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How Teachers Use Mathematics Curriculum Materials in Planning and Implementing Mathematics Lessons[1)]

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The purpose of this study is to investigate how elementary mathematics teachers use and implement a reform-oriented mathematics curriculum material, Everyday Mathematics, and to examine what features the curriculum material has. Eight elementary mathematics teachers in the United States participated in the study. Data sources consist of teacher classroom observation write-ups, interviews, and the curriculum material. The results from the analysis of the curriculum material suggest that 80 percent of the tasks are at the high-level in terms of cognitive demand and 26 percent of tasks are identified as transparent. The results also show that the teachers appeared to adapt the curriculum material and partially take suggestions or activities out of the curriculum material in enacting them in their mathematics classrooms. The analysis of enacted tasks suggests that the levels of cognitive demand were shifted from high-level to low-level; 27 percent of the high-level tasks in the curriculum material were maintained at the high-level as enacted in the mathematics classrooms. The level of cognitive demand shifted in many cases; shifts from high-level to low-level occurred. This contributes to the curriculum material not being transparent to teachers.

Ⅰ. Introduction

For reform in mathematics education, Standards published by National Council of Teachers of Mathematics [NCTM] (1991, 2000) demand substantial changes in teaching practice of mathematics teachers. The role of teachers in mathematics teaching is critical in that teachers are a key to change the ways of mathematics teaching and learning. Teachers are required to create mathematics classrooms in which students can develop conceptual understanding of mathematics, problem solving, and mathematical thinking and reasoning. The change in classroom practices, however, heavily depend on teachers, particularly, teachers' use of curriculum materials. Curriculum materials provide teachers and students with lessons including guidelines, objectives of the lessons, and what teachers and students actually do in mathematics classrooms.

Departing from traditional teacher-centered and procedure-oriented mathematics instruction, new curriculum materials are developed by mathematics educators and mathematicians funded by the National Science Foundation to support the NCTM Standards that emphasize students' conceptual understanding, procedural fluency, mathematical thinking and reasoning with justifications through communication and representation, and exploring problem solving.

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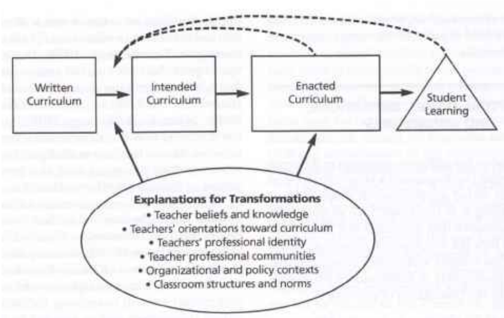
Teachers' role, as a result, should be changed in their mathematics classrooms when using such newly designed curriculum materials. However, implementing such reform-oriented curriculum materials in ways that they promote change ways of learning and teaching mathematics does not occur simply by selecting and using them (Collopy, 2003; Lloyd, 1999; Remillard, 1999, 2002; Thompson & Senk, 2010).

The purpose of this study is to investigate the relationship between teacher and curriculum materials by examining how teachers use the Standards-based or reform-oriented mathematics curriculum material, Everyday Mathematics (University of Chicago School Mathematics Project, 2004), in planning lessons and enacting them in their mathematics classrooms. Relatively few research studies have been explored how teachers use and implement such Standards-based curriculum materials and furthermore, what features the curriculum material has. The guiding questions for exploring the teacher-curriculum material relationship are: a) how elementary mathematics teachers use and implement a reform-oriented mathematics curriculum, b) what features the curriculum material has, and c) how teachers' use and enactment of such curriculum, by inference, are influenced by or related to the features of the curriculum material.

II. Conceptual Framework

Mathematics curriculum, or curriculum materials in this study refers to resources and guides, such as textbooks, teacher's guide, resource book for students, designed to be used by teachers and students during mathematics instruction. Curriculum materials use refers to "how individual teachers interact with, draw on, refer to, and are influenced by material resources designed to guide instruction" (Remillard, 2005, p. 212). This is based on an assumption that curriculum use of teachers involves an interaction between teacher and the materials (Brown, 2009; Remillard, 1999; Drake, 2010; Stein, Remillard & Smith, 2007). For their instruction, teachers choose instructional tasks and resources for students from curriculum materials (Ball & Cohen, 1996; Remillard, 1999, 2005; Stein & Kaufman, 2010). This teacher-curriculum relationship is shown in the curriculum use phases suggested by Stein, Remillard & Smith (2007, p. 322) (Figure 1).



[Figure II-1. Temporal phases of curriculum use (Stein, Remillard & Smith, 2007, p. 322)].

Teachers' use of curriculum materials involves teachers' interpretation of the curriculum materials and teachers' building relationship with curriculum materials (Brown, 2009; Remillard, 2005). Teachers' personal knowledge and experiences influence in offering meaning to the curriculum materials for their use of their classrooms (Ben-Peretz, 1990; Collopy, 2003; Remillard & Bryans, 2004; Stein & Kaufman, 2010). Teachers interpret what curriculum writers intended in the form of text by using them. Further, teachers implicitly and explicitly, develop a dynamic interrelationship by collaborating with curriculum materials. Teachers and curriculum materials participate in selecting and designing activities and tasks (Bieda, 2010; Brown, 2009; Remillard, 1999; Remillard & Bryans, 2004). In so doing, teachers develop a dynamic relationship between the teachers and curriculum materials that emerged as a significant construct for understanding of teachers' use of curriculum materials (Remillard, 2005).

Teachers select and design mathematical tasks for their students and enact them in the mathematics classroom. Remillard (1999) suggested a model of teachers' curriculum enactment in mathematics teaching in which teachers play a role involving and selecting and redesigning curriculum plans as well as enacting such plans for their students in mathematics classrooms. In particular, the model consists of the design arena, the construction arena, and the mapping arena. In the design phase, teachers' role includes selecting and designing mathematical tasks for students by consulting and interacting with the curriculum materials explicitly. The process of selecting, redesigning, and altering tasks to present to students is crucial as the tasks represent what teachers value, that is, teachers' assumptions about what students should learn and more importantly, how students should learn with the tasks selected (Remillard, 1999; Stein, Remillard & Smith, 2007). In the second phase of the model proposed by Remillard (1999), which is the construction stage, teachers enact tasks selected in the tasks selected by interacting with students; the purpose of teachers' activities is to initiate and keep students to engage in working with the selected mathematical tasks. Task adaptation is essential in this construction arena since it cannot be avoided to adapt and adjust tasks to facilitate students' mathematical learning. Finally, teachers make decisions on content organization and the sequence of mathematics curriculum in the mapping phase (Remillard, 1999). Curriculum mapping takes place through the decisions of task selection and enactment (Brown, 2009; Remillard, 1999).

In order to analyze what features of the curriculum material, I adopt the term transparency from Stein and Kim's study (2009), which refers to visibility of the curriculum developers' rationales for their selection and organization of tasks for students. To intelligently select and enact tasks in their mathematics classrooms, teacher ought to be able to see the reason for asking students to do the particular tasks in a particular way as suggested in the curriculum materials. Further, I employ research on the level of the cognitive demands of mathematical tasks (Smith & Stein, 1998; Stein, Grover & Henningsen, 1996). The research studies propose that mathematical tasks can be categorized as doing mathematics, procedures with connections to meaning, concepts, or understanding, procedures without connections to meaning, concepts, or understanding, and memorization according to the cognitive efforts required in accomplishing the tasks (see Task Analysis Guide, Stein, Smith, Henningsen & Silver, 2000, p. 16). Stein et al. further suggested high-level (doing mathematics and procedures with connections) and low-level (procedures without connections and memorization) of cognitive demands for mathematical tasks and leveraged differences between procedural tasks (low level of cognitive demand) and higher level tasks.

Stein and Kim (2009) conducted a comparative study that analyzed two widely-adopted Standards-based elementary mathematics curricula, Everyday Mathematics and Investigations in Number, Data, and Space [Investigations]. Both curricula are designed to contain mathematical tasks for classroom instruction that are to develop students' conceptual understanding. For analysis in the study, lessons/sessions were randomly selected from each grade level in each curriculum and scrutinized in terms of the cognitive demand of mathematical tasks, transparency, and anticipation that are illustrated above. The study suggested that Everyday Mathematics is composed of more procedures with connections tasks (79 percent) than Investigations (11 percent); Investigations contain more doing mathematics task (89 percent) than Everyday Mathematics (12 percent). The study also revealed that 21 percent of Everyday Mathematics lessons were judged to be transparent.

This study investigates teachers' use of a mathematics curriculum material in the design and construction arenas. More specifically, I probe how elementary mathematics teachers use Everyday Mathematics in their planning lessons and enacting the lessons with the curriculum material. In addition, I attempt to explore the role that the features of the curriculum material play in teachers' design and construction, an area that research studies identify but do not elaborate yet. There are relatively few studies to examine and characterize curriculum materials in relation to teaching, teachers' design and construction, and enactment in their classrooms. Such efforts would offer insights on the relationship between curriculum materials and teaching.

III. Methods

1. Context and Participants

This study is a part of a larger study that was conducted in an urban public school district in a large city in the northeast in the United States. For the larger study, twenty-four teachers from four elementary schools in the district were recommended by their principals and to be observed three days in a row every semester for 3 years. However, the larger study began with nine teachers for the first semester of the study. This study investigates eight elementary mathematics teachers from four different elementary schools in one school district. The school district mandated Everyday Mathematics to improve mathematics teaching and student achievement in mathematics in elementary grades at the time of conducting this study. It was the first year of the adoption of Everyday Mathematics when data for this study were collected. Two kindergarten, 4 first grade, and 2 second grade teachers participated in this study; all the teachers were female. The school district is located in an urban area and the population of students was dominantly composed of African-American and Hispanic students; about 90 percent of the students received free or reduced-price lunches and 10 percent of the students are English Language Learners.

2. Elementary Mathematics Curriculum: Everyday Mathematics

Among the curriculum materials provided by Everyday Mathematics, it has been revealed from a survey that teachers seem to use the Teacher's

Guide only (Stein, Kim & Seely, 2006). Although a reference manual that contains descriptions of explanation about mathematical ideas, topics, concepts, and background information was available for teachers, teachers consulted with only Teacher's Guide. Thus, the Teacher's Guide along with tasks for students was examined and analyzed for this study; in particular, the tasks on which mathematics lesson observed is based were analyzed in terms of the level of cognitive demands-doing mathematics, procedures with connections, procedures without connections, and memorization.

The curriculum material Everyday Mathematics consists of a reference manual, Teacher's Guide, and student books. The Teacher's Guide of Everyday Mathematics provides very detailed guides for each lesson. The Teacher's Guide of the curriculum material tells teachers what to do, how to do, and what to ask for and during each lesson. Each lesson consists of Lesson 1: Teaching the lesson, 2: Ongoing learning & practice, and 3: Options for individualizing. Everyday Mathematics is based on the assumptions that students are likely to learn new concepts through repeated experiences and opportunities to develop complete understanding. The curriculum is designed to sequentially provide students with extensions and deeper level of mathematical ideas throughout the material (Stein & Kim, 2006).

3. Data Collection and Analysis

Data sources consist of teacher classroom observations write-ups and interviews, which are collected as part of a multi-year longitudinal study. For this study, I analyzed data that were collected during the first semester for the larger study when the new curriculum material had newly been adopted in the school district. The reason that I focus only on the first semester is to examine how the teachers start with an unfamiliar curriculum material and use it.

The classroom instructions of 9 teachers were observed for two class periods in a row. This happened only during the first term; for the following 2 years, 3 class periods were observed. Fieldnotes were taken by trained researchers that include mathematics educators during the classroom observations and they were elaborated later in a form of write-up consisted of lesson narratives and answers to a set of analytic questions. In addition, all the 9 teachers were interviewed by the trained researchers before and after the successive classroom observations by semi-structured interview protocols; the interview protocols included such as "Describe how you've prepared for these lessons." "How, if at all, have you engaged with the curriculum materials?" "What kinds of things do you look for when you examine the materials?" "What did you want students to learn or be able to do as a result of this task?" "What ways, if any, did you draw on/use materials from Everyday Mathematics as the task unfolded? What are the ways in which you deviated from the curriculum materials? Why?" etc. Interviews lasted approximately 30 minutes and all were audio-recorded and transcribed for analysis. In addition, classroom and curricular artifacts used were collected for analysis.

The analysis was processed through two phases: a) an analysis of what teachers talked about their use of the curriculum material revealed in preand post-interviews; and b) an analysis of how teachers used their curriculum material in planning and implemented it during their mathematics classrooms reflected through classroom observations. Initial reading interview transcripts to look for patterns produced themes that characterize how the teachers use their curriculum material throughout the interviews; the interview transcripts were coded such as "adaptations for my students," "followed the Teacher's Guide," "took out a problem from the Guide," etc. according to the themes emerged. Then, the established themes were used in analyzing classroom observation write-ups. The coded data were sorted by teachers in terms of what they said during the interviews and what they did during their mathematics instruction. In addition, mathematical tasks were identified at the two layers: a) tasks as written in the curriculum material and b) tasks as implemented in the mathematics classrooms. The tasks enacted were identified as tasks that occupied the most of the amount of class time for analysis. Then the tasks at the both layers were analyzed in terms of the level of cognitive demand.

As mentioned above, the curriculum material itself on which the lessons was based along with the Teacher's Guide was analyzed in terms of the level of cognitive demand of tasks (doing mathematics, procedures with connections, procedures without connections, ant memorization) and transparency, whether the material make curriculum developers' rationales visible to teachers so as to help teachers implement the curriculum material as intended. For coding and analyzing the level of cognitive demand of the tasks as written in the curriculum material and as implemented in the mathematics classrooms, I consulted to a task analysis guide (Stein, Smith, Henningsen and Silver, 2000, p. 16). While analyzing the classroom observation fieldnotes, I created an analytical report that focuses on how the teachers' instructions differ from those found in the curriculum material. For transparency, I assigned a code of "yes" or "no" by examining the Teacher's Guide.

IV. Results

1. The Features of Everyday Mathematics

The results from the analysis of the mathematical tasks in Everyday Mathematics on which the teachers' lessons were based in terms of the level cognitive demand suggest that the majority of the tasks are at the high-level (80 percent, 12 out of 15). Among the high-level tasks, 67 percent (8 out of 12) are procedures with connections tasks. 20 percent are categorized as procedures without connections tasks (3 out of 15) as revealed in Table IV-1. For instance, the curriculum material suggests a task for a review by making a class birth-month graph (Everyday Mathematics, Grade 1, 10.1 Data day: End-of-year heights), which is identified as a procedures with connections task. The task focuses first grade students' attention on the use of procedures of organizing data and making line plots for developing understanding of mathematical concept of median and mode. In addition, the task is set up on the data of students' birthdays, which gives real-world context. In contrast, a procedures without connections task is suggested in the curriculum material; the task

<Table IV-1> Cognitive Demand of Tasks in Everyday Mathematics

Cognitive Demand		Number of Tasks in Everyday Mathematics (out of 15)
High-level	Doing Mathematics	4
	Procedures with Connections	8
Low-level	Procedures without Connections	3
	Memorization	0

requires that first graders "show 53 with your base-10 blocks" (Everyday Mathematics, Grade 1, 8. 3 Place value: Hundreds, Tens, and Ones) along with place value mats. In order for the students to successfully complete the task, they should be able to follow procedures suggested in the curriculum to know what the number represented by the base-10 blocks is. However, there is no explanation required to make connections to the meaning of the place value. For example, the students must put base-10 blocks according to given numbers onto the place-value mats and then write proper numerals corresponding to the base-10 blocks displayed, which involves no understanding at all. It has been suggested in the curriculum material to repeat this process as needed. In addition, the task is focused on the students' use of procedures of trading 10 longs (tens) for 1 flat (hundred) and 10 cubes (ones) for 1 long (ten). Again, there is no making connections to the concept involved.

Regarding the matter of the transparency of the curriculum material, the results showed that 73 percent (11 out of 15) were identified as not transparent; only 27 percent were judged as transparent. That is, the Teacher's Guide of the curriculum material does not make the developers' rationales for why certain activities, tasks, questions to ask students, and problem structure are provided for particular mathematical ideas or concepts visible to the teachers. In the case of being transparent, the Teacher's Guide explicitly illustrates that "the authors believe that children must be exposed to concepts and skills many times and in many ways" (Everyday Mathematics, Grade 1, Teacher's Guide, p. 730). In other cases, however, the curriculum material does not provide any reasons that a particular activity should be done in a certain way as suggested in the material. Rather, the material provide a full list of questions to ask students and steps to follow. For instance, it is suggested in the Teacher's Guide that the teachers ask students such as "What number goes here? What's my rule?"(Everyday Mathematics, Grade K, Teacher's Guide, p. 253) "How many cards show fourths?" "What fraction names the shaded part?" "What fraction names the unshaded part?" (Everyday Mathematics, Grade 2, Teacher's Guide, p. 599) Further, the Teacher's guides illustrates that "Children use Fraction cards to compare pairs of fractions, to compare related factions, and to observe the relationships between fractions having the same numerator or the same denominator" (Everyday Mathematics, Grade 2, Teacher's Guide, p. 577). The following excerpt comes from the same lesson on "Equivalent fractions using Fraction Cards in the curriculum material:

Ask children to turn their cards to the picture side. Share observations, such as the following:

- Each Fraction Card represents ONE. All Fractions Cards are the same size.
- The number of strips (or bars) varies from card to card. Some of the strips are shaded. Others are unshaded.
- The fraction shown on the card represents the fractional part of ONE that is shaded.
- The denominator tells the total number of strips on the card. The numerator tells the number of shaded strips. (Everyday Mathematics, Grade 2, Teacher's Guide, p. 599)

The suggestions in the curriculum material are not about why an activity has been designed in the particular way, but all about how to perform an activity in the mathematics classrooms.

2. Teachers' Use and Enactment of Everyday Mathematics

The analysis of interviews and classroom observations suggest variations in ways the elementary teachers used Everyday Mathematics. The variations are significant by the curriculum material they have newly adopted. Furthermore, the elementary teachers showed consistent tendencies in their use of the curriculum material in between what they said explicitly during interviews and what they actually did in their mathematics classrooms with the material.

The teachers in the school district showed differences in their use of their newly adopted curriculum material, Everyday Mathematics. The teachers seemed to follow the curriculum material's organization and suggestions by adapting the recommendations in the curriculum material. In particular, 44 percent (4 out of 9) of the teachers with Everyday Mathematics said that they followed the material closely. Among the four teachers, three teachers actually appeared to follow what the curriculum material suggested for lessons. Three teachers showed consistency between what they said and what they did in their mathematics instruction. Although one second grade teacher among the four exclaimed that she was closely following the curriculum material, her lessons did not seem to follow the material. On the other hand, a kindergarten teacher, Dana (pseudonym), who closely followed the suggestions of the curriculum did not admit that she would follow the material. Rather, she clearly articulated that she was going to modify what Everyday Mathematics structures and suggest for the lesson. Dana said that "I just took it and went with it from here." However, she appeared to follow the curriculum material without making any modifications in implementing the material.

All the teachers with Everyday Mathematics appeared, by and large, to adapt the curriculum material, rather than follow the entire of what it suggests to them. Most of the teachers immensely adapted the curriculum material in their mathematics instruction for their students in various degrees in ways in which they altered problems and questions for students and the order of activities, skipped activities and questions, and omitted discussion in general. For example, the teachers changed numbers in problems that were provided for the students to smaller and easier numbers. Marcie (pseudonym), a first grade teacher, said that she "picked lower numbers" in double-digit addition and "constantly modified it [big numbers] because "it was just too much [for my students] to deal with" in order for the students to be able to easily get to answer to the problems of telling time involving elapsed time. As a result, at the implementation level, Marcie selected an idea from the curriculum material, but not the whole suggestions in carrying out the idea meaningfully in the classrooms. Further, the majority of the class dealt with how to convert a time to the analog representation. The topic of the time is a somewhat arbitrary algorithm to begin with and is not something that can be easily discovered by the students. Despite this, there were no connections made to the meaning and concepts for understanding that underlie for telling time. Another example explains that a teacher modified a question asking students to "write 4-digit numbers from the smallest to largest" to "circle the digit in the 100's place and underline the digit in the 1000's place." In addition, there were a few cases in which teachers added an activity and extended the previous lesson to help their students better understand concepts and ideas of mathematics. Such modifications, however, often were made in a superficial way in which the teachers try just to change numbers in problems sets for their students and to use their students' names in fraction problems. For example, Natalie (pseudonym), a kindergarten teacher, seemed to review the previous lesson by changing suggested manipulatives:

> I just changed it to the child's name in my classroom. I switched it from the day before, it was the granola bar. So, I switched it to chocolate bar the day before and the second day to pick··· just to see how well they could grasp the concept of it. I have been slowing it down. I haven't followed it exactly, that is why I haven't done the matching fraction game. I basically use the strategy that I think will work with the children no matter the concept is, whether it is fractions, multiplication, which every strategy it is, I pretty much follow. And yes, this is typical. We use play dough for making arrays, and that worked very well. It is a simple concept.

The teachers with Everyday Mathematics showed a tendency to take suggestions or activities partially out of the new curriculum material in enacting in their mathematics classrooms. Apparently, they pulled out what they believe would work for their students or "pick and choose" what they believe their students would be able to get out of the activities. From the lesson observations, it was obvious that most of the teachers with the curriculum material seemed to focus on teaching one part among the three parts consisting of each lesson in the curriculum material; the teachers found that "it was kind of really hard because that math was supposed to be an hour and a half and it was really difficult to get the kids to sit there for an hour and a half" and "everything has to be broken down and pulled out exactly" (Becky, pseudonym, a second grade teacher) what they needed. When teaching "Representing 3- and 4-digit numbers with base-10 blocks in her mathematics classrooms, Becky picked the number (e.g., 352) suggested in the curriculum material and let the students volunteer and stand holding base-10 blocks in front of the room; she repeated, the activity with a different number as suggested in the curriculum material. In so doing, Becky, however, did not discuss relationships among base-10 blocks during 'Math Message Follow-Up' that suggests "each is 10 times larger than the next smaller one, and 1/10 the size of the next larger one" (Everyday Mathematics, Grade 2, Teacher's Guide, p. 733), which is suggested in the curriculum and requires the use of procedures with connections to meaning, concepts, or understanding. Thus, the teacher and the students enacted the task procedurally, not paying attention to explanations about representing the numbers with base-10 blocks. For example, the teacher had the second graders write down numbers given on their worksheets without grasp the meaning of the numbers by explaining how to read the numbers from left to right. The students, however, read numbers right to left; they seemed confused about reading and writing numbers right. Further, the students did not seem to appreciate why and how they should represent numbers in the way the teacher told to do. Moreover, even when focusing on one part of the lesson, the teachers tended to choose: a) only one mathematical idea in the part 1 of a lesson, without paying attention to the suggestions provided in the material, b) an activity among several connected activities composing the lesson, and c) to pick only manipulatives and activity sheet for students such as 'Math Journal' out of the curriculum material. In case of using activity sheet, most of the teachers seemed to distribute the sheet to the students without teaching mathematical ideas and concepts embedded in the activity.

The results from the analysis of tasks enacted in the mathematics classrooms suggested that the levels of the cognitive demands of tasks on which the lessons were based were changed (Table IV-2). As revealed in the analysis of mathematical tasks in the curriculum material, Everyday Mathematics, 80 percent (12 out of 15) were identified as high-level tasks. In contrast, only 27 percent were classified as high-level, particularly, procedures with connections tasks at the enactment level in the mathematics classrooms; there was no doing mathematics tasks enacted. 47 percent were implemented as procedures without connections tasks and 20 percent were as memorization tasks. It was noteworthy that there existed shifts from the level of cognitive demand on tasks in the curriculum material to the tasks enacted in the mathematics classrooms. As the shifts occurred, the level of cognitive demand declined from high-level to low-level; doing mathematics tasks apparently were not enacted as intended, and more than half of procedures with connections tasks were not implemented as written in the curriculum material as well. Many high-level tasks in the curriculum material were enacted at the low-level in terms of cognitive demand. Among the high-level tasks, only 4 procedures with connections tasks were maintained at the same level, procedures with connections, when implemented. Two doing mathematics tasks in the curriculum material were implemented as procedures without

<Table IV-2> Cognitive Demand on Tasks enacted in the Classrooms

Cognitive Demand		Number of Tasks enacted (out of 15)
High-level	Doing Mathematics	0
	Procedures with Connections	4
Low-level	Procedures without Connections	7
	Memorization	3
	No Mathematical Thinking	1

connections and memorization tasks, which are categorized as low-level in terms of cognitive demand. Three procedures with connections tasks were enacted as procedures without connections tasks and 1 procedures with connections task as a memorization task. In addition, all of the procedures without connections tasks in the material were enacted at the same level as intended.

V. Summary & Conclusions

This study investigates how mathematics teachers use and implement Standards-based elementary mathematics curriculum material, Everyday Mathematics, for their mathematics lessons and the features of the curriculum material such as transparency and the level of cognitive demand of mathematical tasks. Further, this study attempts to explore how the features of the curriculum material, by inference, affect the elementary mathematics teachers' use and enactment of the curriculum material.

The results from data analyses suggest that the mathematical tasks for students in Everyday Mathematics are mostly at the high level (80 percent) in terms of cognitive demand. In particular, the curriculum material appears to focus on the development of fluency in using and mastery of procedures in learning mathematics; it consists of procedures with connections tasks (high-level, 53 percent) and procedures without connections tasks (low-level, 20 percent). In addition, by examining whether the curriculum material provides rationales or explanations of why and how certain activities or problems suggested in the material are necessary for a particular mathematical concept, idea, or topic in order to support teachers, this study attempt to identify the features of the curriculum material. The analysis reveals that 74 percent of the tasks in the curriculum material do not provide rationales or explanations; the developers' rationales are not possibly visible to teachers. Only a few (26 percent) of tasks in the material provide such support for teachers. This leads to speculate that the features of the curriculum material involving transparency and high-level of cognitive demand of mathematical tasks may influence how elementary mathematics teachers use and enact the curriculum material in mathematics classrooms.

The analysis of elementary mathematics teachers who had begun newly-adopted mathematic curriculum materials suggests that the teachers seemed to try to follow the suggestions from the curriculum material in planning their lessons. However, in enacting the lessons, the mathematic teachers adapted the suggestions provided in ways that they modified problems by changing given numbers, skipped activities, and omitted discussion in most cases. The teachers also appeared to partially take up suggestions or activities from the curriculum material in enacting the lessons. In so doing, however, they seemed to believe they followed the suggestions in the curriculum material very closely.

The findings from the analysis of the enacted tasks in the mathematics classrooms in terms of cognitive demand show that the level of cognitive demand shifted in many cases; shifts from high-level to low-level occurred (53 percent). No doing mathematics tasks in the curriculum material was enacted as doing mathematics; doing mathematics tasks were enacted as procedures without connections or memorization task. Among the high-level tasks in terms of cognitive demand, 27 percent (4 out of 15) of the tasks were maintained at the same level, procedures with connections. Among the procedures with connections tasks, about 33 percent (3 out of 9) were enacted as procedures without connections and about 22 percent (2 out of 9) as memorization. In contrast, the low-level tasks were maintained the cognitive demand at the low level; all the 3 procedures without connections tasks were enacted as such.

The decrease from the curriculum material to the enactment of the material as to the level of cognitive demand on mathematics tasks might come from the features of the curriculum material. In other words, the curriculum material, Everyday Mathematics, consisted of predominantly high-level mathematical tasks in terms of cognitive demand, which may make the teachers difficult in implementing the high-level tasks as intended in the curriculum material (Stein & Kim, 2009). This also contributes to the curriculum material not being transparent to teachers; the teachers would not be able to realize and understand what and how they enact certain mathematical activities and problems for a particular mathematical concept or ideas for their students (Stein & Kim, 2009; Stein, Kim & Seely, 2006).

Further study would need to examine what other features mathematics curriculum material possibly should be identified in order to explore the relationships between curriculum materials and teachers. It is suggested to consider whether curriculum materials provide examples of students' actual work, thinking processes, or possible responses to help teachers implement them as intended (Ball & Cohen, 1996; Davis & Krajcik, 2005; Stein & Kim, 2009), which would develop teachers' pedagogical design capacity (Brown, 2009). Also, it is called for more research studies on mathematics curriculum materials such as how mathematical ideas and concepts are represented in the curriculum materials at the present time and should be represented in the future curriculum materials in order for mathematics teachers to enact the representation intended. Importantly, research studies on how Teacher's Guide ought to be designed and developed to support teachers who are in need for teaching for understanding and results from those studies would be valuable and meaningful in understanding of how teachers learn to teach for students' mathematical understanding (Collopy, 2003; Drake, 2010; Lloyd & Pitts Bannister, 2010). Curriculum materials definitely influence teacher learning and student learning as well (Stein, Remillard & Smith, 2007; Tarr, Chavez, R. E. Reys & B. J. Reys, 2006); how teachers' use of curriculum materials influence student' mathematical learning opportunities should be explored in further studies.

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교사의 수업 계획 및 실제 수업에서의 수학 교과서와 교사용지도서 활용 연구

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수학 교사가 수업을 계획하고 계획한 수업을 실행할 때 교육과정 도서(교과서, 교사용 지도서 등)를 어떻게 활용하는지에 대하여 시행된 연구가 많지 않은 실정이다. 이 논문은 미국의 초등 교사들이 초등 수학 교육과정의 프로그램 중의 하나인 Everyday Mathematics의 교육과정 도서를 어떻게 활용하는지, 또한 Everyday Mathematics가 가지는 교육과정 도서로써의 특징 요소들이 무엇인지 분석한다. 나아가 Stein & Kim(2009)의 연구에서 제안한 교육과정 도서를 규명하는 특징 요소들과 교사들의 교육과정 도서의 활용 간의 연관성을 추정한다. 수집된 자료는 미국 초등 교사의 수학수업 관찰노트와 관찰 전후에 실시한 인터뷰, 수업 시간에 사용한 모든 문서와 자료, 그리고 Everyday Mathematics의 교사용 지도서 등이다. 분석 결과, Everyday Mathematics는 높은 수준의 인지적 노력(cognitive demand)을 필요로 하는 수학과제들로 구성되어 있으며 (80 퍼센트), 교육과정 개발자들의 의도와 이유가 분명하게 드러나지는 않는 것으로 나타났다. 대부분의 교사들은 교사용 지도서를 참조하여 수업을 계획하고 실행하는데 있어서 지도서에서 제시한 문제나 활동을 변형하거나 부분적으로 선택하여 가르치는 것으로 나타났다. 이 과정에서 Everyday Mathematics 교육과정에서 제시한 인지적 노력 수준이 높은 수학 과제들의 27퍼센트만이 같은 수준에서 실행되는 것으로 나타났다. 교과서에서 실행 단계로 이동할 때 수학과제의 인지적 노력 수준이 감소하는 것은 교사용 지도서가 높은 인지적 노력수준의 수학 과제를 교사가 같은 수준에서 실행할 수 있도록 제대로 지원해 주지 못하는 것에 기인하는 것으로 볼 수 있다.

*key words : mathematics teaching(수학 교수), mathematics teachers(수학 교사), mathematics curriculum materials(교과서, 교사용 지도서 등을 포함한 교육과정도서), curriculum use(교육과정 활용), curriculum implementation(교육과정 실행), cognitive demand (인지적 노력).

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