creativity and that teaching mathematics without providing for creativity denies all students, especially gifted and talented students, the opportunity to appreciate the beauty of mathematics and fails to provide the gifted student an opportunity to fully develop his or her talents. He also recommended that classroom teachers should examine their teaching practices and seek out appropriate curricular materials to develop mathematical creativity.

Sriraman (2004) tried to define mathematical creativity. He defines mathematical creativity as the ability to produce original work that significantly extends the body of knowledge or to open avenues of new questions for other mathematicians. However, in this research, creativity in mathematics is not only offering something noble to the world but also even producing something new to learners themselves. In this sense, even young students can be creative. To be creative in mathematics, students need to break free from established mind-sets and think their own ways of solving problems. He conjectured that "in

order for mathematical creativity to manifest itself in the classroom, students should be given the opportunity to tackle non-routine problems with complexity and structure - problems which require not only motivation and persistence but also considerable reflection" (p.32). To do this, mathematics teachers need to see sophisticated mathematical similarities and isomorphic structure among problems and thus encourage their students to think creatively.

Thus, creativity in mathematics education is not only for mathematicians but also for students who try to solve or invent new mathematical strategies (Kruteskii, 1969, 1976; Polya, 1954). Sriraman (2004) employed Gestalt model proposed by Hadamard (1945) to explain his idea of enhancing students' mathematical creativity in the mathematics classroom. That is, by reflecting the process of creative work of mathematicians, he attempted to analyze the detailed process of creation by applying the preparation-incubation-illumination verification model of Gestalt. He argued that students also need a period of incubation to produce creative ideas.

Sheffield (2005) suggested several strategies, such as appreciation, animation, association, alteration, and abdication that they might use to enhance students' creativity and deepen their understanding of mathematical concepts. She argued that even if students never become career mathematicians, they have the habits of mind such as perseverance and flexibility by using creative techniques to solve various mathematical problems. Thus, teachers need to give opportunities and encourage students to pose and solve mathematical problems creatively.

The two terms 'foundations' and 'creativity' are needed to define because they have multiple meanings. In this study, foundations of mathematics and creativity in mathematics were defined as follows.

Foundations of mathematics: I employed Simpson's (2011) definition. That is, foundations of mathematics

are 'the study of basic mathematical concepts (quantity, number, geometrical figure, etc.), how to organize these concepts into a hierarchy of more and less fundamental concepts, how to set up axioms and rules of proof for mathematics, and in the systematic phase, a study of the properties and limitations of such formal systems' (p.2). In this study, 'foundation' is considered as 'fundamental' as Ma (1999) and Schoenfeld (2006) mentioned. That is, from students' level, foundations of mathematics are fundamental concepts and skills for profound understanding of fundamental mathematics that leads to deeper and more flexible knowledge of mathematics.

Creativity in mathematics, like foundations of mathematics, there is no single definition of creativity in mathematics that is generally accepted in research (Mann, 2006; Nadjafikhaha, Sriraman, 2004; Yaftian & Bakhshalizadeh, 2011). In general, creativity in mathematics is not only offering something noble or original to the world but also even producing something new to learners themselves. In this study, I defined creativity in mathematics in a broader sense and thus even young students can thus be considered as creative. I included the main components of creativity such as novelty, fluency, flexibility, elaboration, and sensitivity, as Torrance (1967) mentioned.

## 2. Teachers' Conceptions of Foundations of Mathematics

The term 'conception' has been treated as belief, thought, attitude, perception, opinion, world view, epistemological belief, personal knowledge, perspective, philosophy, ideology, value, understanding and knowledge. 'Conception' in mathematics seems distinct from the other concepts in which it has been all too often dichotomized (e.g. mathematics is either absolute or fallible), whereas the other concepts usually appear as continua (Hoz & Weizman, 2008). Lerman (1990)

suggested a continuum of conceptions of mathematics, where one pole is seeing mathematics as an immutable body of knowledge, which teachers transmit in replicable ways and the other as a social construction learnt through an engagement in problem solving. In this study, I took a position that the conception of mathematics is rather the other concepts usually appear as continua.

The teachers' conceptions of foundations of mathematics are classified in either 'static-stable' or 'dynamic-changeable' (Hoz & Weizman, 2008), which are fragment conceptions and cohesive conceptions (Crawford et al., 1994), respectively. Hoz and Weizman (2008) investigated the descriptions of the conceptions of mathematics as follows.

The 'static-stable' and 'dynamic-changeable' conceptions of mathematics are clusters of all the experts' characteristics of mathematics, respectively, and the official 'open-tolerant' and 'closed-strict' conceptions of mathematics teaching are clusters of all the experts' views on mathematics teaching (p.906).

Quoting several research, they argued that large populations of elementary and high school prospective teachers hold the closed conceptions of mathematics teaching and adopt a traditional view of mathematics teaching that students learn in a passive manner with great emphasis on practice and memorization, whole class discussion. They also identified the relationship between conceptions of mathematics and its teaching. However, some studies have found little correlation between teachers' conceptions of the nature of mathematics and their instruction methods (e.g. Schraw & Olafson, 2002).

Teachers' conceptions of mathematics are important because they play a significant role in teachers' instructional practices in the classroom (Andrews & Hatch, 2000; Ball, 1990; Frank, 1990). Andrews and

Hatch (1999) categorized mathematics teachers' conceptions of mathematics as economic tool, diverse and pleasurable activity, life-tool, service provider, and curricular determination. They also analyzed correlations between conceptions of mathematics. In respect of the five conceptions of mathematics, the interesting finding was that the teachers appeared to hold simultaneously conflicting conceptions. That is, they hold simultaneously both absolutist, mathematics as a service to other areas of activity, and fallibilist, mathematics as a diverse and pleasurable activity, conceptions. Wong (2007) investigated 12 elementary Hong Kong teachers' views about mathematics. The teachers agreed that mathematics is practical, logical, and useful and involves thinking. However, most of the teachers in the study agreed that abstract thinking or abstraction is one of the central goals of mathematics. They also thought that the abstraction can come from various informants on which students can manipulate. Most of them see that the road of abstraction is a long path from the concrete to the abstract.

### 3. Teachers' Conceptions of Creativity in Mathematics

In education, implicit theories and teachers' conceptions of creativity gained the interest of researchers in the mid-1980s. The pioneering researchers (Runco & Bahleda, 1986; Sternberg, 1985, 1988) concluded that individuals use these latent but existing theories in identifying and describing creativity both in themselves and in others. According to Sternberg (1985), implicit theories, within and across cultures, have a great theoretical as well as practical meaning because they contribute to the formulation of the common cultural views on creativity. The basic weakness of implicit theories is that they describe rather than explain behaviors (Sternberg, 1985) and must, therefore, be supplemented

with and related to explicit ones.

In this study, teachers' conceptions were investigated by fragmented versus cohesive which are proposed by Crawford et al. (1994), who identified a set of five categories as being rather fragment or cohesive as follows. They categorized 'fragmented conceptions' as mathematics is numbers, rules and formulae or mathematics is numbers, rules and formulae which can be applied to solve problems. They defined 'cohesive conceptions' as mathematics is a complex logical system, and way of thinking, mathematics is a complex logical system which can be used to solve complex problems, or mathematics is a complex logical system which can be used to solve complex problems and provides insight used for understanding the world.

According to the literature about teachers' conceptions of creativity, most teachers see creativity as producing original and independent work (Diakidoy & Kanari, 1999; Fryer & Collings, 1991; Treffinger, Young, Selby, & Shepardson, 2002). Also, there can be a closer relationship between conceptions and teaching practices (Beswick, 2004; Thompson, 1992). For example, Swedish and Cypriot student teachers beliefs about creativity influenced their teaching practices (Diakidoy & Kanari, 1999), and UK teachers' conceptions of creativity practiced largely affected to their teaching methods (Fryer & Collings, 1991). Investigating over 100 contemporary definitions, Treffinger et al. (2002) identified many key characteristics of creativity as expressed among elementary, middle, and high school students and suggested helpful information to assessing students' creativity. They referred to the characteristics of creativity as generating ideas include fluency, flexibility, originality, elaboration, and metaphorical thinking. Also, they suggested important considerations of the relationship between teacher's assessment of creativity and instructional

programming. According to study of Kennedy (2005) and Beghetto (2007), teachers of older students might routinely dismiss creative thought, particularly in subjects like mathematics, where they may see the acquisition of algorithms as paramount and creativity as a distraction. They concluded that a common characteristic of creativity is a personal activity intended to produce something new.

Beswick (2004) investigated the influence of a teacher's perceptions of student characteristics on the enactment of their beliefs. He emphasized the contextual nature of beliefs and highlighted the importance to teachers' practice of specific teacher beliefs about the various students that they teach. Thompson (1984) also argued that teachers' conception about mathematics and its teaching play an important role in affecting their effectiveness as the primary mediators between mathematics and the learners.

Aiken (1973) argued that the teacher is the key to creative thinking in the classroom. He claimed that teacher's affective and cognitive variables influence in the mathematics classroom. He proposed that analyses of specific teacher behaviors that promote creative responses in students must be continued. Runco and Johnson (2002) studied parents' and teachers' beliefs about the traits of creative children in the USA and in India. They found that the parents and the teachers viewed that creative children are artistic, imaginative and inventive. Bolden, Harries, and Newton (2010) analyzed pre-service primary teachers' conceptions of creativity in the UK. They found that the pre-service teachers' conceptions were narrow, predominantly associated with the use of resources and technology and bound up with the idea of 'teaching creatively' rather than 'teaching for creativity'. Andrews and Hatch (1999) also surveyed mathematics teachers from 200 secondary schools drawn from three regions of England. They found that the teachers had diverse

conceptions of mathematics, which might be a consequence of cultural and curricular ambiguities in respect of mathematics teaching in England.

Kampylis, Berki, and Saariluoma (2009) investigated the conceptions of creativity of 70 inservice teachers who work in Greek State Primary Schools in the Athens region and 62 prospective teachers of the Faculty of Primary Education of the National and Capodistrian University of Athens. They found that the most of the pre-service and in-service teachers thought that the teachers' role play a key role in the enhancement of students' creativity, which was also appeared in the study of Fleith (2000). Fleith found that 90% of American teachers believed that teachers can help students' development of creativity. However, most of the teachers did not feel well-prepared and confident enough to realize this particular expectation.

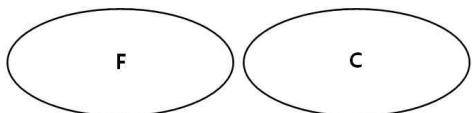
Thompson (1984) conducted case studies to investigate the conceptions of mathematics and mathematics teaching held by three US junior high school teachers. Examination of the relationship between conceptions and practice showed that the teachers' beliefs, views, and preferences about mathematics and its teaching played a significant, albeit subtle, role in shaping their instructional behavior. To investigate teachers' conceptions of creativity and creative students, Aljughaiman and Mowrer-Reynolds (2005) investigated 48 teachers and 1312 students in northern Idaho, USA. They found that teachers had possessed inaccurate concepts regarding what constitutes creativity and revealed conflicts with the classroom behaviors demonstrated by creative students.

This study aimed to analyze and document Korean primary teachers' conceptions of foundations of and creativity in mathematics in relation to primary school mathematics. It is meaningful to investigate Korean teachers' conceptions of foundations of and creativity in mathematics because little is known on Korean

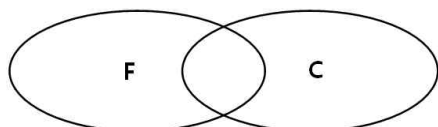
mathematics teachers' conceptions of them.

#### 4. The Relationship between Foundations and Creativity in Mathematics

Foundations and creativity in mathematics are two main factors of mathematics education. The models of the relationship between foundations and creativity in mathematics can be described three models as below. I adopted the idea from Kamii (1979) who explained the relationship between Piaget's theory and behaviorism from psychological and epistemological aspects. Depending on conceptions of foundations and creativity, we can view foundations and creativity in mathematics as mutually exclusive, as shown in figure 1(a), as only partially overlapping, as shown in figure 1(b), or as part-whole relationship, as shown in figure 1(c).



[Fig. 1(a)] The model of mutually exclusion between foundations and creativity in mathematics (F: Foundations, C: Creativity)

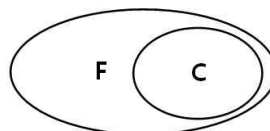


[Fig. 1(b)] The model of intersection between foundations and creativity in mathematics

In the mutually exclusion model in figure 1(a), foundations and creativity are mutually exclusive, thus have nothing in common. From this view, foundations of mathematics are considered as narrow ranges of mathematics and thus independent from creativity in mathematics. If we adopt this model, creativity is totally different from foundations of mathematics,

which is only basic problem solving and skills. Thus, teachers need to foster creativity in addition to teach foundational concepts of mathematics.

In the intersection model in Figure 1(b), foundations and creativity have something in common. From this view, foundations of mathematics share some parts with creativity in mathematics, but they have their own regions. In other words, creativity in mathematics needs some parts of foundations of mathematics, but some parts of creativity have no characteristics of foundations of mathematics. Thus, teachers need to understand the characteristics of overlapping and disjoint parts and think how they need to help students according to the characteristics of them.



[Fig. 1(c)] The model of inclusion between foundations and creativity in mathematics

In the inclusion model in Figure 1(c), foundations include creativity, thus creativity in mathematics is considered as a part of foundations of mathematics. If we adopt this view, we consider foundations of mathematics in a broader sense. As can be seen in the figure, the foundation factor is broader than that of creativity because the foundation factor can explain even every intellectual and moral phenomenon described by creativity, while creativity cannot explain some foundational concepts in mathematics. Thus, in this model, teachers need to understand the characteristics of foundations of mathematics that includes creativity and also differentiate some parts of foundations that cannot be explained by creativity. The investigation of the relationship between the foundations and creativity in mathematics recognized



by the Korean primary school teachers was one of the research questions of this study.

### III. Methods

#### 1. Participants

From 25 elementary schools, the participants were 116 Korean primary school teachers who are teaching 7-12 age (from 1st grade to 6th grade and some of them had special subjects such as English, arts, and physical education) students in Seoul, Korea. There were 14 male and 102 female teachers.

[Table 1] Demographic Information of the Participants

		Primary teachers	
		#	%
Gender	Female	14	12
	Male	102	88
Teaching Experience			
	0-5	31	27
	6-10	27	23
	11-20	32	28
	21-	26	22
Total		116	100

\* Grade to teach: (1st grade: 14, 2nd grade: 15, 3rd grade: 15, 4th grade: 22, 5th grade: 21, 6th grade: 23, Specialists: 16)

This is consistent and representative of primary education in Korea. Their teaching experiences were varied range from less than 5 to more than 20 years. The summarized demographic information of the participants is shown in Table 1. Their major was elementary education in teachers colleges with various minor subjects such as language education, science education, art education mathematics education and so forth. Only twenty eight teachers (24%) learned

mathematics as their minors. Sixty two teachers (53%) have Master degrees in education field. Eighteen teachers (16%) participated at programs for educating and training teachers regarding mathematics education (14) or creativity (4), and the hours of the programs ranged from 3 to 30 hours. They were teaching at 25 schools at 11 local education offices in Seoul city. They can be representative samples in the city.

#### 2. Data collection procedure

I used a snowball sampling method (Patton, 1990). I contacted 25 graduate students at a university who primary school teachers at the same time. All of them agreed to distribute 4~6 questionnaires in their schools and collect them. They were given explanations on how to complete the questionnaire and handed it to the teachers at their schools considering the balance of teachers' age and experience. The survey response rate was 93% (116 out of 125 questionnaires). I developed the first questionnaire by conferring to the questionnaires of Newton and Newton (2009) and Kitchen et al. (2009). The final version of the questionnaire consisted of 29 items divided into four major sections including 2 items for asking to providing order of preference and 2 items for asking free writing style questions. The interview questionnaire with 13 open-ended items also involved questions about conceptions on beliefs and instructions related with mathematical foundations and creativity.

Each item consisted of a statement on foundations of mathematics, creativity in mathematics, teaching and learning mathematics (in separate parts), to which the response was made on a five levels Likert scale (from 'totally disagree' to 'totally disagree'). Over the original questionnaire that consisted of 30 items, 5 mathematics teachers helped revise the questionnaire so to increase its validity and reliability, and revised by eliminating overlapped question. The overall

reliability of Cronbach's alpha was estimated at 0.93, with 25 Likert style survey items. The statements of the questionnaire were listed randomly with positive and negative statements. Eight items are about conceptions on mathematics, seven are about teaching and learning mathematics, and ten are about creativity in mathematics.

The interviews were conducted one week later after completing the questionnaire. The interview was designed and structured to enable teachers to explain and elaborate the ideas that they checked in the questionnaire and to provide additional information. Six volunteer teachers who had previously completed the questionnaire were interviewed in group to check the interpretations and explore these responses further through such questions as, 'Do you think mathematics is a subject that is in accordance with creativity?' and 'If any, what would be some factors that inhibit creativity?'

The 13 open-ended questions included such as 'what do you have in mind when you hear 'creativity' in mathematics?' 'Explain how you can foster creativity in mathematics.' Follow-up interviews with the volunteer participants of 6 primary school teachers were conducted by the researcher, and the group interview lasted about 60 minutes and elicited with the following questions:

- conceptions on foundations of mathematics in the primary level
- conceptions on creativity both in general and in mathematics
- specific instances of emphasis or special instructional programs believed to provide opportunities for children to be creative in mathematics
- the relationship between mathematical achievement and creativity
- constraints for enhancing creativity in mathematics

- the relationship between foundations of mathematics and creativity in mathematics
- whether the mathematics curriculum and textbooks are aptly structured to promote creativity or not.

### 3. Data Analysis

For eliciting conceptions, the phenomenographic method by Marton and Booth (1997) was used. The questionnaire included both closed (with a Likert scale) and open-ended questions (Presser, Rothgeb, Couper, Lessler, Martin, Martin, & Singer, 2004) as well as a word association method (White & Gunstone, 1992) to elicit their conceptions about foundations of and creativity in primary mathematics.

The responses to the questionnaire were analyzed to yield the frequencies and percentages of each category. In analyzing responses to open-ended questions, constant comparison method (Miles & Huberman, 1994) was employed. I used five pre-established categories including nature of foundations of and creativity in mathematics, pedagogical ideas, the relationship between achievement and creativity, contextual factors perceived as constraints on teaching for creativity, and the relationship between foundations of and creativity in mathematics. Three, the researcher and two teachers, read the open responses several times and coded the data individually, and then discussed the coding together to construct agreed-upon codes and produced categories within the larger five categories. For example, the teachers used terms such as "new," "original," and "noble" as in the literature (NACCCE, 1999; Starko, 2005; Torrance, 1967). This response was coded into 'inventing concepts.'

The data were sorted into groups on the basis of similarities in the teachers' conceptions of foundations of and creativity in mathematics. While progress was going on and new groups formed, the earlier groups

were again resorted and items were relocated for mutual exclusiveness among the groups. This process was going on for self-consistent. The researcher was ready to accept the possibility of existence of other group from the teachers' conceptions. The researcher and two teachers sought both confirming and disconfirming evidence by searching for supportive and non-supportive evidence of the conceptions (Erickson, 1986).

The pre-established categories included definition or nature of foundations and creativity in mathematics, instructional ideas, and contextual factors perceived as constraints on teaching for creativity. Each predetermined category described a conception of foundations or creativity in mathematics. However, the list of categories was certainly added by reflection of the teachers' responses. For the content validity of the questionnaire, the three mathematics educators read the responses and coded the data individually and obtained the agreed-upon codes for each category.

The present study focused on responses to questions about teachers' conceptions of foundations and creativity in mathematics and pedagogical ideas about creativity in the mathematics classroom, relationship between creativity and achievement and assessment, perceived constraints on teaching for creativity, and the relationship between foundations of and creativity in mathematics.

#### 4. Results and Discussion

The findings from the questionnaire and interviews are presented together. The interviews allowed the researcher to access teachers' conceptions from different aspects and verify that their questionnaire responses were being interpreted as they were intended. The data from the survey questionnaire responses with the supplementary data from the interview were interpreted. The findings about

teachers' conceptions are categorized into (1) conceptions on the foundations of mathematics, (2) conceptions on creativity in mathematics, (3) conceptions on teaching and learning mathematics, (4) conceptions on the assessment of creativity in mathematics, (5) conceptions on fostering creativity and constraints, (6) relationship of foundations and creativity in mathematics, and (7) the important factors of creativity, obstacles to facilitate students' creativity in mathematics, and the words that recall creativity.

##### 1. Conceptions on the Foundations of Mathematics

Teachers' conceptions of the foundations of mathematics were examined from the analysis of their responses to 6 questions shown in Table 2.

Seventy two percent of the participants agreed or strongly agreed on mathematics is a subject in which students understand and learn the concepts, principles, and laws that are already invented and sixty eight percent agreed or strongly agreed on mathematics is a subject in which students participate in inventing the concepts, principles, and laws. The proportions of two positions are similar. It is interesting that the teachers thought that learning mathematics as collections of the concepts, principles, and laws that were already invented and participating in inventing activities at the same time. This juxtaposition of differing conceptions was appeared in the studies of Andrews and Hatch (1999) and Ernest (1989).

In particular, they took mathematics as a subject of helping students solve their everyday problems as one of characteristics of mathematics (87%). They thought that problem solving as a major part in mathematics activity. They also considered that basic skills are important (73%), but the percentage was little bit low compared with problem solving. The teachers thought that mathematics is a subject that deals with absolutely clear principles/concepts that are not

[Table 2] Teachers' Conceptions on Foundations of Mathematics

Categories	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Students learn concepts, principles, and laws that are already invented	0 (0%)	15 (12.9%)	18 (15.5%)	63 (54.3%)	20 (17.2%)
Students participate in inventing the concepts, principles, and laws	0 (0%)	7 (6.0%)	30 (25.9%)	53 (45.7%)	26 (22.4%)
Helping students solve their everyday problems	0 (0%)	2 (1.7%)	13 (11.2%)	54 (46.6%)	47 (40.5%)
Dealing with absolutely clear principles/concepts that are not ambiguous	2 (1.7%)	13 (11.2%)	19 (16.4%)	47 (40.5%)	35 (30.2%)
Dealing with absolute principles and concepts that are static	3 (2.6%)	37 (31.9%)	26 (22.4%)	35 (30.2%)	15 (12.9%)
Changeable according to socio-cultural situations	4 (3.4%)	32 (27.6%)	31 (26.7%)	33 (28.4%)	16 (13.8%)

[Table 3] Teachers' Conceptions on Creativity in Mathematics

Categories	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Deeply related to creativity	0 (0%)	4 (3.5%)	14 (12.1%)	51 (44.0%)	47 (40.5%)
Not adamant but rather creative	1 (0.9%)	6 (5.17%)	30 (25.9%)	50 (43.1%)	29 (25.0%)
Creativity is an innate ability	2 (1.7%)	41 (35.3%)	26 (22.4%)	40 (34.5%)	7 (6.0%)
High achieving students show high levels of creativity	5 (4.3%)	40 (34.5%)	38 (32.8%)	24 (20.7%)	9 (7.8%)

ambiguous (71%) and absolute principles and concepts that are static (43%). They also considered that mathematics can be changed according to socio-cultural situations (42%). They thought that mathematics is not much ambiguous and much static nor much changeable. In this respect, the juxtaposition of differing conceptions of static and changeable was

appeared.

In the interview, some teachers used the term 'foundation' as 'basic,' 'fundamental,' 'profound,' 'need to learn,' 'important,' and so forth. However, most of them understood 'foundation' as 'fundamental' as used by Schoenfeld (2006) rather than philosophical aspect as Ernest (1991, 2004) stated. The teachers responded

that the foundations of mathematics should be principles and rules, exploration, understanding, logical reasoning, abstract thinking, or creative thinking. Most of them considered foundations of mathematics as interconnections of logical thinking rather than collections of skills.

2. Conceptions on Creativity in Mathematics

Creativity in mathematics is emphasized as one of the crucial aspects in mathematics teaching and learning (MOE & HRD, 2011b; NCTM, 2000). Teachers' conceptions of the creativity in mathematics

were examined from the analysis of their responses to 4 questions shown in Table 3.

Concerning the conceptions of mathematics or mathematics education, most teachers (85%) conceived that mathematics is deeply relevant to creativity. They thought that mathematicians are not adamant but rather creative (68%). They thought that many of mathematicians are lack of creativity. Only 41% of the teachers considered that creativity is an innate ability and 38% of them did not agree with the innate ability of creativity.

In the descriptive items, regarding creativity in

[Table 4] Teachers' Conceptions on Teaching and Learning Mathematics

Categories	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Process of transmitting mathematical concepts, principles, and laws to students	3 (2.6%)	23 (19.8%)	30 (25.9%)	55 (47.4%)	5 (4.3%)
Process of creating concepts and prepositions rather than discovering them	0 (0%)	10 (8.6%)	27 (23.3%)	58 (50.0%)	21 (18.1%)
Process of learning concepts and skills for problem solving	0 (0%)	3 (2.6%)	22 (19.0%)	65 (56.0%)	26 (22.4%)
A process of exploring with assumptions and verification using logical reasoning	0 (0%)	2 (1.7%)	7 (6.0%)	59 (50.9%)	48 (41.4%)
Teaching and learning mathematics is obtaining basic skills including operations	0 (0%)	8 (6.9%)	35 (30.2%)	58 (50.0%)	15 (12.9%)
Teaching and learning mathematics is enhancing problem solving ability	0 (0%)	2 (1.7%)	6 (5.2%)	46 (39.7%)	62 (53.4%)
I enjoy teaching mathematics to students	1 (0.9%)	4 (3.5%)	27 (23.3%)	46 (39.7%)	38 (32.8%)
I aptly understand of the concept of creativity in mathematics education	1 (0.9%)	14 (12.1%)	56 (48.3%)	39 (33.6%)	6 (5.2%)

mathematics, the teachers recalled the words such as 'noble,' 'original,' 'new,' 'unique,' 'problem solving,' 'pose problem,' 'various,' 'flexible,' 'open-ended,' 'divergent thinking,' 'inventive,' 'diverse,' 'sensitive,' 'intuitive,' 'autonomous,' 'joy,' 'manipulative,' 'curiosity,' 'geometry,' and so forth. These words were also appeared in the study of Hong and Kang (2009), but individual teacher mentioned only two or less of the characteristics of creativity in the interview. The participant teachers barely mentioned ethicality as an aspect of creativity. In the interview, a teacher argued that ethicality should be integrated into creativity. For example, a perfect liar could not be a creative. This is similar to the previous research finding that Eastern cultures consider ethicality as requirements for creativity (Hong & Kang, 2009; Kaufman & Sternberg, 2007).

Only 29% of participants agreed with that high achieving students show high level of creativity. They thought that high achievers are not necessarily creative. In the interview, the teachers responded that mathematics is a subject that is in accordance with creativity. The teachers considered that creativity could affect students' academic achievement, but students' academic achievement could necessarily not affect students' creativity. They thought that low achievement students could think creatively, but the cases were rare. From the perspective of the Korean teachers, teachers can find much mathematical contents that are related to creativity and enhance students' creativity in mathematics lessons.

### 3. Conceptions on Teaching and Learning Mathematics

Teachers' conceptions on creativity in mathematics are meaningful because they affect teachers' teaching practices in mathematics (Andrews & Hatch, 2000; Beswick, 2004; Thompson, 1984). Teachers' conceptions on teaching and learning mathematics

were examined from the analysis of their responses to 8 questions shown in Table 4.

The participant teachers thought that the process of teaching and learning mathematics is a process of transmitting mathematical concepts, principles, and laws to students (52%) and a process of creating concepts and prepositions rather than discovering them (68%). Again, the juxtaposition of differing conceptions of transmitting and creating was appeared as the process of teaching and learning mathematics. The teachers might think that mathematics has two faces: One aspect need 'transmitting' such as memorization of formula and drill operations and the other aspect need 'creating' such as finding patterns and making mathematical sentences.

Also, they thought that the important thing in teaching and learning mathematics is obtaining basic skills including operations (63%) and enhancing problem solving ability (93%). The teachers thought that the process of teaching and learning mathematics is a process of learning concepts and skills for problem solving (78%) and a process of exploring with assumptions and verification using logical reasoning (92%). They thought that the main parts of process of teaching and learning mathematics are 'problem solving' and 'exploring.' In the interview, participant teachers consistently emphasize problem solving in teaching and learning mathematics.

The teachers replied that they enjoy teaching mathematics to students (73%). However, only 45% of the responded teachers aptly understand the concept of creativity in mathematics education. Also, few teachers in the interview responded that they were creative. They enjoy teaching mathematics and know the importance of creativity in teaching mathematics, but they are not much creative and have only limited ideas of what the concept of creativity is and how to enhance students' creativity in teaching and learning mathematics. It was the same unsure as to the most

[Table 5] Assessment of Creativity in Mathematics

Categories	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
I effectively assess students' creativity when I teach mathematics	2 (1.7%)	30 (25.9%)	65 (56.0%)	16 (13.8%)	3 (2.6%)
It is difficult to effectively assess students' creativity	0 (0%)	3 (2.6%)	22 (19.0%)	59 (50.9%)	32 (27.6%)

[Table 6] Teachers' Conceptions of Fostering Creativity

Categories	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
I think that teachers can teach or develop students' creativity in mathematics	1 (0.9%)	2 (1.7%)	27 (23.3%)	55 (47.4%)	31 (26.7%)
I emphasize creativity in teaching mathematics	1 (0.9%)	11 (9.5%)	48 (41.4%)	36 (31.0%)	20 (17.2%)
I effectively help students to develop their creativity	0 (0%)	18 (15.5%)	58 (50.0%)	25 (21.6%)	15 (12.9%)
I often use concrete manipulatives to enhance students' creativity	1 (0.9%)	20 (17.2%)	40 (34.5%)	43 (37.1%)	12 (10.3%)
I often use IT (programs, Web materials) to enhance creativity	1 (0.9%)	18 (15.5%)	53 (45.7%)	38 (32.8%)	6 (5.2%)

effective pedagogical approach to employ in enacting those beliefs as Beswick (2004) conducted.

#### 4. Conceptions on Assessment of Creativity in Mathematics

The ability to assess of creativity in mathematics requires critical and integrated thinking as much as assessment of creativity in music (Burnard & Lavicza, 2010). Teachers' conceptions on assessment of creativity in mathematics were examined from the analysis of their responses to 2 questions shown in Table 5.

Results showed that only 16% of the teachers

thought that they could assess students' creativity in mathematics, and 79% of them answered that it is difficult to assess students' creativity. In the interview, they have difficulty to assess creativity in mathematics because there were nothing many materials to be helped. We need to provide good materials with concrete test items to assess students' creativity in teaching and learning mathematics.

#### 5. Conceptions on Fostering Creativity and Constraints

As teachers, it is meaningful to know how to foster creativity and the constraints that hinder the

fostering creativity (Silver, 1997; Teo & Waugh, 2010). Teachers' conceptions on fostering creativity in mathematics were examined from the analysis of their responses to 5 questions shown in Table 6.

The participant teachers thought that they can teach or develop students' creativity in mathematics (74%) and emphasize creativity in teaching mathematics (48%). However, they did not effectively help students to develop their creativity (35%). Many of the teachers (74%) thought that they could teach creativity in mathematics, and almost half of the teachers (48%) emphasized creativity when they teach mathematics in the classroom. However, the teachers stated that they had only little ideas to enhance students' creativity in the mathematics classroom.

For the fostering students' creativity, they often use concrete manipulatives to enhance students' creativity when they teach mathematics (47%) and IT (programs, Web materials) to enhance creativity when I teach mathematics to students (38%). Some teachers used manipulatives and IT to enhance students' creativity in mathematics. In addition to use of various materials, teachers need to pose questions effectively to facilitate students' creativity in mathematics to different levels of students (Small, 2009). Mathematics is traditionally considered as a well-ordered and logical discipline. Thus, we can foster reasoning, but there still are controversies on the topic that teaching can foster creativity. Some research (e.g., Hudson, 1967; Yamamoto & Chimbidi, 1966; Wang, 2011) showed that high achievement and creativity had even negative correlations.

Regardless of their understanding of creativity, most of the participants believed that creativity could be fostered under proper teaching conditions including using manipulatives and information technology (IT). It is extraordinary that the teachers considered using information technology gave a little help to foster creativity in mathematics because IT has favored

most Korean teachers. However, the teachers thought that they could not help students to foster creativity properly when they teach mathematics in the classroom (76%). The results showed that Korean primary school teachers considered that creativity in mathematics could be fostered, but they had difficulty in practicing their ideas in the classroom practices.

#### 6. Important Factors of Creativity, Obstacles to Facilitate Students' Creativity in Mathematics, and the Words that Recall Creativity

In the Interview, regarding important factors of creativity, the participant teachers considered all the creativity factors were important. The order that was considered the most important factor (checked number 1) was Originality (84%), Fluency (8%), Flexibility (6%), Elaboration (1%), and Sensitivity (1%). This conception of creativity also appeared in the study of NACCCE (1999) and Starko (2005). From this result, the participant teachers considered originality is the most important factor in creativity in mathematics. In the interview, the teachers also mentioned the reform of mathematics curriculum and textbook development, the refinement of professional development, and the change of assessment for fostering students' creativity in mathematics.

The order that was considered the biggest obstacle (checked number 1) was the lack of teachers' ideas on enhancing students' creativity (53%), teachers' traditional thinking pattern (19%), lack of time and environment (11%), the influence of the evaluation method (10%), the methodology of the descriptions of the textbook and workbook (5%), and others (2%). The others included classroom structure, curriculum, and multiple choice test items in the mathematics examinations. By the results, I can find that the teachers recognized that the major obstacles of facilitating students' creativity in mathematics is teachers' lack of ideas to enhance creativity and



traditional thinking pattern that does not fit to promote students' creativity.

## V. Conclusion and Implications

For students who will live in the next generation, it is not enough to acquire static knowledge or rote memorization. Instead, they need to learn mathematics with understanding and think creatively. There has been growing recognition of the importance of supporting creativity in primary mathematics in Korea as well as in other countries and teaching for creativity in mathematics is compatible with the current reform agenda (e.g., Bolden et al., 2010; MOE & HRD, 2011b; NCTM, 2000). The mathematics that students learn in the classroom is affected by the teachers' conceptions of foundations of and creativity in mathematics. Thus, it is important to investigate teachers' conceptions of these factors.

This study identified the conceptions of foundations and creativity in mathematics of the Korean primary school teachers and provided implications and suggestions. It is possible that Korean primary school teachers, who were not included in this sample due to sample limitation, would hold different conceptions. Despite this limitation, the participant teachers described in this study are typical of many other primary school teachers in Korea. For instance, compared to other teachers, most of the participant teachers did not have more degrees in mathematics majors or did not experience education program related to mathematics or creativity. I examined the Korean primary school teachers' conceptions of foundations of and creativity in mathematics by identifying categories of teachers' conceptions.

### *Major Findings and Relevant Findings*

The research findings help to explain teachers' conceptions of foundations of and creativity in mathematics.

#### *Finding 1:*

Most of the participant teachers have conceptions on foundations of mathematics as a subject in which students solve their everyday problems. Currently, problem solving is the major portion of mathematics teaching and learning in every country. These teachers' conceptions on foundations of mathematics are aligned with problem solving view of mathematics (Ball & Cohen, 1999). The teachers also have juxtaposition of differing conceptions that was also appeared in the study of Andrews and Hatch (1999). Teaching and learning mathematics is the process of teaching and learning activity that was already invented and will be newly invented at the same time. This conception might come from the multiple nature of mathematics that is considered a subject of drill and practice and exploratory problem solving process at the same time. In particular, along with practicing basic skills, they took obtaining problem solving ability as an ultimate goal of teaching and learning mathematics. Most of the teachers, as Polya (1954) and Krutetskii (1976) mentioned, considered that the mathematical work of even a young student could be an invention.

#### *Finding 2:*

Concerning the conceptions of creativity in mathematics, most teachers conceived that mathematics is deeply relevant to creativity. They think that creativity in mathematics is not just a patent of the mathematician. The findings of this study have shown that the teachers' conceptions of creativity and teaching for creativity, which are consistent with the literature. Although the participant teachers consented that creativity ought to be

encouraged in mathematics, there was a degree of uncertainty about how one might do that in the classroom. This is consistent arguments in the literature such as Beghetto (2007) and Bolden et al. (2010). Even though the teachers considered that creativity in mathematics are crucial, they did not have practical ideas to use in the mathematics classroom. The teachers' typical emphases on creativity were novelty and problem solving in characterizing creativity. If students were to develop mathematical creativity, it is necessary to change classroom practices and curricular materials. The teachers thought that high achievers are not necessarily creative. They considered that creativity could affect students' academic achievement, but students' academic achievement could necessarily not affect students' creativity. They thought that low achievement students could think creatively, but the cases were rare. From the perspective of the Korean teachers, teachers can find much mathematical contents that are related to creativity and enhance students' creativity in mathematics lessons. However, we need to provide various creativity-rich mathematics materials with which teachers can use in the classroom.

*Finding 3:*

The participant teachers thought that they can teach or develop students' creativity in mathematics and half of the teachers emphasized creativity when they teach mathematics in the classroom. However, they did not effectively help students to develop their creativity because they had only little ideas to enhance students' creativity in the mathematics classroom. They recognized that creativity in mathematics is crucial and enjoyed mathematics teaching in the classroom. They generally found it difficult to suggest ways of assessing creativity in mathematics in the classroom. This result was also

appeared in the study of Burnard & Lavicza (2010). They also thought that creativity could be developed in mathematics lessons, but had only limited ideas how to do it.

For the fostering students' creativity, they often use concrete manipulatives and IT technology to enhance creativity when they teach mathematics. Some teachers considered that fostering creativity in mathematics could be possible by asking open-ended questions while they teaching students in the mathematics lessons. Some teachers thought that they could help their students think in various ways and feel joy when they learn mathematics. In this situation, students can experience mathematical power and foster their creativity in mathematics. Revealed in the results, most teachers in the study displayed limited ideas of facilitating their students' creativity in mathematics.

Korean Students have routinely scored high in the international assessment of mathematics such as TIMSS (National Center for Educational Statistics, 2011; Gonzales, 2009) and PISA (OECD, 2011). However, the attitude towards mathematics has continually been negative. Some teachers subscribed to the importance of giving opportunities of a mathematically enriched classroom environment. We need to provide creativity-rich mathematics problems, as Sheffield (2005) suggested, so that students have opportunities to think variously and to be autonomous learners who are able to make their own decisions. Teachers also need to pose questions effectively to facilitate students' creativity in mathematics to various levels of students to improve students' positive attitude towards mathematics (Small, 2009).

*Finding 4:*

The conceptions the relationship between foundations of mathematics and creativity in mathematics are vary. Some Korean teachers think

that creativity in mathematics as a part of foundations of mathematics and the others think that foundations of mathematics and creativity in mathematics have some intersection parts. Their conceptions depend on how they define 'foundations' of mathematics and also 'creativity' in mathematics. According to the range of meaning of 'foundations,' the relationship differs. That is, if they take a broader view of 'foundations' of mathematics, they tend to take inclusion relationship of 'foundation' and 'creativity.' The opinions to the relationship were different, but most of the teachers prefer to choose the inclusive model. If we choose the inclusive relationship, every activity of creativity in mathematics can be a part of activity of foundations of mathematics. Classroom teachers should reflect creative ideas on their teaching practices and use appropriate materials to enhance students' creativity in mathematics. The challenge is for teachers to provide an environment of practices and problem solving that stimulate students' mathematical creativity.

Students today were born into a world that is very different from the one that teachers were learning in ten or twenty years ago. Memorization of algorithms and repeated solving mathematical problems without requiring thoughtful and creative ideas no longer can be useful for students who will live in a new world. Thus, good teaching practices are precisely those that use teaching ability to their full potential, in order to create learning situations for understanding. The teachers responded their limited experience and resources were constraints in promoting creativity in the classroom.

As Beswick (2004) argued, teachers have the power to impact enhancing students' creativity in the classroom. Thus, along with providing rich resources, professionalism of teachers should be the heart of all educational reform movements. We need to rethink teacher education programs for in-service as well as pre-service teachers. The programs should include

identifying foundations of mathematics and concrete ideas for enhancing creativity in all students. In addition, mathematics educators and able teachers should develop and provide rich mathematical resources. From results of the study, pre-service education and in-service programs do little to broaden knowledge and practices of creativity in mathematics. Further research on teachers' conceptions of creativity in mathematics would facilitate mathematics educators and teachers in developing practical curriculum materials and professional development programs.

This study provides only a glimpse of Korean primary school teachers' conceptions of foundations of and creativity in mathematics. As mentioned previously, the results of this study cannot be generalized because of the small sample and the restriction of area. Given these limitations, this study has provided some Korean teachers' conceptions of foundations and creativity in mathematics. We need further study to in-depth study of explore teachers' conceptions of mathematics teaching and its classroom manifestations and any relationships between them. Furthermore, we should continue further research to help for teachers to foster students' foundations of and creativity in mathematics with useful strategies and rich materials.

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## 한국 초등학교 교사의 수학의 기본과 창의성에 대한 인식

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이 연구의 목적은 수학 교수 학습에서 수학에서의 기본과 창의성에 대한 한국 초등교사들의 인식에 대하여 분석해 보는 것이다. 모든 국가의 경제나 교육에 있어서 수학에서의 기본과 창의성을 강화하는 것이 가장 중요한 문제이다. 그 동안 수학에서의 기본과 창의성에 대한 한국 초등교사들의 인식에 대하여 연구한 사례는 거의 없었다. 이 연구를 위한 연구 방법으로 116명의 초등학교 교사들에게 설문지를 통하여 수학에 대한 기본 및 창의성에 대한 인식을 분석하였고, 개방형 질문을 사용하여 필요한 교사들을 대상으로 반구조적인 면담을 실시하였다. 교사들이 수학의 기본과 창의성에 대하여 중요한 것으로 강조를 하고 있으나 수학과외 교수 학습에서 학생들에게 이를 적절하게 강화시키는 데는 어려움을 가지고 있었다. 연구의 결과 교사들이 수학의 기본과 창의성에 대하여 교수 학습에서 학생들에게 이를 적절하게 지도하는 할 수 있도록 하기 위한 예비교사 및 현직교사들의 교육이 필요함을 지적하였다. 그리고 수학교육에서 학생들의 기본 및 창의성을 신장을 돕기 위하여 교사들에게 풍부한 자료의 제공이 필요함을 제안하였다.

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