

# THE TREND AND DIRECTION OF MATHEMATICS EDUCATION RESEARCH IN KOREA<sup>1</sup>

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## Abstract

To explain the overall research trend in mathematics education in Korea over the last 20 years, this paper presents an analysis of 3044 peer-reviewed papers published in seven domestic professional mathematics education journals. The papers were analyzed in terms of publication year, topic, research method, and target research population. In addition, papers on research conducted in the international context were analyzed. The results of this analysis showed rapid quantitative growth since the late 2000s and a diversity of research topics including learners' abilities or characteristics, instruction or teaching methods, and curricula or textbooks. The most popular research methods included pedagogical analyses, case studies, and surveys. In terms of the target research population, students were more popular subjects than curricular materials and teachers in both elementary and secondary schools. A majority of the papers on research conducted in the international context were comparative studies dealing with foreign curricula or textbooks. The paper concludes with several implications regarding issues that need to be further considered to promote mathematics education research.

Key words: mathematics education, Korean research trend, research topics, research methods, target research population, international research

## INTRODUCTION

The purpose of this paper is to identify the trend and direction in mathematics education research in Korea and to obtain information on research in the international context. Thus, this paper analyzes peer-reviewed research articles on mathematics education published in seven domestic professional journals listed on the Korea Citation Index (KCI) of the National Research Foundation. Because the research articles were published by four professional mathematics education organizations in Korea, this paper commences with a brief summary of the background and history of these organizations. It then presents an analysis of the research papers based on publication year, topic, research method, and target research population. In addition, research papers dealing with foreign documents or participants and those co-authored by scholars in other countries are further analyzed to explore the trend in international collaborative research in Korea. Examples of research articles, including those of the author, are presented in the results of the analysis. Thus, this paper aims to inform readers regarding the overall trend and direction of mathematics education research in Korea.

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## PROFESSIONAL MATHEMATICS EDUCATION ORGANIZATIONS IN KOREA

There are two major professional mathematics education organizations in Korea: the Korean Society of Mathematical Education (KSME) and the Korea Society of Educational Studies in Mathematics (KSESM). The KSME, which was founded in 1962, is the oldest academic mathematics education society in Korea. The majority of the members of this organization are mathematicians and mathematics educators across all school levels. The KSME holds biannual local conferences and international conferences to share various research ideas and findings both domestically and internationally. Five journals are currently published by the KSME: *The Mathematical Education*; *The Pure and Applied Mathematics*; *Education of Primary School Mathematics*; *Research in Mathematical Education* (an international journal published in English); and *Communications of Mathematical Education*. Whereas *The Pure and Applied Mathematics* deals with research papers in mathematics, the other journals focus on mathematics education. The research articles published in the journals except the international journal are indexed or abstracted on the KCI. Specifically, *The Mathematical Education*, which has been published since 1963, is the oldest professional mathematics education journal in Korea. This journal is currently published four times a year, and deals with all aspects of mathematics education. *Education of Primary School Mathematics* and *Communications of Mathematical Education* have been published since 1997 and are also currently published quarterly. Note that *Education of Primary School Mathematics* is specifically intended to cover all mathematics education issues related to primary schools (see <http://www.ksme.info/eng/index.asp> for more details).

The other major mathematics education organization is the KSESM, which was founded in 1991 to advance research on practical issues in the field of mathematics education in Korea. The majority of the members of the KSESM are mathematics educators. The organization also holds biannual conferences and two intensive seminars each year. Two journals are published by the KSESM: *Journal of Educational Research in Mathematics*, which has been published since 1991, and *School Mathematics*, which has been published since 1999. The former focuses on theoretical investigations and ideas relating to mathematics education, while the latter deals with practical issues directly related to K–12 mathematics in schools. Both journals have been registered as listed journals on the KCI, and are currently published quarterly (see [https://ksesm.jams.or.kr/co/locale.kci?lang=en\\_US](https://ksesm.jams.or.kr/co/locale.kci?lang=en_US) for more details).

It is worthwhile briefly mentioning two other professional mathematics education organizations because they also publish peer-reviewed research papers that are listed on the KCI: the Korean School Mathematics Society (KSMS) and the Korea Society of Elementary Mathematics Education (KSEME). The KSMS was founded in 1998 to improve the quality of school mathematics by connecting the theory of mathematics education with actual teaching practices. *The Journal of the Korean School Mathematics Society* was launched in 1998 and is currently published quarterly. The KSEME was founded in 1996 to stimulate research and practice specifically related to elementary mathematics education. The majority of members of the KSEME are either professors or in-service elementary school teachers who are also graduate students at one of the 13 universities specializing in elementary teacher education in Korea. *The Journal of Elementary Mathematics Education in Korea* was launched in 1997 and is currently published quarterly.

## OVERVIEW OF THE ANALYSIS

### Journals selected for analysis

To identify the overall trend in Korean mathematics education research, seven domestic journals focusing on mathematics education were selected. As mentioned above, the journals are published by the four professional mathematics education organizations in Korea (i.e., the KSME, KSESM, KSMS, and KSEME). More importantly, the seven journals have been listed on the KCI, which ensures that the research articles published in the journals are of high quality in the Korean context. Note that the journals have to pass a regular and rigorous evaluation to remain listed on the KCI. Thus, all research articles published by each journal from the year when they were first listed on the KCI to June of 2019 were selected for analysis. Table 1 shows the year when the journals were first listed on the KCI and how many research articles were analyzed from each journal. It can be seen that a total of 3044 peer-reviewed research papers were analyzed.

Table 1: The number of research papers analyzed in the seven selected journals

Journal	Year listed on the KCI	Number of research papers
The Mathematical Education	1999	564
Journal of Educational Research in Mathematics	2002	522
School Mathematics	2002	608
Journal of the Korean School Mathematics Society	2004	453
Communications of Mathematical Education	2007	415
Journal of Elementary Mathematics Education in Korea	2008	309
Education of Primary School Mathematics	2010	173

### Data collection and analysis

All of the research papers were listed year by year and by journal in Excel spreadsheets. The papers were then analyzed in terms of publication year, research topic, research method, and target research population. Regarding the publication year, the basic approach was to analyze how many papers were published each year to determine the extent to which mathematics education research has increased over the last 20 years. In addition, the publication years were combined into specific periods to analyze how research topics have changed on either a five-yearly basis or revisions to the national mathematics curriculum.

Regarding research topics, the following seven major topics were used, building on the work of Kim and Pang (2017): general research; curricula or textbooks; learners' abilities or characteristics; instruction or teaching methods; assessment; technology or manipulatives; and teacher education. Each major topic was then classified into between four and six subtopics, resulting in a total of 36 subtopics. For instance, the major topic of learners' abilities or characteristics was divided into the following six subtopics: learners' overall characteristics (e.g., theoretical investigations of learners' characteristics, gender differences, learning styles); learners' mathematical sense (e.g., intuition, number sense, spatial sense); learners' knowledge, concepts, or understanding (e.g., formal or informal knowledge, misconceptions or errors, cognitive processes); learners' mathematical competencies (e.g., problem-solving, reasoning, communication,

creativity or convergence<sup>2</sup>, data processing); learners' affective attitudes and beliefs (e.g., confidence, values, orientation, identity); and other learner-related studies that did not belong to any of the first five subtopics. In cases where a research paper dealt with two subtopics, the frequency of appearance of each subtopic was measured as 0.5.

Regarding research methods, the following four main research methods were used: document analysis; quantitative research methods; qualitative research methods; and mixed research methods. Each main research method was then classified into between two and four sub-methods. For instance, qualitative research methods were divided into case study research, development research, action research, and other research methods using qualitative data. The frequency of application of the various research methods was then analyzed. More importantly, further analyses were conducted to investigate which research methods were used most often in relation to each research topic.

Regarding the target research population, an initial analysis identified whether the paper dealt with elementary school, secondary school, or university level education. Then, additional analyses were conducted at each level of education to identify who (e.g., teachers or students) or what (e.g., curricula or textbooks) was being studied.

In addition, any research paper dealing with foreign documents or participants, or co-authored by scholars from other countries was further analyzed to explore the overall trend in international research in the Korean context. These papers were analyzed based on the research topic, research method, and countries involved.

Seven doctoral students<sup>3</sup> majoring in mathematics education served as coders in the analysis. A detailed explanation of the analytic components (i.e., publication year, research topic, research method, target research population, and international research) was provided for the coders along with a document that included both a list of codes for each component and a description of each component. The coders had the opportunity to code several sample research papers and then cross-check their coding. Whenever there were inconsistencies in coding, each coder explained why he or she had assigned a particular code and discussed the issue until they were in agreement on the appropriate code to use. To ensure consistency in coding, 160 research papers were randomly selected and coded by each coder, resulting in at least 83% agreement among coders in relation to all sub-components. Any discrepancies were discussed until agreement was reached among the coders. Because a large number of research papers had to be analyzed, the rest of the papers were coded separately. However, discussions continued among coders whenever a coder was uncertain about assigning a particular code to a paper until the most appropriate code was decided on.

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2 "Convergence" refers to the ability to create new mathematical knowledge, skills, and experiences, and to solve problems either by connecting ideas within mathematics (i.e., inner connections) or by integrating mathematics with other subjects or real-life contexts (i.e., external connections) (Ministry of Education [MOE], 2015).

3 The author thanks the following graduate students for their assistance: SeonMi Cho, YuJin Lee, YoonYoung Kim, Yejin Park, KyungHun Kim, Jinam Hwang, and Hanee Lee. Special thanks also to Dr. Sunwoo Jin, who helped to coordinate the coding process.

## RESULTS OF THE ANALYSIS

### Publication periods

As can be seen in Figure 1, the number of research papers on mathematics education has generally increased since 1999, and there were three specific years in which the number of research papers increased sharply. In 2002, the number of research papers published jumped from less than 25 to nearly 100, where the number more or less remained until 2007, when it jumped to about 150, before jumping again to about 200 in 2009, where it has more or less remained ever since (note that the 2019 figure only includes research papers published up to June). The three years in which the number of papers jumped sharply are roughly related to the years in which one or two new mathematics education journals were first listed on the KCI.

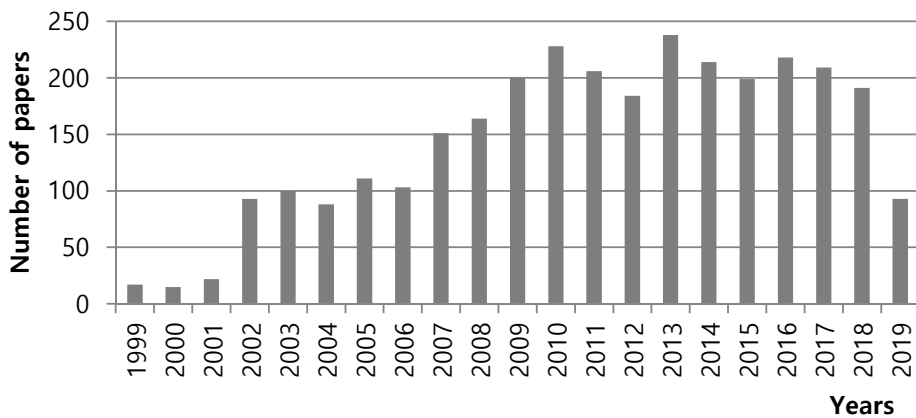


Figure 1: The number of research papers published per year (1999–June 2019)

### Research topics

#### Research topics on a five-yearly basis

Table 2 shows the trend in research topics divided into five-year publication periods. The most popular research topics included learners' abilities or characteristics (23.62%), instruction or teaching methods (19.46%), curricula or textbooks (16.89%), and teacher education (15.95%). In contrast, technology or manipulatives (6.98%) and assessment (5.37%) did not receive much attention from researchers<sup>4</sup>.

The number of research papers has increased on a five-yearly basis. During the period from 1999 to 2004, general research and instruction or teaching methods were the most popular topics, but there was not much difference in the number of research papers published on the various topics, mainly because there were not many research papers published during that period. During the period from 2005 to 2009, the number of research papers that were published increased in each of the seven topics. In particular, learners' abilities or characteristics and instruction or teaching methods became very popular. During the period from 2010 to 2014, the number of research papers that were published also increased in almost all of the topics, and learners' abilities or characteristics and instruction or teaching methods remained the most popular topics.

4 The figures in the tables might not sum to 100% because of rounding discrepancies.

Table 2: The number of research papers by topic on a five-yearly basis

Publication period	Topics*							Total (%)
	GR	C/T	LA/C	I/T	AS	T/M	TE	
1999-2004	73.5**	49.5	46	71	24	32	39	335 (11.01)
2005-2009	92	91.5	186.5	151.5	44	67.5	96	729 (23.95)
2010-2014	122.5	165	267	204.5	58	66	187	1070 (35.15)
2015-June 2019	69	208	219.5	165.5	37.5	47	163.5	910 (29.89)
Total (%)	357 (11.73)	514 (16.89)	719 (23.62)	592.5 (19.46)	163.5 (5.37)	212.5 (6.98)	485.5 (15.95)	3044 (100)

\* GR: general research; C/T: curricula or textbooks; LA/C: learners' abilities or characteristics; I/T: instruction or teaching methods; AS: assessment; T/M: technology or manipulatives; TE: teacher education

\*\* The two most popular topics in each publication period are shaded.

Another notable feature was that the number of research papers on curricula or textbooks and teacher education almost doubled. During the period from 2015 to June 2019, the overall trend was similar, although the number of research papers on each topic declined because the publication period in 2019 only extended to June. However, one notable feature was the number of papers on curricula or textbooks that were published, exceeding the previous five-year total even though the publication period in 2019 only extended to June.

#### Research topics based on revisions to the mathematics curriculum

Table 3 shows how the seven research topics were distributed based on revisions to the national mathematics curriculum. The seventh national mathematics curriculum was revised in 1997 and began to be applied in schools in 2000. Since then, the mathematics curriculum has been revised whenever necessary, specifically in 2007, 2011, and 2015 (see Pang 2014, for details of curriculum changes). Given this context, the publication periods shown in Table 3 are between four and seven years. The seven topics are divided into two groups. One group includes general research, assessment, and technology or manipulatives, which were studied in roughly similar or slightly reduced proportions in each successive period, while the other group includes curricula or textbooks, learners' abilities or characteristics, instruction or teaching methods, and teacher education, which were increasingly studied in each successive period. Studies on learners' abilities or characteristics and instruction or teaching methods significantly increased during the period from 2007 to 2010 and have maintained their popularity, while studies on teacher education increased significantly during the period from 2011 to 2014 and have remained popular.

Another notable feature was that studies on curricula or textbooks increased significantly during the period from 2015 to June 2019, reaching the same level as studies on learners' abilities or characteristics, which had previously been the most popular topic. There has been only one series of elementary mathematics textbooks, workbooks, and teacher manuals produced for Grades 1 to 6 in Korea. In addition, teacher manuals are the main resources for pre-service teachers attempting to pass the National Teacher Employment Test, while mathematics textbooks are the main resources for in-service mathematics teachers. Thus,

Table 3: The number of research papers by topic based on revisions to the national mathematics curriculum

Publication period	Topics*							Total (%)
	GR	C/T	LA/C	I/T	AS	T/M	TE	
1999-2006	91**	87.5	87	121.5	33	54	75	549 (18.04)
2007-2010	101.5	89	198	150	50	66	88.5	743 (24.41)
2011-2014	95.5	129.5	214.5	155.5	43	45.5	158.5	842 (27.66)
2015-June 2019	69	208	219.5	165.5	37.5	47	163.5	910 (29.89)
Total (%)	357 (11.73)	514 (16.89)	719 (23.62)	592.5 (19.46)	163.5 (5.37)	212.5 (6.98)	485.5 (15.95)	3044 (100)

\* GR: general research; C/T: curricula or textbooks; LA/C: learners' abilities or characteristics; I/T: instruction or teaching methods;

AS: assessment; T/M: technology or manipulatives; TE: teacher education

\*\* The two most popular topics in each publication period are shaded.

mathematics educators make every effort to develop the best instructional materials. In relation to the most recent textbook development, a basic but profound change was introduced whereby textbook writers checked the changes to the curriculum to identify the major emphases, read a range of introductory literature on mathematics education to strengthen their theoretical foundation, reviewed numerous research papers on the topic on which they were writing to identify the practical implications, compared and contrasted previous textbooks, and read white papers in an attempt to identify any trends in the changes to the textbooks (Pang, 2017). In conducting this type of analysis, textbook writers often undertake a comparative analysis between Korean mathematics textbooks and their foreign counterparts in a search for alternative approaches. This is a possible reason for the rapid increase in the number of studies on curricula or textbooks in recent years.

#### Detailed analysis of each research topic

Table 4 shows the number of papers published on each subtopic within each major topic. Regarding learners' abilities or characteristics, the most popular subtopic was learners' mathematical knowledge, concepts, or understanding, indeed this was the most frequently studied (11.20%) of all 36 subtopics. This subtopic is mostly about how well students understand specific mathematical concepts, principles, and representations. Thus, this subtopic covers various mathematical constructs including basic addition or subtraction word problems, equations, principles of calculation, fraction computations, functional relationships, algebraic reasoning, co-variational reasoning, graphs of functions, differential coefficients, and probability. Because this subtopic deals with cognitive processes, it includes not only learners' understanding but also their misconceptions or errors. For instance, Kim et al. (2016) analyzed the understanding of the equal sign and equation by a total of 695 students from Grades 2 to 6 and found that the students' performance improved as their grade level rose, providing some evidence of development in the understanding of equations, but that even upper-grade students had difficulties with the items intended to test students' advanced relational thinking. Even though the students in the study knew that the equals sign means "the same as," they thought that it meant the answer to the problem. The finding that such a misconception persists even in the upper grades prompted mathematics educators to analyze the curricular materials and

Table 4: The number of research papers by subtopic within each research topic

	Topics	Frequency (%)	
General Research	Trend of mathematics education	66 (2.17)	357 (11.73)
	Theory of mathematics education (e.g., epistemology, learning theory, psychology, philosophy)	77 (2.53)	
	History of mathematics	40 (1.31)	
	General analysis of mathematical concepts, knowledge, terms, or symbols	174 (5.72)	
Curricula or Textbooks	General research on curricula or textbooks (e.g., trend, changes, theory)	124 (4.07)	514 (16.89)
	Mathematical concepts or terms in analyzing curricula or textbooks	108 (3.55)	
	Teaching methods in analyzing curricula or textbooks	175 (5.75)	
	Use of textbooks or perception of textbooks	27 (0.89)	
	Other curricula- or textbook-related studies	80 (2.63)	
Learners' Abilities or Characteristics	Overall characteristics (e.g., theoretical investigation, gender difference, learning style)	68 (2.23)	719 (23.62)
	Mathematical sense (e.g., intuition, number sense, spatial sense)	20 (0.66)	
	Mathematical knowledge, concepts, or understanding (e.g., formal/informal knowledge, misconception/error)	341 (11.20)	
	Mathematical competencies (e.g., problem-solving, reasoning, communication, creativity or convergence)	157.5 (5.17)	
	Affective attitude and beliefs (e.g., confidence, values, orientation, identity)	114.5 (3.76)	
	Other learner-related studies	18 (0.59)	
Instruction or Teaching methods	General research on instruction or teaching methods	38 (1.25)	592.5 (19.46)
	Study to foster learners' mathematical knowledge or skills	118 (3.88)	
	Study to foster learners' mathematical competencies	87.5 (2.87)	
	Development or application of mathematical tasks or programs	267 (8.77)	
	Socio-cultural environment of mathematics classroom (e.g., classroom culture, norms)	16 (0.53)	
	Other instruction-related studies	66 (2.17)	
Assessment	General research on assessment (e.g., theory, perspective)	22.5 (0.74)	163.5 (5.37)
	Development of assessment methods (e.g., formative assessment, portfolio)	28 (0.92)	
	Development of assessment items and their rubrics	69 (2.27)	
	Use of assessment or perception of assessment	24 (0.79)	
	Other assessment-related studies	20 (0.66)	
Technology or Manipulatives	General research on technology or manipulatives	12 (0.39)	212.5 (6.98)
	Development and use of educational software or programs	134.5 (4.42)	
	Use of calculators	26 (0.85)	
	Use of manipulative materials	37 (1.22)	
	Other technology or manipulatives-related studies	3 (0.10)	
Teacher Education	General research on teacher education (e.g., theory, trend)	15 (0.49)	485.5 (15.95)
	Teacher knowledge or understanding of mathematical concepts	148.5 (4.88)	
	Teacher beliefs or values	92 (3.02)	
	Implementation or analysis of lessons	97 (3.19)	
	Teacher preparation or professional development programs	133 (4.37)	
	Total	3044 (100)	



teaching methods related to the equals sign and equation.

The second most popular subtopic in learners' abilities or characteristics was mathematical competencies. Students' mathematical problem-solving ability has been emphasized since the 1980s in Korea, and other mathematical processes such as mathematical reasoning and communication have been highlighted in the revisions to the national mathematics curriculum. In particular, six mathematical competencies were highlighted in the most recent revision of the curriculum (MOE, 2015), and have been emphasized in the development of concomitant curricular materials. Thus, the number of studies on students' mathematical competencies was bound to increase.

Regarding instruction or teaching methods, the most popular subtopic was the development or application of mathematical tasks or programs, indeed this subtopic was the second most frequently studied (8.77%) of all the subtopics. The development or application of mathematical tasks or programs is related to the revisions of the national mathematics curriculum and textbooks. For instance, when the national mathematics curriculum featured a level-based structure whereby students were required to pass the current level before moving on to the next level, various instructional materials or programs were developed that were tailored to the students' various academic levels. Similarly, as the curriculum gradually started to offer various elective subjects for high school students, relevant mathematical tasks or programs for these subjects were developed. In other cases, as new mathematical constructs (e.g., possibility instead of probability for elementary school students) or mathematical competencies (e.g., creativity or convergence) were introduced to the curriculum, new units or alternative approaches to dealing with them were designed and applied in mathematics classrooms to assess their suitability. More recently, instructional programs reflecting various social needs, such as gender equality, future mathematics lessons, STEM-based lessons, and character-building through mathematics lessons have been developed and applied. In addition, the development or application of mathematical tasks or programs is related to the needs of various types of learners such as mathematically gifted students, students who need special supplementary lessons, high school students who need basic vocational skills, students who are not interested in learning mathematics, and senior citizens.

Regarding curricula or textbooks, three subtopics were most frequently studied: teaching methods (5.75%), general research dealing with overall changes or issues (4.07%), and mathematical concepts or terms (3.55%). In other words, researchers analyzed which teaching methods had been employed or how specific mathematical constructs had been addressed to identify any trends or changes in the previous curricular materials and investigate better approaches or directions for subsequent materials. It should be noted that the subtopic of teaching methods in relation to curricula or textbooks was the third most frequently studied of all the subtopics. A notable feature was that the topic of curricula or textbooks was often examined in the context of international comparative studies. For instance, Na et al. (2018) analyzed the curricula in Australia, China, Finland, Germany, Japan, Singapore, the United Kingdom, and the United States as part of their effort to explore the direction of future mathematics education in Korea. Meanwhile, Pang and Kim (2017) compared and contrasted how congruence and symmetry had been addressed in mathematics textbooks in Finland, Hong Kong, Japan, Korea, and Singapore to provide suggestions on how to deal with these topics in a new textbook.

Regarding teacher education, four subtopics were studied with similar frequencies: teacher knowledge or understanding of mathematical concepts or principles (4.88%), teacher preparation programs or

professional development programs (4.37%), implementation or analysis of lessons (3.19%), and teacher beliefs or values (3.02%). The subtopic of teacher knowledge or understanding covers multiple types of knowledge including mathematics content knowledge, pedagogical content knowledge, and technological pedagogical content knowledge along with various mathematical content strands. A notable feature was that the studies on teacher knowledge or understanding were often connected with the analysis of teaching practices. For instance, An and Pang (2006) analyzed elementary school teachers' knowledge of teaching related to the area of plane figures and investigated the relationship between their knowledge and teaching practices. The subtopic of teacher preparation or professional development programs includes critical reviews of teacher education programs and alternative approaches to professional development such as a practice-based approach, cooperative mentoring, mathematics journals, team projects, and professional learning communities. Thus, foreign teacher preparation and professional development programs have sometimes been reviewed. For instance, Kwon et al. (2012) analyzed programs for the professional development of mathematics teachers in China, Israel, Japan, Singapore, and the United States and explored implications for Korean mathematics teachers.

Regarding general research, the most popular subtopic was general analysis of mathematical concepts, knowledge, terms, or symbols (5.72%). For instance, Lee and Shin (2005) conducted a didactic analysis of sample standard deviation, warning that its definitions were differently introduced in "Mathematics I" and "Probability and Statistics" for high school students. Yim (2018) argued for the significance of the method of using "1 divided by a divisor" as an alternative way of understanding the algorithm of fraction division in the context of measurement division. These studies served as a foundation for textbook writers and teachers aiming to develop a profound understanding of the concepts being studied.

Regarding technology or manipulatives, the most popular subtopic was the development and use of educational software or programs (4.42%), specifically in relation to the content areas of geometry, algebra, or statistics. The software or programs analyzed in these studies included LOGO, Excel, Computer Algebra System, GeoGebra, GSP, and Cabri. These studies tended to analyze how well students would be able to discover mathematical principles and justify their conjectures in a dynamic environment. For instance, Lew and Lee (2013) analyzed how mathematically gifted Grade 9 students configured the hyperbolic plane tessellation using the non-Euclidean hyperbolic disk model of GSP, indicating their cognitive characteristics by using a variety of strategic thinking processes, as well as displaying their recognition of the non-Euclidean geometric system.

Finally, regarding assessment, the most popular subtopic was the development of assessment items and their rubrics (2.27%). In addition to assessment items in relation to specific mathematical content, items relating to mathematical processes or competencies were also developed. For instance, Kim and Han (2018) developed an assessment tool for mathematical problem solving competency that consisted of 40 questions designed to evaluate the student's understanding of the problem, planning, strategy seeking, plan execution, reflection, cooperative problem solving, mathematical modeling, and problem-posing.

## Research methods

Table 5 shows the frequency of use of the various research methods used in mathematics education research in Korea. The most popular research method was document analysis (32.98%), followed by

Table 5: The number of papers by research method and research topic

Research methods		GR*	C/T	LA/C	I/T	AS	T/M	TE	Frequency (%)	
Document analysis	Critique/Review/Summary	114**	22	5	21	10	12	12	196 (6.44)	1004 (32.98)
	Pedagogical analysis	209.5	410	7	66.5	43	32	40	808 (26.54)	
Quantitative research methods	Survey	7	23	141.5	17	18	6	99.5	312 (10.25)	752 (24.70)
	Experiment	2	3	73	90	6	24	24	222 (7.29)	
	Others	3	4	125.5	13	23.5	5.5	43.5	218 (7.16)	
Qualitative research methods	Case study	3	7	238	105	10	51	162	576 (18.92)	918 (30.16)
	Development	2.5	5	13.5	112	32	34	19	218 (7.16)	
	Action research	4	2	16	28	3	15	11	79 (2.60)	
	Others	1	1	9	16	0	5	13	45 (1.48)	
Mixed research methods	Quantitative & Qualitative	0	12	74.5	79	11.5	15	43	235 (7.72)	370 (12.16)
	Others	11	25	16	45	6.5	13	19.5	135 (4.44)	
Total (%)									3044 (100)	

\* GR: general research; C/T: curricula or textbooks; LA/C: learners' abilities or characteristics; I/T: instruction or teaching methods;

AS: assessment; T/M: technology or manipulatives; TE: teacher education

\*\* The two most popular topics for each research method are shaded.

qualitative research methods (30.16%), quantitative research methods (24.70%), and mixed research methods (12.16%). A detailed analysis of the use of each research method in relation to various research topics follows.

Regarding document analysis, pedagogical analysis was the most popular method (26.54%), indeed pedagogical analysis was the most frequently used of all the sub-research methods. In particular, pedagogical analysis was used for studies on curricula or textbooks and general research. Because studies on curricula or textbooks have become very popular in recent years, as described earlier, it is inferred that the frequency of pedagogical analysis has also increased. It should also be noted that under document analysis, critique, review, or summary were mainly used in relation to studies on general research.

Of the quantitative research methods, the survey method was most frequently used (10.25%), this being the third most popular method among all the sub-research methods. Surveys were mainly used in relation to studies on learners' abilities or characteristics, followed by studies on teacher education. Experimental research methods were also popular, specifically in relation to studies on instruction or teaching methods and learners' abilities or characteristics. Of the qualitative research methods, the case study method was most frequently used (18.92%), this being the second most popular method among all the sub-research methods. Case studies were mainly used in relation to studies on learners' abilities or characteristics, followed by studies on teacher education. Development research was mainly used in relation to studies on instruction or teaching methods. Finally, of the various mixed research methods, a mixture of quantitative and qualitative

methods was most popular (7.72%), specifically in relation to studies on instruction or teaching methods and learners' abilities or characteristics.

Table 5 shows the research methods that were most frequently used in relation to the various major research topics. Studies on general research mainly used pedagogical analysis, followed by critique, review, summary within the document analysis category. Studies on curricula or textbooks overwhelmingly used pedagogical analysis, while studies on learners' abilities or characteristics used various research methods, including case studies and surveys. Studies on instruction or teaching methods also used various research methods, including development research and case studies. Studies on assessment mainly used pedagogical analysis and development research, while studies on technology or manipulatives mainly used case studies and development research. Finally, studies on teacher education used various research methods, including case studies and surveys.

### Target research populations

Table 6 shows the number of research papers based on the target research population. The target research populations included similar proportions of elementary school levels (31.96%) and secondary school levels (32.03%), while 9.33% of the research papers studied prospective teachers. Only 5.59% of the research papers included participants from at least two different school levels.

At the elementary school level, the most popular research subjects were students (17.54%), followed by curricular materials such as curricula or textbooks (8.74%), teachers (3.68%), and groups of both teachers and students (1.25%). The distribution was similar at the secondary school level, where the most popular

Table 6: The number of papers by target research population

Target research population		Frequency (%)	
Elementary School	Teachers	112 (3.68)	973 (31.96)
	Students	534 (17.54)	
	Both (Teachers & Students)	38 (1.25)	
	Curricular materials	266 (8.74)	
	Others	23 (0.76)	
Secondary School	Teachers	124 (4.07)	975 (32.03)
	Students	588 (19.32)	
	Both (Teachers & Students)	50 (1.64)	
	Curricular materials	188 (6.18)	
	Others	25 (0.82)	
University	Pre-service elementary teachers	81 (2.66)	284 (9.33)
	Pre-service secondary teachers	202 (6.64)	
	Both	1 (0.03)	
Mixed	Elementary & Secondary Teachers	25 (0.82)	170 (5.59)
	Elementary & Secondary Students	41 (1.35)	
	Elementary & Secondary Materials	44 (1.45)	
	Others	60 (1.97)	
None applicable		642 (21.09)	
Total		3044 (100)	

subjects were students (19.32%), followed by curricular materials (6.18%), teachers (4.07%), and groups of both teachers and students (1.64%). At both the elementary and secondary school levels, there were few papers with teachers as the research subjects. Moreover, there were relatively few papers that had both teachers and students as the research subjects.

At the university level, pre-service secondary school teachers (6.64%) were more popular research subjects than pre-service elementary school teachers (2.66%), indeed pre-service secondary school teachers (6.64%) were also more popular than in-service secondary school teachers (4.07%). Consequently, pre-service secondary school teachers were analyzed more than other groups of teachers.

Among the mixed groups from at least two different school levels, the most frequently used approach was to include both elementary and secondary school levels. For instance, 1.35% of the research papers included students from both elementary and secondary schools as the target research population. However, a notable feature was that this proportion was very low compared with papers using either elementary school students or secondary school students as the target research population.

### **International research**

Of the total sample of 3044 studies, 362 (i.e., 11.89%) were conducted in an international context, that is, they dealt with foreign documents or participants, or were co-authored by scholars from other countries. Note that there was relatively little international research because the research papers analyzed in this study were limited to those published in domestic journals. Korean scholars who are involved in international studies tend to publish their papers in English-language journals or books, which is beyond the scope of this paper. Nevertheless, this analysis of research papers published in domestic journals provides a guide to the kinds of studies that have been conducted in the international context.

Most papers that were classified as international research dealt with foreign documents or subjects in the process of analyzing or comparing curricula, textbooks, students, teacher preparation programs, or teachers. In particular, the number of papers comparing Korean documents or research subjects with their foreign counterparts was higher than the number of papers analyzing documents or research subjects from a single foreign country. Thus, international comparative studies were more frequent than international collaborative studies.

Table 7 shows the research topics that were studied most frequently in the context of international research, along with a detailed analysis of the most popular subtopics. The most popular topic was curricula or textbooks, which accounted for about half of all international research. The most popular subtopics included general research dealing with any trends or changes in curricula or textbooks, followed by analyses of curricula or textbooks focused on teaching methods. For instance, Kim et al. (2016) analyzed the curricula in Australia, China, Finland, France, Japan, Singapore, Taiwan, the United Kingdom, and the United States and investigated the timing of the introduction and scope of direct/inverse proportions and correlation in school mathematics. Nam and Cho (2013) investigated how the relationship between “parallel” lines and “identical” lines could be more clearly explained in the context of slope by analyzing textbooks from Japan, Korea, and the United States.

The second most popular topic was teacher education, wherein popular subtopics included teacher preparation and professional development programs. For instance, Pang (2011) conducted a case study of

Table 7: Topics covered in international research

Topics		Frequency (%)	
General Research		21 (5.80)	
Curricula or Textbooks	General research on curricula or textbooks	66.5 (18.37)	177 (48.90)
	Mathematical concepts or terms in analyzing curricula or textbooks	33 (9.12)	
	Teaching methods in analyzing curricula or textbooks	58 (16.02)	
	Others	19.5 (5.39)	
Learners' Abilities or Characteristics		46.5 (12.85)	
Instruction or Teaching methods		23.5 (6.49)	
Assessment		19 (5.25)	
Technology or Manipulatives		14.5 (4.01)	
Teacher Education	Teacher knowledge or understandings of mathematical concepts	15.5 (4.28)	60.5 (16.71)
	Teacher beliefs or values	13.5 (3.73)	
	Implementation or analysis of lessons	11 (3.04)	
	Teacher preparation or professional development programs	18.5 (5.11)	
	Others	2 (0.55)	
Total (%)		362 (100)	

mathematical pedagogy for prospective elementary teachers in the United States, while Lee (2012) reviewed professional development programs in mathematics education in the United States and identified the key components of a desirable professional development program. Other subtopics such as teacher knowledge, teacher beliefs, and lesson analysis were studied with similar frequencies.

Of the main research methods, document analysis was the most frequently used method in international research, being used in 225 (62.15%) of all papers. This result is plausible given that the most popular research topic was curricula or textbooks, which were mainly studied using document analysis.

An analysis of the countries that were involved in international research revealed considerable diversity, with more than 30 countries or regions involved. The most frequently involved country was the United States (37.26%), followed by Japan (13.52%), Singapore (8.67%), China (6.41%), and Finland (4.16%). These results appear to be related to either ease of access to documents written in English or interest from nearby countries.

## CONCLUSION AND IMPLICATIONS

The purpose of this paper is to present an overview of Korean mathematics education research and to stimulate follow-up research in the international context, specifically in East Asia. The main results provide several implications not only for Korean mathematics education research but also for future directions in international collaborative research.

Korean mathematics education research has shown remarkable growth over the past 20 years, and a stable research atmosphere has existed since 2009, given that approximately 200 research articles are now

published every year. Numerous factors have contributed to this quantitative growth including active research by scholars who studied mathematics education in foreign countries before returning to Korea, increasing numbers of young researchers majoring in mathematics education through graduate programs at universities specializing in elementary or secondary teacher education, the establishment of various academic organizations led by mathematicians and mathematics educators, and the establishment of a number of professional journals. These factors have made it possible for the mathematics education community to grow and share its various research achievements.

The results of an analysis of papers by research topic on a five-yearly basis (see Table 2) show the trend and changes in research topics over the past 20 years. For example, from 1999 to 2004, general research on mathematics education was the most popular topic, while from 2005 onwards, studies dealing with learners' abilities or characteristics were most popular. Overall, learners' abilities or characteristics have been the most popular research topic over the last 20 years, followed by instruction or teaching methods. Since 2010, both curricula or textbooks and teacher education have been studied much more frequently, indeed these were the most frequently studied topics in the international papers published in the domestic journals. The topic of curricula or textbooks may prove to be a relatively accessible topic for future international collaborative research.

In contrast, assessment and technology or manipulatives have not been popular topics in Korean mathematics education research. The most recent revision of the mathematics curriculum in Korea (MOE, 2015) emphasized the need for process-oriented assessment that integrates instruction and assessment, rather than the traditional approach that separated assessment from instruction. Teachers are now expected to provide individual students with timely feedback on their learning performance based on their professional judgement during the instruction process. Considering the significance of assessment, this topic requires more attention from researchers than ever before. Another topic that needs to be highlighted is technology or manipulatives. Given the increasing influence of technology on modern society (Na et al., 2018), further studies in areas beyond the development and utilization of educational software should be encouraged.

The results of the analysis of papers by subtopic (see Table 4) show the diversity of research topics. Of the 36 subtopics, the five most popular subtopics were: learners' mathematical knowledge, concepts, or understanding; development or application of mathematical tasks or programs; analysis of curricula or textbooks focused on teaching methods; general analysis of mathematical concepts, knowledge, terms, or symbols; and learners' mathematical competencies. It is notable that two of these subtopics belong to the major topic of learners' abilities or characteristics. The subtopic of learners' mathematical knowledge, concepts, or understanding has traditionally been widely studied, whereas that of learners' mathematical competencies reflects the relatively recent increased emphasis on this subtopic in the national mathematics curriculum (MOE, 2015). The other three subtopics mentioned above belong to different major topics. This indicates the diversity of subtopics in which many studies are being conducted.

There are at least three subtopics that require further attention from researchers including theoretical aspects of mathematics education. Mathematics education covers both theory and practice (Kilpatrick, 2008). However, the analysis of research papers by subtopic indicates that the majority of papers were mainly focused on practical issues such as analyses of curricula or textbooks in terms of mathematical constructs or teaching methods, analyses of learners' mathematical knowledge or competencies, the

development and application of mathematical tasks or programs, the development and use of educational software, or analyses of teachers' mathematical knowledge. Meanwhile Korean mathematics education research focused on the theoretical aspects of various topics has been scarce. Thus, it is high time researchers reviewed the extant literature with a view to examining the theoretical aspects of each topic based on previous empirical studies.

Another subtopic that requires further research is the use of textbooks or perceptions of textbooks. Although the topic of curricula or textbooks has been the most popular topic in recent years, a detailed analysis of papers on this topic revealed that the majority of studies focused on analyses of the curricula or textbooks themselves based on various criteria. However, there has been little research on how the curriculum is being implemented in classrooms. Similarly, there has been little research on how to use various assessment methods in classrooms.

The final comment in relation to the analysis of papers by subtopic concerns the finding that studies analyzing both students' and teachers' mathematical knowledge or understanding have been much more popular than those analyzing their attitudes, beliefs, or values, even though the latter have increased in recent years. There has been a series of new approaches to teaching and learning mathematics in the Korean context such as open-ended problems, flipped learning, theme-based integration of mathematics with other subjects, and process-oriented approaches. However, fads and slogans do not change the basic principles underlying mathematics instruction. What is crucial is what teachers and students really value in their mathematics teaching and learning (Pang, 2018). Recently, the values and valuing perspective in mathematics education illuminates what values do across different education systems (Clarkson et al., 2019). Future studies of both students' and teachers' values are expected to provide clarification in relation to various aspects that are not explained by the dichotomous distinction between cognition and affect.

Regarding research methods, the choice of research method is an important factor in relation to the quality of research. The analysis of papers based on research methods showed that the most popular method was document analysis, with more than 25% of all studies using pedagogical analysis (see Table 5), particularly studies focused on general research and curricula or textbooks. Document analysis is a valid research method, but there are at least two alternative approaches that increase the reliability of document analysis. One involves combining document analysis with other quantitative or qualitative research methods. For instance, pedagogical analysis can be conducted in relation to mathematical concepts or terms in textbooks, followed by either a survey or case study on how teachers actually teach these concepts or terms or how students actually learn them using the textbooks. The other involves conducting international collaborative research. Recall that the topic of curricula or textbooks is the most frequently studied topic in the international context. It is common for Korean researchers to analyze English-language curricula or textbooks from other countries, but they are forced to rely on official documents. Collaborating with foreign scholars who are experts on these documents and can provide extensive background knowledge can further enhance the reliability of these analyses.

Another possibility in relation to research methods is the increased use of mixed research methods, which can help to overcome the disadvantages inherent in the use of a single research method. The analysis of papers based on research methods revealed that mixed research methods were the least used of all research methods. However, given that mixed research methods were used in relation to all seven major research



topics, it is recommended that they be used more frequently in an effort to further enhance the reliability of the research, regardless of the topic.

The analysis of papers based on the target research population revealed similar patterns at the elementary and secondary school levels, that is, students were overwhelmingly the most popular research subjects, followed by curricular materials and teachers (see Table 6). Studies using both teachers and students as research subjects were scarce, accounting for less than 2% of studies at both school levels. Given that the most popular research topic was learners' abilities or characteristics, it seems logical that students would be the main target research population. However, given that instruction or teaching methods and teacher education were also popular topics, the number of studies using teachers as research subjects was surprisingly low. Considering the importance of the teacher's role in mathematics instruction in both elementary and secondary schools, more studies focusing on teachers, or both teachers and students, need to be conducted.

Another issue regarding the target research population concerns the selection of subjects from more than one school level. It is encouraging that more than 5% of the research papers analyzed in this study selected teachers, students, or curricular materials from both elementary and secondary schools. Because of the continuity of school mathematics, it seems desirable to use both elementary and secondary school levels as the target research population. Similarly, studies focusing on both universities and elementary (or secondary) schools, such as those using pre-service elementary school teachers and in-service elementary school teachers as subjects, are expected to highlight the various aspects of teacher preparation or professional development programs that require further attention.

Finally, even though the number of papers produced in the international context was relatively low, the analysis of these papers revealed the popularity of comparative studies, especially in relation to curricula or textbooks and teacher education. The number of international studies showed an increasing trend in the 2010s, with more and more Korean researchers participating in international conferences such as ICME and PME, and increasing numbers of international conferences and seminars held in Korea. Within this supportive research environment, more collaborative studies with foreign scholars, especially those from East Asian countries, need to be conducted in addition to the frequent international comparative studies undertaken by Korean scholars. These collaborative studies are expected to not only increase the reliability of comparative analyses of curricular materials or teacher education programs but also provide an opportunity to re-interpret the results of analyses and further discuss the underlying factors in the international context. Despite the similar sociocultural backgrounds of East Asian countries, subtle yet significant differences in mathematics education may be revealed through in-depth discussions among international collaborators.

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