

Examining the Current State of Research on Mathematics Curriculum¹⁾

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The purpose of this paper is to examine current state of curriculum research and research methods used in the research in Korea. Results from the review of peer-reviewed research articles suggest that the ways in which the research studies on curriculum in Korea sorted out issues seemed to heavily concentrate on the written and intended curriculum by means of a document analysis. The topics of curriculum studies were biased in the studies of intended curriculum, and a significant number of curriculum studies were related to elementary levels. Regarding the research methods, the findings showed that many studies on mathematics curriculum have focused on national curriculum, textbooks, and curriculum materials, document analysis are the most frequently used methods in the studies of mathematics curriculum. We finally suggest pursuing various research topics and issues on curriculum, balancing weigh on the written and enacted curriculum, and deeper analysis and investigation of textbooks.

Key Words: curriculum research, mathematics curriculum, review of research

I. Introduction

Mathematics curriculum is a key issue in order to improve mathematics teaching and learning. Considerable attention has been paid to mathematics curriculum development and the curriculum revision for the past over sixty years in Korea. The main goals of the mathematics curriculum development and revision have been mainly to improve mathematics learning opportunities for students. The curriculum development and

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revision have been shaped differently according to the influence of other countries and central issues in Korean educational system.

The purpose of this study is to examine the trends and issues of curriculum research in Korea and thus to provide suggestions for future directions in conducting rigorous and sound research on mathematics curriculum issues including teacher, curriculum materials, and student learning. For the purpose, it is necessary to identify issues and trends of the literature on mathematics curriculum so as to better understand the current state of curriculum research in Korea. At the same time, we need to examine the historical issues of curriculum development and revision since 1945 by examining characteristics of each curriculum development and revision period.

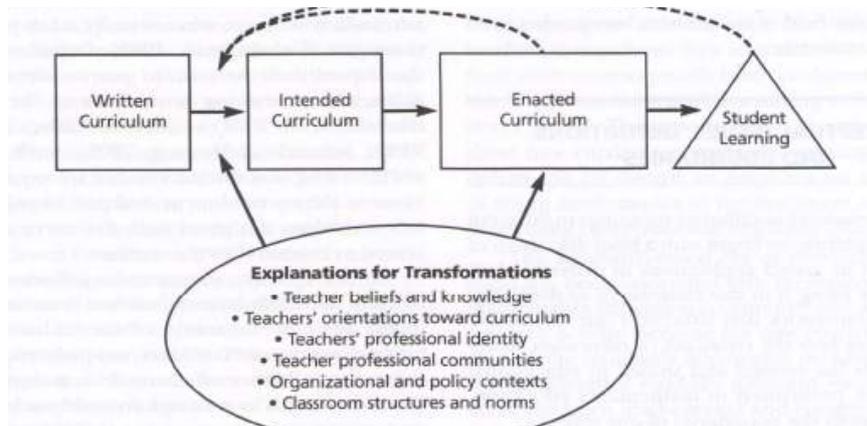
To review the literature on curriculum, we searched peer-reviewed journals of Korea to locate studies focusing on curriculum issues that have been conducted and published from 2000 to 2010. In particular, we searched peer-reviewed journals selected by National Research Foundation of Korea. From the list of journals published in 2011, we found 31 journals and selected 160 papers. We finally examined 124 research articles with exception of the inaccessible. In addition, we examined curriculum documents produced by the government such as curriculum development guidelines and curriculum revision plans for each period of curriculum revision. Finally, this review on the literature on curriculum was guided by the following questions: a) what were the main issues or topics of the research studies; and b) what research methods were utilized in conducting the research studies. In the following sections, we describe the trends traced in mathematics curriculum development and revision processes and issues in the literature on curriculum conducted for the past decade in Korea. Based on which, we finally provide suggestions for future research on mathematics curriculum.

II. Theoretical Background

Curriculum refers to “the substance or content of teaching and learning” and “the material resources designed to be used by teachers in the classroom” (Stein, Remillard & Smith, 2007, p. 321). However, as the designed curriculum is not enacted in schools as planned, many researchers distinguish the planned curriculum (or the intended curriculum) from the enacted curriculum (or the implemented curriculum) (Gehrke, Knapp, & Sirotnik, 1992; Stein, Grover, & Henningsen, 1996). Further, researchers also use the term “the attained curriculum” (Valverde et al., 2002) to examine the effects of the enacted curriculum on student learning. Thus, research on mathematics curriculum varies in terms of its scope and views. The various forms of curriculum has been revealed and differentiated the curriculum as represented in the curriculum materials and the curriculum as enacted in the classroom. Further, Stein et al. (2007) conceptualized

the various forms of curriculum in a series of phases from the written curriculum, the intended curriculum, and to the enacted curriculum as illustrated in Figure 1.

As seen in the Figure1, it assumes that the curriculum in each phase differs significantly and teachers play a central role in the processes of the curriculum. In the transforming processes, understanding the dynamics between teachers and curriculum is critical and the efforts have been devoted to uncover the relationship. In particular,



[Figure 1] Temporal Phases of Curriculum Use (Stein et al., 2007, p. 322)

researchers have attempted to understand what teachers do with mathematics curriculum, the written curriculum and how the teachers' intentions are decided, which is involved in the first transition from the written curriculum to the intended curriculum (Collopy, 2003; Lloyd, 1999; Remillard, 1999; Remillard & Bryans, 2004). As a result, teachers use curriculum materials differently even when using the same curriculum materials. That is, the same tasks in the same curriculum materials can be differently planned and thus used differently by different teachers, which influences opportunities for student learning (Collopy, 2003; Lloyd, 1999; Remillard & Bryans, 2004). In addition, studies shed light on the enacted curriculum in ways in which mathematical tasks of curriculum materials are selected and used in mathematics lessons. Mathematical tasks vary by the nature; contextual problems, problem solving requiring various strategies, exploration and investigation, application of procedures and formulas, memorization of procedures, etc. It is the written curriculum that suggests the mathematical tasks selected and used by teachers for classroom instruction. That is, the nature of mathematical tasks in the written curriculum influences substantially the ways in which the tasks are enacted and students learn mathematics (Smith & Stein, 1998). Enacting cognitively high-level mathematical tasks and maintaining at the same high-level are very difficult and challenging endeavor (Henningesen & Stein, 1997; Stein, Kim & Seely,

2006). Further, the enactment of mathematical tasks from curriculum materials is affected by teacher factors such as teachers' perceptions, beliefs, knowledge, etc. about the curriculum materials and mathematics teaching and learning (Lloyd, 1999; Remillard, 1999; Stein, Remillard & Smith, 2007). Thus, the enacted curriculum can be different even when the same teacher enacts with the same curriculum material, which may affect student learning (Eisenmann & Even, 2009; Kilpatrick, 2003).

In the next sections, we will present the trends in curriculum development and materials of Korea and focal issues and topics of research on curriculum. Then, we will illustrate research methods utilized in the studies.

III. Review of Research on Mathematics Curriculum

1. Curriculum Development and Curriculum Materials

From the liberation of Korea in 1945 to 2006, Korean mathematics curriculum has been revised six times overall. Since 2007, the curriculum has undergone a new revision system that recommends annual revisions or whenever the need for change arises. The revision process has been determined by national curriculum planning. We describe general features of mathematics curriculum changes in the following Table 1 .

From 1946 to 1954, there was a preparation period for developing curriculum. The 1st National Mathematics Curriculum was influenced by progressivism in the U.S. However, the shifted society required new changes of the 1st National Curriculum right after calling a ceasefire. Based on the 1st National Curriculum, general guidelines focused subject matters; however, subject guidelines of the Mathematics Curriculum emphasized problems related to real life. On the other hand, the general guidelines of the 2nd National Curriculum required subjects related to real life; however, the 2nd Mathematics Curriculum centered on the structure of mathematics. Thus, there were conflicts between general and subject curriculum (So, 2000). This kind of conflicts resulted in students' low achievement in mathematics. Hence, the development of the 3rd Curriculum placed value on the logical aspects of mathematics. It was affected by the New Math movement in the U.S. The 3rd Curriculum attempted to introduce abstract mathematics in early grades and continue teaching fundamental concepts in subsequent lessons and extending them. The 4th Mathematics Curriculum started with the emergence of the "Back to Basics" movement in the U.S. Thus, the curriculum reduced mathematical contents and emphasized basic competencies in mathematics. The 5th National Curriculum basically maintained the general features of the 4th Curriculum. The main characteristic was to stress students' activities including extracurricular activities. The 6th Mathematics Curriculum emphasized mathematical thinking to foster mathematical problem solving skills.

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In the late 20th century, constructivism became widespread in Korean education and led the 7th Curriculum toward learner-centered approaches. The main feature of the 7th Curriculum was the development of a framework that considered learners' standpoints such as learners' abilities and psychology. Moreover, the 7th Curriculum was designed as a *level-based differentiated curriculum* that is organized in the *Compulsory Period* (from grade 1 to 10; 10 levels and each level with 2 sub-levels A and B) and the *Elective Period* (from grade 11 to 12; 2 levels and each level with 2 sub-levels A and B). However, the 7th Curriculum has been criticized as having many issues such as difficulties in operating in schools and emotional rejection from teachers, students and parents. To resolve these issues, 2007 Curriculum Amendment was initiated. The revised curriculum changed the level-based differentiated curriculum into *differentiated curriculum*. The main focus of the 2007 Curriculum Amendment was to emphasize

<Table 1> General Features of Mathematics Curriculum Development in Korea

Curriculum	Period	Main Focus
Preparation	1946-1954	Developing curriculum
1st Curriculum	1954-1963	Subject curriculum centered
2nd Curriculum	1963-1973	Real life centered
3rd Curriculum	1973-1981	Subject centered
4th Curriculum	1981-1987	Back to Basics
5th Curriculum	1987-1992	Problem-solving
6th Curriculum	1992-1997	Problem-solving
7th Curriculum	1997-2007	Learner centered
Curriculum revised in 2007 Curriculum revised in 2009	2007- current	Learner centered

students' mathematical thinking and to consider affective aspects in learning of mathematics.

The 2009 Curriculum Amendment changed policies and school operation as a whole. The Curriculum revised in 2009 changed the school system of grades into a grade band system for the Compulsory Period. Elementary school mathematics is divided by three grade bands (1-2 grade, 3-4 grade, 5-6 grade) and middle school has one grade band (7-9 grade). High school mathematics curriculum was classified by *Elective Curriculum*. The high school curriculum consists of three different kinds of courses: a basic course, common courses, and advanced courses. The Elective Period allowed students to select courses based on their ability and knowledge. The high school students were able to select subjects in each course within their yearly time allotment. The main focus of the 2009 Curriculum Amendment was to emphasize the process of students' learning by their development.

As curriculum materials including textbooks, workbooks, and teachers' guides have been developed within the framework of the national curriculum in Korea. The materials are classified into three types: (1) those which copyrights are held by the Ministry of Education, Science and Technology (MEST, hereafter); (2) those which are authorized by the MEST and published by commercial publishing companies; and (3) those which are approved by the MEST. Recently, elementary school curriculum has changed from one textbook per subject to multiple textbooks per subject. It has been classified as Type (1). Middle school and most high school curriculum materials except Korean language, Ethics, and Korean History, have been classified as Type (2).

For developing curriculum materials, the MEST basically provides detailed guidelines. Specifically, the mathematics curriculum materials for middle and high school students have been developed by multiple teams consisting of mathematicians, mathematics educators, and in-service mathematics teachers certified by the MEST.

Hwang (2000) pointed out some issues in the use of curriculum materials in Korea. First, since Korean mathematics teachers used textbooks as the most significant instructional material in their lessons, they tended to follow the contents of textbooks rather than reconstructing mathematical curriculum (Hwang, 2000). Hence, the development of curriculum materials needed the professional development programs of mathematics teachers to use the materials appropriately. Second, traditional Korean textbooks emphasized mathematical knowledge mainly (Hwang, 2000). There still exist controversies what is appropriate school mathematics in the scope or difficulty. However, current views of the development of curriculum materials in Korea centered at students' learning in mathematics. In the recent revision, curriculum developers tried to consider students' learning and attitudes towards mathematics in developing textbooks.

2. Research on Mathematics curriculum

Mathematics curriculum has long been an important topic in the research area of mathematics education because curriculum has a great impact on mathematics learning opportunities for students. Although the mathematics curriculum changes as society changes, there always exist debates about the curriculum revisions. Furthermore, it is the controversy that provides new ideas which leads to future curriculum change. In that sense, research on mathematics curriculum shows the controversy such as the need for change and the vision for future changes. The investigation of trends and issues of research on mathematics curriculum helps us understand mathematics education in some aspects.

To better understand the current state of research on mathematics curriculum in Korea, we investigated the main issues of mathematics curriculum research that have been conducted from 2000 to 2010. In particular, we searched peer-reviewed journals selected by National Research Foundation of Korea. From the list of journals published

in 2011, we found 31 journals and selected 160 papers. We finally examined 124 research articles with exception of the inaccessible. From the first review process, we found the emerging keywords such as curriculum development, mathematical contents, teacher, and students. Then specific coding schemes were developed based on the framework of curriculum use phases suggested by Stein, Remillard and Smith (2007). Finally, we examined the topics of the 124 research articles with the developed coding schemes.

The research articles that we investigated were covered under ten topics about Korean mathematics curriculum: policy, curriculum development, theoretical concept, mathematical content, textbooks, mathematics lessons, classroom management, teacher, learner, assessment, and comparative study on international curricula. We adopted the curriculum phases of Stein, Remillard, and Smith (2007) and modified it to explain Korean curriculum studies.

The first classification of the written curriculum contains the scope of educational policy, curriculum development, and theoretical concepts of curriculum. These studies discussed the concepts and principles of curriculum and curriculum development procedures based on the guidelines provided by the government. It appeared that considerable number of studies focused on the written curriculum around the appearance of curriculum amendment. Such studies on the written curriculum dealt with mathematics in the national curriculum and the analysis of mathematical contents and concepts in textbooks and included the examination of key concepts and problem solving in a specific unit in the textbooks of grades K-12. We found that the largest number of studies discussed the written curriculum. The second classification was the enacted curriculum involving the topics of mathematics lessons and teachers. These studies attempted to analyze beliefs of teachers in mathematics and in mathematics curriculum, and mathematics teaching in the elementary and middle schools. Although there were many studies discussing mathematics lessons in Korea, most of them did not focus on lessons as a part of the curriculum. Hence, we did not count them as the studies of the enacted curriculum. We also found that only 13 percent of the examined research articles discussed the enacted curriculum. The third classification was learned curriculum involving learners and assessment. These studies investigated students' mathematical concepts and class activities and examined students' misconceptions and beliefs about mathematics. We found that the learned curriculum studies appeared the smallest number among the investigated articles. Finally, we found that a comparative study on international curricula was one of the major topics in Korean mathematics curriculum studies. Many researchers in Korea examined Korean mathematics curriculum or a specific textbook compared with one of other countries to provide insights in order to improve an existing mathematics curriculum. These comparative studies appeared as of 18 percent, which is more than the studies on the enacted curriculum.

By reviewing the curriculum studies in Korea, we found that the topics of curriculum studies were biased in studies of written curriculum, in particular, textbooks; a significant number of curriculum studies was related to elementary levels comparing to secondary levels; the topics involved in enacted curriculum and learned curriculum were a few; and the topics related to comparative studies on international curricula contained the limited information of written curriculum such as reform-oriented textbooks developed in other countries.

As stated earlier, the topics of curriculum studies were biased in studies of written curriculum. The written curriculum studies appeared the largest among the investigated studies and moreover, most of the written curriculum studies in Korea were related to analysis of mathematics in textbooks. According to the Stein et al. (2007), textbooks are one of the curriculum materials that influence on students' learning. In order to keep comprehensive understanding of intended curriculum, researchers should pay attention to various curriculum materials and learning environments including textbooks and emergent issues such as changes of students' learning using innovative developed textbooks for the future curriculum studies.

When investigating the studies by grades, research studies on the secondary level, in particular grade 10-12, were relatively fewer than on elementary level. This may possibly infer that research environments related to high school were difficult to access due to college entrance exam that is extremely competitive. However, if curriculum studies were biased in specific grades, then we have only limited understanding of students' activities and their learning. Studies on students from various grades would allow educators to design and develop curriculum. Hence, continued studies in various grades can help us understand relationships between students' learning and the curriculum and utilize the results for developing curriculum.

In addition, we found only a few topics involved in the enacted curriculum and learned curriculum in Korean curriculum studies. In particular, for the past decades, only 2 to 8 percent among the reviewed literature contained case studies related to mathematics classrooms, teachers, and students. The case studies play a significant role in that they make the evidence of how the written curriculum is performed at schools. Even though there was an increasing research trend of case studies of classrooms and learners, researchers in Korea should make more efforts to investigate classrooms including teachers and students in terms of curriculum for the future curriculum development.

Finally, we found that the topics related to the comparative study on international curricula contained the limited information of written curriculum and intended curriculum. We need more information about how the written curriculum was enacted in schools and what the written curriculum has influenced teachers and students in different educational environments.

3. Research Methods Used in the Curriculum Studies

By reviewing the 124 articles we found that research methods of the articles were limited in terms of their scope and depth. Since many studies on mathematics curriculum have focused on national curriculum, textbooks, and curriculum materials, document analysis were the most frequently used methods in the studies of mathematics curriculum. Although they explored different aspects of curriculum in terms of depth and range, their research methods were not different. In fact, around 76% of the articles examined the official documents. Among them, 87% of the document analysis focused on mathematical content or the structure of the content across grade levels. Despite various methods in document analysis, most of the articles only used comparison among the content without any specific rationale for the choice of the subjects and the methods.

Such phenomenon implies that research on mathematics curriculum should be enhanced in terms of its depth and scope. In fact, although more empirical studies have been conducted recently, many studies, around 44% of the articles, were conceptual or historical reviews of school mathematics curriculum. Further, around 74% of the conceptual or historical reviews focused on curriculum reform or future directions for the national curriculum. Although more empirical studies have been conducted recently, this shows that we need to develop and use various research methods to better understand mathematics curriculum. In addition, in order to obtain a more systematic understanding of school mathematics curriculum, it is necessary to investigate a wide range of the data related to curriculum. Even in document analysis, little studies examined artifacts teachers and students generated such as lesson plans, students' homework, etc. It implies that it is necessary to collect more various data to explain the nature of curriculum.

As for approaches in research methods, mixed methods have been rarely used and most of the studies relied on a single data source rather than multiple sources of data such as surveys, interviews, observations, and documents. As for quantitative research methods, surveys were mostly used as the form of data collection. Around 84% of the articles used descriptive analysis of the data indicating the means, standard deviations, percentage, and frequency. Regarding qualitative research methods, more rigorous and various analyses should be conducted. Document analysis was dominantly conducted while only 3% of the articles used the data from interviews and only 5% used the data from observations. Most studies indicated that the data from interviews and observations in the articles were recorded and transcribed. However, codes and coding schemes were not usually described in an article.

As a result, many studies have not used reasonable research methods and instruments. Around 33% of the articles did not use appropriate research methods to answer their research questions or present which research methods were used to analyze the data. Some of them made arguments without any evidence. Many of them

did not explicitly mention how to analyze the data. Some of them did not have internal coherence between research questions and results. A lack of details and specificity may be problematic to make a study rigorous and reliable.

IV. Discussion

We set out to explore the ways in which the literature on curriculum studies in Korea have dealt with issues and have utilized research methods for the past decade. The ways in which the research studies on curriculum in Korea sorted out issues seemed to heavily concentrate on the written curriculum by means of a document analysis such as textbooks, general and subject curriculum development and revision guidelines by the government. It also seems that a curriculum has been considered as being equivalent to a textbook, rather than such guidelines or blueprints of what to teach and how to teach in school mathematics as “the material resources designed to be used by teachers in the classroom.” Even in the textbook or curriculum analysis, the analysis by and large focused on sequencing mathematical topics, rather than on the nature of mathematical tasks in the textbooks or the features of the textbooks and teachers’ guides. Further, few research studies on curriculum distinguished curriculum as the written, intended, and enacted, which results in very few attempts to explore the relationships between the curricula mediated by teachers. Although it is provided with curriculum document, textbooks, workbooks, and teachers’ guides, which are regarded as curriculum materials, there seems that little attention has been paid to curriculum materials except textbooks. Such tendencies may come from the lack of grave efforts to conceptualize the meanings of school mathematics curriculum. As seen from the definition of curriculum of Stein et. (2007), the substance or content of teaching and learning and the resources designed by teachers should be considered for the meanings of mathematics curriculum.

One of the findings from the literature review suggests that a few studies explored the enacted curriculum. The studies utilized mostly a one-shot case study method involving classroom observations and interviews. Despite the fact that teachers play a critical role in enacting the written and intended curriculum, how they enacted the written curriculum appeared to examine in unsystematic ways. Some research studies investigated teachers’ perceptions about curriculum using survey methods, which, however, have not expanded to link the teachers’ perceptions of the curriculum materials and the enactment of curriculum materials. It might suggest that the relationship between teachers and curriculum materials should be vigorously and scientifically explored. Unveiling how the teachers use the curriculum materials may be a beginning step to advance examination of the link between the teachers and the enacted

curriculum. This ultimately should inform and be reflected in decisions of curricular policies.

The literature review also suggests that the curriculum studies have paid little attention to the dynamic relationships among teachers, curriculum materials, and students, which should be explored by using systematic methods. Classroom learning environments are a series of interactions among the teacher, the students, and the content as embodied in the instructional materials (Cohen & Ball, 1999). In order to discover the relationships meaningfully, the investigations should be designed and conducted carefully and rigorously. Especially, multiple perspectives should be considered to investigate classroom activities that are in planning, setting up, and enacting. In addition, multiple methods should be utilized to examine teachers' task selection from curriculum materials, teacher knowledge and experiences, teacher beliefs about and orientations toward curriculum materials, classroom environments and management, curricular policies at the national level, etc.

V. Implications

In this paper, we discussed issues and trends in the literature on curriculum and the research methods used in the literature in Korea. From the review of the literature, we also argued the current state of the research studies on curriculum and emerging concerns. Based on the current state in terms of main issues and research methods in the literature, we would like to share the insights. First, pursuing various research topics and issues on curriculum would be very meaningful; unbalancing weigh on the written curriculum and textbooks should be improved and deeper analysis and investigation of the textbooks more than the appearance or components should be attempted. Such studies would inform significantly to develop and revise curriculum materials. Also, it should promote to develop worthwhile teachers' guides that would support and educate teachers in a meaningful way. Such teachers' guides would help teachers enhance their knowledge and pedagogy that in turn affect the enactment of curriculum materials and student learning. Teachers matter in each phase of the curriculum use framework . Teacher factors influence substantially the ways in which they set up and enact with their students in their mathematics classrooms. In the processes, teachers interact with curriculum materials in anyways. The future research need to make efforts to unpack the nature of Korean mathematics teachers' use of curriculum materials. Finally, it would be crucial to uncover how the curriculum in various phases affect student learning.

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수학과 교육과정연구 분석 및 고찰

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초 록

수학과 교육과정에 대한 연구 논문을 분석하여 한국의 교육과정 연구에 대한 현재의 모습을 살펴보는 것이 이 연구의 목적이다. 특히, 교육과정연구 논문의 주요한 주제 및 동향, 그리고 교육과정연구를 수행하는 데 있어서 사용된 연구방법에 대한 분석하고 고찰하였다. 검토 및 분석을 위해 학술진흥재단에 등록된 학술지에 출간된 교육과정 관련 연구 논문을 검색하였고 그 결과 총 124편의 연구 논문을 분석하였다. 분석 결과, 교육과정 연구 논문의 주제는 문서화된 교육과정 및 의도된 교육과정에 집중되어 있는 것으로 나타났다. 특히, 의도된 교육과정에 편중되었으며 초등 수준에 관련한 연구 논문들이 주로 이루고 있었다. 이러한 주제들은 교육과정 관련 문서나 교과서 분석을 통해 탐색된 것으로 나타났다. 다양한 연구 방법을 활용하거나 심도 있고 체계적인 연구 방법이 활용된 연구 논문의 편수는 많지 않은 것으로 나타났다.

주요 용어: 수학과 교육과정, 교육과정 연구, 문헌 분석

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