USE IN TERMS OF COGNITIVE DEMANDS AND
INFLUENTIAL FACTORS: A MIXED METHOD STUDY

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ELEMENTARY TEACHERS' MATHEMATICS TEXTBOOK USE IN TERMS OF COGNITIVE DEMANDS AND INFLUENTIAL FACTORS: A MIXED METHOD STUDY

By

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ABSTRACT

ELEMENTARY TEACHERS' MATHEMATICS TEXTBOOK USE IN TERMS OF COGNITIVE DEMANDS AND INFLUENTIAL FACTORS: A MIXED METHOD STUDY

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The purpose of this study is to examine teachers' textbook use and its influential factors from a different angle, that of the cognitive demand of mathematical problems and teacher questions, and to provide both depth and breadth of analysis on these topics. A survey was used for the quantitative aspect of the research, along with teachers' lesson plan modifications, observations, and interviews for the qualitative part. Among 169 teachers who participated in the survey, eight teachers were observed and interviewed in order to establish the validity of the survey and to provide additional details.

Textbook use patterns were explored by looking at the relationship between problems and questions in textbooks and those used by teachers in teaching. Influential factors were explored in three levels--individual (e.g., teacher knowledge), contextual (e.g., type of textbook), and teachers' opportunity-to-learn (e.g., Professional development [PD] experiences).

Three noticeable findings emerged. First, there exists relatively a simple relationship between textbook problems and problems used by teachers in teaching. When teachers use problems, they at least maintain the cognitive demand of textbook

problems in teaching, suggesting that the cognitive demand of textbooks play an important role in deciding the cognitive demand of problems used by teachers in teaching.

Second, a complicated relationship exists between *teacher questions* in textbooks and those in teaching. Although textbooks provide higher cognitive demand teacher questions, some teachers decrease these levels in their teaching. Even though teachers use the higher level text problems in teaching, they decrease its level by using lower level teacher questions. This is because the enactment of mathematical problems is a multi-dimensional practice intertwined with teachers' goals, intentions, questions, and interactions of teachers and students.

Furthermore, the critical factor that influences teachers who decrease higher level text to lower level cognitive demand or those who increase a lower level text into higher level cognitive demand is alignment between their teaching goals and those of the textbooks they use. This study also found other important influential factors, such as type of textbook (standards-based curriculum), teacher knowledge, teacher perceptions about student achievement, and PD observation experience. The findings of this study provide curriculum developers, professional developers, and teacher educators with information about ways in which they can support teachers in order to help teachers make better use of their texts.

This dissertation is dedicated to my parents,

Joo Yeoul Son and Ae Soon Kim,

For their unconditional love and support,

which has given me the confidence to face the world.

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I have always realized that I am very lucky not only to have this great opportunity, but also to get enormous support and warm friendship from others. I would like to specially thank them all. My co-advisors and dissertation directors, Drs. Sharon Senk and Sandra Crespo, are my wonderful teachers, mentors, and professors, who guided me to the current place. They have profoundly shaped the research and writing of this study. They read numerous drafts, found time to meet with me, and provided insightful feedback. They offered endless encouragement through my thinking and writing process, providing the right balance of challenge and support. They are the best teachers, mentors, and role models for me. I am forever grateful to them.

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INTRODUCTION

Historically, curriculum materials or textbooks have been a key agent of policies to regulate mathematics practice in ways that align instruction with the reformers' ideas. Unlike objectives, assessments, and other mechanisms that seek to guide curriculum, textbooks are concrete, and provide the daily stuff of lessons and units, what teachers and students do. Textbooks are, therefore, often used as a means to shape what students learn (Bruner, 1960; Dow, 1991).

However, despite their central role in instruction, there has been controversy over the role of textbooks in research and practice. There are two different perspectives on the role of textbooks in practice—(1) "Textbooks as mechanism of deskilling the professional work of teaching" and (2) "Textbooks as agents of instructional improvement" (cf. Russell, 1994).

Some educators argue that curriculum materials that were designed to shape mathematics instruction "de-skill" the professional work of teaching, severely limit teachers' discretion over curriculum, and therefore limit teachers' and students' opportunities to learn. Advocates of this view acclaim teachers who create original materials and lessons (Apple & Jungck, 1990; Elliott, 1990).

In contrast, other educators argue that curriculum materials can make up for lacks in teacher knowledge and experience (Ball & Feiman-Nemser, 1988; Ball & Cohen, 1996; Collopy, 2003; Ma, 1999; Remillard, 2000; Russell, 1997). Advocates of this view, in particular, reformers, often consider a new textbook as a main tool to change instructional practice (Cohen & Ball, 1990; Stigler & Hiebert, 1999). By providing new curriculum materials, reformers assume that teachers will follow textbooks, change their instructional practices in the way they intended, and consequently improve students' mathematics achievement (Cohen & Ball, 1990; Corcoran, 2003; Remillard, 2004; Stigler & Hiebert, 1999).

Do curriculum materials really hamper or help teachers, teacher learning, and teaching? What are the affordances and limitations of different ways of following a text book? Ball and Cohen (1996) urge that if textbooks are a key component in most classrooms, we need to try to understand the relationship between the textbook and teachers' practice. In fact, the hostility to textbooks and the idealized image of professional autonomy have inhibited careful consideration of the constructive role that textbooks might play (Ball & Cohen, 1996). Between two perspectives on the role of textbooks described above, this dissertation study prefers the second, which is that curriculum materials could contribute to professional practice if they were created with closer attention to processes of curriculum enactment. Indeed, a textbook is the most commonly used instructional tool, and in some cases it is the only one which the teacher depends on. Textbooks can have a strong influence or even dominate the nature and sequence of teaching. For this reason, it is very important that textbooks are used *well.* Yet, too little is known about how teachers use textbooks, in particular, about what would be a good way to use their textbooks.

Problem Statement

Locating this dissertation study at the intersection of curriculum and teaching, I reviewed the research literature associated with three areas: Reform in mathematics education, textbook use, and its influential factors. A number of studies have focused on teachers' mathematics practice in the context of changes in national and state reforms (EEPA, 1990; March & Odden, 1991; Spillan, 1995; Spillan & Zeuli, 1999; Wilson, Peterson, Ball, & Cohen, 1996; Weiss, Pasley, Smith, Banilower, & Heck, 2003). Several studies have contributed to our understanding of how teachers use their textbooks as an attempt to revise their practice, and have provided a substantial number of categories of teachers' textbook use patterns and influential factors (Freeman & Porter, 1989; Freeman, Belli, Porter, Floden, Schmidt, & Schwille, 1983; Kauffman, 2002; Schmidt, Porter, Floden, Freeman, & Schwille, 1987; Stodolsky, 1989; Sosniak and Stodolsky, 1993).

However, there are limitations associated with the previous research on teachers' textbook use, in particular, to answer my questions.

First, despite findings about the value and influence of textbooks, the existing studies on reform and practice do not help us better understand how teachers revise their practice with textbooks according to reform efforts. Reformers have gauged teachers' implementation of reform ideas based on "inclusion of new mathematics topics," "use of variety of manipulatives", "use of calculator," etc. Some even consider "less use of textbooks," as one indicator that reform has permeated the classrooms (e.g., Goertz, Floden, & O'Day, 1995).

However, textbooks are still the visible curriculum in most classrooms. Teachers use textbooks to identify topics to be covered, and they select problems and questions from textbooks to make topics concrete (Ball & Cohen, 1996). In addition, textbooks provide opportunities for teachers to learn. Textbooks can function as an important support for teachers, especially beginning teachers, by providing detailed information that is useful for making decisions (Kauffman, 2002) and as a professional development tool for teachers to increase their understanding of content (Ball & Cohen, 1996; Collopy, 2003; Ma, 1999; Remillard, 2000; Russell, 1997). Moreover, textbook change has been viewed as a main tool to revise and support teachers' instructional practice. Therefore, we need to understand teachers' practice in connection with the influence of textbooks in order to better understand teachers' reform efforts.

Second, while researchers have documented mathematics instructional changes with different criteria, such as, "new mathematics topics," "variety of manipulatives," "calculator," etc, in order to understand teachers' implementation of reform ideas, these criteria do not suggest what kinds and levels of student learning opportunities are created.

The *Professional Standards for Teaching Mathematics* (NCTM, 1991) states that opportunities for student learning are not created simply by putting students into groups, by placing manipulatives in front of them, or by handing them a calculator. Rather, the level and kind of thinking in which students engage with mathematical problems, what Stein and Smith (2000) called, "cognitive demands" of mathematical problems *determines* what students will learn (p. 19).

However, most of the previous research on textbook use focused on the maximal extent of coverage, such as to what extent teachers use textbooks in planning and teaching school subjects (e.g., Freeman & Porter, 1989; Freeman, Belli, Porter, Floden, Schmidt, & Schwille, 1983; Sosniak & Stodolsky, 1993). There have been few studies looking at how teachers transform mathematical problems presented in textbooks when planning and teaching mathematics in terms of cognitive aspects and what factors support and constrain these transformations.

Teachers use textbooks to create students' learning opportunities. According to NCTM's (1991) document, the kinds and levels of mathematical problems and questions teachers use from their textbooks influence kinds and levels of learning opportunities with which student are provided. To understand what learning opportunities teachers provide students with, we need to explore how teachers use their textbook in terms of cognitive demands. Although several studies (e.g., Stein & Smith, 1998; Stein, Grover, & Henningsen, 1996; 1999, Stein, Smith, Henningsen, & Silver, 2000) have examined teachers' practices in terms cognitive demands, they fail to consider the value and influence of textbooks. They did not consider the teacher-texts relationship (i.e. how the cognitive demands of mathematical tasks presented in *textbooks* were changed when teachers planned and implemented them during instruction). There is a need for an examination of how mathematics tasks presented in textbooks are transformed by teachers by using the construct of cognitive demand. This dissertation study therefore explores whether and how the cognitive demands of the textbook versions of problems and questions are changed when teachers moved content from text to teaching.

Furthermore, we need to understand teachers' textbook use in depth and in breadth by combining quantitative methods and qualitative methods. Most of the previous studies that have examined textbook use patterns employed case studies. There are a few studies that examined teachers' textbook use using a quantitative method. Although case studies on teachers' textbook use provide detailed descriptions of how teachers use textbooks and what factors influence their textbook use, the results from case studies are varying. For instance, some researchers reported that teachers' beliefs about textbooks are the most important, but others reported that teachers' knowledge is important. Patton (1990) suggests the importance of using quantitative methods and qualitative methods together, and highlights the advantages of combining survey and case study methods. Since it is important to understand instructional practice at the micro and macro-level (Stecher & Borko, 2002), to provide macro-level and micro-level analysis, this study examined teachers' textbook transformation patterns and its influential factors by combining quantitative (survey) and qualitative (case study) methods.

This research focuses on the topic of fractions. Fractions typically represent a serious excursion into abstract mathematics (Wu, 2005). It is well known that many students and even adults have difficulties with the meaning of fractions and understanding operations with fractions (e.g., Behr, Wachsmuth, Post, & Lesh, 1984; Hiebert & Behr, 1988; Wu, 2001). Nevertheless, mathematicians and educators agree that instructional programs should enable all students to understand fractions and these operations meaningfully and conceptually, use efficient and accurate methods for computing, and use these operations to solve problems (Kilpatrick, Swafford & Findell, 2001; NCTM, 2000). This study therefore focuses on the topic of fractions and examines elementary teachers' textbook use.

Purpose of the Study

The purpose of this dissertation study is to examine teachers' textbook use and its influential factors from a different angle, that of the cognitive demand of mathematical problems and teacher questions, and to provide both depth and breadth of analysis with respect to teachers' textbook use and its influential factors.

The aim of the study was to extend the previous work, offer a new perspective, that of the cognitive demand of mathematical problems and teacher questions, and examine teachers' textbook use and its influential factors from this perspective in order to gain insight into the potential for textbooks to contribute to reform in mathematics teaching. It is hoped that the knowledge about teachers' mathematics textbook transformation patterns in terms of cognitive demands and the supports and constraints that influence them gained through this study will help enrich a dialogue among reformers, curriculum policy makers, and teachers, and lead to more effective ways of enhancing teachers' efforts to respond to recent reforms.

Research Questions

This study is guided by the following research questions:

1. *What transformation patterns do elementary teachers exhibit as they move content from text to teaching if the transformation is looked at in terms of cognitive demands of problems and questions?*

2. *What factors are associated with various textbook transformation patterns?*
   - Contextual-level factors:
     (1) Does type of textbook (standards-based vs. conventional) influence teachers' transformation patterns? In what ways?
     (2) Do teachers' perceptions of the state or district objectives or curriculum frameworks influence teachers' transformation patterns? In what ways?
     (3) Does teachers' perception of the state-wide tests (e.g., MEAP) influence teachers' transformation patterns? In what ways?
     (4) Do teachers' perceptions of students' achievements or ability levels influence teachers' transformation patterns? In what ways?
   - Individual-level factors:
     (5) Does teachers' knowledge about the topic of fractions influence their transformations? In what ways?
     (6) Do teachers' views about the textbook influence their transformations? In what ways?
     (7) Does teachers' fidelity to text influence their transformations? In what ways?
     (8) Do teachers' beliefs about teaching and learning influence their transformations? In what ways?
     (9) Do teachers' emphases on student objectives (understanding vs. procedural-fluency) influence their transformations? In what ways?
   - Teachers' opportunity-to-learn factors:
     (10) Does the content of professional development (PD) activities influence teachers' transformations? In what ways?
     (11) Does the pedagogy of PD influence teachers' transformations? In what ways?
     (12) Does the total amount of hours teachers received in PD activities influence teachers' transformation patterns? In what ways?

Definition of the Terms

Transformation: The process of moving content from textbook to teaching has been described as "implementation", "adaptation", or "modification". However, this study prefers using "transformation" to indicate all these processes. It is because teachers make a choice when they enact curriculum, even the choice to use the problem exactly as it is from the textbook involves transformation. Therefore, any pattern of textbook use can be expressed as a "transformation" in this study. What changes with regard to the cognitive demands is the nature of the transformation. Transformation patterns are explored by looking at whether and how the cognitive demand of problems and teacher questions presented in textbooks were maintained, increased, or decreased. Transformation patterns were analyzed in three phases as teachers move content from text to teaching as shown in Figure 1.1.

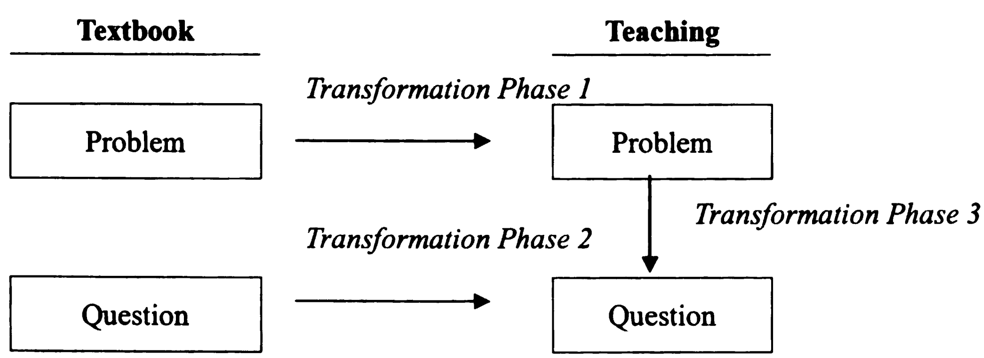


Figure 1. 1 Three Phases of Transformation Patterns

Transformation patterns in phase 1 describe the relationship between the cognitive demand of mathematical *problems* presented in textbooks and that of *problems* used by teachers in teaching. Transformation patterns in phase 2 describe the relationship between the cognitive demand of *teacher questions* presented in textbooks and the cognitive demand of *teacher questions* used by teachers in teaching. Transformation patterns in phase 3 refer to the relationship between the cognitive demand of *problems* used in teaching and the cognitive demand of *teacher questions* used in teaching.

Significance of the Study

This study attempts to provide policy makers, curriculum developers, and teacher educators with information about what is needed to help teachers make better use of their textbooks. First, this study attempts to increase knowledge concerning the texts-teacher relationship (i.e., how teachers use textbooks and in what ways) and the factors that influence teachers' decisions. This understanding is essential when curriculum materials are considered the primary strategy for improving practice.

Second, this study attempts to demonstrate a different way of analyzing teachers' use of textbooks (i.e., analysis of textbook use in terms of the cognitive demand of problems and questions). If all teachers are to have opportunities to promote students' understanding and foster students' ability to engage in developing conjectures, and in justifying their mathematical procedures and solutions, core dimensions of instruction will have to change substantially, especially the mathematical tasks (i.e., the problems, questions, and exercises students work on) and classroom discourse norms (i.e., the ways teachers pose questions and the ways teachers interact with students about mathematics). This study looks at these dimensions in terms of cognitive demands in order to expand the literature in the areas of teachers' use of textbook in mathematics education.

Third, this study attempts to contribute to current reform efforts seeking to change teaching practices in ways that promote students' understanding and foster students' ability to engage in ways that promote students' understanding and foster students' ability to engage in developing conjectures, framing and solving mathematical problems, and justifying their mathematical procedures and solutions. This study identified the factors (e.g., types of textbooks, teacher knowledge, etc) that influence teachers who revised their instruction. This understanding will help reformers, school administrators, and teacher educators to consider in what ways they can support teachers when teachers attempt to revise their practices according to reform ideas.

Overview of the Dissertation

In this chapter, I have established the central questions of the study as well as the purposes of this study. Chapter 2 synthesizes the findings from the existing literature about teachers' textbook use and influential factors. It also points out the limitations of the previous studies about textbook use and addresses an alternative analytical framework that was used to understand the texts-teacher relationship in terms of the cognitive demand of problems and questions.

Chapter 3 presents research design and methods. It includes an overview of the mixed methods research design and provides a rationale for choosing this research design. This chapter also describes the data collection instruments, data collection procedures, details of participants, and methods of data analysis.

Chapters 4 and 5 present the findings from the survey. Chapter 4 presents the findings from the survey that examined what transformation patterns teachers exhibited as they moved content from text to teaching. It also presents the findings from the analyses of teachers' actual lesson plan modification. Chapter 5 presents the findings from the survey that examined the factors affecting the distinction between transformation patterns exhibited in Transformation phase 1, Transformation phase 2, and Transformation phase 3, respectively that are reported in Chapter 4.

Chapter 6 presents the finding from the case studies that examined how teachers transformed problems and teacher questions in terms of cognitive demands as they moved content from text to teaching in fractions units. The case studies also examined factors influencing teachers' textbook use in teaching.

Chapter 7 synthesizes what the findings of the survey and the case study suggest about the role that textbooks might play in reform in mathematics education and the factors that we need to consider in order to help teachers make better use of their textbooks. This chapter also provides implications of the findings from this study.

Chapter 2

LITERATURE REVIEW

This chapter synthesizes the findings from the existing literature about teachers' textbook use and influential factors, and proposes an alternative framework to guide my dissertation study. This chapter is organized into four sections. The first section synthesizes the findings from the prior research conducted about teachers' textbook use and influential factors to distinguish what has been learned and accomplished in this area of study and what still needs to be explored. This section not only includes the claims made in the existing literature but also examines the research methods used to better understand whether the claims are warranted.

The second section points out the problems of the current research literature, in particular in terms of the analytical framework as well as in terms of the research method used, which, in turn, permits me to take a new perspective and to propose a new combination of methods for the analysis of teachers' textbook use in this study.

The third section presents the theoretical framework this dissertation study builds on, that of the cognitive demand of mathematical problems and teacher questions. The fourth section addresses hypothesized transformation patterns as teachers move content from text to teaching and hypothesized factors influencing teachers' transformations.

Research on Teacher's Textbook Use and Influential Factors

Research on teachers' textbook use and influential factors in practice goes back for decades (Freeman & Porter, 1989). Several key studies have contributed to our understanding of teachers' textbook use and influential factors in practice (Freeman & Porter, 1989; Freeman, Belli, Porter, Floden, Schmidt, & Schwille, 1983; Kauffman, 2002; Kon, 1993; Schmidt, Porter, Floden, Freeman, & Schwille, 1987; Stodolsky, 1989; Sosniak and Stodolsky, 1993; Weiss, Pasley, Smith, Banilower, & Heck, 2003). Although most of the studies on teacher's textbook use have accompanied the analysis of factors that affected teacher's different styles, I review them separately to provide a clear view of textbook use and influential factors.

Research on Teacher's Textbook Use

Table 2.1 shows a summary of the findings from the previous studies and presents different trends about teachers' textbook use that this study needed to consider

Table 2. 1 *Summary of the Previous Studies on Textbook Use Patterns*

Study	Focus	Method	Findings
1. Bagley (1931)	The extent to which the textbook dominates instruction	Analysis of the results of previous surveys on the matter, from as early as 1898, collected from state and local inspectors and supervisors.	Texts were followed almost slavishly; the curiosity of the students was seldom aroused; rarely was an inquiring spirit stimulated by the teacher

Table 2.1 (Continued)

2. Freeman & Porter (1989)	The extent to which a teacher's instruction matched the topics and sequencing presented in a mathematics textbooks	Three aspects of instruction: (a) The total number of minutes of mathematics instruction, (b) a list of topics, activities, and problems each students studied, (c) estimates of the total amount of time spent on each topic.	(a) *Textbook-bound* teachers (b) *Focus-on-the-basic* style of teachers (c) *Focus-on-district-objectives* style of teachers
3. Freeman, Belli, Porter, Floden, Schmidt, & Schwille (1983)	Exploring what is covered by the aggregate of nationally used fourth-grade standardized tests	Match between the content of material presented in fourth-grade mathematics textbooks and the content of items on standardized tests for that grade level	(1) the *textbook-bound* teacher who omits nothing (2) the *textbook-bound* teacher those who selectively omits sections (3) the *focus-on-the-basic* teacher who includes a unit on measurement (4) the *focus-on-the-basic* teacher who does not include a unit on measurement (5) the *focus-on-district-objectives* teacher.
4. Schmidt, Porter, Floden, Freeman, & Schwille (1987)	To look for patterns of effects across the influential factors and define teachers' patterns of content decision-making	Short questionnaires and interview and probes that request a description of teachers' lessons over a year and effect on that content of nine factors, such as teachers' past experience	(1) the *classic textbook-follower* without alteration (2) *textbook follower/strong student influence* (3) *follower of district objectives* (4) *follower of conception and past experience*
5. Stodolsky (1989)	To what extent and in what ways teachers adhere to textbook content and suggestions of teacher's guide in order to be teaching by the book in social studies	Three components of textbooks: (a) topic (b) actual material contained on the pages in the books (c) Activities suggested in the teacher's editions that accompany student texts.	(1) Teachers covered only the topics in the books, though not necessary all of those topics or in the order presented. (2) At the level of content, Teachers were very autonomous in their textbook use and only a minority of Ts really followed the text in the page-by-page manner.
6. Sosniak & Stodolsky (1993)	To see how robust the textbook use was across subjects	Four fourth grade teachers Observation and interview	Textbooks were not blueprints; they were simply material available, "tools, props, curriculum embodiments" (p. 270).

Table 2.1 (Continued)

7. Kon (1993)	The role of textbook in planning and influential factors	Analysis of the instructional activities listed in the lesson plan in terms of its (a) duration, (b) instructional grouping, (c) use of text or other instructional materials and interview.	(a) Textbook as a primary resource (b) Textbook as an active resource (c) Textbook as a limited source.
8. Lambdin & Preston (1995)	To see how teachers adopt new curriculum materials	34 teachers using sixth grade *Connected Mathematics*	(1) The frustrated methodologist (2) The teacher on the grow (3) The standards bearer
9. Remillard &Bryans (2003)	To examine the ways in which teachers use *Investigations*	Observation and interview of eight elementary school teachers	Three main categories of use: (1) Intermittent (2) Adopting and adapting (3) Through piloting
10. Drake & Sherin (2002)	To describe teachers' practices when using standard-based textbooks	Use a framework of models of curriculum use (1) reading curriculum materials (2) evaluating curriculum materials (3) adapting curriculum materials	The teachers developed a vision of reform instruction through the use of the curriculum materials and consequently the teachers began to trust the curriculum

First, the previous studies revealed that the notion that teachers' content decisions are dictated solely by the textbook cannot be supported. That is, teachers do not strictly follow the textbooks. One of the first studies regarding textbook use (Bagley, 1931) had as its primary concern "the extent to which the textbook still dominates instruction in American Schools" and reported teachers' excessive dependence on textbooks.

However, the rest of the studies revealed that there are distinct styles of textbook use. For example, Freeman and Porter (1989) focused on overlap between textbook content and content taught in instruction. They found three categories of teachers' textbook use: (a) *textbook-bound*, in which the teacher followed the textbook page by page; (b) *focus-on-the-basics,* in which the teacher taught lessons directly related to basic mathematical concepts and skills and skipped lessons viewed as being unrelated to these concepts or skills; and (c) *focus-on-district-objectives,* in which teachers followed closely their district's recommendations on the topics to be taught. Indeed, most of the previous studies on textbook use reported that what teachers teach is in the books, but they do not teach everything that is in the textbook (e.g., Stodolsky, 1989). This finding suggests that textbooks do not control the elementary curriculum to the extent ordinarily assumed, and teachers regularly modify textbooks in their classrooms (Freeman & Porter, 1987; Stodolsky, 1989; Schwille et al., 1982; Schmidt, et al., 1987).

Second, several studies questioned the long held conviction that teachers who closely follow the textbook teach more traditionally than in reform ways, and revealed contradicting results. For example, Freeman and Porter (1989) showed that the teachers who deviated most from the textbook placed a greater emphasis on drill and practice of computational skills, while those who followed the text more closely emphasized applications and conceptual understanding. Moreover, studies on teachers' use of the standard-based textbooks revealed that the teachers "developed a vision of reform instruction" through the use of the curriculum materials (Drake & Sherin, 2002; Lloyd & Behm, 2002; Remillard & Bryans, 2004), suggesting that "thorough piloting" of the standards-based textbooks by the teachers, while not a panacea, can play important roles in fostering reform-based practices (Remillard & Bryans, 2004).

Third and lastly, the previous studies suggest the necessity of studying what influences the decisions that teachers make regarding content and pedagogy when using textbooks. The previous studies on textbook use revealed that various factors lead teachers to use textbooks differently. For example, in Freeman and Porter's (1989) study, the *focus-on-district-objectives* teacher category indicates that district objectives have much more influence than the textbook itself when selecting content. The *focus-on-the-basics* teacher category shows that teacher's beliefs about what to teach and how to teach have stronger effect on content decisions than the textbook itself. These findings imply a need for understanding teachers' larger curricular agendas and the role the textbook play in them, suggesting that researchers who study textbooks and their use in classrooms also have to pay attention to a connection between teachers' thinking and beliefs about instructional plans and activities, and their actual use of materials (Sosniak & Stodolsky, 1993, p. 272). Built on previous studies, my dissertation study involves studying teachers' enacted curriculum and the role that texts play in it.

Research on Influential Factors on Teachers' Textbook Use

A number of studies examined what factors influence the decisions that teachers make regarding content and pedagogy. Table 2.2 shows the summary of the previous studies that examined the various influential factors on teachers' decision making. This shows different findings and tendencies in the previous studies that examined influential factors on teachers' decisions and that this study needed to consider.

Table 2. 2 *Summary of the Studies on Influential Factors*

Study	Factors examined	Findings
1. Freeman & Porter (1989)	• Teacher view on text • Teacher view on master basics	• Teachers' adherence to textbook topics is a function of the degree to which teachers see the textbook as a legitimate content authority and of their own convictions about the content for Ss to master.
2. Schmidt, Porter, Floden, Freeman, & Schwille (1987)	• Teachers' beliefs about math • Educational experiences • District Objectives/ Tests • Textbook • Different subject-matters • Parents/ Student • Other teachers	• Textbooks have the greatest influence on content selection decision, followed by teachers' conceptions and then students. • The other factors had little overall impact on content decisions. • Parents especially had no noticeable impact.
3. Ball & Feiman-Nemser (1988)	• Pre-service training experience	• Due to teacher education programs that emphasized that textbooks can only be used as a limited resource, most of the students from both programs were unprepared to use the given textbooks in their practice
4. Kaffeman (1989)	• Teachers' skill & knowledge • Teacher beliefs & attitude toward textbooks • School context/ students • District objectives • Subject matter being taught • Nature of textbook	• Beliefs about mathematics and mathematics instruction (particularly how those beliefs do or do not match the available curriculum materials) is dominant individual-level influence. • Most prominent contextual factors are institutional norms and expectation for textbook use

Table 2.2 (Continued)

5. Kon (1993)	• Educational experiences • Teacher views on the goals of social education • Teacher view on how to teach it • School characteristics • Classrooms characteristics	• The factors are quite varied and interrelated. • No single factor consistently stands out.
6. Remillard (1996;1997;1999; &2000)	• Teacher beliefs about mathematics • Beliefs about teaching and learning • Teacher perception about students and their learning	• Teacher beliefs about the nature of mathematics and about teaching and learning influenced how teachers read the textbook • Within the construction area, where the curriculum is constructed by adapting tasks according to the students' performance and reactions to the planned tasks, the teachers examined and analyzed the tasks guided by their ideas about learning and about what students need to know
7. Remillard & Bryans (2004)	• Teacher view about mathematics and the teaching of mathematics • Teacher view of a particular curriculum	• Engagement with the curriculum materials is affected by the teachers' orientation toward using a curriculum, and in turn it influences the teacher's views and ideas of and about mathematics
8. Weiss, Pasley, Smith, Banilower, & Heck (2003)	• Teacher knowledge • Teacher beliefs • Teaching experience • State/district curriculum standards • Test accountability • Students • Professional Development • Teacher collegiality • Textbooks	• State/district curriculum standards has the greatest influence on content select decision, followed by textbooks, tests, teacher knowledge, beliefs, & experience, student characteristic, teacher collegiality, and PD experience • Teacher knowledge, beliefs, & experience has the major influence on instructional strategy, followed by textbooks, student characteristic, PD experience, teacher collegiality, tests, and state/district curriculum standards

First, some researchers place the teacher-text relationship at the center of analyses of teaching (e.g., Freeman & Porter, 1989), whereas other researchers consider teachers' larger curricular agendas and the role the textbook plays in them (e.g., Schmidt, Porter, Floden, Freeman, & Schwille, 1987; Weiss, Pasley, Smith, Banilower, & Heck, 2003), focusing less on the teacher-textbook relationship and more on the teacher-curriculum relationship (Remillard, 2005). Although the second type of research did not explain why some teachers use their textbooks in a particular way, these studies revealed the crucial role of textbooks in deciding content selections and instructional strategies, and suggested the necessity of study examining the factors influencing teachers' textbooks use. For example, Schmidt, Porter, Floden, Freeman, and Schwille (1987) examined nine factors affecting teachers' content decisions as shown in Table 2.2 and revealed that textbooks had the largest impact on most of the teachers' content decisions, followed by teachers' conceptions, and then students. Along the same line, in a more recent report of a large national observation study on K-12 mathematics and science education, Weiss, Pasley, Smith, Banilower, & Heck (2003) also reported that the textbook designated for a class is the second most important factor that influences both the selection of content and instructional strategies.

Second, the previous studies suggest the importance of examination of the factors from multiple aspects. Although the existing research has identified many influences over what teachers actually teach, findings vary among the studies. One possible reason is that while some researchers have focused on only individual-level influences, such as teachers' beliefs about textbooks (e.g., Sosniak & Stodolsky, 1993), others explored both individual-level and contextual-level influences (e.g., Kauffman, 2003). Knapp (2000) suggests the importance of studying the connection between individual teachers and their workplace environments. He noted the difficulty of conducting this kind of research. Yet, since individual teachers reside in the contexts in which they work, a better approach would be to look at the influential factors on teachers' textbook use considering both individual factors and contextual factors.

Furthermore, the previous studies suggest studying influential factors on content selection and instructional strategies separately. Recently, Weiss, et al. (2003) explored what led teachers to select the content in the lessons, and why they chose the pedagogy and the materials used in the lessons. With 364 mathematics and science teachers in K-12 grade, Weiss, et al. conducted interviews and classroom observations and found that different factor influence content selection and instructional strategies differently. They reported that state and district curriculum standards had the most influence on their content decisions and next was the textbook/program designated for the classroom. Teachers' knowledge, beliefs, and experience had the most influence on their instructional strategies. This finding suggests that we need to examine influential factors differently by separating content selection and instructional strategy.

Problems of the Current Research Literature on Textbook Use

Several studies have contributed to our understanding of teachers' attempts to revise their practice with textbooks and have provided us with a substantial number of categories of teachers' textbook use patterns and influential factors. However, there are limitations associated with the previous research on teachers' practice concerning textbooks.

First, despite findings about the value and influence of textbooks, the existing studies on reform and practice do not help us better understand how teachers revise their practice with textbooks according to reform efforts. Reformers have gauged teachers' implementation of reform ideas based on "inclusion of new mathematics topics," "use of variety of manipulatives", "use of calculator," etc, However, they often consider "less reliance on textbooks," as one indicator that reform has permeated the classrooms (e.g., Goertz, Floden, & O'Day, 1995).

However, textbooks are the visible curriculum in most classrooms. Teachers use textbooks to identify topics to be covered, and they select problems and questions from textbooks to make topics concrete (Ball & Cohen, 1996). In addition, textbook change has been viewed as a main tool to revise and support teachers' instructional practice. Therefore, we need to understand teachers' practice in connection with the influence of textbooks in order to better understand teachers' reform efforts.

Second, the criteria that researchers have used to understand the teacher-text relationship do not suggest what kinds and levels of student learning opportunities are created.

The *Professional Standards for Teaching Mathematics* (NCTM, 1991) states that opportunities for student learning are not created simply by putting students into groups, by placing manipulatives in front of them, or by handing them a calculator. Rather, the level and kind of thinking in which students engage with mathematical tasks, what Stein and Smith (2000) called, "cognitive demands of student thinking" determines what they will learn (p. 19).

However, most of the previous research on textbook use focused on the maximal extent of coverage, such as to what extent teachers use textbooks in planning and teaching school subjects (e.g., Sosniak & Stodolsky, 1993). There is little research on how teachers use their textbook to provide different kinds and levels of student thinking that shape students' experience in the classroom.

The QUASAR project (Quantitative Understanding: Amplifying Student Achievement and Reasoning) examined how mathematical tasks are transformed by teachers from the standpoint this study investigated, that is, in terms of cognitive

demands (Henningsen & Stein, 1997; Silver & Stein, 1996; Stein, Grover, & Henningsen, 1996; Stein & Smith, 2000). Although the QUASAR project examined how the cognitive demands of mathematical tasks planned by teachers were changed during instruction, they did not consider the teacher-texts relationship (i.e. how the cognitive demands of mathematical tasks presented in *textbooks* were changed when teachers planned and implemented them during instruction). There is a need for an examination of how mathematics tasks presented in textbooks are transformed by teachers by using the construct of cognitive demand. This dissertation study therefore explored whether and how the cognitive demands of the textbook versions of problems and questions are changed when teachers moved content from text to teaching.

Furthermore, most of the previous studies that have examined textbook use patterns and the influential factors employed case study, and there are a few studies that examined teachers' textbook use using a quantitative method. Although case studies on teachers' textbook use provide detailed descriptions of how teachers use textbooks and what factors influence their textbook use, the results from case studies are varying.

For instance, some researchers reported that teachers' beliefs about textbooks are the most important, but others reported that teachers' knowledge is important. Recently, with 364 mathematics and science teachers in grades K-12, Weiss, and his colleagues

(2003) provided more general quantitative findings regarding influential factors on content decisions and instructional strategies. Unlike case studies, Weiss et al's study does not provide detailed information about how such factors are related to teachers' content selection and instructional strategies.

Patton (1990) suggests the importance of using quantitative methods and qualitative methods together and highlights the advantages of survey and case study methods.

> The advantage of a quantitative method is that it is possible to measure the reactions of a great many people to a limited set of questions, thus facilitating comparison and statistical aggregation of the data. This gives a broad, generalizable set of findings presented succinctly and parsimoniously. By contrast, qualitative methods typically produce a wealth of detailed information about a much smaller number of people and cases. This increases understanding of the cases and situations studied but reduces generalizability (p. 14).

It is important to understand instructional practice at the micro and macro-level (Stecher & Borko, 2002). The methodological weakness of the previous studies I pointed out above suggests the need for a combination of quantitative and qualitative methods in order to compensate for those weaknesses. In order to provide macro-level and micro-level analysis, this dissertation study examined teachers' textbook transformation patterns and influential factors by combining quantitative (survey) and qualitative (case study, combination of observation and interview) methods.

In summary, the existing research literature on teachers' textbook use has limitations in its analytical framework, as well as its methodological aspects. Therefore, this dissertation study extends the previous work and offers a new perspective, that of the cognitive demand of mathematical problems and teacher questions, to examine teachers' textbook use and its influential factors. In addition, this study used a mixed method approach to provide both depth and breadth of analysis with respect to teachers' textbook use and its influential factors. In the next section, I will address an alternative analytical framework that was used to understand the texts-teacher relationship in terms of the cognitive demand of problems and questions.

Conceptual Framework

This section presents the theoretical framework this dissertation study builds on, that of the cognitive demand of mathematical problems and teacher questions, and the hypothesized transformation patterns and influential factors. In this section, I first describe the importance of the cognitive demands of mathematical problems in forming students' opportunity to learn in mathematics lesson. I also emphasize the importance of the cognitive demand of teacher questions in supporting students' learning. Second, I address the analytical framework used to classify various types of mathematical problems and teacher questions in terms of cognitive demands. Third and finally, I describe the hypothesized transformation patterns and influential factors derived from the previous studies as associated with teachers' use of textbooks.

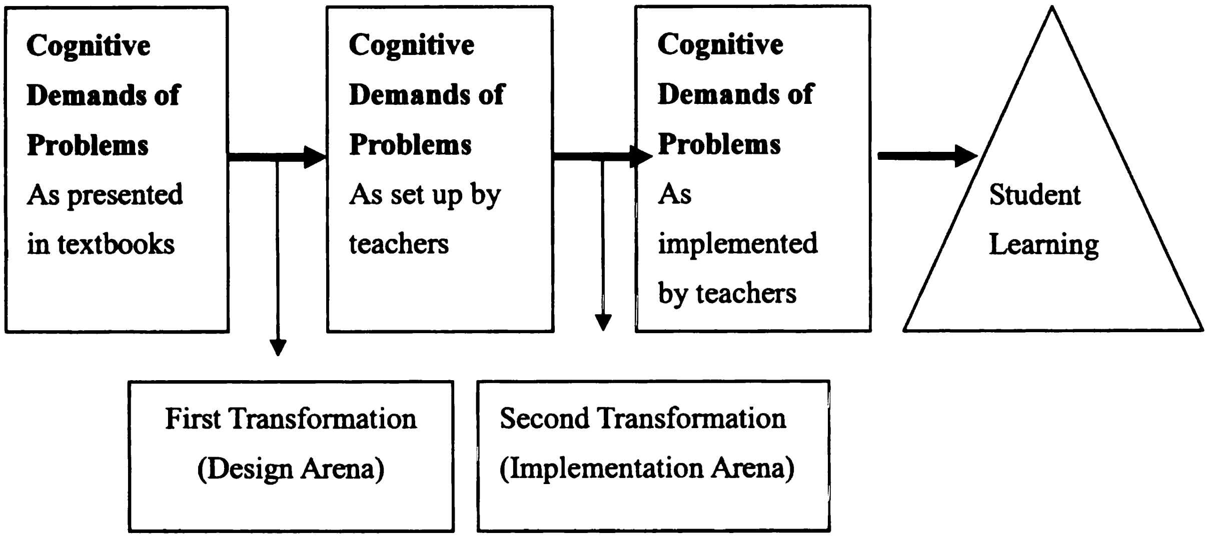
Importance of Cognitive Demands of Problems and Questions

Mathematical problems used in instruction form the basis of students' opportunities to learn mathematics (Doyle, 1983, 1979; 1980; Stein & Smith, 2000). The *Professional Standards for Teaching Mathematics* (NCTM, 1991) articulated that opportunities for student learning are not created simply by placing manipulatives in front of students, or by handing them a calculator. Rather, the level and kind of thinking in which students engage with mathematical problems, what Stein and Smith (2000) called, "cognitive demands of problems" determines what they will learn (p. 19).

Indeed, mathematical problems draw students' attention to particular ways of thinking about and doing mathematics. For example, if the problems students work on present the mathematical ideas as finished products, students will not need to think through the concepts and engage in using them to reason about mathematics, and thereby they may perceive mathematics as a statement of end products—definitions, rules, and procedures--for memorization. Conversely, if a problem students work on demands engagement with concepts through reasoning and argument, students will learn mathematics by engaging in mathematical thinking, offering conjectures, responding to one another's ideas (and the teacher's), and defending and justifying their ideas, as opposed to mainly knowing computational procedures and following predetermined steps to compute correct answers (NCTM, 1989, 1991, 2000). Therefore, being aware of the cognitive demand of problems is central in the selection of mathematical tasks from textbooks or in the creation of mathematical tasks.

The cognitive demands of mathematical tasks are maintained or changed as teachers move content from textbook to teaching. Figure 2.1 describes the processes of how the cognitive demand of mathematical tasks unfolds from textbook to teaching by teachers. The framework developed from the QUASAR project (Quantitative

Understanding: Amplifying Student Achievement and reasoning) was adapted (Silver & Stein, 1996).



Source: Adapted from Stein, M.K., Grover,B.W., Henningsen, M. (1996). "Building Student Capacity for Mathematical Thinking and Reasoning: An Analysis of Mathematical Tasks Used in Reform Classrooms." American Educational Research Journal, v(33), pp.455-488.

Figure 2. 1 Transformation of Mathematical Tasks in Terms of Cognitive Demand

First, mathematical tasks or (problems) are presented in textbooks. These mathematical tasks reflect curriculum developer's intention of what mathematics is and how students should learn mathematics. The cognitive demands of problems and questions presented in textbooks are decided by curriculum developers.

These cognitive demands of textbook problems and questions are transformed first by teachers when teachers plan lessons. Teachers use, adapt, or alter textbook problems and questions to present their students. In this process, various factors influence teachers' selection of problems. The tasks that a teacher selects, regardless of the extent to which they differ from those described in the textbook, represent the teacher's assumptions about content (what and how students should learn). Depending on the cognitive demands of problems selected by teachers, the cognitive demands of problems presented in textbooks are maintained or changed into different levels.

The cognitive demand levels of the mathematics tasks planned and set up by teachers are again changed during instruction. Teachers enact the planned tasks in the classroom by posing questions to guide students work on mathematical tasks and responding to students' interactions with them. In the second transforming process, the ways the teacher and students talk, what they talk about, and how they agree and disagree are especially important here because they can fundamentally transform the manner in which a particular academic task is enacted by teacher and students (Spillane & Zeuli, 1999). In particular, teacher questioning has the potential to greatly facilitate the learning process in a way that transfers factual knowledge to conceptual understanding (Brown & Campione, 1990; Brown, Collins, & Duguid, 1989; Simon, 1986; Spillane & Zeuli, 1999). For example, even though teachers select the tasks that concentrate on factual knowledge, teachers pose questions that require students to use higher order thinking or reasoning. By engaging in this kind of teacher questioning, students do not remember only factual knowledge. Instead, they can use their knowledge to problem solve, to analyze, and to evaluate. Depending on the cognitive demands of teacher questions teachers use during instruction, the cognitive demand of mathematical tasks set up by teachers can be decreased, maintained, or increased, which eventually contribute to the kinds and levels of student opportunity to learn. The following section describes the framework that was used to classify the cognitive demand of problems and teacher questions presented in textbooks and used by teachers in teaching.

Framework for Cognitive Demands of Problems

This study employed the Stein and Smith's (2000) framework. A mathematical problem in this study refers to a mathematical object to be solved by students. Mathematical problems typically differ with respect to the level of cognitive demand they place on student learning. Mathematical problems presented in textbooks and in teaching are categorized into two levels with respect to cognitive demands—(1) low-level and (2) high-level.

Low-level cognitive demand problems. This type of problems asks students to perform a demonstrated procedure in a routinized way and hence place low-level, mostly proceduralized demands on student learning. Low-level cognitive demand problems would involve reproducing facts, rules, or formulas and consist of two types of tasks-- *memorization tasks* and *procedures without connection tasks*. *Memorization tasks* involve exact reproductions of what students learned previously. Mathematical problems in this type of task are clearly and directly stated. There is little ambiguity about what needs to be done and how to do it. No connection is made to the concepts, meanings, or understandings that underlie the procedure being used. Problems in this type of task require no explanations or explanations that focus solely on describing the procedure that was used. For instance, in the topic of fractions, this type of task could consist of problems requiring students to memorize the equivalent forms of specific fractional quantities (e.g., $\frac{1}{2} = 0.5 = 50\%$).

Another type of low-level problem is *procedures without connections tasks,* which also do not require students to make connections to the concepts or meanings that underlie the procedure being used. *Procedures without connections tasks* require limited cognitive demand for successful completion. Problems in this type of task are focused on producing correct answers rather than developing mathematical understanding. A typical example is a problem that asks students to convert fractions to percents or decimals using standard conversion algorithms in the absence of additional context or meaning (e.g., convert the fraction $\frac{3}{8}$ to a decimal by dividing the numerator by the denominator to get 0.375; change 0.375 to a percent by moving the decimal point two places to the right to get 37.5%).

High-level cognitive demand problems. High-level problems ask students to make conceptual connections and to think and reason in sustained and thoughtful ways. Like low-level cognitive demand problems, high-level cognitive demand problems could involve using procedures, but must do so in a way that builds connections to underlying concepts and meaning. High-level problems also consist of two types of tasks--*procedures with connection tasks* and *doing mathematics tasks.* Problems in *procedures with connection tasks* require students to make connections between ideas and procedures, possibly by using multiple representations. The purpose of addressing procedures in these tasks is to develop deeper levels of understanding of mathematics concepts and ideas. Procedures usually are represented in multiple ways, such as visual diagrams, manipulatives, symbols, and problem situations. For instance, problems might ask students to use a diagram to illustrate how the fraction $\frac{3}{5}$ represents the same quantity as the decimal 0.6 or 60%. Students could also be asked to record their results in a table containing the decimal, fraction, percent, and pictorial representations, thereby allowing them to make connections among the various representations and attach meaning to their work by referring to the pictorial representation of the quantity every step of the way.

Another high-level problem is *doing mathematics tasks*, which would entail

asking students to explore the relationships and invent ways to solve problems. Students would not be provided with the conventional procedures to solve the problems. Rather, students could be asked to use a visual diagram to solve the problem, or be allowed to choose a method for solving the problem. In this type of task, students are challenged to apply their understanding of mathematics concepts in novel ways.

Framework for Cognitive Demands of Teachers Questions

A question in this study refers to a pedagogical object suggested in the textbook and used by teachers in teaching that directs the students to think in certain ways and to reflect on their math work. As in the case of the cognitive demand of problems, the *cognitive demand of questions* here refers to as the kind and level of student thinking required when (students) engage with "teacher questions".

Six categories were adapted by blending the revised Bloom's taxonomy (Anderson & Krathwohl, 2001), Stein and Smith's framework (2000), and the TIMSS Video study's (2003) mathematics cognitive domains, in order to describe the cognitive demands of teacher questions. These six categories lie in continuum from *remembering* through *evaluating*, which are categorized into three different cognitive levels—(1) low-level, (2) medium level, and (3) high-level. The first two categories—*remembering and knowing procedures*—are low-level teacher question. The middle category—

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understanding—is medium level. The rest three categories—*applying, reasoning*, and *evaluating*—are high-level teacher questions.

Low-level cognitive demand questions Low-level cognitive demand of teacher questions concentrate on factual information that can be memorized or carrying out algorithmic procedures. This type of question can limit students by not helping them to acquire a deep, elaborate understanding of the subject matter. Low-level cognitive demand of teacher question consists of two categories--*remembering* and *knowing procedure*. *Remembering* type of question requires students to draw up previously learned knowledge. This kind of question is used for students to tell teachers what they already know because of what teachers have taught them and what they have perceived and/or experienced for themselves. Students are asked to recognize or recall information.

Another type of low-level question is *knowing procedures*. This type of a question asks students to carry out algorithmic procedures for +, -, ×, ÷, or a combination of these with whole numbers, fractions, and decimals. This kind of question is used for students to compute given problems based on an algorithm.

Medium level cognitive demand questions *Understanding* category is the medium level cognitive demand, which means that, in this type of question, it is hard to tell whether questions require high-level of student thinking or low-level of student thinking. Typically, this type of questions tests students' comprehension. This level of question is used for students to demonstrate that they understand what they know. Students are asked to reword, rephrase, or describe what they know.

High-level cognitive demand questions This level of questions can be defined as questions that require students to use higher order thinking or reasoning skills. By using these skills, students do not remember only factual knowledge. Instead, they use their knowledge to problem solve, to analyze, and to evaluate. *Applying, reasoning* and *evaluating* categories are high-level questions. *Applying* category question is used for students to be able to select and use knowledge to complete a task by taking what they have already learned and applying it to other situations. Students are asked to apply known facts, principles, and/or generalizations to solve a problem.

Another type of high-level question is *Reasoning* category, which encourages analysis. Teachers use this type of questions for students to be able to support their arguments and opinions by organizing ideas into logical patterns of understanding. Students are asked to analyze and provide a justification for the truth or falsity of a statement by reference to mathematical results or properties. Students are also asked to apply mathematical procedures in unfamiliar or complex contexts and support their arguments and opinions by organizing ideas into local patterns of understanding.

Evaluating question is the highest level that involves making a judgment based upon the application of a set of standards or criteria. Teachers want students to consider the values implicit in their thinking by looking at evidence and establishing criteria. Students are asked to synthesize and integrate to evaluate results and determine how closely a concept or idea is consistent with standards or value. Some of the thinking skills are: synthesizing and integrating, summarizing, judging, criticizing, or arguing.

In my dissertation, I believe that teachers should ask a combination of all three levels of teacher questions in order to foster student understanding and achievement. For example, it is possible that teachers have to break high level cognitive demand problems into lower level questions in order to help students to understand, thus using low level questions as a scaffold to high level learning opportunities. However, evidence from previous studies reported that teachers spend most of their time asking low-level cognitive questions (Hiebert & Wearne, 1993; Klinzing, Klinzing-Eurich, & Tisher, 1985; Wilen, 1991). Teachers rarely ask 'higher order' questions, even though these have been identified as important tools in developing student understanding (Hiebert & Wearne, 1993; Klinzing, Klinzing-Eurich, & Tisher, 1985).

Previous studies reported that student learning gains were greatest in classrooms in which instructional tasks consistently encouraged high-level student thinking and reasoning and least in classroom in which instructional tasks were consistently procedural in nature (Silver & Stein, 1996; Stein & Smith, 2000). I argue that teachers in both instruction and evaluation should devote "a minimum of one-third" of the time allotted to questioning to levels above memory (Sanders, 1966, p, 156).

In this study, referring to the ratio Sanders articulated, I classified the cognitive demand of mathematics problems and teacher questions presented in mathematics and that of mathematical problems and teacher questions used by teachers into two levels--(1) higher level and (2) lower level. If more than 1/3 of problems are high-level problems and questions, these textbooks (or teachers) were considered as providing higher level of problems and teacher questions. Otherwise, these textbooks (or teachers) were considered as providing lower level of problems and teacher question.

Hypotheses of Transformation Patterns and Influential Factors

Hypothesized Transformation Patterns

Based on the frameworks for the cognitive demand of mathematical problems and teacher questions described above, four hypothetical transformation patterns from textbook to teaching were expected to appear with respect to the cognitive demand of problems and the cognitive demand of teacher questions as shown in Figure 2.2.

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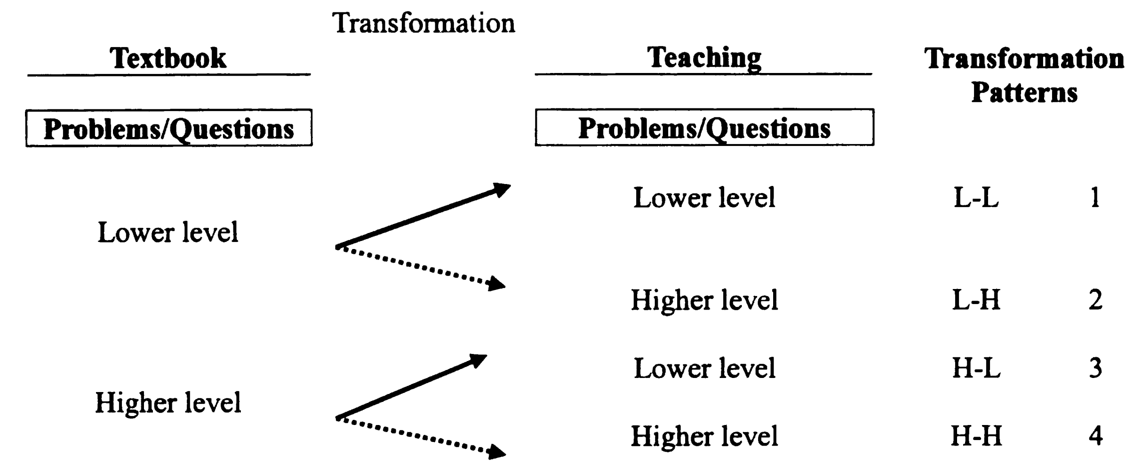


Figure 2. 2 Hypothetical Textbook Transformation Patterns

The first transformation pattern describes the situation where teachers have textbooks that require lower level problems and questions, and they use lower level problems and questions in their teaching. The second transformation pattern describes the case where teachers transform lower level of textbook problems and questions into higher level cognitive demand problems and questions in teaching. Conversely, the third transformation pattern illustrates the situation where teachers have textbooks that provide higher level problems and questions, but they lower the higher level in their teaching. The fourth transformation pattern describes the situation where teachers have textbooks that provide higher level problems and questions, and they maintain the cognitive demand in their teaching. Among four transformation patterns, some reformers and researchers may favor the second and fourth transformation patterns (e.g., Silver & Stein, 1996; NCTM, 1989, 1991, & 2000), since problems and questions in these teachers' classes will demonstrate that mathematics is comprised of key ideas and concepts that can be used to construct procedures for solving problems as opposed to a statement of end products for memorization.

However, several very well-known studies (e.g., Cohen, 1990; Doyle, 1986; Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1993; Stigler & Hiebert, 2004) have found that many teachers reduce the cognitive level of problems and questions when they use them in their teaching. For example, The Third International Mathematics and Science Study included a video component whose examination suggests that teachers in the highest-achieving counties maintained the high level of tasks whereas teachers in the U.S implemented none of the high level problems in the way in which they were intended (Stigler & Hiebert, 2006). According to them, the U.S. teachers turned most of the high level problems into low level problems such as procedural exercises or just supplied students with the answers to the problem.

Consistent with the results from Stigler and Hiebert' study, Cohen (1990) reported that due to teachers' lack of knowledge, teachers decreased the high level of tasks presented in curriculum materials as they conducted in their instruction. Cohen examined one teacher, Mrs. O, who believed that she had changed her mathematics teaching in ways that provide students with high level of student thinking by using the high level problems and questions presented in the new curriculum materials. However, his analyses revealed that although Mrs. O used the new materials (high-level problems) in her teaching, she conducted the class in ways that discouraged exploration of students' understanding, which will be categorized into H-L pattern in this study. Thus, according to previous studies, one might expect to see a large number of teachers in the H-L pattern or the L-L pattern and a smaller number of teachers who follow the H-H pattern. In particular, if one did an observational study, it would not be surprising to find that many who identified themselves as H-H would be classified as H-L by an observer.

As a consequence of these studies, much more emphasis has been put on teacher education and professional development programs in order to help teachers use problems and questions in ways that improve students' understanding. In addition, with the availability of reform-inspired curriculum materials that provide high-level problems and questions, there is considerable emphasis on the wide-spread adoption of new curriculum materials in current education. School districts increasingly regulate mathematics teaching practices by mandating the use of a "single" curriculum (Remillard, 2005).

However, as Ball and Cohen (1996) pointed out, too little is known about how teachers use textbooks. In keeping with the findings from previous studies and current emphasis on teacher education and curriculum policies, this study examined what patterns elementary teachers exhibit as they move content from text to teaching in terms of cognitive demands of problems and questions.

Hypothesized Influential Factors

Teachers do not work in a vacuum. Various factors influence teachers' decision. Existing research has identified two distinct influences—(1) Individual-level influence and (2) contextual level influence. Some researchers reported individual-level influences on teachers' textbook use. For examples, teachers' knowledge (Ball & Feiman-Nemser, 1988; Brophy, 1982; Cohen, 1990; Kauffman, 2002), teachers' beliefs about mathematics teaching and learning (Barr, 1988; Cohen, 1990; Stodolsky, 1989; Schmidt, et al, 1987), and teachers' view about textbooks (Ball & Feiman-Nemser, 1988; Freeman, & Porter, 1989) are reported as all associated with teachers' use of textbooks.

Other researchers reported contextual-level influences on teachers' decision. For example, teacher perception of state/district curriculum framework (Freeman, & Porter, 1989; Schmidt et al., 1987; Weiss, et al. 2003), state-wide tests (Freeman, & Porter, 1989; Schmidt et al., 1987; Weiss, et al. 2003), and school climate (e.g., limited time and resource) (e.g., Wilson, 1990) all influence teachers' use of curriculum materials.

Although these studies did not examined influential factors on teachers' textbook use in terms of the cognitive demands, this study assumes that identified factors described above would also influence teachers' use of textbook in terms of the cognitive demand since individual teachers reside in the contexts in which they work and influences of contextual factors are mediated by influences of individual factors (Knapp, 2002). Builds on the previous studies, this study hypothesizes that both individual-level and contextual-level influence over teachers' use of textbooks in terms of cognitive demands,

However, this study extends these two-level influences to three-level--*individual-level* factors, *contextual-level* factors, and *teachers' opportunity-to-learn* factors. The previous research categorized "professional development opportunities" into either *individual-level factors* or *contextual-level factors* (see Kauffman (2002)'s study and Ball & Feiman-Nemser (1993)'s study). Yet, professional development participation is the mixture of individual-level influence and contextual-level influence. In some districts, participating in professional development opportunities is mandatory, but in other district it is voluntary. Profession development participation is mandatory to some teachers but not other teachers. In addition, regardless of whether it is from individual-level or contextual-level influence, professional development participation provides teachers with opportunities to learn. As such, this study separated and added one more category, *teachers' opportunity-to-learn factors* to examine the effect of professional development opportunities over teachers' use of textbooks. Table 2.3 presents the hypothesized factors associated with teachers' textbook transformation patterns in terms of cognitive demands.

Table 2. 3 *Hypothetical Textbook Transformation Patterns*

Factor-level	Sub-category
Contextual-level	District textbook policy Type of textbook (standards-based vs. conventional) Teacher perception of students' mathematics achievement Teacher perception of state/district curriculum frameworks Teacher perception of state-wide tests (e.g., MEAP test)
Individual-level	Teacher knowledge Teacher beliefs about teaching and learning Teacher view on textbooks Teacher emphasis of student objectives Teacher fidelity to textbook
Teachers' opportunity to learn	Professional development participation hours Types of content areas studied on PD activity Types of pedagogy participated in during PD activity

Chapter 3

RESEARCH DESIGN AND METHODS

This chapter consists of three sections. The first section presents an overview of the mixed methods research design and a rationale for choosing this research design. The second and third sections describe the quantitative research method and qualitative research method, respectively, describing the data collection instrument and procedures, details of participants, as well as methods of data analysis.

Research Design Overview

This dissertation study employed a mixed method design that combines both quantitative and qualitative research methods to explore elementary teachers' textbook transformation patterns in terms of cognitive demands and influential factors. Figure 3.1 shows an overview of the study design.

A survey was developed to collect data for the quantitative aspect of the research. An interview protocol and observation protocol were developed for the qualitative part. I used the survey in order to explore the general ideas of the ways in which teachers transform the cognitive demand of problems and teacher questions when they move mathematics content from text to teaching. The factors that are associated with textbook transformation patterns were also explored.

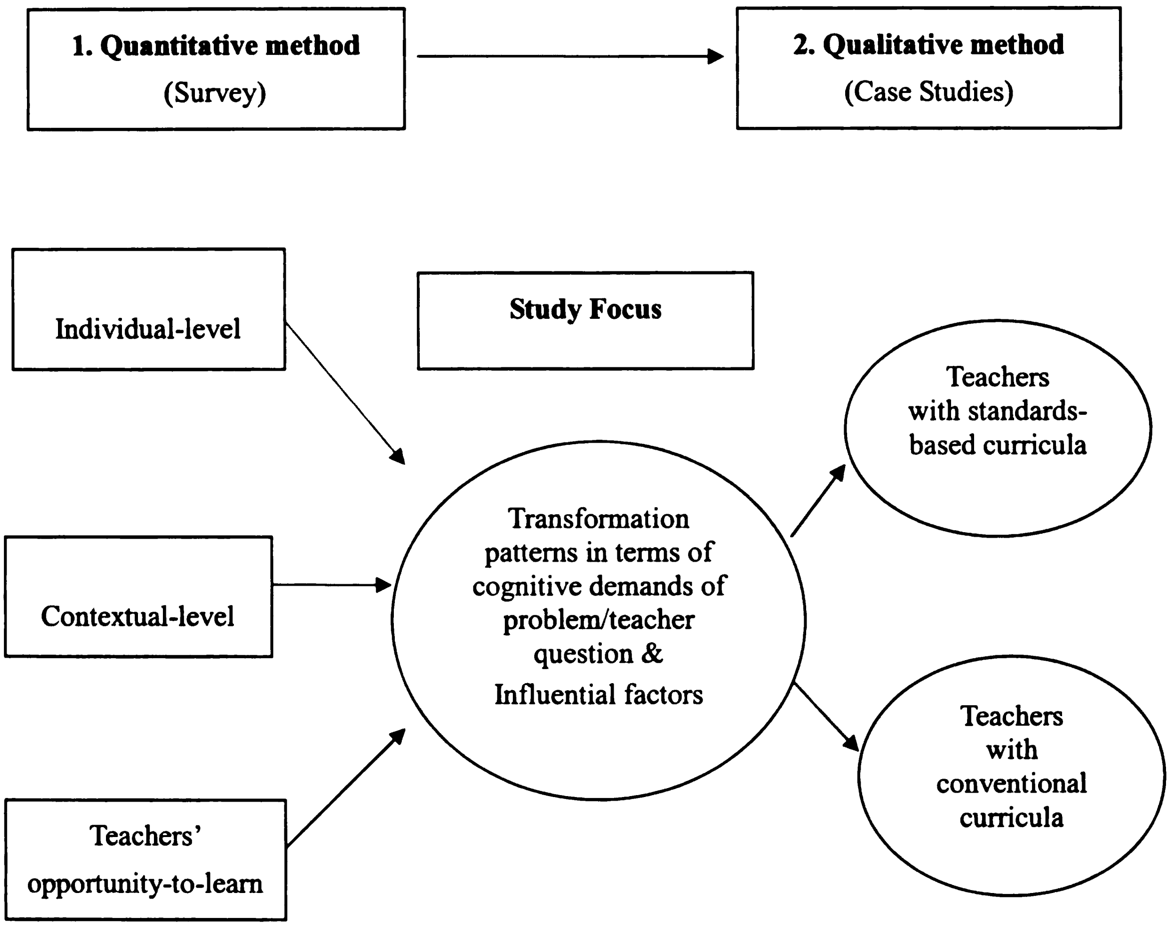


Figure 3. 1 Overview of Study Design

The purpose of the survey was to address two research questions: (1) What transformation patterns do elementary teachers exhibit as they move content from text to teaching if the transformation is looked at in terms of cognitive demands of problems and questions?; and (2) What factors are associated with various transformation patterns?

Next, I planned to select about 8 teachers from among the survey participants purposefully for the case studies in order to gain more in-depth understanding of teachers' textbook transformations and influential factors. I planned to observe each teacher's lesson once (in some cases, twice) and interview each teacher. During the interview(s), I sought to answer the same research questions as those in the survey mentioned in the previous paragraph.

The quantitative (a survey) and qualitative (observation & interview) methods complement each other. For instance, studies based on qualitative methods can provide a detailed description of a small number of teachers' use of textbooks in terms of cognitive demands, but they do not provide a general picture of what factors influence their use of textbooks. In contrast, quantitative methods can miss information that the qualitative methods can provide (i.e., detailed descriptions). Therefore, using two methods sequentially, this study intended to provide both breadth and depth of analysis on teachers' use of textbooks in terms of cognitive demands and influential factors.

Quantitative Research Methods

Survey Development and Validation

The survey was developed by employing items from Weiss, Pasley, Smith, Banilower, and Heck, (2003), Ravitz, Becker, and Wong (2000), Desimone, Porter, Birman, and Garet (2002), and Choi (2005). Several survey items were modified based on the Third International Mathematics and Science Study (TIMSS) questionnaires, Freeman and Porter (1989), Schmidt, Porter, Floden, Freeman, and Schwille (1987), and Stein and Smith's (2000) framework.

After developing the survey, survey validations were conducted in three different processes. The surveys must offer an accurate portrait of what teachers do in their classrooms and how teachers use their textbook in their classroom. However, there are several reasons to be concerned that they might not. First of all, in the survey much of the data are self-reported by teachers. Teachers might provide biased responses to a survey because they feel that they should (for a variety of reaons) respond to the questions in "acceptable" or "socially desirable" ways; or teachers might unknowingly provide misleading responses to the survey questions (Mayer, 1999). In particular, research suggests that teachers sometimes truly believe they are embracing pedagogical reforems, but in pratices, their teaching comes nowhere near the vision of the reformers (Cohen, 1990). In addition, the teaching process consists of complex interactions between students and teachers. Surveys are limited in their abilities to portray a valid picture of the schooling process, and in particular, aspects of curricular practices, such as the interactions between teachers and students and their role in the learning process (Burstein et al., 1995; Mayer, 1999).

To minimize these methodological limitation and use more valid surveys, the pilot studies were conducted in three ways. First, I examined content validity, which can be obtained from literature and experts (Carmines & Zeller, 1979). I asked a Ph.D. graduate student who had eight years of teaching experience in elementary schools in the U.S in mathematics education to check if the survey made sense to her as a graduate student studying mathematics education, as well as a teacher who understands teaching practice well. Although I have been studying mathematics education in Michigan, my limited experience as an international student in the U.S. context might have potentially generated some misunderstanding among my targeted participants.

After that, I asked five other Ph.D. students who were studying mathematics education to indicate their opinions about the degree of relevance of each item in my survey by marking one of three statements (Good, So So, or Not Good) about each survey item and providing specific explanations about their opinions when they chose "So So" or "Not Good". Overall, most items were perceived as "Good". For items perceived as "So So" or "Not Good," I revised the statements based on their comments.

Lastly, the survey items were validated by five in-service teachers. The key issue in this validation process is whether the intended participants make sense of the questions asked of them. I tried to understand whether teachers' understanding of the question matched what I had in mind.

This pilot study was conducted through think-aloud protocols, which involve participants verbally describing their thinking as they are performing a set of given tasks (Swanson, O'Connor, & Cooney, 1990). This validity test enabled me to see how participants made sense of the survey questions asked of them and how they interpreted and justified their choices. Based on teachers' comments, I revised the survey instrument and reformatted the survey to facilitate easier reading. The wording of some questions was changed for clarity, the scales of items were changed and some items were removed.

In addition, this validity test with in-service teachers enabled me to compare their estimates of the cognitive demands of their texts and my own classification of them. Using the survey, I intended to examine the relationship between the cognitive demands of problems and questions presented in textbooks and the cognitive demands of problems and questions used by them in teaching. My own classification of the cognitive demands of texts provided one potential external standard against which to assess the validty of teacher self-reports. All five participants in the pilot studies used standards-based curricula, which were categorized as providing higher level cognitive demand of problems and questions by my analyses (Stein & Kim, 2007); and their perceptions of the cognitive demand were similar to mine although one teacher's estimates of her own practice were a little bit upwardly biased.

Overall, these survey validation processes helped me to revise the survey in a way that would capture a more valid and accurate portrait of how teachers use their textbooks in terms of the cognitive demands of problems and questions and what factors influnece these transformation patterns.

The Revised Survey

The revised survey consisted of 25 questions organized in three parts: (1) background information, (2) textbook use in fraction units, (3) three levels of factors that influence teachers' use of textbooks including contextual-level factors, individual-level factors, and teachers' opportunity-to-learn factors. The survey is attached in Appendix A.

Questions 1-8 collect demographic data. Among the remaining questions, 16 are used to answer the research questions. These are summarized in Table 3.1.

Table 3. 1 *Measures Used in Statistical Analysis*

	Measures	Item number
A. Textbook transformation patterns		
	Cognitive demands of problems in textbooks and in teaching	Q 18
	Cognitive demands of questions in textbooks and in teaching	Q 19
B. Factors influencing textbook use		
Contextual-level	Student math achievement	Q 8
	District textbook policy	Q 9
	Type of textbook	Q 12
	District curriculum framework	Q 23
	State-wide tests	Q 23
Individual-level	Teacher knowledge	Q 21
	Teacher view on textbook	Q 13
	Teacher beliefs on teaching	Q 22
	Teacher emphasis on student learning	Q 16
	Teacher fidelity to textbook	Q 14
Teachers' opportunity-to-learn	Professional development (PD) participation hours	Q 24
	Content type in PD	Q 24
	Pedagogy Type during PD	Q 25
C. Textbook transformation pattern validation		
	Cognitive demands of lesson plan modification	Q20

Among the 16 main measures are two measures for teachers' transformation patterns, five measures for contextual-level factors, five measures for individual-level factors, three measures for teachers' opportunity-to-learn factors, and one measure for validation of identified textbook transformation patterns.

Survey Participants

Prior to data collection, a description of this study and the data collection instruments were reviewed and approved by the University Committee on Research Involving Human Subjects (UCRIHS). The survey data were collected from summer 2006 through fall semester 2007. For survey participant recruitment, the letter introducing this study was sent out to instructors and elementary teachers who were taking Master's courses at a large suburban Midwestern University or those who were registered for professional development programs.

Because the study aimed to include teachers who taught fractions, targeted participants were originally teachers from second to sixth grade. According to Michigan's Mathematics Grade Level Content Expectations (GLCE), these are the grades at which fractions are taught. However, different districts develop different content frameworks and pacing guides, thus teachers in 1st grade were also included if they said they taught fraction concepts. Participants were recruited among teachers who were taking Master's courses at a large suburban Midwestern University or those who were registered for professional development programs. Thus, these participants are convenient samples meaning that the participants do not represent the entire population. In particular, given their participations in either Master programs or profession development programs, these teachers might be very familiar with reform ideas (e.g., NCTM standards) or might be influenced by these programs and might thereby show different transformation patterns from those identified by other researchers (e.g., Cohen, 1990; Stigler & Hiebert, 2004) or previous studies (e.g., Stein & Smith, 1998).

A total of 169 teachers from first to sixth grade participated in this study. Table 3.2 presents a summary of the characteristics of the survey participants as well as brief information on teachers' use of the textbook assigned by their districts or schools.

Table 3. 2 *Characteristics of Survey Participants*

	Category	Frequency (N=169)
Type of school	Public	161 (96%)
	Private, religious	4 (2%)
	Other (e.g. Chart)	4 (2%)
Gender	Male	33 (20%)
	Female	136 (80%)
Grade taught	1st	18 (11%)
	2nd	28 (17%)
	3rd	30 (18%)
	4th	26 (15%)
	5th	35 (21%)
	6th	33 (18%)
Teaching experience	0 to 4 years	45 (26%)
	5 to 9 years	52 (31%)
	10 to 14 years	21 (12%)
	15 to 19 years	16 (10%)
	20 years or above	35 (21%)
Use the textbook assigned by district	Yes	162 (96%)
	No	7 (4%)
Use other textbooks	Yes	53 (32%)
	No	115 (68%)

Almost all survey participants were working in public schools and were female. The distributions for the grade-level were similar among six different grade levels, even there were a few more fifth grade teachers. Approximately 74% of teachers had teaching experience of five years or longer. Virtually all reported using the textbooks assigned to them by their district or school. About one-third of the teachers used other textbooks additionally, suggesting that the assigned textbooks are the primary source for teachers to plan and teach mathematics in their practice.

Survey Data Analysis

Figure 3.2 describes the processes of survey data analyses

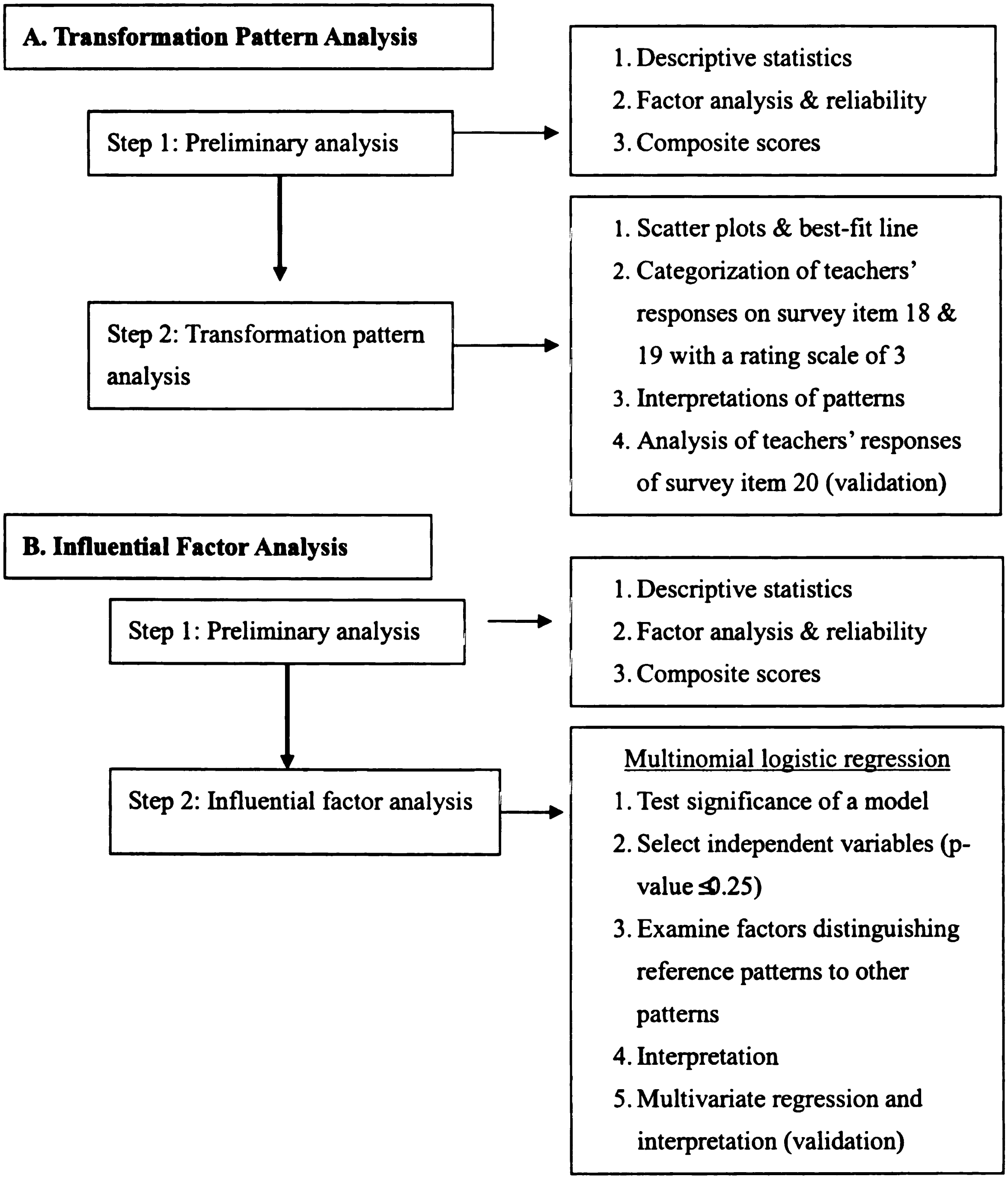


Figure 3. 2 Survey Data Analysis Process for the Study

Data analyses of survey items 1-19 and 21-25 was done using the Statistical Package of the Social Science (SPSS) version 15.0. Details are provided in the following chapters. To validate the findings from survey items 18 and 19, survey item 20 asks the teachers comment on and modify a lesson plan reproduced from a lesson about equivalent fractions. Each teacher's response on survey item 20 was analyzed with two questions in mind: (1) What did the teachers actually modify from the daily lesson plan in terms of student objectives, classroom activity, mathematical problems, and teacher questions? and (2) How did teachers modify the lesson in terms of the cognitive demand of problem and questions? Once these data were coded, frequencies and of the description statements were also obtained by using SPSS version 15.0.

Qualitative Research Method

Case Study Participants

Among the 169 survey participants, a total of eight teachers were chosen to participate in the second part of the study, the case studies. These teachers were selected purposively from 52 survey participants who volunteered to participate in the case study. Two criteria were used in the selection of participants. The first criterion was grade level. Although fraction concepts are introduced from first or second grade, this topic is developed intensively from fourth to sixth grade at the elementary level. Therefore, I only selected teachers who were teaching in those grades.

The second criterion used in the selection of case study participants was the type of textbooks teachers used. One suggestion from the findings based on teachers' self-reports was that types of textbooks (standards-based versus conventional curriculum) play an important role in deciding the cognitive demand of problems and teacher questions used by teachers in teaching. So I selected teachers who used standards-based and conventional textbooks.

Case Study Data Collection Procedures

Each participant was observed at least once when they were teaching units about fractions and a post-observation interview was conducted that lasted approximately 45-60 minutes. Prior to starting the interview, participants consented to being tape recorded. Although each participant was observed and interviewed once or twice, case study data were collected over the period of a year, since teachers taught fraction units at different times.

Case Study Instruments

Three sets of data were collected from the eight elementary teachers—(1) teachers' planned lessons, (2) my observation and observation notes, and (3) structured interviews.

Teachers' planed lessons using teachers' manuals Before teaching the lessons, teachers were asked to provide their lesson plan. However, rather than keep a detailed lesson plan, teachers were asked to use problems and teacher questions presented in the teacher's guide of their textbook to create their lesson plan. Teachers circled problems and teacher questions they planned to use from the teacher's guide and gave a copy to me. With this lesson plan from the teacher's guide, I observed each teacher's lesson once or twice. These planning lessons from the teacher's guide helped me to see the main activities that would take place during the lesson. This also allowed me to examine what were the similarities and differences between the textbook lesson and the lesson planned by teachers.

Classroom observation (and notes) The classroom observations focused on examining the teachers' use of textbooks in practice. While I was observing each teacher's lesson, I took field notes, especially regarding what the teachers or students recorded on the boards. Classroom observations permitted me to examine the changes made between their planned lesson and their enacted lesson. I looked to see in what ways the teachers enacted the planned lesson from their textbook and examined what kinds of teacher questions they used.

Post-observation Interview The post-observation interview was designed to elicit data on teachers' use of textbooks and factors influencing their practices. This made it possible for me to examine how teachers reflected on their use of textbooks from the planning stage to teaching practice and explore what teachers recognized as constraints or support in their use of textbook. The interview protocol consists of two parts—(1) Use of their textbooks in planning and teaching fractions and (2) Influential factors on their textbook use.

(1) Use of textbooks in planning and teaching lessons This set of questions was designed to explore the process of teachers' transformation from textbook lessons to planned lesson and lesson taught. Teachers were asked to explain resources they used in planning lessons and similarities or differences between the existing textbooks, their planned lessons, and the lesson taught with respect to student objectives, classroom activities, problems, and teacher questions. Teachers were also asked to provide a rationale for why they added or deleted particular activities, problems, and questions from the textbook. Furthermore, teachers were asked to explain their plan for the next lesson using textbooks. Questions about teachers' use of textbooks in planning and teaching lessons were adopted from the interview protocol employed by Kauffman (2002).

(2) Influential factors on the use of textbooks Questions related to teacher knowledge, teacher learning goals, teacher view of textbook were asked in order to examine whether these factors function as possible constraints on or supports to teachers' use of textbooks. To examine teachers' knowledge about fractions, teachers were asked to describe the big ideas in the fraction unit. To examine whether learning goals align with problems and questions used in teaching in terms of cognitive demands, teachers were asked to provide learning goals for the specific lesson I observed as well as overall goals for students' mathematics learning. Teachers were also asked to answer whether there were any parts of the book they found particularly helpful and in what ways their textbook was not helpful.

Lastly, teachers were asked to consider the factors which influenced their use of textbooks when teaching fractions in order to explore what teachers recognized as constraints or support in their use of textbook. Appendix B describes the specific questions of the interview protocol.

Case Study Analysis

The case study data analysis involves: (1) analyses of textbook lessons, (2) analyses of teachers' taught lesson, and (3) interview data. Because textbook lessons and teachers' taught lessons were analyzed in the same way, I describe them together.

Textbook Lesson Analysis Textbook lessons and teachers' taught lesson were analyzed in light of two aspects—(1) mathematics content covered and (2) cognitive demands of learning goals, problems and teacher questions.

(1) Mathematics content covered This study first examined the similarities and differences in the mathematics content of the lessons presented in their textbook and the lesson teachers taught, in particular with regard to the lessons' goals and choice of problems, activities and teacher questions.

(2) Cognitive demands of mathematics content covered This study next examined the similarities and differences between the textbook and taught lesson in terms of cognitive demands of these lesson's goals, problems and questions. First, learning goals presented in the textbook lesson and articulated by teachers were classified as either higher level or lower level based on the revised Bloom's taxonomy (Anderson & Krathwohl, 2001).

Second, each problem presented in the textbook lesson was classified as either high-level or low-level based on Stein and Smith's (2000) framework. Next, referring to teachers' planned lesson and my observation notes, each problem used by teachers was classified into either high-level or low-level.

After that, the ratio of "1/3" is used to determine the overall cognitive demand of problems presented in textbooks and the overall cognitive demand of problems used by teachers in teaching. For example, if a textbook provides problems that require high-level cognitive demand more than 1/3 of the total problems, it was considered as providing higher level cognitive demand problems. Conversely, if a textbook provides them as less than 1/3 of the total problems, it was considered as providing lower level cognitive demand problems. The ratio of 1/3 was selected based on previous studies. For example, Sanders (1966) articulated that teachers in both instruction and evaluation should devote "a minimum of one-third" of the time allotted to questioning to levels above memory (p. 156). Referring to ratio of cognitive domain in TIMSS 1999 video study, Kadijević (2002) stated that:

> The chosen target percentage to the cognitive domains in grade 8—knowing facts and procedures (15%), using concepts (20%), solving routine problems (40%) and reasoning (25%)—are quite appropriate and well balanced (p. 98).

In the TIMSS cognitive domain, only *reasoning* is matched with the high cognitive levels in teachers' questions and its percent (25%) is less than the ratio of one-third that Sanders articulated. Therefore, the ratio of 1/3 is considered an appropriate criterion to decide the overall cognitive demand of problems and questions in textbooks and in teaching.

Third, teacher questions presented in textbook lesson were categorized into three cognitive levels—high, medium, and low level--based on the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001). As in the analysis of problems in terms of the cognitive demands, if a textbook (a teacher's guide of the textbook) provided teacher questions that require high-level cognitive demand more than 1/3 of the total questions, it was considered as providing higher level cognitive demand teacher questions. Otherwise, it was considered as lower level.

For the cognitive demand of teacher questions in the lesson taught, interview data and my observations were used. One interview question was: "What questions did you pose to have students get involved with these activities?" and "What are typical questions you frequently use in your teaching?" By using teachers' reports and my observations, the cognitive demand of teacher questions used in the lesson taught was decided.

Interview data analysis The interview data were analyzed via the following steps. First, interviews were transcribed into printed text. I then read the transcripts carefully. While I obtained a general sense of the information through that reading, I made a list of themes related to the findings from survey and emergent ideas from the reading of the data (Cresswell, Tashakkori, Jensen & Shapley, 2003; Glaser & Strauss, 1967; Miles & Huberman, 1994). A third step was to code the content of transcripts in relationship to these themes. The N-vivo computer software allowed me to categorize the responses. Next, analytic case study narratives were written for each teacher (within-case analysis) (Miles & Huberman, 1994). Finally, cases were compared to one another based on the textbook transformation patterns identified from the analysis of each teacher's textbook lesson and observed lesson in order to explore possible reasons why teachers used the same textbook differently or used different textbooks in a similar way (across-case analysis).

Interview data were triangulated for each case with the survey, the textbook lesson, and the observation (and notes). For example, teachers were asked to describe their use of the textbook, and the survey had similar questions, including the percentage of teaching time or lessons when the teacher would use the textbook. At the same time, observation data would corroborate what was stated during the interview and in the survey. To ensure that the narrative of each case and the claims made therein were accurate and trustworthy descriptions of each case and lesson tapes selected were reviewed again and compared with the narrative.

Chapter 4

RESULTS FROM THE SURVEY:

TRANSFORMATION PATTERNS OF COGNITIVE DEMANDS

This chapter is organized into four sections. The first section presents preliminary information about the cognitive demand of problems and questions presented in textbooks and the cognitive demand of problems and questions used by teachers in teaching. These results are based on the analysis of teachers' responses on survey items 18 and 19.

The second section presents the results of transformation patterns in terms of the cognitive demands. Transformation patterns were explored in three phases as shown in Figure 4.1.

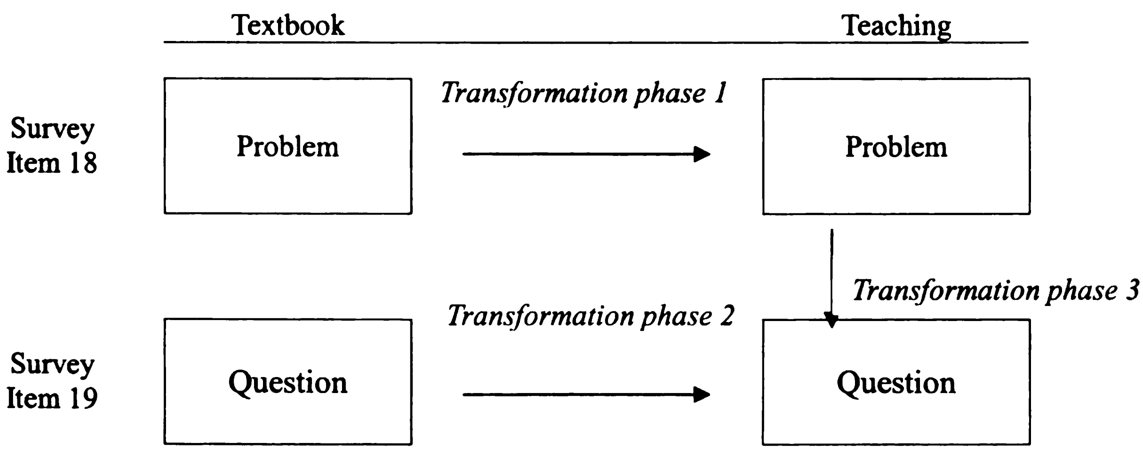


Figure 4. 1 Three Analyses of Transformation Patterns

The third section presents the findings from the teachers' transformations of an actual lesson plan given in survey item 20. The fourth section summarizes and synthesizes the findings regarding transformation patterns from the survey, as well as from the lesson plan modifications.

Preliminary Analysis

Descriptive Analysis

Based on an initial summary of teachers' responses on survey items 18 and 19, a descriptive analysis was performed to provide preliminary information about the problems and questions presented in textbooks and those used by teachers in teaching.

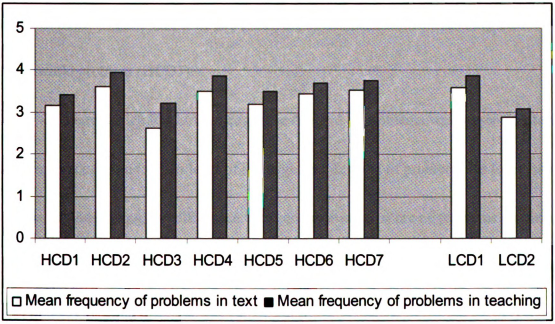
In survey item 18, to measure the cognitive demand of problems in textbooks and the cognitive demand of problems used by teachers in teaching, teachers were asked to indicate how often various types of problems were presented in their textbooks and how often teachers used corresponding types of problems in their teaching. A five-point Likert scale was used, which was coded 1= Never, 2 = Rarely (once a unit), 3 = Sometimes (2-3 times a unit), 4 = Often (4-5 times a unit), 5 = Almost all lessons. Table 4.1 displays the basic statistics obtained from item 18, including the mean and standard deviation.

Table 4. 1 *Summary of Descriptive Statistics of the Data for Item 18*

Item #	Types of problems	Textbooks		Teaching	
		M	SD	M	SD
18 a	Problems requiring methods of inquiry	3.15	0.98	3.42	0.87
18 b	Problems requiring explanation & justification	3.61	1.02	3.95	0.80
18 c	Problems requiring computations with speed	2.63	1.07	3.21	1.12
18 d	Problems involving communication	3.51	1.04	3.87	0.96
18 e	Problems requiring developing own methods	3.19	1.11	3.50	0.94
18 f	Problems emphasizing the relationships	3.45	0.93	3.70	0.83
18 g	Problems requiring the use of representations	3.53	0.93	3.75	0.89
18 h	Problems requiring real world application.	3.60	0.88	3.87	0.78
18 i	Problems requiring recalling facts and formulas	2.89	1.14	3.07	1.04

Table 4.1 shows that the mean frequency ratings of all types of problems used in teaching are greater than those presented in textbooks. It suggests that teachers reported that they used all types of problems in their teaching more frequently than the textbook did.

Each type problem mentioned in Question 18 was categorized into either high-level cognitive demand (HCD) or low-level cognitive demand (LCD), based on the Stein and Smith's framework (2000). Among nine problems, only two—problems requiring computations with speed and problems recalling facts and formulas—were classified as requiring low-level cognitive demand. The rest were categorized as requiring high-level cognitive demand. Figure 4.2 illustrates the data presented in Table 4.1.



Note: HCD1= Use method of inquiry HCD2=Use explanation/Justification, HCD3= Communication, HCD4=Develop own method, HCD5=Understand relationships, HCD6=Use representation, HCD7=Application, LCD1=Compute with speed & accuracy. LCD2=Recall facts

Figure 4.2 Mean Frequency Rating for Different Types of Problems in Textbook and Teaching

First, the frequencies in all types of problems used in teaching are slightly higher than those presented in textbooks, indicating that teachers reported that they used each type of problems more often than the textbook did. In particular, teachers reported that problems that require computation with speed and accuracy—which demand low-level of student thinking (LCD1)—were used in teaching much more often than those presented in the textbooks (note that the difference in frequency is greatest for this question).

Second, among problems categorized into the high-level cognitive demand category (HCD1 to HCD7), problems that require students to explain and justify their ideas were used most often (HCD2), followed by problems requiring communication with peers and teachers (HCD4), and problems that require students to apply concepts to a real-world problem (HCD7).

To know which level of the cognitive demand of problems was presented more often in textbooks and which level of the cognitive demand of problems the teachers used more often in teaching, the difference between the average score of problems requiring high-level cognitive demand and that of problems requiring low-level cognitive demand both in textbooks and teaching was calculated for each teacher. A difference of 0 signifies that teachers reported using high-level problems with the same frequency as low-level cognitive demand problems. If the difference is less than 0, it means that teachers reported using low-level cognitive demand problems more often than high-level cognitive demand problems. If the difference is greater than 0, it signifies that teachers reported using high-level cognitive demand problems more often than low-level cognitive demand problems. Figure 4.3 shows the results of this analysis.

While many teachers had scores close to zero, there is a noticeable skew towards the positive end of the continuum (i.e. difference is greater than zero) in both textbook problems and problems used in teaching. Sixty eight percent of teachers had scores greater than 0 with regard to textbooks and the same percentage of teachers had scores greater than 0 with regard to teaching. This indicates that on average, teachers reported that high-level cognitive demand problems appeared more frequently in their textbooks than did low-level cognitive demand problems, and they also reported that, in their teaching, they used high-level cognitive demand problems more often than low-level ones.

In addition, although the same percentages of teachers had scores greater than 0 in textbooks and in teaching, a comparison of the percentage of teachers who scored less than 0 in textbooks (26.6%) and the percentage of teachers who scored less than 0 in teaching (27.2%) shows that more teachers reported that they used low-level problems in teaching more often than such problems presented in their textbooks.

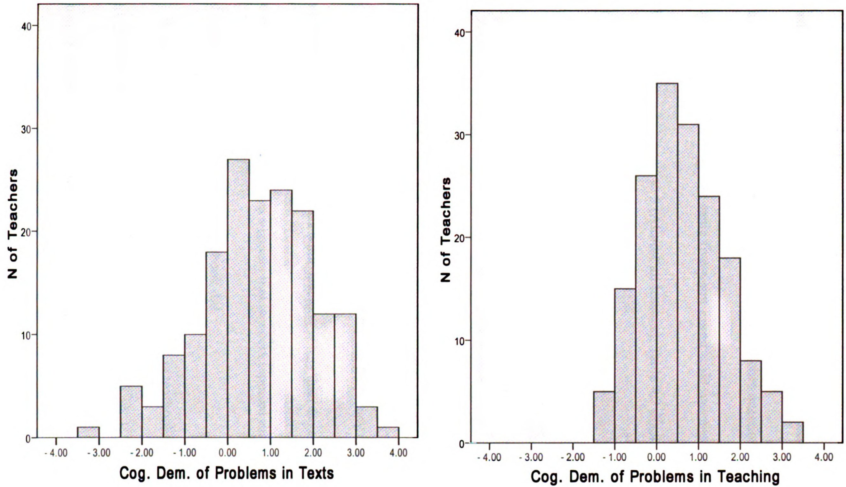


Figure 4. 3 Average Frequency Differences between High-level and Low-level Problems in Textbooks and in Teaching

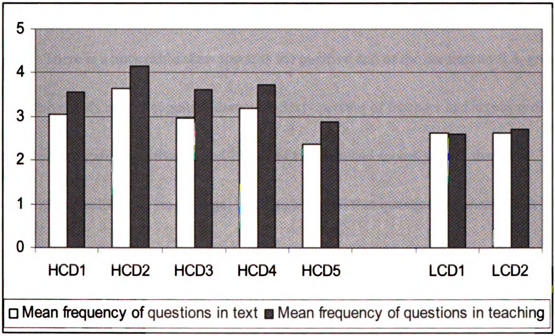
In survey item 19, to measure the cognitive demand of teacher questions presented in textbooks and that used by teachers in teaching, teachers were asked to indicate the frequency of the presence of various types of teacher questions both in their textbooks and in their teaching. The same five-point Likert scale was used as in survey item 18, ranging from 1 (Never) to 5 (Almost all lessons). Table 4.2 displays the basic data for item 19.

Table 4. 2 *Summary of Descriptive Statistics of the Data for Item 19*

Item #	Types of Teacher Questions	Textbook		Teaching	
		M	SD	M	SD
19 a	Pose open-ended questions	3.16	1.07	3.61	0.95
19 b	Require students to explain reasoning when giving an answer	3.73	1.02	4.18	0.74
19 c	Ask students to explain concepts to one another	3.16	1.17	3.71	0.90
19 d	Ask students to consider alternative solutions	3.38	1.19	3.85	0.95
19 e	Ask students to read from a textbook in class.	2.73	1.31	2.65	1.25
19 f	Ask students to answer questions about what they have read.	2.73	1.29	2.84	1.25
19 g	Ask students to evaluate each other's ideas	2.56	1.21	3.02	1.12

Among the seven types of teacher questions, only the frequency of asking students to read from a textbook in class while teaching is less than the corresponding questions found in the textbooks. This suggests that teachers reported that they used this type of question less frequently than the textbook did.

To explore tendencies of teacher questions presented in textbooks and used by teachers in terms of the cognitive demand, applying similar cognitive demand categories as in item 18, these teacher questions were categorized into two levels—(1) high-level cognitive demand (HCD) and (2) low-level cognitive demand (LCD). Two types of teacher questions—teacher questions that ask students to read from a textbook in class and teacher questions that ask students to answer questions about what they have read—were classified as requiring low-level student thinking. The rest were classified as requiring high-level student thinking. Figure 4.4 presents the results of this analysis.



Note: HCD1= pose open-ended questions, HCD2= require students reasoning, HCD3= Ask students alternative methods, HCD4=Ask students peer-evaluation, HCD5=Ask student explanation, LCD1= Read from textbook. LCD2= Answer from textbook

Figure 4. 4 Average Frequency Ratings for Different Types of Questions in Textbook and in Teaching

Note that teachers indicated that they used questions categorized as high-level cognitive demand (HCD1 to HCD5) more often than those presented in textbooks, whereas they indicated that they used questions categorized as the low-level (LCD1 & LCD2) in a similar frequency to their textbooks. Among the questions categorized as high-level cognitive demand, teachers reported that they most often used questions that required that students explain their reasoning when giving an answer (HCD2).

As was done to analyze results of question 18, the differences between the average scores of questions requiring high-level of student thinking and that of problems requiring low-level were obtained. Figure 4.4 illustrates the results.

There is a noticeable skew towards the positive end of the continuum (i.e. greater than zero equals higher cognitive demand). Sixty percent of teachers had scores greater than 0 with regard to textbooks and 73.4% of teachers had scores greater than 0 in teaching, indicating that on average, teachers believed that questions requiring high-level cognitive demand are presented more often in textbooks and are used more often in teaching than questions involving low-level cognitive demand.

However, different from the result of Question 18 concerning the cognitive demand of problems, as the percentages of teachers who had scores greater than 0 in textbooks and in teaching show, teachers reported that they more often used high-level cognitive demand questions in teaching than those presented in their textbooks. In particular, a comparison of the percentages of teachers who scored less than 0 in textbooks (33.3%) and in teaching (19.5%) shows that teachers reported that they used low-level questions in teaching less than such questions presented in their textbooks.

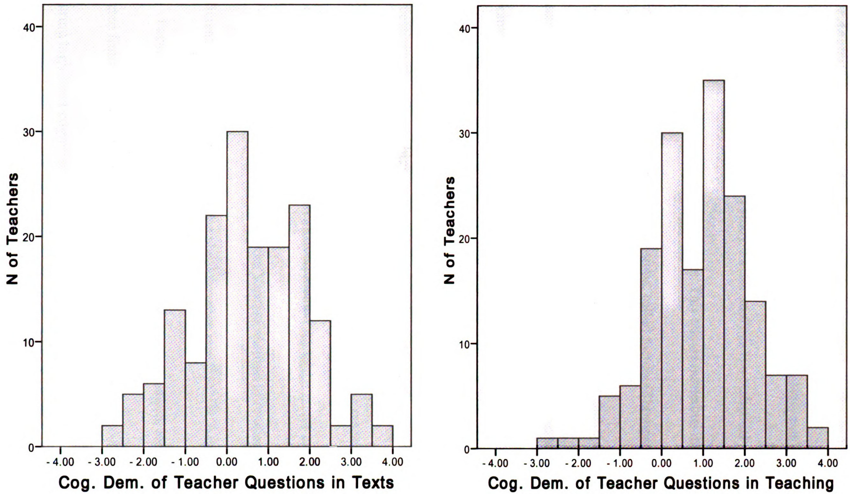


Figure 4. 5 Average Frequency Differences between High-level and Low-level Questions in Textbooks and in Teaching

Factor Analysis

After the descriptive analysis was completed, factor analysis was conducted to test the theoretical categories of this study. Factor analysis is a statistical procedure used to uncover relationships among many variables. This allows numerous inter-correlated variables to be condensed into fewer dimensions, called factors (Thompson, 2004). Although all the survey questions were designed based on theory, factor analysis was conducted in order to examine whether the sub-items measure each factor cluster together. For example, problems used in survey item 18 were classified into either high-level or low-level. Using factor analysis, this study attempted to investigate whether problems and questions classified as high-level or low-level clustered together.

Exploratory factor analysis was used since the nature of the research itself is exploratory. The principal component analysis method for initial factor extraction, with the criterion eigenvalue greater than 1 and the Varimax method of rotation was applied. Coefficient display formats suppress the absolute value less than .05 in the factor analysis.

Factor analysis results revealed that without any manipulation, two factors were extracted from the responses to each survey item 18 and 19, which are—(1) the factor measuring high-level cognitive demand and (2) the factor measuring low-level cognitive demand. The reliability of each factor was calculated to verify whether a scale consistently reflected the construct it was measuring. Table 4.3 presents the resulting factors, the survey item numbers comprised of the factor, and its reliability.

Table 4. 3 *Results of Factor Analysis and Reliability*

Factors measuring	Survey item #	Textbook	Teaching
		Cronbach α	Cronbach α
Problems			
High-level cognitive demand	Q 18 a,b,d,e,f,g,h	0.89	0.83
Low-level cognitive demand	Q 18 c,i	0.61	0.50
Teacher questions			
High-level cognitive demand	Q 19 a, b,c,d, g	0.88	0.80
Low-level cognitive demand	Q 19 e,f	0.78	0.79

The Cronbach's alpha in all factors was greater than or equal to 0.5. In particular, factors measuring high-level cognitive demand in both textbooks and in teaching and in both problems and questions are highly reliable ($\alpha \geq 0.8$).

For the exploration of transformation patterns in terms of the cognitive demand of problems and questions, the factor measuring high-level cognitive demand in both problems and questions was selected for several reasons. First of all, factors measuring low-level cognitive demand had lower reliability than the general acceptance level of reliability for research instruments, 0.70 (Cheung & Lee, 2001; Lee & Turban, 2001; Teo, 2001), whereas the reliability of all factors measuring high-level cognitive demand exceeded 0.8. This indicates that the factors measuring high-level cognitive demand were very reliable (or, at least, teachers understood survey item 19 in the same way).

In addition to this technical reason, there has been much more emphasis on high-level mathematical thinking in mathematics education. For example, *Professional Standards for Teaching Mathematics* (NCTM, 1991) stressed the importance of providing higher level cognitive demand in student learning opportunities. Along the same lines, *Principles and Standards for School Mathematics* (2000) described the kinds of tasks that teachers should play in promoting higher level cognitive demand. In correspondence to such needs and emphasis, the factor measuring higher level cognitive demand in both problems and questions was selected and analyzed in exploring transformation patterns in terms of cognitive demand.

Composite Scores and Average Composite Scores

In the third and final step of the preliminary analysis, individual teacher's responses on survey items that measure high-level cognitive demand in both problems and teacher questions were combined into a single composite measure, called a composite score, and the composite score was divided by the total number of survey items. This new score, the average composite score, was utilized in exploring transformation patterns in terms of cognitive demand of problems and questions. For example, for the analysis of transformation patterns, teachers' ratings for the presence of high-level problems in textbook and in teaching were added together, and then the sum was divided by the total number of sub-items (i.e.,[Q19a+Q19b+Q19c+ Q19d+Q19e]/5).

These resulting average frequency ratings of high-level problems and questions in textbooks and those of high-level problems and questions in teaching were utilized for the analysis of transformation patterns.

Transformation Patterns in Terms of Cognitive Demands

Transformation Patterns in Terms of Cognitive Demand of Problems

Figure 4.6 shows a scatterplot displaying the relation between the cognitive demand of fraction problems presented in textbook and the cognitive demand of fraction problems used by teachers in teaching. If we assume that teachers' reports about the level of problems in the textbooks are predictive of the textbook problems they are using, the associations shown in the scatterplot in Figure 4.6 are an indication of differences in teachers' responses about the frequency of high-level textbook problems and those about the corresponding high-level problems used in teaching.

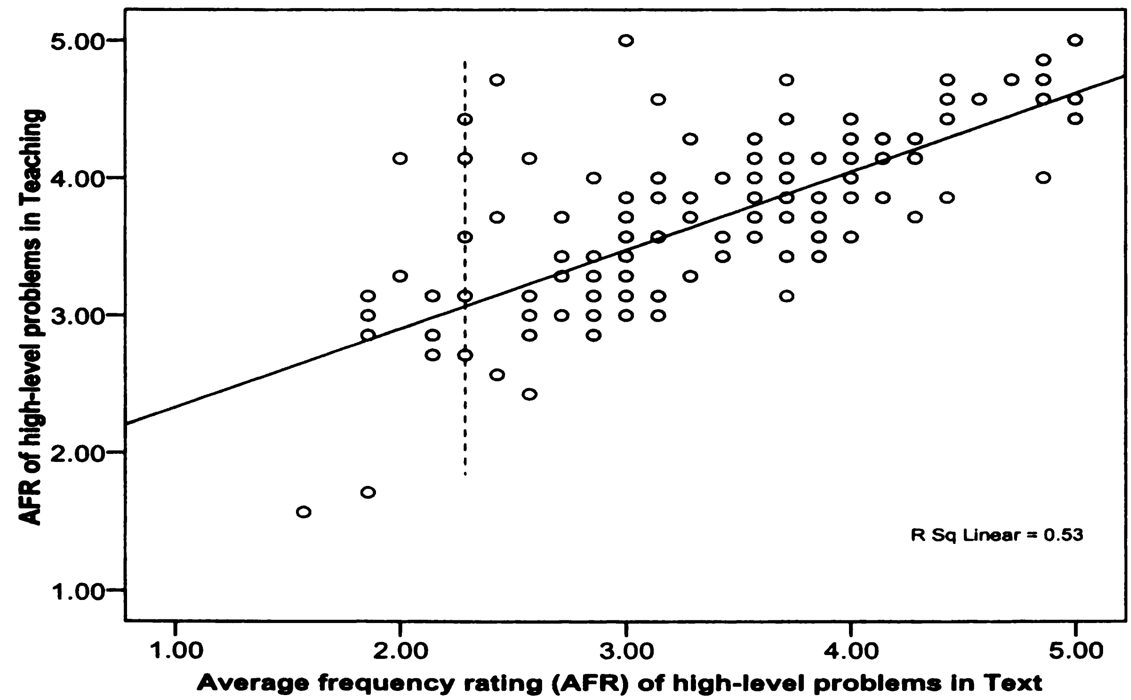


Figure 4.6 Scatterplot of Teachers' Responses about the Average Frequency of High-level Problems

In Figure 4.6, we notice that, in general, as the value of the average frequency rating of high-level problems presented in textbook increases, so does the value of the average frequency rating of high-level problems used by teachers in teaching. This scatterplot clearly indicates that, per individual teacher, there is a positive association between the frequency of high-level problems presented in *textbooks* and the frequency of high-level problems used by teachers in *teaching*. This also suggests that there is a tendency for low frequencies of the presence of high-level problems in textbooks to be associated with low frequencies of the presence of high-level problems in teaching.

To find the line that best represents the relationship between the frequency rating of high-level problems in textbooks and that in teaching, correlation and regression were used. The best-fit line shown in the scatterplot summarizes the linear relationship between the presence of high-level problems in textbooks and that in teaching. The strength of this relation, $r^2 \approx 0.53$, indicates that according to teachers' reports, about 53 percent of the variance in the use of high-level problems in teaching was accounted for by the frequency of high-level problems in textbooks.

This positive relationship shows two different transformation patterns. One pattern is what I will refer to as an H-H pattern. This pattern occurs when, teachers have textbooks that provide higher level problems, and they use the higher level problems in their teaching. The other pattern is what I will refer to as an L-L pattern in which teachers have textbooks that demand lower level cognitive demand problems and they use problems in teaching that demand lower level of student thinking.

Other possible patterns exist in addition to these two patterns, since there are variations around the linear relationship. For example, teachers represented on the dashed vertical line shown in the scatterplot above, agreed on the frequency of high-level problems in their textbooks, whereas none of them indicated the same frequency of high-level problems used by them in teaching. Notice that there is much variation in the frequency of high-level problems used by these teachers in teaching, ranging from approximately 2.5 to 4.5. These variations show that other transformation patterns exist as well.

To explore the transformation patterns in terms of the cognitive demand of problems, the frequency rating scale 3 out of a 5-point Likert scale (2-3 times a unit) was selected based on previous studies (e.g., Sanders, 1966; Kadijević, 2002; Martin, Mullis, & Chrostowski, 2004) so that the cognitive demand of textbook problems and the cognitive demand of problems used in teaching were categorized into requiring either higher level or lower level. For example, Sanders (1966) articulated that teachers in both instruction and evaluation should devote "a minimum of one-third" of the time allotted to higher level cognitive demand above in both instruction and evaluation (p. 156). Since one unit in a textbook ranges typically from a minimum of 4 lessons to a maximum of 10 lessons, a scale of 3 (2-3 times a unit) was considered to adequately correspond to the suggested ratio of one-third of the time allotted.

Using a scale point of 3 as an average frequency rating on both axes, I divided the scatterplot into 4 quadrants representing the four possible transformation patterns, H-H, H-L, L-H, and L-L. For example, if an average frequency rating of high-level problems presented in textbooks was greater than or equal to 3, textbooks were considered as requiring higher level cognitive demand of student thinking. Otherwise, the textbooks were categorized as providing lower level cognitive demand. For the cognitive demand of problems used by teachers in teaching, the same procedure was employed.

Figure 4.7 illustrates the resulting transformation patterns in terms of the cognitive demand of problems.

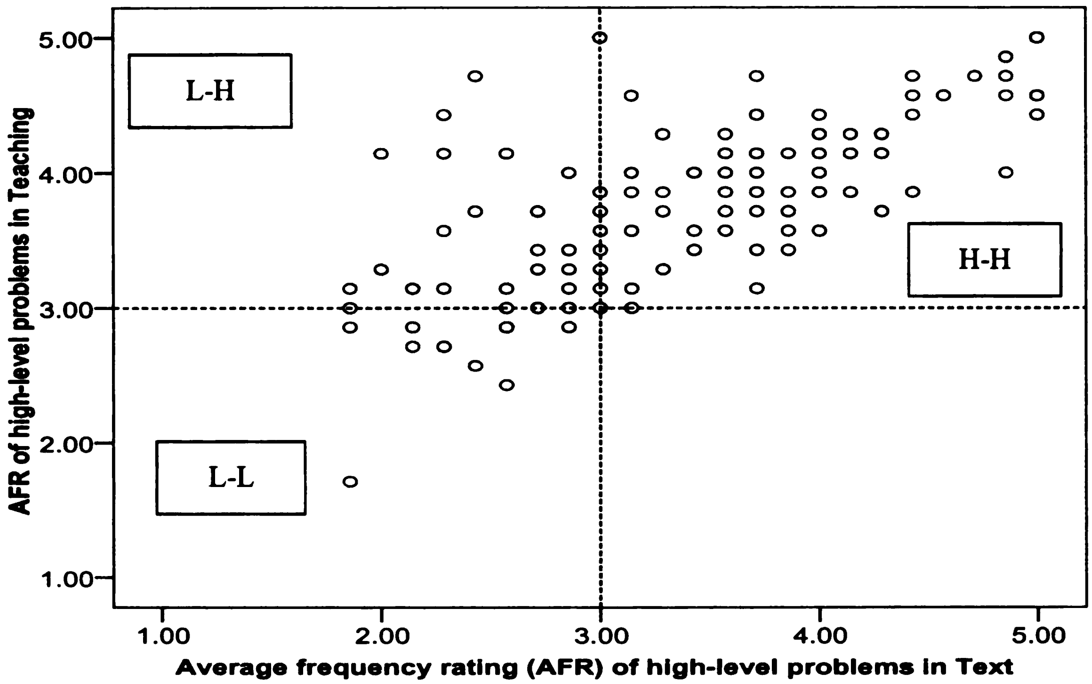


Figure 4. 7 Scatterplot Illustrating the Process of the Categorization of Transformation Patterns in Terms of the Cognitive Demand of Problems

Three transformation patterns were identified in the data in terms of the cognitive demand of problems: (1) L-L, (2) L-H, and (3) H-H. One pattern, H-L, was not represented by any individual teacher in this study. Within the L-L pattern, since teachers' average frequency rating of high-level problems is lower than 3, the cognitive demand of problems both in textbooks and in teaching was categorized as lower level. In H-H, since teachers' average frequency rating of high-level problems is greater than or equal to 3, the cognitive demand of problems both in textbooks and in teaching were categorized as higher level. In the L-H pattern, teachers' responses about the cognitive demand of problems in their textbooks were categorized as lower level and those about the cognitive demand o

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demand of problems in teaching were as higher level. Table 4.4 shows a frequency distribution of the transformation patterns.

Table 4.4 *Frequency Distribution of the Transformation Patterns of Problems*

Pattern	Cognitive Demand of Problems in Textbook	Cognitive Demand of Problems in Teaching	Frequency (n=169)	Percent (100%)
1	Low	Low	12	8
2	Low	High	32 (4)	18
3	High	Low	0	0
4	High	High	125 (7)	74

Note: The number in ( ) represents the numbers of teachers who had 3 as average composite score in each pattern

These frequencies reveal interesting trends. First, a relatively large percentage of teachers (74%, 125 out of 169) were categorized as having textbooks that require higher level of student thinking. Second, there are different transformation trends between teachers categorized as having textbook problems that require lower level cognitive demand and those categorized as having textbook problems with higher level cognitive demand. According to teachers' self-reports, when teachers have textbook problems that require a lower level of student thinking, 30% teachers (13 out of 44) were categorized as maintaining its cognitive demand level (L-L pattern), whereas 70% of the teachers (31 out of 44) were categorized as increasing the cognitive demand of problems in teaching (L-H pattern).

Interestingly, all teachers categorized as having textbooks that require higher level cognitive demand were categorized as using problems that require higher level cognitive demand of student thinking. These results revealed that when teachers perceived their textbook problems as requiring higher level of student thinking, these teachers reported that they at least maintained the same level of cognitive demand in teaching. Although there exists the possibility of the effect of various other factors on this (e.g., student needs, lack of supplementary materials, curricular mandates, etc.), these findings suggest that teachers in this study reported that they either maintained or increased the cognitive demand of problems presented in textbook when they used problems in their teaching. This implies that the cognitive demand of textbook problems plays an important role in maintaining the cognitive demand of problems in teaching.

Transformation Patterns in Terms of Cognitive Demand of Questions

Teachers' average frequency ratings of high-level questions in textbooks and those of high-level questions in teaching were obtained from responses to Question 19. Figure 4.8 shows the resulting scatterplot that displays the association between the variables. Again, if we assume that teachers' reports about the level of teacher questions in the textbooks are predictive of the textbook questions they are using, the associations shown in the scatterplot in Figure 4.8 are an indication of differences in teachers' responses about the frequency of high-level textbook questions and those about the corresponding high-level questions used in teaching.

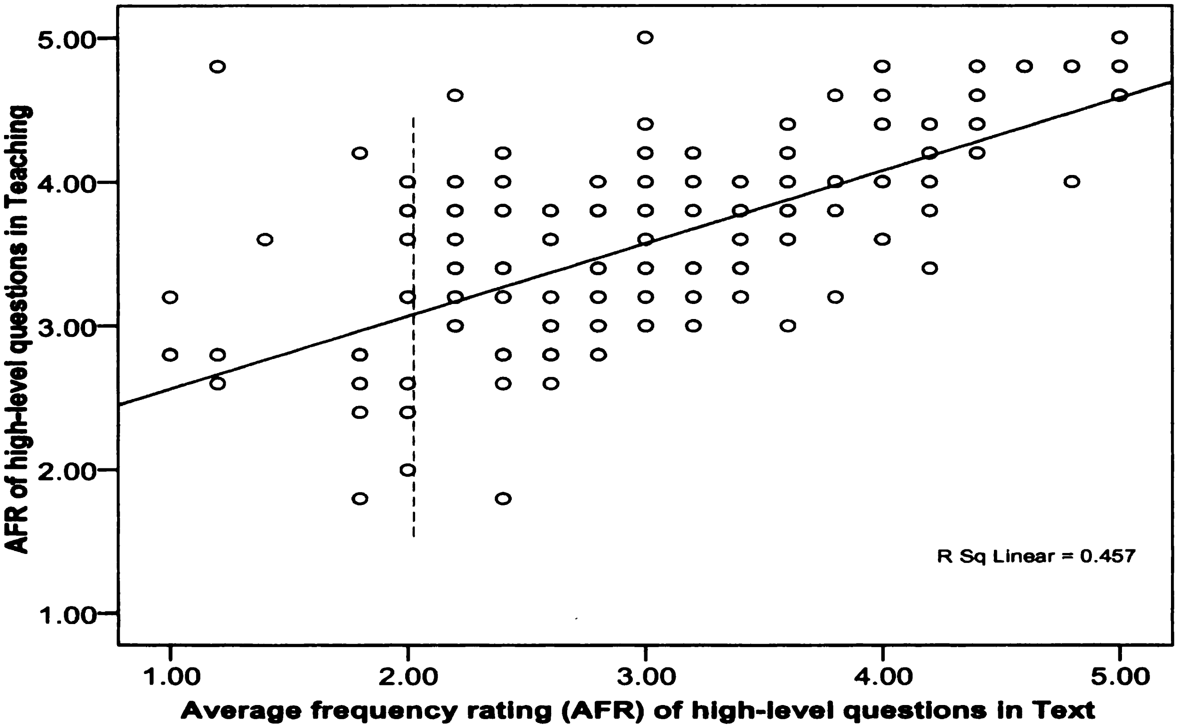


Figure 4. 8 Scatterplot Illustrating Teachers' Average Frequency Rating (AFR) of High-level Teacher Questions in Textbooks against Teachers' AFR of High-level Teacher Questions in Teaching

This scatterplot indicates that, in general, as the value of the average frequency rating of the presence of high-level teacher questions in textbooks increases, so does the value of the average frequency rating of the use of high-level teacher questions in teaching.

The best-fit line shown in the scatterplot summarizes the linear relationship between the presence of high-level teacher questions in textbooks and the use of high-level teacher questions in teaching. The strength of this relation, $r^2 = 0.457$, indicates that, according to teachers' reports, about 46 percent of the variance in the use of high-level teacher questions in teaching was accounted for by the presence of high-level teacher questions in textbooks. This positive relationship indicates that there are two prominent transformation patterns in terms of the cognitive demand of questions. One pattern is the H-H, where teachers have textbook questions that require higher level of student thinking and they use questions that also require higher level of student thinking. The other pattern is the L-L pattern, in which teachers have textbook questions that require lower level of student thinking and they, in turn, use questions in teaching that require lower level of student thinking.

In addition to these two patterns, other patterns exist since there are variations around the linear relationship, as the dashed vertical line shown in Figure 4.8 illustrates. Teachers represented on that line agreed on the presence of high-level teacher questions in their textbooks. However, none of these teachers reported the use of high-level teacher questions in their teaching at the same level. This suggests that, although these teachers agreed on the same level of cognitive demand in textbook questions, they responded differently about the cognitive demand of questions they used in teaching. These variations show that other transformation patterns exist as well.

The same criteria (the rating scale of 3) and the same procedures were used to determine the cognitive demand of teacher questions in textbooks and that of teacher questions in teaching. Based on a rating scale of 3, teachers' average frequency rating of high-level teacher questions in textbooks and that in teaching were categorized into either requiring higher level or lower level cognitive demand. Figure 4.9 shows the resulting categories of the transformation patterns in terms of the cognitive demand of teacher questions.

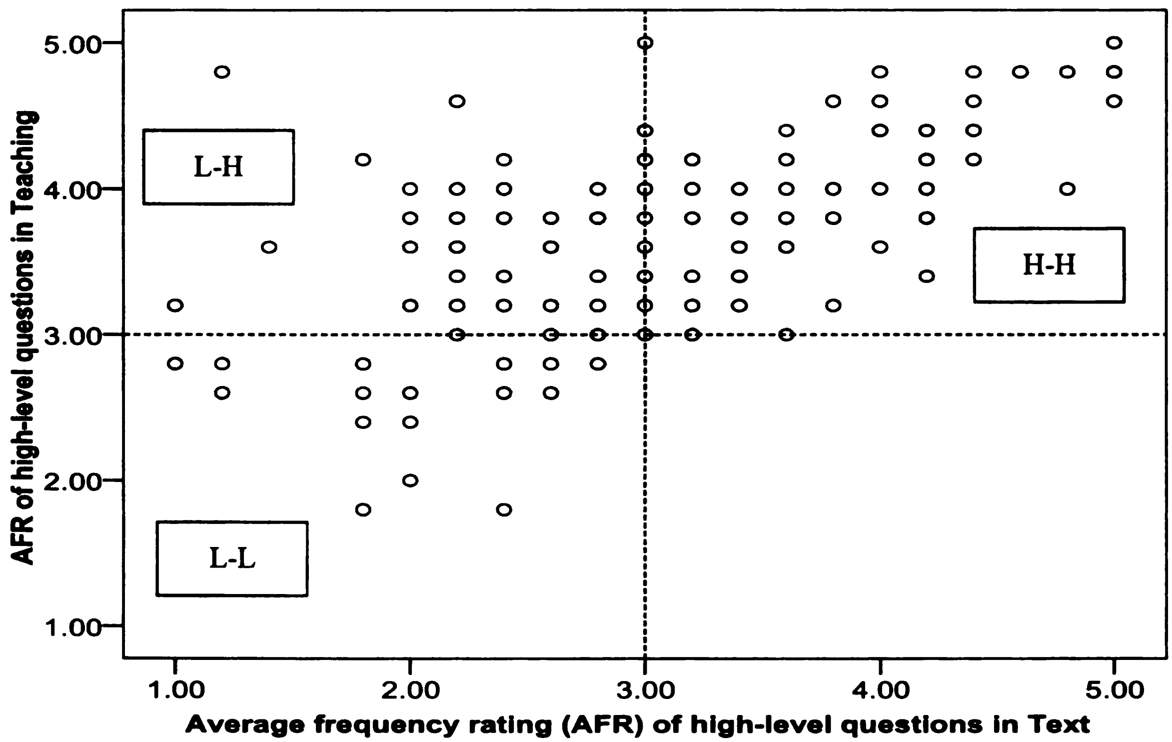


Figure 4.9 Scatterplot Illustrating the Categorization of the Transformation Patterns in Terms of the Cognitive Demand of Questions in Textbooks and in Teaching

The same types of transformation patterns as in the cognitive demand of problems were also identified in terms of the cognitive demand of teacher questions: (1) the L-L pattern, (2) the L-H pattern, and (3) the H-H pattern. The H-L pattern was once again empty. Table 4.5 shows the frequency distribution of each transformation pattern in terms of cognitive demand of teacher questions from textbook to teaching.

Table 4.5 *Frequency Distribution of Ttransformation Pattern of Teacher Questions*

Cognitive Demand of Questions in Textbook	Cognitive Demand of Questions in Teaching	Frequency (n=169)	Percent (100%)
Low	Low	27	15
Low	High	43	26
High	Low	0	0
High	High	99	59

Similar to the findings in transformation phase 1, more than half of teachers (59%, 99 out of 169) were categorized as having textbook questions that require higher level of student thinking. In addition, these teachers reported using teacher questions in their teaching that demand higher level of student thinking. These results revealed that when teachers reported the cognitive demand of teacher questions in textbooks as higher level, they declared that they at least maintained their cognitive demand in teaching (notice that the H-L quadrant is empty).

Interestingly, when teachers perceived their textbook questions as demanding lower level of student thinking, more than half (63%, 44 out of 70 teachers) reported that they increased the cognitive demand of teacher questions in teaching. Taken together with the findings in phase 1, this finding suggests that the cognitive demand of textbook problems and questions associates with the cognitive demand of problems and questions used by teachers in teaching.

Transformation Patterns between Problems and Questions in Teaching

This section presents the results of transformation patterns in phase 3, the relationship between the cognitive demand of fraction problems in teaching and the cognitive demand of teacher questions in teaching (see Figure 4.1). Results of responses to survey item 18, measuring the frequency of high-level problems in teaching and survey item 19, measuring the frequency of high-level questions in teaching were analyzed. Figure 4.10 shows the resulting scatterplot.

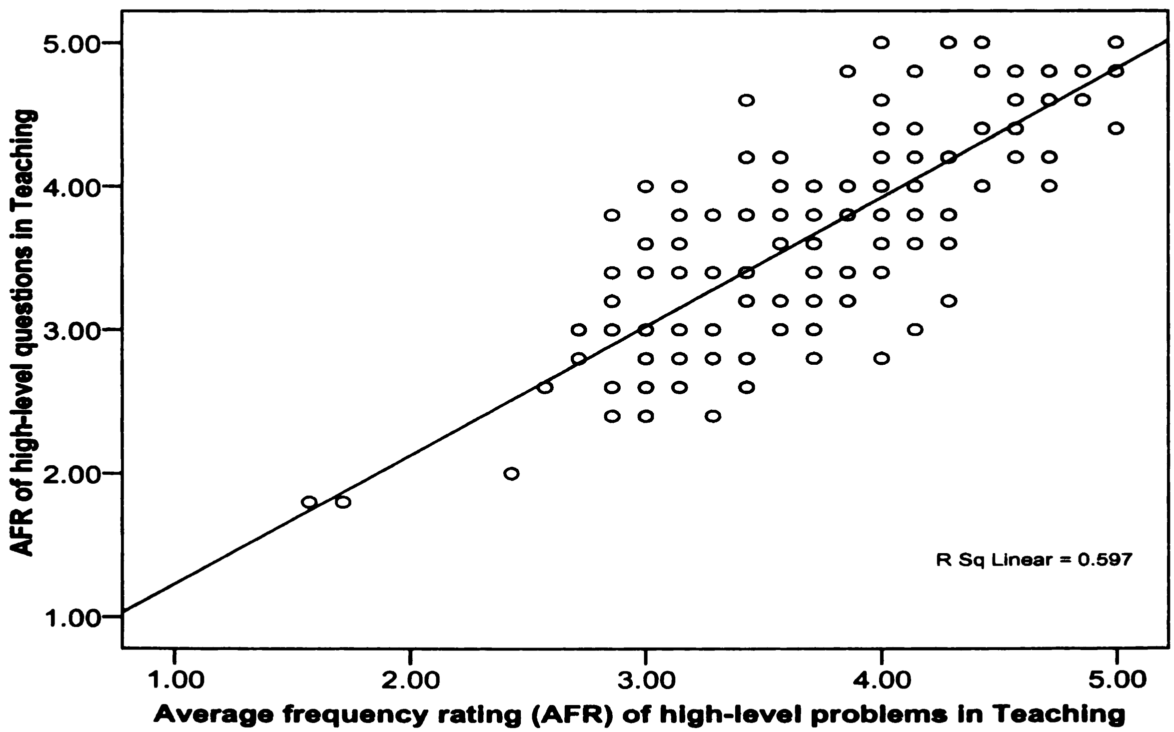


Figure 4.10 Scatterplot of Teachers' Responses about the Average Frequency of High-level Problems in Teaching against the Average Frequency of High-level Questions in Teaching

It is noticeable that the distribution is negatively skewed, indicating that most teachers reported using high-level problems frequently in their teaching, as well as high-level questions in teaching.

In addition, Figure 4.10 shows that as the value of the frequency rating of high-level problems in teaching increases, so does the value of the frequency rating of high-level questions in teaching. It indicates that, for an individual teacher, there is a positive association between the frequency of high-level problems used in teaching and the frequency of high-level teacher questions used in teaching. This also suggests that there is a tendency for low frequencies of high-level problems used in teaching to be associated with low frequencies of high-level teacher questions in teaching. These relationships suggest two prominent transformation patterns. One pattern is the H-H pattern in which teachers' responses on the cognitive demand of problems in teaching and those of teacher questions in teaching are both categorized as requiring higher level of student thinking. Also present is the L-L pattern, requiring lower level cognitive demand problems in teaching, and lower level cognitive demand questions in teaching.

The best-fit line shown in the scatterplot summarizes the strength of the linear relationship, $r^2 = 0.597$, between the frequency of high-level problems and the frequency of high-level teacher questions in teaching. This relationship is the strongest among the three transformations (notice that the strengths of the linear relationship in phase 1 and phase 2 are 0.53 and 0.456 respectively). This might be expected, since both variables in Transformation 3 were involved in teaching. However, there are also variations around the linear relationship, indicating that other transformation patterns exist.

To examine the possible transformation patterns, the average frequency ratings of problems and teacher questions in teaching were categorized into either higher level cognitive demand or lower level, using a scale point of 3 as the boundary between the two categories. Figure 4.11 shows the result of the categorization.

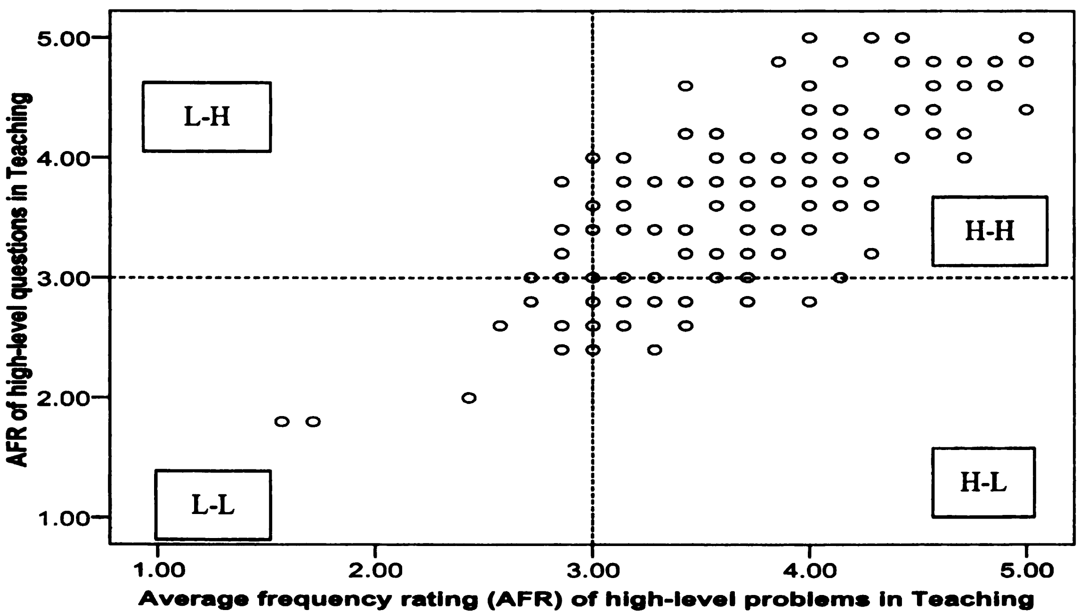


Figure 4.11 Scatterplot Illustrating the Categorization of the Transformation Patterns in Terms of the Cognitive Demand from Problems to Teacher Questions in Teaching

Four transformation patterns were identified from the figure. In addition to the H-H, the L-L, and the L-H patterns, the H-L pattern, which did not appear in transformation phase

1 and 2, was exhibited in this transformation that presents the relationship between the cognitive demand of fraction problems in teaching and the cognitive demand of teacher questions in teaching. Using average frequency ratings in the H-L pattern, teachers' responses regarding the cognitive demand of the problems used in teaching were categorized as requiring higher level of student thinking, and those describing the cognitive demand of the questions used in teaching were categorized as requiring lower level of student thinking. In the L-H pattern, teachers' responses about the cognitive demand of problems in teaching were classified as lower level cognitive demand, but the cognitive demand of teacher questions in teaching were categorized as demanding higher level of student thinking. Table 4.6 shows the frequency of each transformation pattern.

Table 4. 6 *Frequency Distribution of Transformation Patterns in Phase 3*

Pattern	Cognitive demand of problems in teaching	Cognitive demand of questions in teaching	Frequency (Total=169)	Percent (100%)
1	Low	Low	7	4
2	Low	High	6 (2)	4
3	High	Low	19 (2)	11
4	High	High	137 (5)	81

Note: the number in ( ) represents the numbers of teachers who had 3 as average composite score in each pattern

All four possible patterns occur (L-L, L-H, H-L, and, H-H), with H-H being the most prevalent. The H-L pattern and the L-H pattern suggest that the cognitive demand of problems can be fundamentally changed by the cognitive demand of questions teachers use. This finding indicates that it is necessary to explore the factors that influence teachers; discussion to change the cognitive demand of questions.

Validation from Lesson Plan Modification

This section presents the findings from the analyses of teachers' lesson plan modifications to the survey presented in Question 20. In this item, teachers are provided a lesson planning scenario for teaching the concept of equivalent fractions to 4th graders, and they were asked to describe the modification(s) they would make to the lesson components—student objectives, classroom activities, problems, and questions—all of which were lower level in the original plan, itself categorized as lower level overall. The daily lesson plan utilized in survey item 20 appears in Appendix A.

This analysis was conducted to validate one common transformation pattern, the L-H pattern, in which teachers who have textbook problems and questions that require lower level of student thinking, increase their cognitive level to higher level when they use problems or questions in their teaching. This pattern appeared consistently in the analyses of transformation patterns in the three phases. However, this finding is rather inconsistent with the findings from previous studies. For example, Kennedy (2005) reported that teachers decreased the cognitive demand of textbooks by modifying difficult problems into easy ones. While little is known, in general, about how teachers use textbooks (Ball, 2000), still less research exists that examines how teachers use textbooks that provide lower level of problems and questions, which is still prevalent.

In addition, as described earlier, transformation patterns from textbook to teaching were identified from survey data—which relies on teachers' self-reports. One limitation of self-report for this study is the potential for teachers to provide biased responses to the survey because they feel that they should respond to the questions in "acceptable" or "socially desirable" ways; or teachers might unknowingly provide misleading responses to the survey questions. For these reasons, to validate this finding and to know more about what and how teachers modify the lower level problems and teacher questions in a lesson plan, survey question 20 was used.

Among 169 survey participants, 51 teachers (30%) answered that either they would use the lesson plan exactly as it is. The rest, 118 teachers (70%), responded that they would modify the lesson plan. These 118 teachers' modification(s) of the original lesson plan were explored with the following three questions: (1) How many teachers provided their modification(s) in a way that survey item 20 required, such as including student objectives, classroom activities, problems, and question? (2) What did teachers actually modify from the daily lesson plan with regards student objectives, classroom activities, problems, and questions? (3) Did teachers increase the cognitive demand of the given lesson with respect to problems and questions and how did they do so?

How Many Components Teachers Provided in Their Lesson Plan

Before exploring transformation patterns in teachers' lesson plan modifications, the lesson components--student objectives, classroom activities, problems, and questions—were defined based on previous studies. (1) In this study, a student objective refers to a statement describing what students should learn or be able to do as a result of student engagement in classroom activities, problems, or teacher questions. Some teachers stated student objectives explicitly and other teachers did it implicitly. For example, only five teachers out of 118 teachers clearly labeled student objectives in their modification. The rest of the teachers stated them within classroom activities, problems, or teacher questions. As a clue for identifying student objectives stated implicitly, "to" was used. Some examples of student objectives stated implicitly are: "To find the discovery on their own," "To understand the concept of equivalent fractions," etc.

(2) In this study, a classroom activity refers to a request that students use physical objects, or to participate in games related to the lesson. As a cue for identifying classroom activities, a statement requiring students to do something physically was used. For example, in a following statement--"Have students use manipulatives," "use manipulatives" indicates a classroom activity.

(3) In this study, a problem is defined to be a mathematical situation or object for

the students to solve or figure out. For example, in the statement below, "to find the fraction cards equivalent to ½" is a mathematical object for students to figure out.

> "I would first have them find ½ then they would look through the rest of their cards to find ones that matched up exactly with ½"

(4) In this study, a question is a statement indicated by the verb "to ask". Unlike the cases of student objectives, teacher questions stated implicitly were not counted. For example, in the statement above, "have them find ½" could involve using questions. However, the statement could also involve showing students how to find ½; and because of this ambiguity, such statements were not counted as a "question".

The analysis revealed that among 118 teachers who answered that they would modify the lesson, 10 teachers (9%) included the four components in their lesson modification; 17 (14%) teachers included three components; 37 (31%) included two components; 21 (18%) included only one component. A relatively large proportion of teachers (33 out of 118, 28%) indicated that they would modify the given lesson in survey item 20, but did not provide any modification.

Among the four components, teachers attempted to modify (or supplement) the classroom activities most often (76 teachers out of 118), followed by problems (56 teachers), student objectives (43 teachers), and then teacher questions (15 teachers).

What Teachers Modified in Each Component

Table 4.7 presents categories of teachers' modifications in student objectives, classroom activities, problems and questions and the frequencies of each category.

Table 4.7 *Category and Frequency of Each Component in Teachers' Lesson Plan Modifications*

Components	Category	Examples	*N of Teachers
Student objectives	• Set up content-specific student objectives	Understand the concept of equivalent fractions	35
	• Set up non-content-specific student objectives	My students need to be an active part of the activity	8
Problems	• Add or supplement additional problems	Have students draw pictures of different equivalent fractions	36
	• Modify the given problems to make them easier for students	I would change the denominators to 261 when first introducing this concept	2
	• Add the real world situation problems	Attempt to make the fractional work more "real" putting it into a story problem format	12
	• Select and use some of problems in a given lesson	I may still use some of the sample problems to have them build and solve.	5
Activity	• Add concrete materials or hands-on activities	I would give the students an opportunity to use manipulatives when first solving the problems.	76
	• Use group works or games	I would add on a mathematical game to reinforce ideas taught	8
Questions	• Use different questioning	I would also include a writing portion under each segment of slightly different questions having students explain how they know their answer is correct or why it is.	7
Others	• Modify pacing	Divide the given one lesson into several lessons	7
	• Change teaching approach (teacher-centered to student-centered)	Have students explore or discover the relationship between two fractions and find the patterns on their own	13

Note: N of teachers in each category is out of 118 teachers who described their modification.

How Teachers Increased the Cognitive Demand of the Lesson

Table 4.7 shows that 35 teachers set up different student objectives from the daily lesson, 36 teachers added additional problems, 76 teachers included hands-on activities or manipulatives for classroom activities, and 7 teachers planned to use different questioning. These teachers' modification(s) were explored to determine whether and how teachers maintained or increased the cognitive level of the given lesson. To do so, the framework that describes teachers' modification associated with maintenance or change in the level of cognitive demand of each component was developed based on the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001) and Stein and Smith (2000). Although the factors increasing or decreasing cognitive demands for all four components were developed, student objectives were not used to determine the change of the cognitive demand level in a lesson plan. This is because student objectives differ from the rest of the components in a lesson plan in that student objectives present one's goals for student learning, whereas the rest of the components are means selected by teachers to achieve these goals. Table 4.8 presents the framework that illustrates teachers' modifications in each component of a lesson plan, which is associated with maintenance or change in the cognitive demand.

Table 4. 8 *Framework for Categorizing Teachers' Modifications in Terms of Cognitive Demands*

Criteria	Modifications associated with the decrease of low-level (1)	Neither or hard to tell (2)	Modifications associated with the increase of high-level (3)
Student objectives (Bloom's Taxonomy, 2001)	• Describe student objective (or rationale) that emphasizes remembering and knowing procedures.	• Describe rationale for modification or student objectives in terms of relevance of diverse learners (i.e. needs of hands-on or real-life connection). • Describe student objectives that focuses on only increasing students' interest in mathematics or that know concepts.	• Describe student objective (or rationale) that emphasizes application, reasoning, and evaluate the meaning, concepts or algorithm.
Activity & Problems (Stein & Smith, 2000)	• Add activities and problems that either specifically called for or use of the procedures that do not require students to make connections to the concepts or meanings that underlie the procedure being used. • Add activities or problems that require students to involve exact reproduction of previously seen material.	• Add activities that require students to use manipulatives/hands-on activities/game or group work but do not describe its purpose or its purpose is unclearly written or describe its purpose as enhancing student interactions/motivation. • Add activity/problem/example but do not describe clearly how teachers would use them. • Mention that they would add activities and problems that build on students' prior knowledge but do not describe actual activities and problems for that purpose. • Modify the given problem context into a real life situation. • Add activities and problems that build on students' prior knowledge.	• Add activities that ask students to find relationship or patterns between equivalent factions. • Add activities and problems that require students to use various representations of equivalent fractions (i.e., drawing pictures to find or display all equal fractions to a given fraction). • Add activities and problems that emphasize relationships between equivalent fractions or patterns among equivalent fractions. • Add activities and problems involving communication with peers and teachers.

Table 4.8 (Continued)

Questions (Stein & Smith, 2000)	• Plan to use questions that require students to involve reproducing previously learned facts, rules, formula, or definitions. • Plan to use questions that focus on producing correct answers rather than requiring students to give explanations, or allow explanations that focus solely on describing the procedure that was used.	• Do not mention how they would use questions in the given lesson.	• Plan to use questions that require students to explain their reasoning when giving answers. • Plan to use questions that ask students explain their understanding about equivalent fractions to one another

With this framework, each individual teacher's modification in classroom activities, problems and questions was classified in three categories—(1) Lower level, (2) Higher level and (3) Hard to tell. In determining the cognitive demand level of each individual teacher's modification, the category of "hard to tell" was collapsed into the other two categories. For example, if a teacher's modifications in some components were categorized as "hard to tell" and those in other components were categorized as lower level, this teacher's modifications were categorized as "decrease the level of cognitive demand of the lesson." On the contrary, if a teacher's modifications in some components were categorized into "hard to tell" and those in other components were categorized as higher level, the overall modifications were then categorized as "increase the level of cognitive demand of the lesson". None of the teachers were categorized as both lower level and higher level.

Table 4.9 presents the frequencies of teachers who were identified as increasing the cognitive level of the given lesson plan and those identified as maintaining or decreasing to a lower level.

Table 4. 9 *Frequencies of Transformation Patterns in Teachers' Lesson Plan Modifications*

	Transformation patterns		N of teachers
	The daily lesson plan	Modified lesson plan	
Decrease the cognitive demand	L	L	13 (11%)
Increase the cognitive demand	L	H	19 (16%)
Hard to tell	L	Hard to tell	86 (73%)

A large proportion of teachers were classified in the category "hard to tell." However, consistent with the findings from teachers' self-reports, these results indicate that some teachers maintained the lower cognitive levels of the given textbook lesson, whereas other teachers increased the lower cognitive demand level toward a higher level. These findings validate the trends from teachers' self-reports that, when teachers have textbook problems and questions that require lower level of student thinking, some teachers tend to increase their level, at least in their planning.

After this analysis was completed, I further explored to what extent teachers' responses in question 20 (see table 4.9) were consistent with those in survey questions 18 and 19. In particular, since a large number of teachers were categorized as the "Hard to tell" in question 20, I compared teachers' responses across these three different survey questions and explored whether and their responses were similar in light of the cognitive demand.

Among 169 survey participants, 51 teachers answered that they would use the lower level problems and questions presented in the lesson plan exactly as it is. Among 118 teachers who attempted to modify the lesson plan, 13 teachers were categorized as maintaining or decreasing the given lesson plan (see Table 4.9). Therefore, the total number of teachers decreasing the given lesson plan are 64 teachers. Table 4.10 presents the frequency of teachers categorized into three different categories by lesson plan modification.

Table 4. 10 *Frequency (Percentage) of Different Transformation Patterns Exhibited in Questions 18 and 19 by Types of Lesson Modification*

	Pattern	Type of Lesson modification Decrease the cognitive demand (L-L)	Increased the cognitive demand (L-H)	Hard to tell	Frequency (%)
Q18: Problems	H-H	39 (30%)	14 (11%)	72 (58%)	125 (100%)
	L-H	12 (38%)	3 (6%)	17 (53%)	32 (100%)
	L-L	3 (25%)	2 (17%)	7 (58%)	12 (100%)
Q19: Questions	H-H	28 (28%)	13 (13%)	58 (59%)	99 (100%)
	L-H	14 (33%)	3 (7%)	26 (60%)	43 (100%)
	L-L	12 (41%)	3 (11%)	12 (48%)	27 (100%)
		64 (13+51)	19	86	169

A large number of teachers categorized by questions 18 and 19 as increasing the cognitive demand (i.e., H-H & L-H) were classified as "Hard to tell" in lesson plan modification; some of them were even classified as decreasing the cognitive demand in lesson plan modification. In contrast, some teachers categorized by questions 18 and 19 as decreasing the cognitive level (i.e., L-L) were found to be increasing the cognitive demand in lesson plan modification.

Using teachers' lesson plan modification, this study attempted to minimize issues of accuracy of self-reports. Although only a small number of teachers were categorized as increasing the cognitive demand of the lesson, these results validate the existence of the L-H pattern. However, a large number of teachers, in particular, ones identified as increasing the cognitive demands, were categorized as "Hard to tell".

One possibility is methodological limitation. Participants were asked to respond to 25 survey items in a limited time. The number of items and time might act as constraints for teachers to respond to the survey. In a situation where teachers were asked to describe their modification in detail as in question 20, teachers are likely to provide a brief lesson plan, and therefore their modification can easily be categorized as "Hard to tell."

Another possibility is that teachers might unknowingly provide misleading responses to the survey questions. Research suggests that teachers sometimes truly believe they are embracing pedagogical reforms, but in pratice, their teaching is a mixture of the vision of traditional methods and reformers (Cohen, 1990). As table 4.7 shows, a large number of teachers modified the lesson by adding the use of manipulatives/hands-on activities or real-world problems. However, these modifications do not mean that teachers increase the cognitive demands of the given lesson. Without more information about how teachers use these manipulatives or real-world problems in their lesson plan modification, and/or without observing their actual lesson, it is hard to decide whether they would increase the cognitive demands of the lesson. Through the lesson plan modification I attempted to provide more accurate results, but these methodological limitations provide the necessity of the case studies.

Summary

This chapter presents the findings from the survey that examined transformation patterns when teachers moved content from text to teaching in terms of cognitive demands. Transformation patterns were explored in two ways using a survey: (1) teachers' self-reports and (2) teachers' lesson plan modifications.

First, transformation patterns were explored by looking at the relationship between the presence of high-level problems and teacher questions in their textbooks and the presence of high-level problems and teacher questions in teaching. In survey item 18 (and item 19), teachers were asked to indicate on a five-point Likert scale the frequency of the various types of problems (and teacher questions) in textbooks and then in their teaching. Using a scale of 3 out of 5 Likert scale, teachers' responses about the frequency of problems in textbooks and in teaching were classified into either lower level or higher level. For example, if a teacher's average frequency rating of problems in textbooks is greater than or equal to 3, textbook problems is classified as requiring higher level cognitive demand. Otherwise, it is classified as requiring lower level. Transformation patterns from textbook to teaching were analyzed in three phases: (1) problems to problems, (2) questions to questions, and (3) problems in teaching to teacher questions in teaching.

Three transformation patterns from textbook to teaching were exhibited in terms of the cognitive demand of problems and teacher questions (i.e., L-L, L-H, & H-H). Four transformation patterns appeared between the cognitive demand of problems in teaching and that of teacher questions in teaching (i.e., L-L, L-H, H-L, & H-H).

Next, to validate these findings from survey items 18 and 19, in particular the L-H pattern, whether and how teachers modify the lesson plan classified as lower level cognitive demand of student thinking. Two patterns appeared: L-L & L-H.

Three common findings emerged from teachers' self-reports and lesson plan modifications. First, teachers claimed to at least maintain the cognitive demand of textbook problems and questions in their teaching (i.e., L-L & H-H pattern). This finding resonates with those of previous studies (e.g., Remillard & Bryans, 2003; Drake & Sherien, 2002), suggesting that the cognitive demand of textbooks plays an important role in deciding the cognitive demand of problems and teacher questions used in teaching.

Another common finding was that when teachers perceived their textbook problems and questions as requiring lower level cognitive demand, some teachers tried to increase its cognitive demand in their teaching (i.e., L-H) whereas others maintained the lower level cognitive demand in teaching. This finding is inconsistent with the findings from previous studies (e.g., Cohen, 1990; Kennedy, 2005; Stigler & Hiebert, 2006). However, the analysis of teachers' lesson plan modifications validated L-H pattern.

Furthermore, the H-L pattern appeared in describing the relationship between the cognitive demand of problems in teaching and that of teacher questions in teaching. This pattern has been often reported from previous studies (e.g., Cohen, 1990; Kennedy, 2005; Henningsen & Stein, 1997; Stein et al., 1996; Stigler & Hiebert, 2006). Although teachers in this pattern reported using problems that required a higher level of student thinking, they eventually decreased the cognitive demand of the problems by using a lower level of teacher questions in teaching. This pattern urges us to examine influential factors on teachers' decision-making.

There are several aspects to consider. First, in contrast with the previous studies (e.g., Stigler & Hiebert, 2006), a large number of participants were categorized in the H-H pattern. In addition, none of teachers were categorized as the H-L pattern in describing the relationship between textbook problems and questions and problems and questions used by teachers in teaching. This discrepancy may be related to the use of the code of 3 as the cut off score in classifying the cognitive demand of problems and questions in textbook and in teaching into either higher level cognitive demand or lower level cognitive demand. Although this study chose this cut off score based on the previous studies (e.g., Sanders, 1966), perhaps the use of code of 3 as the cut off score might be too generous. We may see the H-L pattern and less teachers in H-H pattern if a code of 4 was used.

In addition, this study used high-level cognitive demand problems and questions in exploring textbook transformation patterns. What would happen if one compared teachers on their frequency of using the low-demand options in questions 18 and 19? This is an alternative way of asking the same research question that may avoid teachers' embracing of theoretically fashionable terms. However, due to the small number of survey items measuring the low-demand options, in particular, relatively low reliability, high-level cognitive demand problems and questions were used. Future research should explore transformation patterns using both high-and low-level problems and questions in survey in order to capture more accurate portrait of what teachers do in their classrooms and how they trasform their textbook in their classroom. In the next chapter, I describe factors associated with these different transformation patterns.

Chapter 5

RESULTS FROM THE SURVEY:

INFLUENTIAL FACTORS ON TRANSFORMATION PATTERNS IN TERMS OF COGNITIVE DEMANDS

Data reported in the previous chapter revealed three transformation patterns from textbook to teaching in terms of the cognitive demand of problems and questions, and four transformation patterns in terms of the cognitive demand between problems in teaching and teacher questions in teaching. This chapter presents the findings from the survey that examined which factors were associated with the various textbook transformation patterns exhibited. The research question I sought to answer was: What factors are associated with various textbook transformation patterns?--that is, I wondered what factors distinguish teachers exhibiting one transformation pattern from teachers in the other patterns in phase 1, phase 2, and phase 3?

This chapter is organized into four sections. The first section begins with preliminary information about the dependent variables and the independent variables. Descriptive statistics were utilized and interpreted to provide initial summary of teachers' responses on each sub-item of the independent variables. The second section briefly introduces a multinomial logistic regression used for the analysis and provides the rationale of why multinomial logistic regressions were used. The third section presents the findings from multinomial logistic regressions that illustrate the factors affecting on the distinction between transformation patterns exhibited in problem-problem text phase, question-question text phase, and problem-question enactment phase, respectively.

Preliminary Analysis of Dependent and Independent Variables

Dependent variables in this study are transformation patterns exhibited in each phase. For example, in the problem-problem text phase, teachers are categorized into three patterns—L-L pattern, L-H pattern, and H-H pattern. The dependent variables are comprised of these three groups of the transformation patterns. Table 5.1 presents the number of teachers categorized into each category of dependent variables.

Table 5. 1 *Descriptive Statistics of Dependent and Independent Variables Explored*

Transformation phases	Category of Dependent variables	N of Teachers (N = 169)
Problem-problem text phase	L-L pattern	12
	L-H pattern	32
	H-H pattern	125
Question-Question text phase	L-L pattern	27
	L-H pattern	43
	H-H pattern	99
Problem-Question enactment phase	L-L pattern	7
	L-H pattern	6
	H-L pattern	19
	H-H pattern	137

In order to examine the factors influencing group membership of transformation patterns, survey items measuring three levels of factors—contextual-level, individual-level, and teachers' opportunity-to-learn factors—were developed. Factor analyses were performed in order to examine whether various survey items really measure what they intend to measure. Teachers' responses for each variable were factor analyzed to determine which item should be discarded and which should be used to create summated scales. Table 5.2 presents the results. The survey is attached in Appendix A.

Table 5. 2 *Descriptive Statistics of the Independent Variables Explored in Factor Analysis*

Level	Factor Number	Name of Factors	N	Survey Item Number	Cronbach
Contextual	1	District Curriculum policy		9	
		Same textbooks across grade level	123		
		Other textbook Policy	46		
	2	Teacher perception of Student math achievement		8	
		Mostly high achieving	8		
		Other achievement level	161		
	3	District curriculum Framework		23	
		Alignment of district curriculum framework with NCTM	169		
	4	Teacher perception of State-wide Tests		23	
		Alignment of state-wide tests with NCTM	169		
	5	Type of textbook	158	12	
		Standards-based	103		
		Conventional	55		
Individual		Teacher Knowledge			
	6	Content Knowledge	169	21 a,b,c,d,e	0.85
	7	Pedagogical Knowledge	169	21 g,h,i,j,k	0.85
	8	Curriculum Knowledge	169	21 l,m,n, o	0.81
		Teacher beliefs about teaching			
	9	Constructivist approach	169	16 a,d,g,h,j	0.82
	10	Traditional approach	169	16, b,c, f,i	0.79
	11	Teacher View on Textbook	169	13 a,b,c,d,e	0.93
		Teacher Emphasis of Student Objectives			
	12	Understanding-oriented	169	22 b,c	0.76
	13	Procedural Fluency oriented	169	22 a,d	0.84
	14	Teacher Fidelity of Textbook		14 b,c,d,e	0.82
Teacher-Learning-Oppor.		Type of Content in PD			
	15	PD Content Knowledge	169	24 a,b,c,d,e	0.90
	16	PD Pedagogical Content Knowledge	168	24 g,h,i,j	0.84
	17	PD Curriculum Knowledge	169	24 l,m,n	0.78
		Type of pedagogy in PD			
	18	Presentation	169	25 a (-b)	0.57
	19	Observation	169	25 c, d	0.75
	20	Active Participation	169	25 e,f,g,h,i	0.76
	21	Total PD hour	157	25	

A total of 21 factors in Table 5.2 were utilized as independent variables in order to explore influential factors on the distinction between the transformation patterns. After factor analyses, a composite score and an average composite score were calculated. The composite score was created by simply adding individual item scores and the composite score was divided by the total number of survey items. This new score, *the average composite score*, was utilized in exploring the factors influencing transformation patterns. For example, for "teacher view on text", individual teacher's responses on survey item 13 (a, b, c, d, & e) were added together and then divided by 5. This new score was used in exploring influential factors on textbook transformation patterns. Descriptive statistics were utilized to provide initial summary of teachers' responses on each sub-item used to measure three levels of factors.

Descriptive Findings from the Contextual-Level Factors

Five factors were derived from previous studies on textbook at the contextual-level--(1) "District policy regarding the textbook series", (2) "Teacher perception of overall student mathematics achievement", (3) "Teacher perception of state curriculum framework", (4) "Teacher perception of state-wide tests", and (5) "Type of textbook" (see Appendix A for the description of each survey item).

In survey item 9, teachers were given five options for district policies regarding textbook use and were asked to indicate the one that applied them. In survey item 8, teachers were asked to indicate the mathematics achievement level of students in their classroom. Table 5.3 presents the resulting frequency distributions.

Table 5. 3 *Frequency of Different Textbook Policies and Student Math Achievement Level*

Factors	Sub-category	Frequency (n=169)
District textbook policy	a. Same textbook series in the building	123 (73%)
	b. Different series across grade level in the building	26 (15%)
	c. Own textbooks per schools	10 (6%)
	d. No policy	3 (2%)
	e. Different policy from those listed above	7 (4%)
Student achievement	a. Mostly high achieving	8 (5%)
	b. Mostly average achieving	98 (58%)
	c. Mostly low achieving	23 (14%)
	d. Students at a range of achievement level	40 (24%)

According to Remillard (2005), school districts increasingly regulate mathematics teaching practice by mandating the use of a single curriculum. The frequency of this policy shown in Table 5.1 corresponds to this trend.

In survey item 23, teachers were asked to indicate the degree of agreement or disagreement about state-wide tests and state curriculum framework. Table 5.4 presents the frequencies of agreement and disagreement on them.

Table 5. 4 *Frequency Rating of Agreement on State Curriculum Framework and Tests*

Factor		Agreement	Middle position on a 5 point scale	Disagreement
State curriculum framework	a. Obligation	161 (95%)	5 (3%)	3 (2%)
	b. Alignment with their beliefs	97 (57%)	49 (29%)	23 (14%)
	c. Alignment with NCTM ideas	111 (66%)	48 (28%)	10 (6%)
State-wide tests	d. Obligation	135 (80%)	29 (17%)	5 (3%)
	e. Alignment with their beliefs	37 (22%)	73 (43%)	59 (35%)
	f. Alignment with NCTM ideas	40 (24%)	96 (56%)	33 (20%)

There are common tendencies in teachers' perception of the state curriculum framework and the state-wide tests. First, a large percentage of the teachers agreed that they had an obligation to follow the district curriculum framework and to teach the content of state-wide tests (95% and 80%, respectively). However, a relatively lower percentage of teachers agreed that the district curriculum framework and state-wide tests were aligned with NCTM reform ideas (66% and 24%), and an even smaller percent of teachers reported that the district curriculum framework and state-wide tests matched with their beliefs about what is important in mathematics.

According to a body of research about the effect of tests, teachers gear their teaching methods and strategies to the type of performance elicited by standardized tests, particularly when the tests are the basis for important decisions about students or schools (Haney & Madaus, 1986; Darling-Hammond, 1990; Darling-Hammond & Wise, 1985; Goodlad, 1984; Bussis, 1982). Supporting this finding, the data suggests that although teachers think that state curriculum framework and state-wide tests mismatched with their beliefs of what is important in mathematics or with NCTM reform ideas, a large percentage of teachers feel an obligation towards implementing the state curriculum framework and teaching the content of state-wide tests.

In survey item 12, teachers were asked to list the title of textbooks students and teachers used in their class. For the analysis, these listed textbooks were classified into two types based on Stein and Kim's (In press) framework—(1) standards-based curriculum and (2) conventional curriculum.

Among 169 participants, 158 teachers (93% out of 169) listed the title of textbooks they were using. In total, 12 different textbooks were identified. Table 5.5 presents the frequencies of the textbooks listed by teachers in this study.

Table 5.5 *Frequency of Different Textbooks Used by Teachers*

Types of textbook	The title of textbooks	Frequency	Total (N=158)
Standards-based	Investigations in Number, Data & Space	53 (31%)	103 (65%)
	Connected Mathematics	11 (7%)	
	Everyday Mathematics	20 (12%)	
	Math Trailblazers	19 (11%)	
Conventional	Scott Foresman Addison-Wesley	22 (14%)	55 (35%)
	Health Math	5 (3%)	
	Harcourt	17 (11%)	
	Saxton	4 (3%)	
	Prentice Hall	4 (3%)	
	Silver, Burdett & Ginn	6 (4%)	
	Math to Know	1 (1%)	
	Think Math	1 (1%)	

Descriptive Findings from the Individual-Level Factors

Five variables derived from previous studies (e.g., Ball & Feiman-Nemser, 1988; Brophy, 1982; Cohen, 1990; Kauffman, 2002; Barr, 1988; Stodolsky, 1989; Schmidt, Porter, Floden, Freeman, & Schwille, 1987) were included at the individual-level: (1) "Teacher knowledge", (2) "Teacher beliefs about teaching approach", (3) "Teacher view on textbook", (4) "Teacher emphasis of student objectives", and (5) "Teacher fidelity to textbook".

In survey item 21, teachers were asked to rate on a five-point Likert scale various types of knowledge identified as important for teaching mathematics from the literature. Table 5.6 presents minimum values, maximum values, mean, and standard deviation of teachers' average rating about each type of teacher knowledge.

Table 5. 6 *Descriptive Statistics for Teacher Knowledge Variables*

Factors	Variables	Min.	Max.	M	SD
Content Knowledge	Whole numbers	3	5	4.38	.62
	Rational numbers	1	5	3.92	.84
	Geometry	2	5	3.96	.72
	Measurement	2	5	4.09	.78
	Data Analysis & Probability	2	5	3.76	.84
Pedagogical Content Knowledge	Knowledge of how students learn	2	5	4.07	.61
	Ways of teaching strategies	2	5	4.05	.65
	Ways of improving student basic skills	2	5	3.78	.70
	Ways of improving understanding	2	5	3.76	.67
	Ways of improving problem solving	2	5	3.81	.65
Curriculum Knowledge	Ways of using curriculum material	2	5	3.84	.72
	Ways of modifying difficult problem	2	5	3.94	.61
	Ways of modifying easy problem	2	5	3.82	.72
	Ways of developing high-order thinking	2	5	3.70	.69

Teachers in this study rated their knowledge on whole number the highest not only in content knowledge area but also across all three types of knowledge—content knowledge, pedagogical content knowledge, and curriculum. This suggests that teachers reported that they had stronger knowledge about whole number than any other types of content knowledge.

In addition, among the five content knowledge areas, teachers reported that they have relatively lower content knowledge on rational numbers than other areas. A minimum rate of 1 (*Very poor)* that appeared only in this area supports this finding. Six teachers out of 169 (4%) indicated that they had very poor or poor knowledge on rational numbers.

Furthermore, the means ratings suggest that among three types of knowledge—content knowledge, pedagogical content knowledge, and curriculum knowledge--curriculum knowledge was reported as the weakest one.

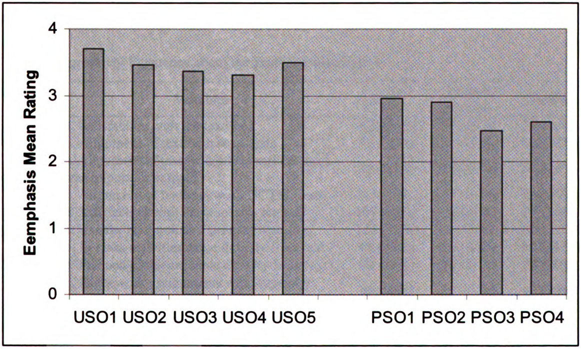
In survey item 22, teachers were asked to rate several pairs of statements about teaching philosophy or beliefs on a 4-point Likert-type scale in such a way as to indicate which statement between constructivist perspective and traditional transmission perspective came closer to their own point of view. Table 5.7 presents the frequency of teachers' agreement with contrasting statements of teaching philosophy.

Table 5. 7 *Teachers' Agreement with Contrasting Statements of Teaching Philosophy*

	Favored the more constructivist statement	Favored the more Traditional Position
Facilitator vs. Explainer	112(66%)	57 (34%)
Sense-making vs. Curriculum coverage	119 (70%)	50 (30%)
Breadth vs. Depth	88 (52%)	81 (48%)
Multiple activities vs. Short-term whole-class assignment	93 (55%)	76 (45%)
Student-oriented vs. Teacher-directed	140 (83%)	29 (17%)

Overall, teachers substantially preferred the constructivist philosophy to the traditional-transmission philosophy in their response to each of these items. The data suggest that given an argument between support for a philosophical position consistent with constructivist approaches and one reflecting a more traditional viewpoint, many more teachers in this study will select agreement with constructivist approaches than with traditional teaching practices.

In survey item 16, teachers were asked to indicate the degree of emphasis on the various student objectives for teaching fractions. For the analysis, these student objectives were classified into two types based on *Adding It Up* (NRC, 2001): (1) procedural fluency-oriented student objectives (PSO) and (2) understanding-oriented student objectives (USO). Figure 5.1 shows the average rating of each student objective.



Note: USO1= Lean mathematical concepts, USO 2=Learn to reason, USO3=Learn to explain ideas, USO4=Learn to connect ideas, USO 5=Learn to how to solve problems, PSO1=Learn algorithms, PSO2=Develop computational skills, PSO3=Speed and accuracy, PSO4=Standardized test.

Figure 5. 1 Emphasis Placed on the Different Student Objectives

Teachers reported using understanding-oriented student objectives (USO1 to

USO6) much more than procedural fluency-oriented student objectives (PSO1 to PSO4). In particular, the student objective regarding learning mathematical algorithms/procedures received moderate emphasis.

For "teacher view of textbook" teachers were asked to indicate how much they agree or disagree (on a five point Likert-scale) with five statements about the textbook they were using in survey item 13. For "teacher fidelity to textbook," teachers were asked to indicate how much they agreed or disagreed with the six statements in survey item 14. Table 5.8 presents the frequency of agreement and disagreement to the given statements.

Table 5. 8 Agreement Frequency about the Textbook Satisfaction

Factors	Variables	Agree	Middle position	Disagree
View of text	a. Satisfaction with the textbook	107 (63%)	35 (21%)	27 (16%)
	b. Alignment of text with state-tests	92 (55%)	21 (12%)	56 (33%)
	c. Alignment of text with what teachers think was important in math.	95 (56%)	41 (24%)	33 (20%)
	d. Alignment of textbook with NCTM ideas	113 (66%)	33 (20%)	23 (14%)
	e. Satisfaction with the teacher's manual	107 (63%)	35 (21%)	27 (16%)
Fidelity to text	a. Use the textbook as a primary resource	123 (73%)	10 (6%)	36 (21%)
	b. In-class activities came directly from text	99 (59%)	28 (17%)	42 (24 %)
	c. Planned problems came directly from text	99 (59%)	36 (21%)	34 (20%)
	d. Homework assignments were typically drawn from the textbook	98 (58%)	28 (17%)	43 (25%)
	e. Most of questions planned to use came directly from teachers' manual of the text	86 (51%)	26 (15%)	57 (33%)

A relatively larger percentage of the teachers agreed that they used their textbooks as a primary resource than that of teachers who agreed that they satisfied with their textbooks. In addition, more than half of teachers in this study have fidelity to their textbooks.

They reported intensively using their textbooks in selecting problems, activities and homework assignments. Teachers' fidelity to their textbook or teachers' reliance on their textbook has been often criticized from the public or educators or reformers. However, without consideration of consequent result of teachers' textbooks use (i.e., the kinds and levels of student learning opportunities), it is hard to tell whether teachers' modifications of their textbooks need to be encouraged or whether teachers' reliance on their textbooks would be criticized. Therefore, this study examined whether teachers' fidelity to their textbooks (teachers' reliance on their textbooks) has a significant effect on teachers' transformation patterns.

Descriptive Findings from Teachers' Opportunity-to-Learn factors

Three sub-variables derived from the previous studies (e.g., Ball & Feiman-Nemser, 1988; Ma, 1999) were included under the *teachers' opportunity-to-learn variables*: (1) "Total participation hours in professional development (PD) activities", (2) "Type of content areas teachers studied during PD activities", and (3) "Type of pedagogy teachers participated in during PD activities".

For "total participation hours in PD", teachers were asked to write down approximately how many total hours they had spent on professional development (PD) activities in the last 24 months including attendance at professional meetings, workshops, conferences, and formal courses for which teachers received college credit in survey item 24. Among 169 participants in this study, 157 teachers wrote down their approximation of PD hours received, which ranged from 1 hour to 360 hours.

For "content types teachers studied in PD" and "pedagogy types during PD", teachers were asked to indicate how much time they spent on PD activities relative to various types of knowledge identified as important for teaching in survey item 24 and to indicate the frequency of various activities teachers participated in during PD in survey item 25. Table 5.9 presents descriptive statistics of this factor

Table 5. 9 *Mean Time (in Hours) and Standard Deviation Spent on Professional Development (PD) Activities*

Factors		Variables	M	SD
PD Content	Content knowledge	Whole number	2.15	.96
		Rational number	2.05	.96
		Geometry	2.07	.95
		Measurement	1.95	.84
		Data Analysis & Probability	1.95	.92
	Pedagogical Content Knowledge	Knowledge of how students learn	2.53	1.01
		Specific ways of teaching strategies	2.59	.98
		Specific ways of improving basic skill	2.20	.95
		Specific ways of improving understanding	2.40	1.02
		Specific ways of improving problem solving	2.34	1.01
	Curriculum Knowledge	Specific ways of using curriculum material	2.33	1.01
		Specific ways of modifying problems	1.79	.90
		Specific ways for higher order thinking	2.33	1.07
PD Pedagogy	Passive participation	Listening to a lecture	3.41	1.07
	Active participation	Presentation	2.21	1.15
		Being observed	2.04	.97
		Observe demonstration	2.68	1.08
		Observe a lesson of expert	2.05	.98
		Design lessons	2.56	1.11
		Analyze student work	2.68	1.02
		Lead discussion	2.39	1.12
		Demonstrate lessons	2.07	1.03

The means ratings show that among three types of knowledge—content knowledge, pedagogical content knowledge, and curriculum knowledge, teachers on average spent more time studying pedagogical content knowledge than any other types of knowledge during PD activities. In addition, teachers in this study spent the least amount of time studying specific ways of modifying problems followed by measurement and data analysis and probability. Furthermore, the means ratings show that teachers in this study participated in passive learning more often than active learning during PD activities

Based on these understanding of teachers' overall responses on each factor explored, this study examined the research question, whether and how teachers' responses in each factor differ according to the transformation patterns. The following section presents the statistical methods utilized in order to explore influential factors on these transformation patterns.

Multinomial Logistic Regression

A multinomial logistic regression (MLR) is an extension of the binary logistic regression technique that predicts a two-categorical dependent variable. A multinomial logistic regression is used when the dependent variable has more than two groups.

Like multiple linear regression, logistic regression develops equations that describe the relationship between multiple independent variables and a single dependent variable. In order to develop a regression equation, the categorical dependent variable in logistic regression is transformed into the natural log of the odds ratio. The frequency of categories in the dependent variable is first transformed into a probability that an event will occur. Then, the dependent variable is transformed into an odds ratio, which is ratio of the probability that an event will occur to the probability that an event will not occur. After that, this odds ratio of the dependent variable is transformed to be the natural log of the odds, which is called a logit.

For example, suppose these are two textbook transformation patterns of a dependent variable, which are H-H pattern coded 1 and L-L pattern coded 0. Among 100 teachers, 70 teachers were categorized as the H-H pattern and 30 teachers were in the L-L pattern. Research interest is to model the factors characterizing teachers in the H-H pattern compared to teachers in the L-L pattern. Then, using the frequencies of two patterns, logistic regression develops the probability of being categorized into the H-H pattern (P=0.7) and the probability of not being categorized into the H-H (i.e., the probability of being categorized into the L-L pattern, P =0.3).

The probability of being categorized into the H-H pattern is used as reference category. Although teachers in the L-H pattern are equally interesting for their ability to transform lower level cognitive demand into higher level, a small number of teachers are categorized into the L-H pattern compared to teachers in the H-H pattern. In addition to this sample size problem, since logits (logistic regression contrasts) are formed based on the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern, we do not lose information about L-H patterns. For these reasons, H-H pattern was chosen as the standard.

In logistic regression, the dependent variable is expressed as ratio of the probability of being categorized into the L-L pattern to the probability of not being categorized into the H-H pattern (= $\frac{0.3}{0.7}$ =0.428), which is called odds ratio (= $\left[\frac{\text{Prob (L–L pattern)}}{\text{Prob (H–H pattern)}}\right]$. Then, the odds ratio of the dependent variable is again transformed into natural log of the odds, which is $\log\left[\frac{\text{Prob (L–L pattern)}}{\text{Prob (H–H pattern)}}\right]$. After that, the natural log of logits as dependent variable is predicted from a weighted combination of the independent variables.

As a result of these transformations (probability→ odds →then natural log of the odds ratio), the dependent variable ranges from minus to plus infinity, as a continuous variable. The logistic regression model can be written as:

$$\log\left[\frac{\text{Prob (event)}}{\text{Prob (no event)}}\right] = a + b_1 * x_1 + b_2 * x_2 + \ldots + b_k * x_k$$

Where a = Intercept (constant)

k	=	Number of independent variables
b_1 *to* b_k	=	Coefficients estimated for the k predictor variables
X_1 *to* X_k	=	Values of the k independent variables

Positive coefficients in the logistic regression increase the probability that an event will occur, which is the probability of being categorized into the L-L pattern. Negative coefficients decrease the probability that an event will occur. In other words, negative coefficients increase the probability that event will not occur, which is the probability of being categorized into the H-H pattern.

Although logistic regression finds a "best fitting" equation just as linear regression does, it uses a maximum likelihood method, which maximizes the probability of getting the observed results given the fitted regression coefficients. Therefore, logistic regression does not assume linearity of relationship between the independent variables and the dependent variable, does not require normally distributed variables, does not assume homoscedasticity, and in general has less stringent requirements (Polit, 1996). This makes it especially suited to the present study because some independent variables did not fulfill the assumption of homoscedasticity.

This study employed multinomial logistic regressions since the dependent variable is comprised of three or four categories (e.g., L-L, L-H, H-L or, H-H patterns). In Transformation phases 1 and 2 where the dependent variable is comprised of three categorical indexes, two logistic regression contrasts were developed based on: (1) the probability of being categorized into the L-L pattern compared to the probability of being categorized into the H-H pattern and (2) the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern.

In the cases of Transformation phase 3 where the dependent variable is comprised of four categorical indexes, three logistic regression contrasts were developed based on the natural log of : (1) the probability of being categorized into the L-L pattern compared to the probability of being categorized into the H-H pattern; (2) the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern; (3) the probability of being categorized into the H-L pattern compared to the probability of being categorized into the H-H pattern. The following sections present the findings from these multinomial logistic regressions that describe influential factors on the distinction between transformation patterns. Using a SPSS 15.0 version, multiple multinomial logistic regressions were explored.

Factors Influencing Textbook Transformation Patterns in Terms of Cognitive Demands of Problems

This section presents the findings from multinomial logistic regression used to answer the following research questions: What factors are associated with the transformation patterns in Transformation phase 1. Figure 5.2 presents the dependent variable and the independent variables explored in the analysis.

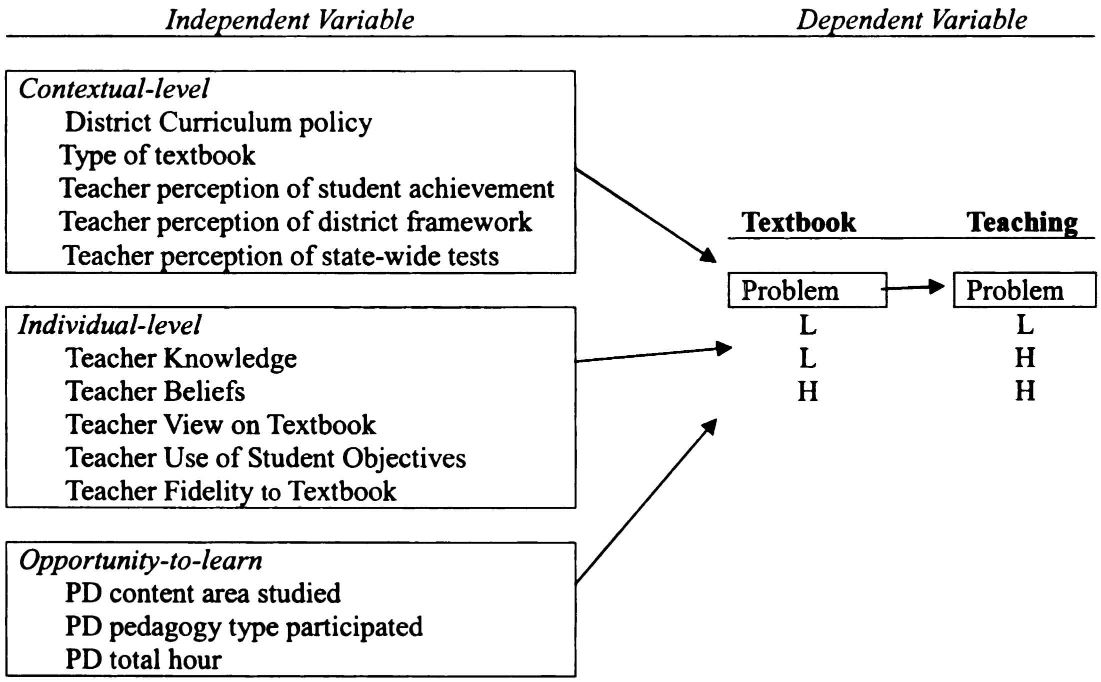


Figure 5. 2 Dependent and Independent Variables in Transformation Phase 1

Because the dependent variable consists of three categorical indexes, two nonredundant logits (logistic regression contrasts) are formed; (1) based on the probability of being categorized into the L-L pattern compared to the probability of being categorized into the H-H pattern and (2) based on the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern. The last category (the H-H pattern=4) was set up as the baseline or reference group to which the other two groups (L-L pattern and L-H pattern) were compared based on the independent variables.

One more analysis was conducted after setting up the L-L pattern as the reference group in order to explore the factors that influence teachers to raise the level of cognitive demand of problems. One logistic regression contrast was formed based on the probability of being categorized into the L-H pattern compared to the probability of being categorized into the L-L pattern.

All independent variables shown in Figure 6.1 were included in the original multinomial logistic regression model. A total of 21 independent variables presented in Table 5.2 were entered in the original multinomial logistic regression model.

The goal of the analysis is to select variables that result in a "best" model that represent the factors distinguish teachers in the H-H pattern compared to teachers in the L-L pattern and the L-H pattern, or vice versa. According to Hosmer & lemeshow (2000), when the number of variables in the model is large relative to the number of participants, the model may be "overfit" and produce numerically unstable estimates (e.g., unrealistically large estimated coefficients and/or estimated standard errors). Since the sample size of this study, 169 participants is small relative to the number of variables explored in the model (i.e. 21 independent variables), to find a "best" model, several predictive variables were dropped from subsequent analyses.

In the selection of variables for the final model, the significance of the overall model and goodness-of-fit was considered first. With the condition that the overall model is statistically significant ($p < 0.05$) and the model adequately fits the data (the p-value of goodness-of-fit is greater than 0.05), any variable whose variable test has a p-value <0.25 was considered a candidate for the model along with all variables of known importance. Hosmer and lemeshow (2000) recommend that a 0.25 level be used as a screening criterion for variable selection based on the work by Bendel and Afifi (1977) on linear regression and on the work by Mickey and Greenland (1989) on logistic regression. These authors show that use of a more traditional level (such as 0.05) often fails to identify variables known to be important. According to them, use of the higher level has the disadvantage of including variables that are of questionable importance at the model-building stage. Indeed, it is possible for individual variables not to exhibit strong confounding, but when taken collectively, considerable confounding can be present in the data. Therefore, for these reasons, this study used a p-value <0.25 as a criterion in the selection of the variable for a logistic regression model. Based on this criterion, only seven variables were included in the final model. The final model includes the seven individual variables: (1) " Type of textbook;"" (2) "Teacher fidelity to textbook"; (3) "Teacher view on Textbook"; (4) Teacher use of understanding-oriented student objectives (USO); (5) "Teacher use of procedural fluency-oriented student objectives" (PSO); (6) "Teacher pedagogical content knowledge" (PCK) ; (7) "Teacher presentation experience during PD". Table 5.10 shows correlations for the variables used in the subsequent analysis. "Type of textbook" variable is excluded since it is categorical.

Table 5. 10 *Correlations for the Variables Included in the Final Model*

	1	2	3	4	5	6
1. Fidelity to Textbook	1					
2. View on Text	.543(**)	1				
3. Understanding-oriented student objectives	.166(*)	.184(*)	1			
4. Procedural fluency-oriented student objectives	.110	.057	.316(**)	1		
5. Pedagogical Content Knowledge	-.080	.013	.116	.045	1	
6. PD Presentation	-.054	.016	.129	-.041	.063	1

Note. * p<.05, **p<.001

For the multinomial logistic regression examining the effects of the seven independent variables, the likelihood ratio test for the overall model revealed that the overall model was significantly better than the intercept-only model (χ^2=72.101, p <0.000). In other words, the null hypothesis that the regression coefficients of the independent variables are zero was rejected. In addition, the likelihood ratio test for individual effects reveals that among the 7 variables included in the final model, 5 variables are significantly related to the categories of the dependent variable ("Type of textbook" : χ^2 [2]=12.099, p <0.000; "Teacher use of understanding-oriented student objective": χ^2 [2]=15.727, p <0.000; "Teacher fidelity to textbook", χ^2 [2]= 13.855, p <0.000;"Teacher view on textbook": χ^2 [2]=7.324, p <0.05; "teachers' pedagogical content knowledge": χ^2 [2]=9.629, p <0.001).

Table 5.11 reports the parameter estimates (regression coefficients) from the logistic regression model examining the effects of the independent variables on three transformation patterns exhibited in Transformation phase 1.

Table 5.11 *Parameter Estimates from Logistic Regression Model for Examining Effect of Seven Independent Variables on the Distinction between Patterns Exhibited in Transformation Phase 1*

	Transformation patterns in terms of the cognitive demand of problems			
	L-L		L-H	
Variables	β	Odds	β	Odds
Intercept	6.775		9.487	
Type of Textbook				
[Conventional texts=1]	2.159*	8.664	1.465**	4.326
[Standards-based =0]	-	-	-	-
Teacher Fidelity to Textbook	-1.662**	.190	-.687*	.503
Teacher View on Textbook	1.137	3.118	-.296	.744
Teacher use of understanding-oriented student objective	-2.546**	.078	-1.990**	.137
Teacher use of procedural fluency-oriented student objective	1.660*	5.257	.235	1.265
Pedagogical Content Knowledge	-1.964*	.140	-1.103*	.332
Presentation experience during PD	.661	1.936	.685	1.983

Note. The reference category is the H-H pattern. R^2 = 0.479 (Nagelkerke), N=158. * p<.05, **p<.01

Estimates of the independent variables are provided for the distinction between teachers in the L-L pattern compared to teachers in the H-H pattern and on the distinction of teachers in the L-H pattern compared to teachers in the H-H pattern. Table 5.11 presents logistic regression coefficients (β) in the second and fourth column, which correspond to *b* coefficients in multiple regression. These logistic regression coefficients construct prediction equations and generate predicted values, which are called logistic scores in logistic regression. If regression coefficients of the factors are positive, this factor increases the odds ratio of the probability of being categorized into the L-L pattern or the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern. If regression coefficients of the factors are negative, this factor decreases the odds ratio of the probability of being categorized into the L-L pattern or the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern.

The odds ratios in Table 5.11 present a measure of effect size. The odds ratios of the independents indicate relative importance of the independent variables with respect to chance of being categorized into the L-L pattern compared to chance of being categorized into the H-H pattern, or chance of being categorized into the L-H pattern compared to chance of being categorized into the H-H pattern.

Table 5.11 presents effect of sizes among the seven factors. Five factors—"type of textbook", "teacher fidelity to textbook", "teacher use of understanding-oriented student objective", "teacher use of procedural-oriented student objective", and "pedagogical content knowledge"--are found to be significantly related to characterizing teachers in the L-L pattern and teachers in the H-H pattern. Four factors—"type of textbook", "teacher fidelity to textbook", "teacher use of understanding-oriented student objective", and "pedagogical content knowledge"--are found to be significantly related to characterizing teachers in the L-H pattern and teachers in the H-H pattern.

Factors Distinguishing L-L Pattern from H-H Pattern

The coefficients of "type of textbook" and "teacher use of procedural fluency-oriented student objectives" are significant and positive, which means that these factors increase the probability of being categorized into the L-L pattern compared to the probability of being categorized into the H-H pattern. In contrast, the coefficients of "teacher fidelity to textbook", "teachers use of understanding-oriented student objectives", and "teacher pedagogical content knowledge" are significant and negative, which means that these factors increase the probability of teachers being categorized into the H-H pattern. A closer look at the coefficients (β) suggests more interesting trends with respect to the factors that affect the probability of teachers being categorized into the L-L pattern compared to the probability of teachers being categorized into the H-H pattern.

First, in survey item 12, teachers were asked to list the title, year, and edition of textbooks (e.g., Everyday Mathematics, Grade 3, 2001, 2nd edition.) students and teachers used in their class. Teachers' responses to this survey item were first recoded using the titles teachers provided, and then these textbooks were classified into two types—(1) standards-based curriculum and (2) conventional curriculum—based on Stein & Kim's definitions (2006). *Investigations in Number, Data, and Space, Connected Mathematics, Everyday Mathematics,* and *Math Trailblazers* were categorized into "standards-based" curriculum (code 0). The rest of curricula were categorized into "conventional" curriculum (code 1).

Table 5.11 shows that the logistic regression coefficient of "type of textbook" coded the value 1, which is "conventional textbook", is significant and positive ($\beta = 2.309$, $p < 0.05$). This result indicates that teachers in the L-L pattern are more likely to use conventional textbooks, than teachers in the H-H pattern. Conversely, teachers in the H-H pattern are more likely to use "standards-based textbooks" than teachers in the L-L pattern.

Second, the coefficient of "teacher use of procedural fluency-oriented student objectives" factor is also significant and positive ($\beta = 1.622$, $p < 0.01$). To measure "teacher use of procedural fluency-oriented student objective", teachers were asked to indicate the degree of emphasis on several student objectives categorized as procedural fluency-oriented (e.g., develop students' computational skills; learn to perform computations with speed and accuracy). The positive coefficient of this factor means the increases of the chance of being in the L-L pattern compared to the chance of being in the H-H pattern. It suggests that teachers who reported frequent use of student objectives categorized as procedural fluency-oriented student objectives are more likely to be categorized into the L-L pattern than into the H-H pattern.

Unlike "type of textbook" variable and "teacher use of procedural-oriented student objectives" factors, the coefficients of the rest of three variables identified as significant are negative: "Teacher fidelity to textbook" (β =-1.852, p <0.01), "Teacher use of understanding-oriented student objectives" (β =-2.558, p <0.05), and "Teacher pedagogical content knowledge" (PCK) (β =-2.032, p <0.05).

First, to measure "teacher fidelity to textbook", teachers were asked to indicate on a five-point Likert scale how much they agree with the given statements that asked whether their in-class activities, problems, questions, and homework assignment came directly from the textbooks. The negative coefficient of this variable (β =-1.852, p <0.01) indicates that this factor decreases the chance of being categorized into the L-L pattern compared to that of the H-H pattern. This result implies that teachers in the L-L pattern were less likely to report that their lessons came directly from the textbook they were using than teachers in the H-H pattern. In other words, teachers in the H-H pattern reported heavier reliance on their textbook than teachers in the L-L pattern. Therefore, teachers who report the faithful use of their textbooks are likely to be categorized as the H-H pattern rather than as the L-L pattern.

Second, the coefficient of "teacher use of understanding-oriented student objectives" variable is also significant and negative (β =-2.558, p <0.05). To measure "teacher use of understanding-oriented student objective", teachers were asked to indicate the degree of emphasis on several student objectives categorized as understanding-oriented (e.g., learn to reason mathematically; learn to explain ideas effectively). The negative coefficient of this variable suggests that teachers who reported that they frequently used student objectives categorized as understanding-oriented student objectives were more likely to be in the H-H pattern than in the L-L pattern.

Finally, to measure "teacher pedagogical content knowledge", teachers were asked to rate the following types of knowledge: knowledge of how students learn (e.g., common mistakes/confusion), specific ways of teaching strategies, specific ways of improving student basic skills, specific ways of improving understanding, and specific ways of improving problem solving. The negative coefficient of this value (β =-2.032, p

<0.05) suggests that teachers in the L-L pattern were less likely to rate their knowledge as higher level than teachers in the H-H pattern. In other words, according to teachers' self-reports, teachers who reported higher level of PCK are likely to be in the H-H pattern.

The odds ratio in Table 5.11 presents a measure of effect size, relative importance of the independent variables in terms of effect on the dependent variable's odds (Menard, 2001). Among five variables identified as significant, "type of textbook" (8.664) has the strongest effect on distinguishing teachers in the L-L pattern from teachers in the H-H, followed by "teacher use of procedural fluency-oriented student objectives" (5.257), "teacher fidelity to textbook" (0.190), "teacher pedagogical content knowledge" (0.140), and "teacher use of understanding-oriented student objectives" (0.078).

Factors Distinguishing L-H Pattern from H-H Pattern

Table 5.11 indicates that four factors--"type of textbook" , "teacher fidelity to textbook" , "teachers' use of understanding-oriented student objectives", and "teacher PCK" are significantly related to the distinction between teachers in the L-H pattern and those in the H-H pattern. Among four factors, only the coefficient of type of textbook variable is significant and positive, whereas the coefficients of "teachers' fidelity to textbook", "teachers' use of understanding-oriented student objectives", and "teacher

PCK" factors are negative. These results indicate that "type of textbook" (conventional textbook) factor increases the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern, whereas "teacher fidelity to textbook", "teacher use of understanding-oriented student objectives", and "teacher pedagogical content knowledge" factors increases the probability of being categorized into the L-H pattern compared to the probability of being categorized into the H-H pattern. A closer look at the coefficients (β) of these variables reveals interesting results.

First, the logistic regression coefficient of "type of textbook" coded "conventional textbooks", is significant and positive ($\beta = 1.509$, $p < 0.01$). This result suggests that teachers in the L-H pattern are more likely to use conventional textbooks, than are those in the H-H pattern. Conversely, teachers in the H-H pattern are more likely to use standards-based textbooks than teachers in the L-H pattern.

Second, the coefficients of the rest of the factors--"teacher fidelity to textbook", "teacher use of understanding-oriented student objectives", "teacher PCK"--were found to be significant and negative. The results suggest that for "teacher fidelity to textbook", teachers in the L-H pattern were less likely to report that their lesson came directly from the textbook than teachers in the H-H pattern. In other words, teachers in the H-H pattern are more likely to agree that they rely on their textbook more strongly than teachers in the L-H pattern; for "teachers' use of understanding-oriented student objectives" factor (β=-1.967, p <0.01), teachers who reported that they frequently used student objectives categorized as understanding-oriented student objectives were more likely to be in the H-H pattern than in the L-H pattern; for "teacher pedagogical content knowledge", teachers in the L-L pattern were less likely to rate their knowledge level as higher than teachers in the H-H pattern. In other words, teachers who rate higher level of PCK are likely to be in the H-H pattern.

The odds ratio in Table 5.11 indicates that "types of textbook" (4.326) has the strongest effect on distinguishing teachers in the L-H pattern from teachers in the H-H, followed by "teacher fidelity to textbook" (.503), "teacher PCK" (0.332), and then "teacher use of understanding-oriented student objectives" (0.137).

Factors Distinguishing L-H Pattern from L-L Pattern

To explore the factors that influence teachers to raise the level of cognitive demand of problems, one more analysis were conducted after setting up the L-L pattern as the reference group. Table 5.12 reports the parameter estimates (regression coefficients) from the logistic regression model examining the effects of the independent variables for the distinction between teachers in the L-H pattern compared to teachers in the L-L pattern.

Table 5. 12 *Parameter Estimates from Logistic Regression Model for Examining Effect of Seven Independent Variables on the Distinction between L-H and L-L Patterns in Phase 1*

	L-H	
Variables	β	Odds
Intercept	2.712	
Type of Textbook		
[Conventional texts=1]	-0.694	.499
[Standards-based =0]	-	-
Teacher Fidelity to Textbook	.975	2.650
Teacher View on Textbook	-1.433*	.239
Teacher use of understanding-oriented student objective	.557	1.745
Teacher use of procedural fluency-oriented student objective	-1.425	.241
Pedagogical Content Knowledge	.861	2.366
Presentation experience during PD	.024	1.024

Note. The reference category is the L-L pattern. $R^2 = 0.479$ (Nagelkerke), *N*=158. * p<.05, **p<.01

Table 5.12 indicates that only the parameter estimates for "teacher view on textbook" (β=-1.433, p <0.01) is significantly related to the distinction between teachers in the L-H pattern and those in the L-L pattern. In particular, the coefficient of "teacher view on textbook" is negative, indicating that this factor increases the probability of being categorized into the L-H pattern compared to the probability of being categorized into the L-L pattern. This suggests that teachers in the L-H pattern were less likely to report that they were pleased with the textbook than teachers in the L-L pattern. In other words, teachers in the L-L pattern are more likely to agree that they were pleased with their textbook more strongly than teachers in the L-H pattern.

The type of textbook is found to be insignificant in distinguishing teachers in the L-H pattern from teachers in the L-L pattern, indicating that teachers in the L-H pattern and in the L-L pattern are using the same type of textbook (i.e., conventional textbooks).

Factors Influencing Textbook Transformation Patterns in Terms of Cognitive Demands of Teacher Questions

This section presents the findings from multinomial logistic regressions used to answer the following research question: What factors are associated with the transformation patterns in Transformation phase 2? Figure 5.3 presents categorical dependent variables and independent variables explored in this analysis.

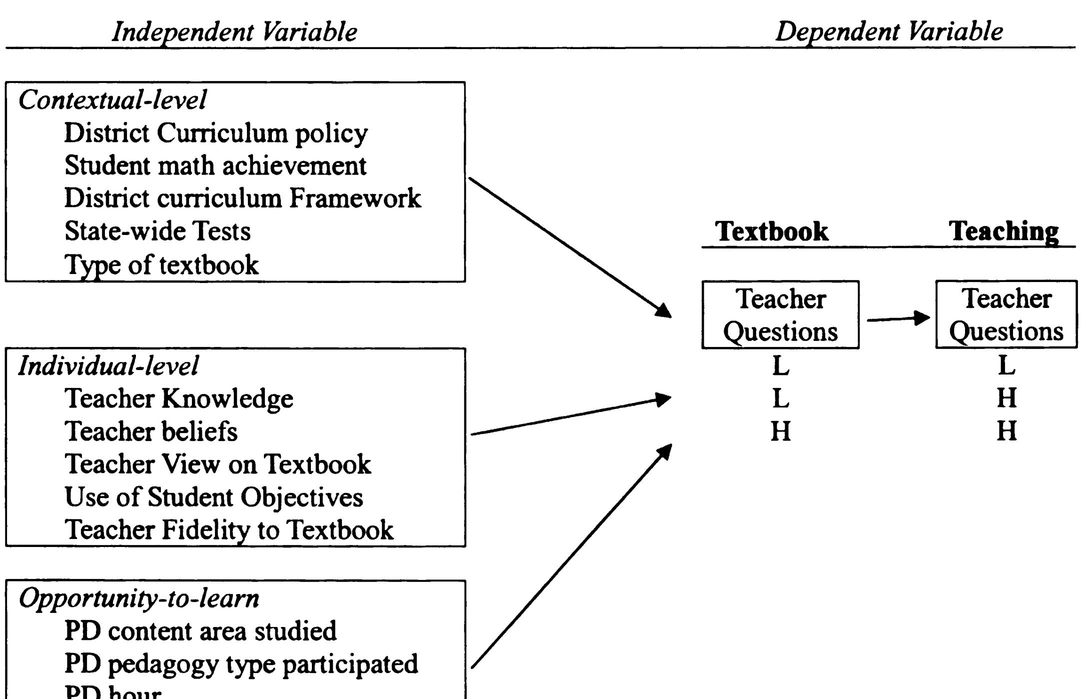


Figure 5. 3 Dependent and Independent Variables in Transformation Phase 2

All independent variables shown in Figure 5.3 were included in the original multinomial logistic regression model. A total of 21 independent variables were entered in the original multinomial logistic regression model. The same procedures were used to identify the variables that were associated with teachers' transformation patterns in terms of the cognitive demand of teacher questions. With the condition that the overall model is statistically significant ($p < 0.05$) and the model adequately fits the data (the p-value of goodness-of-fit is greater than 0.05), any variable whose variable test has a p-value <0.25 was considered a candidate for the final model along with all variables of known importance.

The final model in Transformation phase 2 includes the eight variables: (1) "Type of textbook" (Conventional vs. Standards-based); (2) "Teacher perception about students' achievement" (High achieving vs. the other levels); (3) "Teacher fidelity to textbook"; (4) "Teacher view on textbook"; (5) "Teacher beliefs about traditional approach"; (6) "Teacher beliefs about constructivist approach"; (7) "Teacher use of understanding-oriented student objectives"; (8) "teachers' observation experience during PD activity". Since the first two variables--(1) "Type of textbook"; (2) "Teacher perception about students' achievement"—are categorical, they were excluded in exploring correlations between identified factors. Table 5.13 presents correlations for the variables used in the subsequent analysis.

Table 5.13 *Correlations for the Variables Included in the Final Model*

	1	2	3	4	5	6
1. Teacher Fidelity to Text	1					
2. Teacher View on Text	.543(**)	1				
3. Teacher beliefs about traditional approach	-.023	-.049	1			
4. Teacher beliefs about constructivist approach	.153(*)	.017	-.033	1		
5. Teacher use of understanding-oriented objectives	.166(*)	.184(*)	-.023	-.031	1	
6. Teacher Observation during PD	.136	-.017	-.082	.057	-.009	1

Note. * p<.05, **p<.001

For the multinomial logistic regression examining the effects of the independent variables, the likelihood ratio test for the overall model revealed that the overall model was significantly better than the intercept-only model (χ^2 =80.099, p <0.000). In other words, the null hypothesis that the regression coefficients of the independent variables are zero was rejected. In addition, the likelihood ratio test for individual effects reveals that among eight variables, five variables are found to be statistically significant in characterizing teachers exhibiting transformation patterns in terms of the cognitive demand of teacher questions ("type of the textbook": χ^2 [2] = 22.470, p <0.000; "Teacher perception about students' achievement": χ^2 [2] = 6.616, p <0.05; "teacher fidelity to textbook": χ^2 [2] = 11.741, p <0.004; "teacher use of understanding-oriented student objective": χ^2 [2] = 7.927, p <0.01; "teacher beliefs about traditional approach": χ^2 [2] = 6.404, p <0.05 (emphasis of sense-making and depth). Although, the rest of variables included in the final model were found to be insignificant, it was expected that when taken collectively, considerable confounding could be present in the data.

Among three categories of the dependent variable (i.e., L-L pattern, L-H pattern and the H-H pattern), the H-H pattern was set up as the baseline or reference group to which the other two groups (L-L pattern and L-H pattern) were compared based on the independent variables. Therefore, multinomial logistic regressions form two logistic regression models (contrasts): one logistic regression model for examining the factors that affect the probability of being categorized into L-L pattern compared to the probability of being categorized into the H-H pattern and the other for examining the factors that affect the probability of being categorized into L-H pattern compared to the probability of being categorized into the H-H pattern.

Table 5.14 reports the parameter estimates from the logistic regression model examining the effects of the independent variables on the distinction between three different transformation patterns exhibited on Transformation phase 2. Estimates of the independent variables are provided for the distinction between teachers in the L-L pattern compared to teachers in the H-H pattern and on the distinction of teachers in the L-H pattern compared to teachers in the H-H pattern.

Table 5.14 *Parameter Estimates from Logistic Regression Model Examining Effects of Predictor Variables on the Distinction between Patterns on Transformation Phase 2*

	Transformation patterns of teacher questions			
	L-L		L-H	
Variable	(β)	Odds	(β)	Odds
Intercept	5.346		10.338	
Type of Textbook				
[Conventional texts =1]	1.526**	.574	2.491**	12.072
[Standards-based texts =0]	-	-	-	-
Teacher perception of student achievement				
[High achieving=1]	-.099	1.408	-2.169*	.114
[Other levels=0]				
Teacher Fidelity to Textbook	-.938**	.347	-.835**	.434
Teacher View on Textbook	.730	.410	-.145	.865
Teacher use of understanding-oriented student objectives	-1.820**	.616	-.490	.613
Teacher beliefs about constructivist approach	.006	.432	-1.084*	.338
Teacher beliefs about traditional approach	-.469	.453	-.802	.448
Observation of Teaching in PD	.180	.281	-.304	.735

Note. The reference category is H-H pattern. R2 = 0.470 (Nagelkerke), N=156. * p<.05, **p<.01

Table 5.14 shows that three factors—"type of textbook", "teacher fidelity to textbook", and "teacher use of understanding-oriented student objectives" are significantly related to distinguishing teachers in the L-L pattern from teachers in the H-H pattern. Four factors—"type of textbook", "teacher perception of student mathematics achievement" "teacher fidelity to textbook", and "teacher beliefs about constructivist approach" are significantly related to distinguishing teachers in the L-H pattern from teachers in the H-H pattern.

Factors Distinguishing L-L Pattern from H-H Pattern

The coefficients of "type of textbook" variable are positive whereas the coefficients of "teacher fidelity to textbook" and "teacher use of understanding-oriented student objectives" variable are negative. A closer look at the coefficients (β) of these three factors found to be significant reveals interesting findings.

First, the logistic regression coefficient of "type of textbook" coded as "conventional textbook", is significant and positive (β =1.1.45, p <0.05). This indicates that the parameter of textbook type coded the value 1 increases the odds of the given category of the dependent variable (i.e. the L-L pattern) compared to the reference category response (the H-H pattern). This result suggests that teachers in the L-L pattern are more likely to use conventional textbooks than are those in the H-H pattern. Conversely, teachers in the H-H pattern are more likely to "standards-based textbooks" than teachers in the L-L pattern in Transformation phase 2. This finding is consistent with the finding in Transformation phase 1, suggesting that type of textbooks is a significant indicator characterizing teachers in the H-H pattern and in the L-L pattern in terms of cognitive demands of problems as well as in terms of cognitive demands of teacher questions.

Second, the logistic regression coefficient for "teacher fidelity to textbook" (β =-.938, p <0.001), and "teacher use of understanding-oriented student objectives" (β =-1.802, p <0.01) are significant and negative. This result implies that for "teacher fidelity to textbook" variable, teachers in the L-L pattern were less likely to report that their lesson came directly from the textbook than teachers the H-H pattern. For "teacher use of understanding-oriented student objectives" variable, teachers in the L-L pattern were less likely to report the frequent use of student objectives categorized as understanding-oriented than teachers in the H-H pattern. That is, teachers who report the frequent use of student objectives categorized as understanding-oriented are more likely to be in the H-H pattern than in the L-L pattern.

The odds ratio in Table 5.14 presents a measure of effect size, which is relative importance of the independent variables in terms of effect on the dependent variable's odds. Among 3 variables identified as significant, "type of textbook" (4.723) has the strongest effect on distinguishing teachers in the L-L pattern from teachers in the H-H pattern, followed by "teacher use of understanding-oriented student objectives" (0.347) and "teacher fidelity on textbook" (0.616).

Factors Distinguishing L-H Pattern from H-H Pattern

Table 5.14 also indicates that four factors--"type of textbook" variable, "teacher perception about student mathematics achievement", "teacher fidelity to textbook", and "teacher beliefs about constructivist approach" factors are found to be significant in distinguishing teachers in the L-H pattern from teachers in the H-H pattern in transformation phase 2. The coefficients of "type of textbook" and "teacher perception of student achievement" are positive whereas the coefficients of "teacher fidelity to textbook" and "teacher beliefs about constructivist approach" variable are negative. A closer look at the coefficients (β) of these three factors found to be significant demonstrate important trends, exhibit certain patterns.

First, the logistic regression coefficient of textbook type coded the value 1is significant and positive (β =2.490, p <0.001). This result indicates that teachers in the L-H pattern are more likely to use textbook type coded as "conventional textbooks" than those in the H-H pattern. As in the comparison between L-L and H-H, variable, teachers in the H-H pattern are more likely to use "standards-based textbooks" than teachers in the L-H pattern.

Second, for "teacher perception of student mathematics achievement", in survey item 8, teachers were asked to indicate mathematics achievement level of students in their classroom. Teachers had the option of indicating that their students were mostly high achieving, mostly average achieving, mostly low achieving, or at a range of achievement level. Teachers who perceive their student mathematics achievement as mostly high are likely to provide more high cognitive demand problems and questions rather than teachers who perceive their students' mathematics achievement as being at other levels (Saracho, 2003). For "teacher perception of student mathematics achievement", mostly high achieving was coded the value 1 and the other achievement levels (that is, mostly average achieving, mostly low achieving, and students at a range of achievement level) were coded the value 0. The logistic regression coefficient of student achievement level coded the value 1 is significant and positive (β =-2.155, p <0.01). This result suggests that teachers in the L-H pattern are less likely to indicate their students' mathematics achievement level as "other achievement levels" than teachers in the H-H pattern. In other words, teachers in the L-H pattern are more likely to indicate their students' mathematics achievement level as mostly high achieving than teachers in the H-H pattern. This result implies one possible reason why teachers in the L-H pattern transform cognitive level of teacher questions presented in their textbook into higher level when using teacher questions in their teaching. That is, since teachers perceive their students' mathematics achievement level as mostly high, they may change lower level cognitive demand of textbook teacher questions into higher level.

Third, the negative coefficient of "teacher fidelity to textbook" factor (β =-1.084, p <0.05) indicates that teachers in the L-L pattern were less likely to report that their lesson came directly from the textbook than teachers the H-H pattern.

Fourth, for "teacher beliefs about constructivist approach", questions which presented two pairs of contrasting statements about teaching philosophy—(1) curriculum coverage vs. sense-making and (2) breadth vs. depth-- were used. Teachers were asked to rate these two pairs of statements on a 4-point Likert-type scale in such a way so as to indicate which statement among the pair came closer to their own point of view. "Teacher beliefs about constructivist approach" means importance of sense-making over content coverage and importance of depth vs. breadth. The negative coefficient for "teacher beliefs about constructivist approach" variable (β =-1.084, p <0.05) are significant and negative, suggesting that teachers in the L-H pattern more strongly agreed on the importance of curriculum content-coverage over sense-making and importance of depth over breadth in student learning than teachers in the H-H pattern. That is, teachers in the H-H pattern are more likely to agree to sense-making and breadth with regard to student learning than curriculum content-coverage and depth.

The odds ratio in Table 5.14 indicates that "type of textbook" (12.072) has the strongest effect on distinguishing teachers in the L-H pattern from teachers in the H-H, followed by "teacher fidelity to textbook" (0.434), "teacher beliefs about constructivist approach" (importance of sense-making over curriculum coverage and importance of depth over breadth) (0.338), and then "teacher perception of student mathematics achievement" (.114).

Factors Distinguishing L-H Pattern from L-L Pattern

Table 5.15 reports the parameter estimates from the logistic regression model examining the effects of the independent variables for the distinction between teachers in the L-H pattern compared to teachers in the L-L pattern in transformation phase 2.

Table 5. 15 *Parameter Estimates from Logistic Regression Model for Examining Effect of Eight Independent Variables on the Distinction between the L-L and the L-H Patterns*

	L-H	
Variable	(β)	Odds
Intercept	4.992	
Type of Textbook		
[Conventional texts =1]	.965	2.264
[Standards-based texts =0]	-	-
Teacher perception of student achievement		
[High achieving=1]	-2.070	1.126
[Other levels=0]		
Teacher Fidelity to Textbook	.103	1.108
Teacher View on Textbook	-.875*	.417
Teacher use of understanding-oriented student objectives	1.331*	3.784
Teacher beliefs about constructivist approach	-.625	.535
Teacher beliefs about traditional approach	-.808	.446
Observation of Teaching in PD	-.488	.614

Note. The reference category is the L-L pattern. $R^2 = 0.479$ (Nagelkerke), N=158. * p<.05, **p<.01

Table 5.15 indicates that the parameter estimates for "teacher view on textbook" variable (β =-.875, p <0.05) and "teacher use of understanding-oriented student objectives" factors (β =1.331, p <0.05) are found to be significant in distinguishing teachers in the L-H pattern from teachers in the L-L pattern in transformation phase 2. The coefficient of "teacher view on textbook" is negative, indicating that teachers in the L-H pattern are less likely to report that they were pleased with their textbook than teachers in the L-L pattern. In other words, teachers in the L-L pattern are more likely to agree that they were pleased with their textbook more strongly than teachers in the L-H pattern.

In contrast, the coefficient of "teacher use of understanding-oriented student objective" is positive, indicating that teachers in the L-H pattern are more likely to report the frequent use of student objectives categorized as understanding-oriented than teachers in the L-L pattern, That is, teachers who report the frequent use of student objectives categorized as understanding-oriented are more likely to be in the L-H pattern than in the L-L pattern.

The odds ratio in Table 5.15 indicates that "teacher use of understanding-oriented student objective" (3.784) has the strongest effect on distinguishing teachers in the L-H pattern from teachers in the L-L and followed by "teacher view on textbook" (0.417).

Factors Influencing Transition Patterns between Fraction Problems in Teaching and Teacher Questions about Fractions in Teaching

This section presents the findings from multinomial logistic regression used to answer the following research question: What factors are associated with the transformation patterns in Transformation phase 3? Figure 5.4 presents categorical dependent variables and independent variables explored in this analysis.

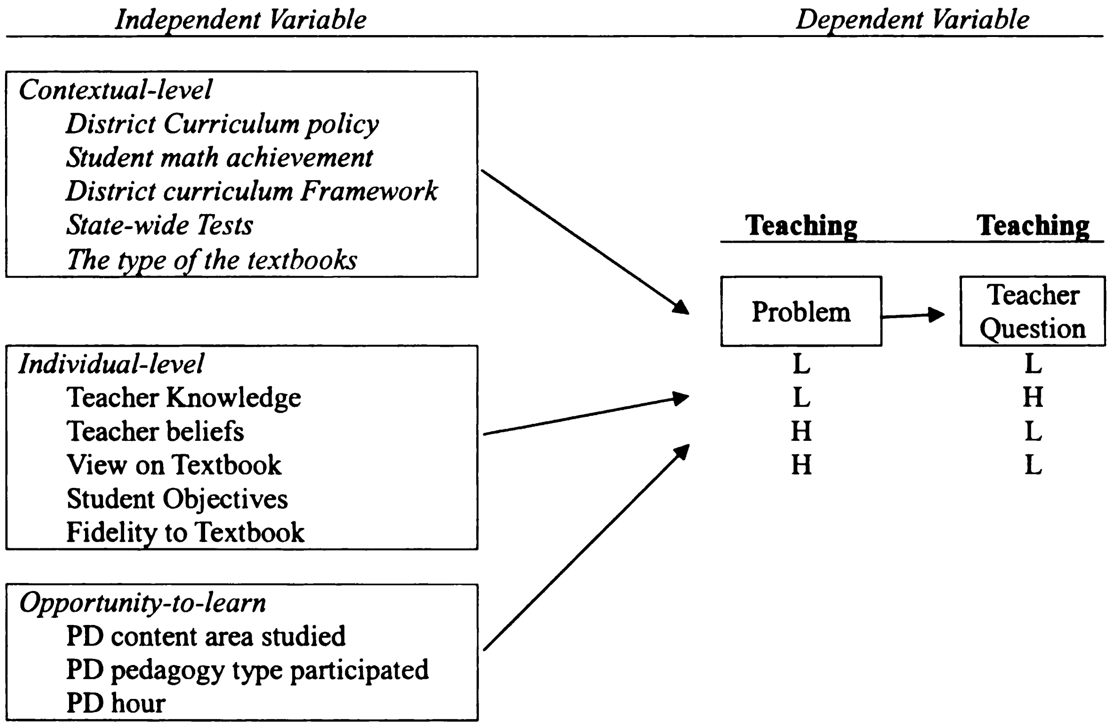


Figure 5. 4 Dependent and Independent Variables in Transformation Phase 3

All independent variables shown in Figure 5.4 were included in the original multinomial logistic regression model. A total of 21 independent variables were entered in the original multinomial logistic regression model. The same procedures were used to identify the variables associated with teachers' transformation patterns. With the condition that the overall model is statistically significant ($p < 0.05$) and the model adequately fits the data (the p-value of goodness-of-fit is greater than 0.05), any variable whose variable test has a p-value <0.25 was considered a candidate for the model along with all variables of known importance.

The final model included the seven individual variables: (1) "Type of textbook",

(2) "Teacher fidelity to textbook", (3) "Teacher view on textbook", (4) "Teacher use of understanding-oriented student objectives", (5) "Teacher use of procedural fluency-oriented student objectives", (6) "Teacher beliefs about traditional approach", and (7) "Teachers' PD observation experience". The categorical variable, "type of textbook" factor, was excluded in correlations for the variables used in the subsequent analysis. Table 5.16 reports correlations between the variables explored.

Table 5. 16 *Correlations for the Variables Included in the Final Model*

	1	2	3	4	5
1. Teacher fidelity to textbook	1				
2. Teacher view on textbooks	.543(**)	1			
3. Teacher use of understanding-oriented objectives	.166(*)	.184(*)	1		
4. Teacher use of procedural fluency-oriented objectives	.110	.057	.316(**)	1	
5. Teacher beliefs about traditional approach					
6. PD observation	.136	-.017	-.009	-.055	1

Note. * $p<.05$, ** $p<.001$

For the multinomial logistic regression examining the effects of the seven independent variables, the likelihood ratio test for the overall model revealed that the overall model was significantly better than the intercept-only model (χ^2 [18] =43.978, p <0.000). In other words, the null hypothesis that the regression coefficients of the independent variables are zero was rejected. In addition, the likelihood ratio test for individual effects reveals that among 3 variables, 3 variables are found to be statistically significant in characterizing teaching exhibiting these transformation patterns ("teacher fidelity to textbook": χ^2 [3]= 174.844, p <0.01; "type of textbook": χ^2 [3]= 173.382, p <0.01; "teacher use of understanding-oriented student objective" variable: χ^2 [3]=174.623, p <0.01). The rest of variables included in the final model were found to be insignificant. However, since the p-value of these variables are smaller than 0.25, it was expected that when taken collectively, considerable confounding can be present in the data.

Table 5.17 reports the parameter estimates from the logistic regression model examining the effects of the independent variables on the distinction of teachers in the L-L pattern and teachers in the L-H pattern from teachers in the H-H pattern.

Table 5. 17 *Parameter Estimates from Logistic Regression Model Examining Effects of Predictor Variables on the Distinction between Patterns in Transformation Phase 3*

	Patterns in Transformation phase 3					
	L-L		L-H		H-L	
Independent variable	(β)	Odds	(B)	Odds	(B)	Odds
Intercept	-9.793		-1.275		2.236	
Type of textbook						
[Conventional texts =1]	2.814	16.684	2.063	7.870	.839	2.306
[Standards-based texts=0]	-	-	-	-	-	-
Teacher fidelity to textbook	-3.448**	.032	-.121	.886	-.286	.752
Teacher view on textbooks	1.642	5.165	.716	2.047	.578	1.782
Teacher use of understanding-oriented objectives	-2.526	.080	-1.513	.220	-1.539**	.215
Teacher use of procedural fluency-oriented objectives	2.130	8.419	1.502	4.490	-.416	.660
Teacher beliefs about traditional approach	2.973*	19.548	-.959	.383	-.026	.974
PD observation experience	1.156	3.177	-1.419	.242	.196	1.217

Note. The reference category is H-H pattern. R2 = 0.332 (Nagelkerke), N=156. * p<.05, **p<.01

Table 5.17 shows that two factors—"teacher fidelity to textbook" and "teacher beliefs on traditional approach"—are found to be significant in characterizing teachers in the L-L pattern compared to teachers in the H-H pattern. None of factors are significant in characterizing teachers in the L-H pattern compared to teachers in the H-H pattern. Only one factor—"teacher use of understanding-oriented student objective" --is significant in characterizing teachers in the H-L pattern compared to teachers in the H-H pattern. A closer look at the coefficients (β) of these factors found to be significant reveals interesting findings in each contrast.

Factors Distinguishing L-L Pattern from H-H Pattern

Two factors—"teacher fidelity to textbook" (β =-3.448, p <0.01) and "teacher beliefs about traditional approach" (β =2.973, p <0.01)—are found to be significant in characterizing teachers in the L-L pattern compared to teachers in the H-H pattern. First, the logistic regression coefficient for "teacher fidelity to textbook" is significant and negative. This result implies that for "teacher fidelity to textbook" variable, teachers in the L-L pattern were less likely to report that their lesson came directly from the textbook than teachers the H-H pattern.

Second, the coefficient of "teacher beliefs about traditional approach" variable is significant and positive. For "teacher beliefs about traditional approach", questions which presented the categories of contrasting statements about teaching philosophy—(1)

Facilitator vs. Explainer and (2) Multiple activities vs. Short-term whole-class assignment -- were used. Teachers were asked to rate these two pair of statements on a 4-point Likert-type scale in such a way so as to indicate which statement among the pair came closer to their own point of view. Although previous research conducted on this topic in various ways, I used this contrasting statement to categorize teacher beliefs about traditional approach. One is called traditional approach and the other is constructivist approach. "Teacher beliefs about traditional approach" means importance of a role of the teachers' as explainer over facilitator and importance of short-term whole-class assignment over multiple activities (see Chapter 4 or Appendix for more specific explanation). The positive coefficient of this factor indicates that, in this study, "teacher beliefs about traditional approach" factor increases chance of teachers being categorized into the L-L pattern rather than into the H-H pattern. This means that if teachers report strong agreement with the role of a teacher as an explainer and use of short-term whole-class assignment, they are more likely to be categorized into the L-L pattern than into the H-H pattern.

The odds ratio in Table 5.17 presents a measure of effect size, which is relative importance of the independent variables in terms of effect on the dependent variable's odds. "Teacher beliefs about traditional approach" (19.548) has the strongest effect on characterizing teachers in the L-L pattern from teachers in the H-H pattern, followed by "teacher fidelity to textbook" (0.032).

Factors Distinguishing H-L Pattern from H-H Pattern

Only one factor—"teacher use of understanding-oriented student objective" factor (β =-1.539, p <0.01)--is significantly related to distinguishing teachers in the H-L pattern from teachers in the H-H pattern. The regression coefficient for "teacher use of understanding-oriented student objectives" is negative, suggesting that frequent use of understanding-oriented student objectives decreases chance of teachers being categorized into the H-L pattern. Teachers who report the frequent use of student objectives categorized as understanding-oriented student objectives are likely to be categorized into the H-H pattern. That is, teachers in the H-L pattern reported less frequent use of understanding-oriented student objectives. This result explains why teachers in the H-L pattern decrease the cognitive level of teacher questions in their teaching or at least it contributes to explaining this trend.

Factors Distinguishing H-L and L-H from L-L Pattern

Table 5.18 reports the parameter estimates from the logistic regression model examining the effects of the independent variables on the distinction of teachers in the L-H pattern and teachers in the H-L pattern from teachers in the L-L pattern.

Table 5.18 *Parameter Estimates from Logistic Regression Model Examining Effects of Predictor Variables on the Distinction Based on the L-L Pattern in Transformation Phase 3*

	Patterns in Transformation phase 3			
	L-H		H-L	
Independent variable	(*B*)	Odds	(*B*)	Odds
Intercept	8.518		12.029	
Type of textbook				
[Conventional texts =1]	-.751	.472	.839	2.306
[Standards-based texts=0]	-	-	-	-
Teacher fidelity to textbook	-3.327*	27.860	3.163*	23.635
Teacher view on textbooks	-.926	.396	-1.064	.345
Teacher use of understanding-oriented objectives	1.102	2.752	.987	2.683
Teacher use of procedural fluency-oriented objectives	-.629	.533	-2.546	.078
Teacher beliefs about traditional approach	-3.932*	.020	-2.999*	.050
PD observation experience	2.575*	.076	-.959	.383

Note. The reference category is L-L pattern. R2 = 0.332 (Nagelkerke), N=156. * p<.05, **p<.01

Three factors are found to be significant in distinguishing teachers in the L-H pattern from teachers in the L-L pattern in transformation phase 2: "teacher fidelity to textbook" variable (β=-3.327, p <0.05), "teacher beliefs about traditional approach (β=-3.932, p <0.05), and "PD observation experience" factors (β=2.575, p <0.05). The coefficients of "teacher fidelity to textbook" variable and "teacher beliefs about traditional approach" are significant and negative, suggesting that teachers in the L-H pattern were less likely to report that their lesson came directly from the textbook than teachers in the L-L pattern; and they were also less likely to report agreement with the role of a teacher as an explainer than teachers in the L-L pattern.

The coefficient of "PD observation experience" is significant and positive, indicating that teachers in the L-H pattern are more likely to report their frequent participation of observation experience in their professional development programs than teachers in the L-L pattern.

Two factors--"teacher fidelity to textbook" variable ($\beta = 3.163$, $p < 0.05$) and "teacher beliefs about traditional approach ($\beta = -2.999$, $p < 0.05$)—are also found to be significant in distinguishing teachers in the H-L pattern from teachers in the L-L pattern in transformation phase 2. The coefficients of "teacher fidelity to textbook" variable is positive whereas the coefficient of "teacher beliefs about traditional approach" is negative, suggesting that teachers in the H-L pattern were more likely to report that their lesson came directly from the textbook than teachers in the L-L pattern; and they were less likely to report agreement with the role of a teacher as an explainer than teachers in the L-L pattern.

The odds ratio in Table 5.18 indicates that "teacher fidelity to textbook" (27.860) has the strongest effect on distinguishing teachers in the L-H pattern from teachers in the L-L, followed by "PD observation experience" (0.076) and "teacher beliefs about traditional approach" (0.20). For distinction between teachers in the H-L pattern from teachers in the L-L, that "teacher fidelity to textbook" (23.635) has the strongest and followed by "PD observation experience" (0.050).

Summary

This chapter presented the findings from multinomial logistic regressions that examined which factors were associated with various textbook transformation patterns exhibited in Transformation phase 1, Transformation phase 2, and Transformation phase 3, respectively.

The factors that distinguish teachers in the H-H pattern from teachers in the other patterns were found to be "type of textbook", "teacher fidelity to textbook", "teacher use of understanding-oriented student objectives" and "teacher pedagogical content knowledge" across Transformation phase 1, Transformation phase 2, and Transformation phase 3. Compared to teachers in the L-L pattern and teachers in the L-H pattern, teachers in the H-H pattern are more likely to use "standards-based" curriculum; report heavier reliance on their textbook in the selection of problems, questions, and homework assignment; report the frequent use of student objectives categorized as understanding-oriented; rate their level of pedagogical content knowledge higher than teachers in other transformation patterns. In other words, teachers in the L-L pattern and the L-H pattern are more likely to use conventional textbooks; report less reliance on their textbook; less use of understanding-oriented student objectives; and report lower level of pedagogical content knowledge compared to teachers in the H-H pattern.

In addition to the factors described above, several factors were found to important indicators that characterize teachers in the L-L pattern, teachers in the L-H pattern, or teachers in the H-L pattern compared to teachers in the H-H pattern. "Teacher use of procedural fluency-oriented student objectives" was found to increase chance of teachers being categorized into the L-L pattern compared to teachers in the H-H pattern. Teachers in the L-L pattern are likely to report more frequent use of procedural fluency-oriented student objectives than teachers in the H-H pattern.

"Teacher perception of student mathematics achievement (high achieving vs. other achievement levels)" is a factor characterizing teachers in the L-H pattern compared to teachers in the H-H pattern. Teachers in the L-H pattern are more likely to report their students' mathematics achievement level as mostly high achieving than teachers in the H-H pattern.

Furthermore, "teacher use of understanding-oriented student objectives" was found to be an important factor that explains the differences between teachers in the H-H pattern and teachers in the H-L pattern. Teachers in the H-L pattern are more likely to report less frequent use of understanding-oriented student objectives than teachers in the H-H pattern.

These factors identified from this chapter provide a possible reason for why different textbook transformation patterns appeared in terms of cognitive demands. Based on the analysis of teachers' self-reports, the strongest factor that distinguishes teachers in the H-H pattern from other transformation patterns (i.e., the L-L pattern and the L-H pattern) is the type of textbooks teachers use. When teachers use standards-based curriculum, they are more likely to provide higher cognitive level of problems and questions in their teaching. These teachers at the same time are likely to use their textbooks closely and put more emphasis on understanding of mathematical concept than procedural-fluency.

However, teachers in the H-L pattern showed that even when teachers use standards-based curriculum, they can provide lower level of teacher questions since they put more emphasis on procedural-fluency than understanding of mathematical concepts.

When teachers use conventional textbooks, some teachers are likely to provide the lower level of mathematical problems and teacher questions (L-L pattern) whereas others provide the higher level of mathematical problems and teacher questions in teaching (L-H pattern). Teachers in the L-L pattern, teachers who provide lower level of mathematical problems and teacher questions with conventional textbook, are more likely to put more emphasis on procedural-fluency than understanding of mathematical concepts and to perceive the role of a teacher as an explainer rather than a facilitator.

However, teachers in the L-H pattern, teachers who provide higher level of mathematical problems and questions in their teaching are more likely to perceive their students' mathematics achievement as mostly high achieving. Because of different perception of student mathematics achievement, some teachers are likely to transform the lower cognitive demand of mathematical problems and teacher questions presented in textbook into higher level in their teaching.

The factors that distinguish teachers in the L-H pattern from teachers in the L-L pattern were found to be "teacher views on conventional textbook", "teacher use of understanding-oriented teaching goals", and "teacher observation of experts' teaching during professional development programs." Compared to teachers in the L-L pattern, teachers in the L-H pattern are less likely to agree that they were pleased with their textbook than teachers in the L-L pattern; these teachers moreover are more likely to report heavier emphasis on understanding-oriented teaching goals and to report their frequent opportunities to observe expert teachers and to be observed teaching during their professional development programs than teachers in the L-L pattern.

Interestingly, teachers' fidelity to their textbook--teachers' faithful use of their textbook--was found to be an indicator that distinguishes teachers in the H-H pattern from teachers in other patterns. According to teachers' reports, the more teachers closely follow their textbook, the more they tended to be categorized into H-H pattern. Although teachers' fidelity to their textbook is often criticized by reformers or educators (e.g., Apple & Jungck, 1990), the finding of this study suggests that teachers' fidelity to their textbook itself should not be considered the indicator or criteria to gauge teachers' practice; teachers' fidelity to their textbook should be considered in conjunction with the type of textbook teachers' use.

However, these findings are based on teachers' self-reports. Despite these insights about teachers' use of textbooks, previous studies identified significant discrepancies between teachers' reports and the practices observed by researchers (Cohen et al., 1997). To minimize this kind of criticism drawn from methodological limitation and to examine how the findings from teachers' reports work in actual practice, this study further examined teachers' textbook use and influential factor through case studies. Next chapter will present the findings from the case studies.

Chapter 6

RESULTS FROM THE CASE STUDIES:

TEACHERS' TEXTBOOK TRANSFORMATION PATTERNS AND INFLUENTIAL FACTORS

This chapter presents the findings from the case studies that examined how teachers transformed problems and teacher questions in terms of cognitive demands as they moved content from text to teaching when teaching units about fractions. The case studies also examined factors influencing teachers' textbook use in teaching. I sought to answer the same research questions in the case studies as those in the survey: (1) What transformation patterns do elementary teachers exhibit as they move fraction content from text to teaching if the transformation is looked at in terms of the cognitive demands of problems and questions? (2) What factors are associated with these transformation patterns? The case studies were conducted to establish the validity of the written survey and to provide additional details about teachers' transformation patterns that can not be obtained from the survey.

This chapter is organized into four sections. The first section summarizes how the case study participants were chosen, the method used to collect and analyze data, and the overview of patterns identified from the case studies. In most cases, the patterns observed in the case studies were consistent with the patterns of teachers' responses on the survey. However, this chapter also examines cases in which the results of the survey did not correspond to the patterns observed in the case studies.

Three transformation patterns from textbook to teaching were exhibited in the case studies: The second section describes a representative case of teachers who use higher level problems and questions in their teaching. The third section describes a representative case of teachers who use higher level of problems from their textbooks but use lower level of questions in their teaching. The fourth section describes a representative case of teachers who use lower level problems and questions in their teaching. In each section, I attempt to infer possible reasons why each pattern appears. In addition, by cross-case comparison and analysis, I also attempt to explore why discrepancies occur between teachers' responses on the survey and the case studies.

Methods Used to Select and Analyze Teachers for the Case Study

Among 169 survey participants, 52 teachers volunteered to participate in the case study. None of the teachers whose survey responses were categorized as the H-L pattern or the L-H pattern volunteered to participate in the case study. The grade level and types of textbook teachers use were considered to select the case study participants. Since understanding of fractions is developed intensively from fourth grade to sixth grade, teachers who were teaching these grade levels were considered first. Among 52 teachers, 27 teachers taught the targeted grade levels--fourth (6), fifth (15), and sixth (6) grade. I then tried to select teachers who used different types of textbooks (standards-based vs. conventional textbooks) since the finding from the survey showed that the type of textbook is an important factor in deciding the cognitive demand of problems and teacher questions in teaching.

Ultimately, eight teachers were selected to be observed and interviewed. More teachers classified as the H-H pattern in the survey participated in the case study than teachers classified as the L-L pattern since most of the teachers who were willing to participate in the case study were classified as the H-H pattern in the survey and a few teachers were classified as the L-L pattern. Table 6.1 shows a summary of the characteristics of the case study participants including transformation patterns identified from their responses on the survey (all names are pseudonyms).

Table 6. 1 *Information about the Case Study Participants*

Teacher	Grade	Teaching Year	Textbook used	Transformation pattern in Survey	
				Problems	Questions
Catherine	6	9	Connected Mathematics	HH	HH
Tom	5	33	Everyday Mathematics	HH	HH
Michelle	5	19	Investigations	HH	HH
Brad	4	7	Math Trailblazers	HH	HH
Karen	4	3	Math Trailblazers	HH	HH
Teri	5	13	Harcourt	LL	LL
JoAnne	5	14	*Investigations & Scott Foresman	HH	HH
Randy	5	33	Investigations & *Scott Foresman	LL	LL

Note: * signifies the main textbook

Each teacher was observed and interviewed at least once (and some twice) while they were teaching a fraction unit. During the observation, I took field notes focusing on problems and questions the teachers or students worked on. Interviews were tape-recorded. In the analysis of transformation patterns, audio-taped interview data, the transcripts of interviews, documents related to teachers' use of textbooks (teachers' lesson plan from the teacher's manual and my observation notes), and my observation were used.

As in the survey, transformation patterns in the case studies were explored by examining the relationship between the cognitive demand of problems and questions in textbooks and that of problems and questions used by teachers in their lesson(s). The first step of the analysis was to classify each problem and question presented in textbook lesson and used in the taught lesson as either high-level or low-level. Each problem in the textbook and in the taught lesson was classified into either high-level or low-level based on Stein and Smith's (2000) framework as described in Chapter Two. Similarly, teacher questions in the textbook lesson were categorized into three cognitive levels—high, medium, and low level--based on the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001). For the cognitive demand of teacher questions in taught lesson(s), teachers' reports on typical questions frequently used in their teaching and my observations were analyzed and classified as either high, medium, or low-level.

The second step of the analysis was to decide the overall cognitive level of problems and questions in the textbook lesson and taught lesson based on the selected the ratio of 1/3 (Kadijević, 2002; Sanders, 1966). For instance, if more than 1/3 of the total problems were high-level in textbooks and/or in teaching, textbook problems and problems used in teaching were considered as requiring *higher level* of student thinking. Otherwise, they were considered as requiring lower level of student thinking (see Chapter two for more detailed explanation).

Three transformation patterns were exhibited in the case studies. One pattern occurred when teachers provide higher level problems and questions from a textbook, and they use higher level problems and questions in their teaching. For example, a teacher used the following problem presented in *Math Trailblazers* (Grade 4, Wagreich, et al, 2004, p. 922), "Look for patterns in the number sentences, $\frac{1}{2}=\frac{2}{4}$, $\frac{1}{2}=\frac{4}{8}$, and $\frac{1}{2}=\frac{5}{10}$ and find another equivalent fractions." This problem requires students to focus on the relationship between numerators and denominators and use the patterns, as opposed to simply following the rule, in order to find other fractions equivalent to one half. This teacher also used questions presented in the teacher's manual of *Math Trailblazers* that require students to engage in thinking, reasoning, problem-solving, justifying, and communicating about mathematics. These questions include the language like “look for”, “explain”,” justify”. Problems and questions presented in this pattern require students to use *procedures with connection* to concepts, meaning or understanding and *doing mathematics* (Hiebert, 1999; Stein & Kim, 2007). Four teachers (Catherine, Tom, Michelle, and Brad) were identified as having taught lessons which correspond to this pattern. All four used standards-bases mathematics curricula.

Another pattern occurred when teachers use higher level problems from a textbook, but use lower level of teacher questions in teaching. Karen and JoAnne were classified as following this pattern. Although these teachers used standards-based curricula and presented the suggested examples and problems from the lesson guide, they shifted the focus from finding relationships to following rules, used teacher questions that require only a correct answer, and thereby provided lower level student learning opportunity.

The third pattern occurred when teachers use lower level problems and questions from a textbook in their teaching. For example, one teacher used the following problem presented in *Scott Foresman - Addison Wesley Mathematics* (Randall, et al., 2005, pp. 372), “Find the sum. Simplify, $3\frac{1}{3}+2\frac{1}{6}$.” This problem requires students to use a well-established procedure for finding the sum, and not to connect the procedure to meaning or the underlying concepts—the need for the same whole unit in order to add two fractions with unlike denominators. In keeping with the cognitive demand of the problem, this teacher used questions that focus on merely getting the one answer. Most of the classes observed that were taught the problems and questions by teachers (Teri, JoAnne, and Randy) in this pattern required the use of procedures without connection to concepts, meaning or understanding or memorization (reproducing previously learned facts, rules, formulae, or definitions or committing them to memory) (Romberg, 1983; Stein & Kim, 2007).

Teri used a conventional textbook. JoAnne and Randy used a combination of standards-based and conventional textbooks in their classrooms. Depending on the type of textbook she used, JoAnne's teaching was categorized into either the L-L pattern (with conventional textbook) or the H-L pattern (with standards-based textbook). Although JoAnne indicated in the survey that the standards-based curricula as her main textbook, she used the conventional textbook on the first day I observed her lesson. Although she selectively used problems and teacher questions from the conventional textbook, she ended up with providing lower level cognitive demand of problems and teacher questions. When I observed a second lesson, she used the standards-based curriculum and provided the problems that require multiple representations for fractions in her teaching. But like the case of Karen, she used teacher questions that require only correct answers rather than engaging in thinking and reasoning.

Among the eight teachers, two teachers--Karen and JoAnne--showed discrepancies between their responses on the survey and actual teaching. These two teachers commonly reported using higher level teacher questions in their teaching with textbooks presenting higher level teacher questions (the H-H pattern) in the survey. However, in my observation, they were categorized as using lower level teacher questions with standards-based curriculum, which is the H-L pattern in terms of the cognitive demand of teacher questions (notice JoAnne also was categorized as the L-L pattern with conventional textbook).

The following sections will describe each transformation pattern in detail combined with the analysis of the cognitive demand of problems and questions presented in textbook lessons and that of problems and questions used in lesson(s). To describe each of the three main transformation patterns, one case was selected as representative. Each case functions as an anchor to make comparisons among and generalizations about other teachers in the same pattern. For the H-H pattern, the case of Brad was selected and for the L-L pattern, the case of Randy was selected. For the H-L pattern, Karen's case is used. Although the case of JoAnne is interesting, her use of standards-based textbook can be explained from the case of Karen and her use of conventional textbook can be explained from the case of Randy. In addition, since Karen and Brad were categorized into different transformation patterns even though they taught the same lesson with same textbooks, it was interesting to see why such different transformation patterns appeared.

Within-case analysis and cross-case comparisons between the transformation patterns allowed me to infer possible explanations of why teachers use the same textbook differently or use a different textbook in a similar way as well as why discrepancies occur. Although one selected case was used to describe each transformation pattern, interview data from other teachers in the same pattern were also used to describe and elicit the possible reason why teachers used their textbooks in such a way and why the discrepancies happened between teachers' response on the survey and actual teaching.

Higher Level Textbook Problems and Questions to Higher Level Problems and Questions in Teaching: Pattern 1

Four teachers use tasks in ways that can be described as the H-H pattern, in which teachers have textbook problems that provide higher level problems and questions, and they use higher level questions in their teaching. All used "standards-based textbooks", which were developed based on a philosophy for learning and teaching mathematics that is consistent with that of NCTM standards (1991, 1999, & 2000). However, it is not the use of standards-based textbook alone that sets these four teachers apart from other teachers. It was also the conception of knowing and doing mathematics represented in higher level of problems and supported by higher level of teachers' questions in his practice set him apart from teachers in other patterns. The features of the following vignette from Brad's teaching exemplify practices of other teachers in this pattern.

A Vignette of Brad

Brad has 7 years of teaching experience at the elementary school. The school in which he taught serves students from both middle and working-class backgrounds. Brad described his class as "average achieving" in mathematics achievement. On average, a slightly lower percentage of students in the school (82%) met or exceeded standards for mathematics of the 2007 Michigan Educational Assessment Program (MEAP) than that of the state average (85%).

On the day I observed Brad's lesson, he taught the topic of equivalent fractions using *Math Trailblazers* (Wagreich et al., 2004). Before observing his class, Brad gave me a copy of his lesson plan, reproduced as Figure 6.1, which came directly from the teachers' manual of his textbook.

At a Glance
1. Ask students to use their fraction chart from Lesson 3 to find all of the fractions that are equivalent to ½. List these on the board or overhead. 2. Ask students to compare the numerators and the denominators of the equivalent fractions in order to look for patterns. 3. Ask students to suggest other factions that are equivalent to 1/2 4. Write number sentences on the board or overhead showing the equivalencies 5. Students look for patterns in the number sentences 6. Students use the patterns (multiplying or dividing the numerator and the denominator by the same number) to find fractions equivalent to 3/4, 1/3, and 2/5. 7. Students use the patterns to complete number sentences involving equivalent fractions 8. Students complete *Questions 1-5* on the *Equivalent Fractions* Activity Pages in the Student Guide as independent practice 9. Assign Homework *Questions 1-15* on the *Equivalent Fractions* Activity Pages in the Student Guide. Students will need their fraction charts to complete this assignment

Source: From *Math Trailblazers Fourth Grade Teacher's Lesson Guide* (p. 924), by Wagreich, P., Goldberg, H., Bieler, J.L., Beissinger, J.S., Cirulis, A., Gartzman, M., Inzerillo, C., Isaacs, A., Kelso, C.R., & Peters, L(2004), TIMS Project, Dubuque, IA:Kendall/Hunt.

Figure 6. 1 Summary of Lesson Activities in a Lesson

Brad started out his lesson by reviewing what students learned in the previous lesson, such as finding the missing factor in a number sentence and the multiples of 2s. Then he began the "teacher-led" activity suggested in the lesson guide. He asked students to find equivalent fractions to one half using a fraction chart that they used in the previous lesson. By looking at fraction chart, students found all fractions equivalent to one half, for example, "two fourths, three sixths, four eights, five tenths, and six twelfths." When students said that there were no more equivalent fractions, Brad said "those are the equivalent fractions to one half on our charts. Are there more equivalent fractions to one half?" Students agreed that there were more equivalent fractions. From there, Brad introduced the topic saying "today we are going to find equivalent fractions".

As suggested, Brad listed all equivalent fractions to one half on the board, such as $\frac{1}{2}=\frac{2}{4}=\frac{3}{6}=\frac{4}{8}=\frac{5}{10}$. He then asked students to explore the patterns among denominators "two, four, six, eight, and, ten". Students found that "they are all even, skipping counting, multiples of two". Brad continued to have students explore the relationship between the numerator and denominator of each equivalent fraction. Students found the patterns, which are "Double the numerator and you get a denominator", "two times the numerator is the denominator", and "the numerator is half of the denominator."

As students figured out the relationship, Brad then put a fraction $\frac{20}{40}$ and $\frac{15}{30}$ on the board and asked students to see whether these fractions were equal to one half. He then said to his students "you know me, right? If you say "yes", I am going to say, "how do you know"? If you say "not", [I say] "why not?" When Brad called on one student, he answered "because if we take way the zeros it's just the same as two fourth." Another student added that "because twenty plus twenty equals forty and that (20) is half of 40". In watching Brad interact with his students, it was obvious that a teacher-led activity in his class involves discussion with the teacher and students rather than recitation or lecture in which only the teacher talks. In particular, by using teacher questions that require reasoning and explanation, Brad seemed to try to elicit opinions and ideas--not just "right" answers-- from students.

As students were able to recognize the relationship between the numerator and the denominator of fractions equivalent to one half (e.g., the numerator is half of the denominator), Brad set equivalent fractions separately, for example, $\frac{1}{2}=\frac{2}{4}$, $\frac{1}{2}=\frac{4}{8}$, and $\frac{1}{2}=\frac{5}{10}$, and asked students to explore the relationship in the number sentences. For example, pointing out the first number sentence, he asked students to look at two equivalent fractions and find any pattern *by comparing the numerators of the fractions and then the denominators*.

Although most of students seemed to see the relationship at the end of the class, which is "one times two is two" and "two times two equals four," several students struggled with finding this relationship and provided incorrect answers. One common error that repeatedly came up in his class was comparing the denominator of the first fraction and the numerator of the second factions to find the pattern. For example, in the first number sentence $\frac{1}{2}=\frac{4}{8}$, one selected student answered, "If you take four and time it two you get eight." This gave me an opportunity to see how Brad reacted to those students and what kinds of questions he used.

One of the challenges that many teachers face when they try to conduct lessons that take account of and productively build on student responses is how to respond to students' incorrect response (e.g., Ball, 2001; Brown & Campione, 1994; Chazen & Ball, 2001; Lampert, 2001; Leinhardt & Steele, 2005; Schoenfeld, 1998; Sherin, 2002). It is often reported that teachers take over students' thinking and reasoning, tell students how to do the problem, and thereby reduce the cognitive demands of student thinking (Stein & Smith, 2000).

However, in this instance, and many other similar instances, Brad accepted the student's incorrect reasoning and had students discuss it. Sometimes, he redirected and let students know what he wanted them to look at in order to find the relation between the number sentences. For example, Brad responded back to the student "Okay, but you are looking at the numerator and denominator four eights. I want you to compare the *numerator* of one half to the *numerator* of four eights". Then he asked another student to share her/his ideas. The selected student answered "You multiple it one times four equals four". These strategies seemed to work well in his classroom. When Brad asked students to find the relationship in the rest of the number sentences, students responded correctly and were able to explain why. Indeed, this strategy gives students an opportunity to listen to each other, and not just take the teacher's word.

When students were able to find the pattern in number sentences, Brad asked students to generate the rule for equivalent fractions. He first went over the process they did in each number sentence $\frac{1}{2}=\frac{2}{4}$, $\frac{1}{2}=\frac{4}{8}$, $\frac{1}{2}=\frac{5}{10}$, $\frac{1}{2}=\frac{6}{12}$, and asked to students, "How could we use what we did here to help us find another equivalent fraction for one half?" Several students tried out their conjecture, but they could not articulate the rule for finding equivalent fractions. In response, Brad gave the rule saying "you multiply the numerators and the denominator by the same number to get an equivalent fraction." Several students shouted out "cool." After letting students know the rule, Brad asked students to find equivalent fraction to one half by multiplying the number "eight" and "nine." Students came up with "eight sixteenths" and "nine eighteenths." These students' correct responses made me think that students were capable of using the rule that Brad told without much difficulty in order to find equivalent fractions.

Like teachers in other patterns, Brad did not continue to push students to generate the rule for finding equivalent fractions when students could not create the rule. However, one feature that distinguishes his practice from teachers in other patterns was that Brad did not just ask students to use the rule but also asked them to verify the rule. After letting students know the rule for finding equivalent fractions, Brad asked students to apply this rule to find equivalent fractions, for example, to three fourths, and also check that answer from a fraction chart. He said "let's see if we can prove it with one that is on your fraction chart. Now, three fourths is equivalent to six eights. Look at three fourths. Look at six eights. Is it true?" Students said "yes." Brad not only used this questioning technique, but was intentional in his use of it. For example, in an interview, he said,

> On the fraction chart, it shows fraction one through twelfth. I want them to recognize and physically see it that three fourths is equal to six eighths. They can look at that from the fraction chart and say "I can see it, three fourths is equal to six eighths". Or if I say, they are going to take my word for it that those are equivalent. It's going to be less connection because they could not see that for themselves (interview, 4/24/2007).

Brad said that he wanted to have his students recognize how the rule works for finding equivalent fractions. It was interesting to see that Brad transformed a lower level question, which is "apply the rule to find equivalent fractions", into a higher level one, "prove it", using the context. With additional examples, Brad and his student repeated the validation process---applying the rule and then checking the results from the fraction chart. This lesson took 45 minutes. Brad only covered an introductory "teacher-led" activity up to statement five in Figure 6.1. From the perspective of someone who didn't see the lesson, it might appear that Brad did only the "teacher-centered" part of the lesson, which might lead one to assume that his teaching was more conventional, less constructivist, and lower level in its cognitive demand. Instead, he turned the "teacher-led" activity into one which was facilitated by the teacher but depended on students' discovery of patterns and reasoning concerning the rule for finding equivalent fractions.

On the following day, he continued to cover the remaining parts in the lesson guide. He used problems and examples presented in the teacher's manual in the same manner he did on the first day. He also assigned _Questions 1-5_ from the Activity Pages, as_suggested in the lesson guide, to his students. Students worked individually on that assignment. He worked around and gave some help. When I went around, I noticed all but a few students in his class solved the problems correctly.

Similarities and Differences between the Textbook Lesson and the Lesson Taught in Terms of Cognitive Demands

Although Brad spent more than the one period the textbook recommended for this lesson, he closely followed suggestions presented in the lesson guide. Most of the examples, problems, and teacher questions came directly from the teachers' manual of *Math Trailblazers*. Therefore, he (at least) maintained the cognitive demand of the student objectives, the problems, and the teacher questions presented in textbooks.

Lesson goals As suggested in Figure 6.1, the students are expected to find patterns and use these patterns to find other equivalent fraction. This objective asks students to develop a conjecture, which correspond to a higher level student objective category, *reasoning,* in the Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001).

During the interview, Brad said that his goal was the same as the goal presented in the lesson guide. During the interview, Brad said,

> Today I tried to get them discover for themselves. "Look for the pattern and tell me what you see." And then through class discussion, different kids were talking about it. I hope they would draw the conclusion and they came up with discovery to me (interview, 4/24/2007).

His goal is not to use the algorithm to find equivalent fractions. Brad set the goal for students to develop an understanding of equivalent fractions and use that understanding to develop a conceptually based algorithm. Brad's goals are thus aligned with the textbook, and in keeping with higher level cognitive demand.

Problems The cognitive demands of problems were analyzed in both an introductory teacher-led activity as well as student-exercise. In Brad's class, mathematical problems in the teacher-led activity include: (1) Find all of the fractions from a fraction chart that are equivalent to 1/2, (2) Look for patterns by comparing the numerators and the denominators of the equivalent fractions to one-half, (3) Look for patterns in the number sentences involving fractions equivalent to one half, and (4) Find fractions equivalent to 3/4, 1/3, and 2/5 using the patterns (multiplying or dividing the numerator and the denominator by the same number). Based on Stein and Smith's framework (2000), these problems require students to use *procedures with connection* to concepts, meaning or understanding, which demand complex thinking and reasoning and a considerable amount of cognitive effort.

Brad assigned a total of sixteen problems as a student exercise in the Equivalent

Fraction Activity of the student textbook. Some problems are presented with contexts whereas other problems are without context. For example, the first problem is addressed in the real-world context where Elam wants to know how many eighths of a cup of sugar is the same as three fourths of a cup to bake some cookies. In this problem, students are asked to explain a strategy that Elam can use and find the missing numerator. This problem requires student not just to use the procedure for equivalence between two fractions, $\frac{3}{4} = \frac{(\ )}{8}$, but also to do the reasoning and explain it, which demands a considerable amount of cognitive effort.

However, there are also problems that require the recall of the previously learned rule for finding equivalent fractions in "student exercise", for example, "complete the number sentence, $\frac{3}{4} = \frac{?}{8}$ and check your work using your fraction chart (Wagreich et al., 2004, p. 224)." Without understanding Brad's class, this problem can be categorized as requiring lower level cognitive demand. However, as the following comment indicates, from his viewpoint, this problem was very meaningful to his students.

> Seeing the equivalent fractions when they multiply numerator and denominator times the same number, they give me equivalent fractions. Looking at the fraction chart and seeing that, because I think that's the part they are going to thinking, that's going to give them most understanding as opposed to just knowing the rule. Yeah, I want them to know the rule, follow the equivalent fraction rule. That's important.... But, as a teacher I want those kids to understand exactly what that means when they are making equivalent fractions. That means that kids know that they [equivalent fractions] are equal and they can see it (interview, 4/24/2007).

Through the discussion in Brad's class, students attempted first to find patterns, then to derive the rule, and finally to verify the rule from a fraction chart. Therefore the above problem that could have involved just reproducing the equivalent fraction rules *instead* involved justification and verification of procedures to find equivalent fractions, which lead to deeper levels of understanding of the idea of equivalent fractions. Indeed, the cognitive demand of the problem depends on how it was used in the context of the lesson. What might have seemed like a lower level cognitive demand problem, in the context of Brad's lesson, became part of a higher level cognitive demand process. This problem therefore required students to use *procedures with connection* to concepts, meaning or understanding.

Although general procedures may be followed to find equivalent fractions, students do not need to follow the procedures mindlessly. Brad's teaching suggests that a teacher can help students use procedures with connections to the conceptual ideas that underlie the procedures and develop understanding. Overall, most of problems presented in the textbook and used by Brad require higher level student thinking.

Teacher Questions The question most frequently used in Brad's class was "What are the patterns between the numbers and the denominators?" which is suggested in the lesson guide of *Math Trailblazers*. Figure 6.1 indicates specific teacher questions suggested in the lesson guide. Many use verbs which require higher level thinking *of students*, such as asking students to "compare" fractions and "look for patterns". In my observation, I noticed Brad using these questions frequently. In addition, he also frequently used teacher questions that require students to explain, justify, and verify their thinking, for example, "How do you know?", "Is it true?", "Prove it." These questions led students to see the need to explain their ideas, make conjectures, test them out, and verify them, which require higher level thinking of students. In an interview, he provided his rationale for using this type of questions,

> One point I said, "You know me. I need you to explain *why*". Because that's never enough for them to just say "here is the answer". I always want them to explain why. For this, I want them to explain why that works. I need to explain their thinking and give them a deeper understanding. And a lot of time, they are right in their math and in their explanation I have to write out how they solve the problem. They get used to talking like that. That's going to easier for them to write like that too. I don't ask "yes or no" type of questions. I am always pushing them to explain their thinking (interview, 4/24/2007).

The cognitive demand of problems alone does not guarantee students' higher level of learning opportunities. Classroom discourse—e.g., the ways the teacher uses questions, the way teacher and students talk, what they talk about, how they agree and disagree—are important to the cognitive demands because they can fundamentally transform the cognitive demand of a particular task as a teacher enacts them in the classroom (Spillane & Zeuli, 1999). Overall, Brad constantly used teacher questions that require students to see relationships between fractions, explain and justify their thinking, verify it, and thereby maintained the complexity of the mathematical problems. Similarly, the other three teachers categorized in this pattern closely followed their textbook lesson(s) and maintained the higher level cognitive demand in their teaching.

Influential Factors on the Textbook Transformation Pattern

One noticeable feature that sets teachers in this pattern apart from teachers in other patterns is their faithful use of textbooks that provide higher level problems and teacher questions. For example, Brad claimed to be a "follower" of the textbook. In the survey, he strongly agreed that he was pleased with the textbooks and that the textbook series matches what he thought was important in mathematics. He also strongly agreed that he used the textbook as a primary resource. In keeping with this, he reported rarely omitting questions or activities presented in his textbook and almost every day using the problems and questions in the textbook exactly as they are phrased. Therefore, survey responses confirm this conclusion about his faithful use of the textbooks.

However, textbook use is not the sole factor that determines the content of mathematics instruction in his classroom. During interviews, he said that although he used their textbook as a primary resource, the Grade Level Content Expectations (GLCE) from the State of Michigan decide what gets taught in his classroom.

> First thing is we got the Grade Level Content Expectations from the State of Michigan and So I look at that. If a lesson doesn't necessarily fit with what the content expectation

> is to be taught, we might omit it or omit part of it. Because what we found was that we are given all these grade level content expectations (GLCE), so we got all these GLCEs needed to be covered. But if we taught everything in Trailblazers in the order that it is in there, we aren't going to get to the GLCEs. So we have to start omitting something that were in the *Trailblazers* some lessons that weren't going to help to teach those GLCEs. And also for everything that wasn't in Trailblazers but was expected to teach, then we have to supplement. In the fractions unit, in particular, we teach it all [lessons presented in *Trailblazers*] because there are so many GLCEs related to fractions. In the case of Trailblazers there things aren't in Trailblazers, we need to supplement (interview, 4/24/2007).

Indeed, this practice of maintaining higher level problems and teacher questions in teaching is important because it has the potential to suggest a different idea of what counts as mathematical knowledge and doing mathematics in school. For teachers in this pattern, mathematics was not presented as a statement of end products—definitions, rules, procedures-for memorization. Rather, the problems used by teachers in this pattern exposed concepts and ideas that can be used to construct procedures for solving problems (Lampert, 1986).

Moreover, along with questions requiring higher level of student thinking, doing mathematics in these teachers' classroom does not mean mainly following predetermined steps to compute correct answers (Greeno, 1990; Romberg, 1983; Spillane & Zeuli, 1999). As showed in Brad's classroom, doing mathematics involves engaging in mathematical thinking, offering conjectures, responding to one another's ideas (and the teacher's), and solving problems as well as explaining, justifying, and defending their ideas and solutions. This contrasts sharply with the manner of doing mathematics in other classrooms where mathematics is typically presented as the statement of established mathematical truths. Such a different notion of doing mathematics and knowing mathematics sets teachers in this pattern apart from teachers in other patterns.

Analysis of interview data revealed two additional factors that are associated with maintaining a high level of cognitive demand in problems and questions used in teaching.

Understanding and sense-making as a teaching goal One common factor that influences these teachers' use of the textbook is their notion about how students learn. During interviews and in teaching practice, all four teachers--Brad, Tom, Catherine, and Michelle put priority on understanding and sense-making in learning mathematics. None of the teachers put priority on tests (e.g., MEAP) in teaching mathematics. As described earlier, Brad articulated his goal in teaching mathematics, in particular, knowing "why," not only knowing "how". Likewise, the other teachers in this pattern pointed out the importance of understanding and reasoning in learning mathematics. For instance, Tom, who has 33 years of teaching experience, closely followed *Everyday Mathematics* in my observation. He used textbook problems that require students to explore *relations* between fractions and decimals using representations (e.g., concrete, pictorial, symbolic) in teaching. He also used teacher questions that require students to explain, justify, and defend their answers using pictures and words. During an interview, he articulated his goals as follows:

> I want them to kind of think mathematically and be able to justify their answers and I use that same philosophy in science. So it's not whether or not they get the right answer. Whether they can defend their answers is the most important. The right answer is important but whether they have some thinking to backup their answers so that's the most important. So that's what I'm trying to get them to that point (interview, 12/05/2006).

Teachers in this pattern commonly said that students needed to learn not only mathematics concepts, procedures, and rules, but also mathematical ways of thinking, such as explanation, justification, and verification, which require higher level of thinking.

Alignment of Teachers' goals with the Standards-based curriculum Another common factor in this pattern is that all four teachers--Brad, Tom, Catherine, and Michelle perceived that the textbook they used matched well with what they wanted to teach. During the interview, all four teachers commonly reported that they really liked the textbook they were using because the conception of doing mathematics and knowing mathematics presented in the textbook matched with their notion about how students learn mathematics. For example, Tom said,

> I think if this is much better than the old method that we had, the old method was just practice memorization. This one is making them think more about mathematics and more creative. But it's a lot of regimentation. But at least it's making them think a little bit higher mathematically and down here (interview, 12/05/2006).

All four teachers remarked that they were pleased with their textbooks since the curriculum materials they used emphasized exploration and student understanding. Such emphasis presented in curriculum materials matched with their notion about how students learn mathematics. This factor accounts for us why these teachers closely follow their textbooks.

Higher Level Textbook Problems and Questions to Higher Level Problems but Lower Level Questions in Teaching: Pattern 2

Two teachers—Karen and JoAnne use tasks in ways that can be described as the H-L pattern in which teachers use textbooks that provide higher level problems and questions, but they use lower level teacher questions in their teaching. The case of Karen is used to illustrate his pattern although she used higher level problems, she regularly lowered the cognitive demand of problems by using lower level teacher questions, and thereby she eventually provided lower level student learning opportunities. Karen *infrequently* used teacher questions that require justifying and explaining their answers. The features of the following vignette exemplify practices of both teachers observed who followed this pattern.

A Vignette of Karen

Karen has four years of teaching experience. She works together with Brad at the same elementary school and in the same grade. Like Brad, Karen also perceived her students as mostly average achieving. I observed the same lesson "equivalent fractions" in Karen's class, which I observed in Brad's class.

On the day I observed Karen's lesson, the following terms were written in vertical order on the left side of the board, "$\frac{1}{2}$, denominator, numerator, $\frac{20}{40}$, other" were written in vertical order. On the opposite side of the board, the word "equivalent fraction" was written.

Like Brad, Karen began the lesson by reviewing what students learned previously. She asked students to "tell me one thing that you know about fractions." As students came up with their ideas about fractions, for example, "the top number is called a numerator and the bottom is called a denominator," or "the numerator tells you how many pieces we're looking at and the denominator says how many pieces make up the whole," Karen continued to connect students' ideas to other ideas by asking students what is the numerator and what is the denominator in $\frac{1}{2}$.

Karen then addressed the topic they were going to work with together. She said to her students "Today, we are going to talk about equivalent fraction" and asked students to write the words "equivalent fraction" down in their notebook. In Karen's class, "writing down" is one of the routines students use while studying mathematics. For the rest of the class, Karen frequently had students write down what she dictated.

As students finished writing it down, Karen started to use activities suggested in the lesson guide. Karen asked students to look at the fraction chart they used in the previous lessons and find all of the fractions that were equivalent to one half. Like Brad's class, students in Karen's class easily came up with the equivalent fractions. As suggested in the lesson guide, Karen asked students to arrange these equivalent fractions in an order such that a denominator gets bigger. As in Brad's class, students arranged them and Karen wrote them on the board, such as $\frac{1}{2}=\frac{2}{4}=\frac{3}{6}=\frac{4}{8}=\frac{5}{10}$. Karen again asked students to write this arrangement of these equivalent fractions down underneath the word "equivalent fractions" in students' notebook. In the meantime, she told them that all of these fractions are the same size.

As students finished writing down equivalent fraction sentence, Karen asked students to find patterns by comparing the denominators. Students noticed two patterns, "counting by twos" and "even", but they did not come up with the answer that Karen expected, which is multiples of two. In this instance, Karen interacted differently from Brad. While Brad gave hints, waited until students volunteered to answer, and had students discuss the incorrect answer, Karen told her students the expected answer. This interaction with students exemplifies how teachers decrease the cognitive demand of problems during instruction. Henningsen and Stein (2000) reported that teachers often decrease the cognitive demand of student thinking by taking over student reasoning and telling students how to do the problems.

For the rest of the lesson, I repeatedly observed this pattern. For example, after having students find the relationship between the numerators and between the denominators of fractions equivalent to one half, Karen asked students to look at the numerators and denominators together of each of equivalent fractions and find patterns. Several students responded, but none provided her expected answer. Karen again said to students "the numerator is half of the denominator, isn't it?" Indeed, Karen's telling was more obvious when students did not figure out patterns in the number sentences. She wrote four number sentences on the board and said;

> I have on the board four number sentences. Four number sentences. The first one, one half equals two fourths. The second one, one half equals four eighths. The third one, one half equals five tenths and the fourth one is one half equals six twelfths. Look at that pattern in these number sentences, first by looking at the numerators and then by looking at the denominators. What do you see?

$$\frac{1}{2}=\frac{2}{4} \qquad \frac{1}{2}=\frac{4}{8} \qquad \frac{1}{2}=\frac{5}{10} \qquad \frac{1}{2}=\frac{6}{12}$$

One student answered but his answer did not show the relationship between numbers and denominators. The same mistake occurred in Karen's class as in Brad's class. In both Karen's and Brad's classes, when students were asked to find the relationship in the number sentences as above, students tended to compare the denominator of the first fraction and the numerator of the second fraction, and find the relationship. For example, in Karen's class, one student found the relationship for the first number sentence, such as "If you take two and times it two you get four". Karen responded to this study as follows: "Is this what you were saying? One times two is?" Karen paused and students said "two". Karen again said "two times two is?" and paused. Students said "four."

Although Karen set up problems finding the relationship and used it to find other equivalent fractions, as students became confused, Karen gave the pattern as a rule that students needed to follow. Karen said, "Here is the rule. Get your pens ready. If you multiply both the numerator and the denominator of a fraction by the same number, the result will be an equivalent fraction". Karen asked students to copy out the rule in their notebook, and repeatedly stated the rule while students were writing the rule down. During an interview, Karen mentioned that "students need to memorize it to apply it," contrast with Brad who said that "students need to make a discovery for themselves."

By using the rule, Karen tried to have students see patterns in the rest of number sentences. For example, Karen asked students to take a look at the third number sentence $\frac{1}{2}=\frac{5}{10}$ and see whether the rule works. Some students nodded their heads to say yes and some kids shook their heads for no. She said that

> That's what the rule says. Multiply both the numerator, that's my numerator and the denominator by the same number. The result will be an equivalent fraction and I said over here that one half equals five tenths (interview, 04/27/2007).

Karen led the students through four number sentences involving equivalent fractions, all the while focusing on the procedure. For example, for the fourth number sentence, Karen repeatedly asked, "Three times what equals six?" Karen paused and students said "two." Karen asked again, "Four times what equals twelfths?" and paused. Students said "two." Karen's questions became procedure-oriented, required only multiplication facts. The conversations that Karen had with students during this portion of class revealed what her goal for the lesson was: writing equivalent fractions by applying the rule.

Like Brad, Karen asked students to explain and justify their answers. For example, Karen also asked students to see if it is true that one third equals two sixths. However, in her class, it was sufficient and acceptable for students to rely on the rule. Consider the following Karen' remark: "We said it's true if we could multiply both the numerator and the denominator by the same number to come up with the answer. What number do I multiply one times two is equal?"

During the final portion of the class, Karen had students work on the problems from the textbook, Questions 1-5 on the *Equivalent Fractions Activity Pages* in the *Student Guide*. Students occasionally raised their hands with questions. Karen answered individual questions. Karen ended up the lesson by asking students to create the number sentences involving equivalent fractions such as "one times two is two and six times two is twelve", which is expressed as $\frac{1 \times 2}{6 \times 2} = \frac{2}{12}$ in a numerical form. Karen called out one student. But the selected student said "I don't know how to do this". Karen called out other students. A few students could make the number sentences described above. Indeed, when I walked around while students worked on the student exercise problems, I noticed that a majority of students struggled with finding equivalent fractions.

On the following day, Karen continued to have her students work on problems that she did not cover in the previous lesson. She even had students work on homework problems in class, however, in the same manner she did on the first day. Karen kept emphasizing knowing procedures and applying it on the second day. For example, she repeatedly said "that what the rule said. Apply the rule" to find fractions equivalent to $\frac{3}{4}$, $\frac{1}{3}$, and $\frac{2}{5}$.

Similarities and Differences between the Textbook Lesson and the Lesson Taught in Terms of Cognitive Demands

There were similarities between Karen and Brad, chiefly on the dimension of the mathematical problems they set up. The same mathematical problem was used in both classes and was set up in essentially the same manner. The ways in which students actually went about working on the problems differed, however, in the two classes. During instruction, Karen shifted the emphasis from meaning, concepts, or understanding to using procedures. She took over students' thinking and reasoning and specified explicit procedures for finding equivalent fractions. As class went on, Karen's questions became much narrower, asking students to fill in the blank rather than construct an answer (e.g., "two times two is?). Karen attempted, and rarely managed, to elicit students' mathematical thinking using her questions.

Learning goal Indeed, Karen's goals for learning are not the same as Brad's. Brad's learning goals are for students to discover the patterns between equivalent fractions and use that pattern to find equivalent fractions. His priority is on meaning and sense-making. In contrast, Karen's learning goal is more procedural. During the interview, Karen articulated her learning goal as "proficiency in writing equivalent fractions" for the lesson I observed, and "mastering the concepts and applying it" in general. Like Brad, Karen remarked that "I want kids to be able to do that and explain themselves". However, the nature of "explaining" in Karen's class differs from the nature of explaining in Brad's. In her class, explaining is a tool for restating the process of how to apply the rule to get the correct answer. Karen changed the learning goal suggested in the lesson guide *from* developing relationship between equivalent fractions *to* using the procedure to find finding equivalent fractions, which is a lower level of student thinking.

Problems Karen used the same mathematical problems as those used in Brad's class for an introductory teacher activity and student exercise. Therefore, the problems set up in Karen's class focus students' attention on the discovery of patterns and the use of the patterns for finding equivalent fractions, which demands complex thinking and a considerable amount of cognitive effort.

Teacher Questions The questions most frequently used in Karen's class were "what number do we multiply?" which require only multiplication facts. In Karen's class, the procedure of "how to do it" was stressed above all else. In an interview, she confirmed her typical questions as below:

> I think probably the question that I asked over and over again and maybe not in this exact word is "What number should I multiply both the numerator and the denominator by to find the equivalent fraction?" I probably said that a hundred times (interview, 04/27/2007).

Her remark "a hundred times" shows not only how frequently she used this type of questions during the class but also how she was aware of her frequent use of this type of questions in her class. Students in Karen's classroom were rarely pushed to elaborate on their answers. If students' responses reflected the correct answer, the teacher did not raise follow-up questions to make students' mathematical thinking explicit. If students' responses reflected the incorrect answer, teachers paraphrased the answer, changing it to make it more "accurate." Although *Trailblazers* provide a lot of suggestions in the lesson guide for how teachers should approach questioning or approach discussing concepts, Karen did not use those questions. She shifted the emphasis of their work from meaning or understanding to the use of procedure without connections, and decreased the cognitive demands of teacher questions in ways that require lower level of student thinking.

Indeed, Karen used the similar questions that Brad used, such as "is that true?" However, in her class, explaining seems to means for describing *how to get the answer* rather than justifying and defending their ideas. It was sufficient and acceptable for students to rely on the rule in her class, which signifies that the nature of explaining requires different cognitive level of student thinking from that in Brad's. Notice that Karen used a higher level technique (explaining) in a lower level way in context whereas Brad used a lower level problem as higher level in the context of the lesson. Students' opportunities to appreciate doing mathematics in Karen's class are curtailed by questions that require lower level of student thinking. Students in her class might learn and do mathematics as involving merely following predetermined steps to compute correct answer as opposed to involving mathematical thinking and sense-making.

Influential Factors on the Textbook Transformation Pattern

Karen supplements the lessons from *Trailblazers* with practice problems. While

Brad claimed to be a "follower" of *Math Trailblazers*, Karen claimed to be "modifier" of the textbook. She reported that, in total, 50% of lessons came directly from *Math Trailblazers* and the rest 50% came from other resources such as other textbooks. She said that she supplements the textbook with more practice problems from other textbooks, in particular, an old textbook, *Houghton Mifflin Mathematics*. During an interview, Karen said,

> I've used old textbooks. I find that in the *Trailblazers* series there is a lot of introducing the concepts but not a lot of mastering the concepts… We have some old texts [*Houghton Mifflin*] like that has more practice than the *Trailblazers* does....*Houghton Mifflin* has some from when I was in school so 1980's. The Trailblazers series provide a lot of explore, look at, manipulate but it's very shallow in the practice areas as you can see from the lesson that there's I don't know ten problems or seven problems (interview, 04/27/2007).

Together with her use of lower level teacher questions, frequent supplementing of the standards-based textbook with more practice problems reduces the cognitive demand of student thinking.

Why did Karen transform her textbook in that way? What factors account for Karen's transformation? During the interview, Karen provided the rationales for why she added practice problems out of her obligation to meet the Grade Level Content Expectations (GLCE) for Michigan. In addition, Karen's notion of how students learn also is a factor that influences her use of the textbook and her teaching practice.

Conflict between Teachers' Goal and Perceived Goals of the Textbook Karen believes that she should cover all the content presented in the GLCEs. Karen described her use of the textbook as follows:

> When I start out at the beginning of the year, I lay out the content expectations that the state has mandated then I try to match up the text with the GLCEs. So when I get to each unit I have to first make sure that I've covered all of those content expectations. Because that's what the state says we have to do. The district has said, this is the text we're using and that the Trailblazers series. But the district also has said that the Trailblazers series does not cover all of the Michigan grade level content expectations. So therefore you must supplement. So when I'm planning I take a look at the lessons that are in the Trailblazer series and I see which ones of those cover the grade level content expectations and then I look at all the holes that are left over and start using other resources (interview, 04/27/2007).

Karen's obligation to the contents of the GLCEs influences her pedagogy. During an interview, Karen said,

> When I was at a math meeting a year and half ago we were talking about the new content expectations, what 4th graders are required to know….The curriculum director at the time said, these things are suppose to be taught to mastery and here was this huge group of experts saying, we're introducing the concepts but the children are not practicing it enough to say that we've mastered it….So I'm working really hard on trying to make sure that I can pull from anywhere that I can find practice stuff to make sure my kids are going home and working on it on their own, working on it with friends here, that their parents are informed about what we're doing and also working with them at on it (interview, 04/27/2007).

Indeed, "mastery of the concepts" can be interpreted in various ways. Some may think it only from procedural aspects, such as proficiency in computation, whereas others consider it from both conceptual aspects and procedural aspects of the mathematics contents. Considering the recommendations in the GLCEs, definition of mastery requires both conceptual understanding and computational skill (Mcthighe & Wiggins, 2005; Wormeli, 2006). However, Karen seems to recognize the definition of mastery from the procedural aspects. This understanding may cause her to lead instruction more procedure-oriented and emphasize application of the rule in her class.

Procedural fluency as a Teaching Goal Indeed, Karen's obligation to meet the GLCEs is in keeping with her notion of how students learn, as evidenced by the focus of her questions on procedures—on *how* rather than *why.* Karen put more emphasis on application of the rule than on sense-making or meaning in learning mathematics. Karen articulated her goals as "proficiency in writing equivalent fractions" and "mastering the concepts and applying it" in general. This differs from the evidenced by teachers in the first pattern which matches the category "understanding-oriented". Together with Karen's view on the emphasis of Grade Level Content Expectations, her learning goal seems to push her to supplement the textbook with more practice problems and change the emphases from understanding to following rules to solve problems in her classroom.

Lower Level Textbook Problems and Questions to Lower Level Problems and Questions in Teaching: Pattern 3

Three teachers use tasks in ways that can be described as the L-L pattern, in which teachers have textbook problems that provide lower level problems and questions, and they use lower level questions in their teaching. All used "conventional textbooks." Although teachers in this pattern selectively used problems and examples from their textbooks, most of the problems focused on mathematical facts and procedures, as distinct from mathematical knowledge that required higher level of student thinking. Moreover, they spent most of their time asking low-level cognitive questions to elicit correct answers. As a result, the conception of doing mathematics and knowing mathematics presented in the mathematical problems and teacher questions in their classroom differs substantially from that of teachers in other patterns, in particular, teachers in the first pattern. The features of the following vignette from Randy's teaching exemplify practices of other teachers in this pattern.

A Vignette of Randy

Randy has 33 years of teaching experience. He is currently teaching fifth grade. He perceived his students as mostly average achieving as Brad and Karen did. In his district, teachers have two different textbook series—one is *Investigations* and the other is *Scott Foresman - Addison Wesley Mathematics*. Which textbook teachers use is up to the teachers. He indicated *Scott Foresman - Addison Wesley Mathematics* (Randall, et al., 2005 as his main textbook. I observed two lessons in Randy's class. Like other teachers, lessons were organized into two activities: an introductory "teacher-led" activity and "student exercise". However, different from teachers in other patterns, a "teacher-led" activity in his class is more of lecture and demonstration rather than discussion. Randy guided the students through example problems, with the problem broken down into simple steps. Then the students were given practice problems to accomplish on their own.

On the first day I observed, Randy taught "adding and subtracting mixed numbers" and the second day, he taught "adding mixed numbers". Like other case study participants, before observing his class, Randy gave me his lesson plan using the teacher's manual of *Scott Foresman - Addison Wesley Mathematics*, Grade 5 (Randall, et al., 2005, pp. 372-374).

The lesson guide states a learning goal as "Add and subtract mixed numbers". This lesson is organized into three big parts; (1) Introduce, (2) Teach, and (3) Close and Assess. In an introduction, students review adding and subtracting fractions with unlike denominators. In Teach part, teachers are recommended to address Example 1, which illustrates procedure of subtracting mixed numbers, and to ask students to work on practice problems. Two more example problems were presented in the textbook lesson. In Close and Assess, teachers are suggested to have students demonstrate how students would find the sum with two mixed numbers.

Like teachers in other patterns, Randy started out his lesson with reviewing what they learned previously. Randy asked students "what is mixed numerals?" Several students tried out, such as "whole number" and "mixed with a fraction." When one student said “a whole number in a fraction,” Randy said “Yes, I like that definition. It’s a whole number okay complimented with a fraction.” He again asked students to find the definition of mixed numerals in the glossary presented in their textbooks. As one student read aloud from the textbook, Randy said, “Okay, it is a whole number and part of the next whole number.”

He addressed the topic they were going to work with together, such as “that is what we are going to be adding and subtracting today.” Randy then began the “example problem” suggested in the lesson guide of his textbook. He took the suggested example below from his textbook. He first wrote it on the board and then asked students to copy down the problem as Karen did. Randy asked students “what do you think we need to do?”

$$\begin{array}{r} 3\frac{1}{2} \\ -\ 2\frac{1}{8} \\ \hline \end{array}$$

Indeed, this example problem is presented as a word problem in the textbook. However, without introducing a story or problem contexts, Randy asked students to tell him how to solve the problem. Word problems often provide contexts that allow students to connect the problem to a familiar context in their own lives. Problem contexts or word problems can provide practice with real-life problem situations, motivate students to understand the importance of math concepts, and help students to develop their creative, critical and problem solving abilities (NCTM, 1991; Verschaffel, 2002).

However, Randy spent no time discussing the textual aspects of the problem as it was presented. Rather, Randy quickly reduced the word problem to a mechanical fraction subtraction problem. He provided the following rationale for studying this topic: " It's on our assessment and that's why we're doing it." None of the other teachers in other patterns put priority on assessment.

Textbook lesson provides four steps to solve this problem: (1) change mixed number into improper fractions, (2) find equivalent fractions, (3) subtract the fractions, and (4) subtract the whole number. He led the students through this problem at each stage. Randy was calling on individual students to answer questions. While observing his lesson, I paid attention to how Randy reacted to students' incorrect answer. I noticed that like the teachers in the H-L pattern, Karen, Randy barely paused, moving quickly on to the correct answer. Even Randy did not raise follow-up questions if students' responses did not reflect the correct answer. If students' responses reflected the correct answer, he paraphrased the answer, changed it slightly to make it more accurate and explicit. For example, as students finished writing it down, Randy asked, "What do you think the first thing we have to do?" One selected student said "We have to simplify the numbers still."

Randy responded back to the student by saying "Not yet. At the end yes, we will have to simplify at the end if we get to the end." Another selected student said "I just want to say that we change the denominator and numerator." Randy responded back to students "Which means we are finding what?" As none of students did answer, Randy said to students "The equivalent fractions. We're finding equivalent fractions. We have to find equivalent fractions here at least for one of them because what do we need before we can add." One student asked back to Randy "We need to have them have the same denominator?" Randy answered "yes, they have to have the same denominator".

In watching Randy interact with his students, it was obvious that a teacher-led activity in his class involves recitation or lecture in which the teachers talk most of the time. Considering Randy's questions that asked students to fill in the blank rather than construct an answer. Randy seemed to try to elicit just "right" answer from students.

After working one example with his students, Randy assigned the first part of the "practice" problems to students. All practice problems asked students to find each sum or difference and then simply the answer, which required only procedure. While students were working on practice problems from the textbook, Randy answered individual questions, prompted the next step in the procedure, pointed out mistakes.

As students finished working on the given tasks, Randy demonstrated the following example of "adding mixed number" in the same manner he did in the first example.

$$\begin{array}{rcr} 4\frac{1}{2} & = & 4\frac{3}{6} \\ +5\frac{1}{3} & = & +\ 5\frac{2}{6} \\ \hline & & 9\frac{5}{6} \end{array}$$

Like other problems Randy and his students worked on, this problem also requires low cognitive demand of student thinking. After demonstrating how to do this problem, Randy asked students to work on the rest of practice problems.

Clearly, students had learned a set of steps to go through in order to solve these problems, for example, change the mixed number into improper fractions, subtract, and change the fractions into mixed number, etc. However, his class is procedure-oriented. For example, in the classes I observed, there was no drawing and no use of manipulatives. During the interview, Randy described his class as "very much traditionally lesson from the textbook." The conversations that Randy had with students during this portion of class reveal what his goal for the lesson was: mastery of the "procedure" for adding and subtracting mixed numbers.

Similarities and Differences between the Textbook Lesson and Lesson Taught in Terms of Cognitive Demands

Like teachers in the H-H pattern, Randy maintained the cognitive demand of problems and teacher questions in his teaching. However, the problems and questions that Randy and Teri used commonly require the straightforward application of a formula, which demand students to remember and apply a series of rules and procedures to arrive at the right answer. The conception of mathematical knowledge that dominated in the problems and teacher questions used by teachers in this pattern differed substantially from teachers in the first pattern.

Learning goal Randy used the same goal presented in the conventional textbook. He put priority on knowing procedures over understanding the concepts and sense-making. For example, Randy articulated his goal as "to get students to understand this one specific algorithm in adding and subtracting mixed numerals." When he was asked to explain what he meant by "understanding", he said, "know how to *apply* the algorithm in adding and subtracting mixed numbers" (interview, 01/23/2007). Even though he used the verb "understand," for Randy, "understand" seems to mean know the process of how to "apply" the rule to add and subtract mixed numbers, which requires students to remember and memorize rules and procedures.

Problem Randy also used problems from the textbooks that afford lower cognitive demand of student thinking. A typical problem presented in the lesson is "Find each sum or difference. Simplify, $3\frac{1}{3}+2\frac{1}{6}$" (Randall, et al., 2005, pp. 372). This type of problem exclusively focuses on procedural mathematical knowledge that requires the recall of previously learned information. There is no connection to what underlying this procedure. Many of the problems found in conventional textbooks in this study ask students to perform a demonstrated procedure in a routinized way and hence place low-level, mostly proceduralized demands on student learning as opposed to the problems found in standards-based curricula asking students to make conceptual connections and to think and reason in sustained and thoughtful ways (Stein & Kim, 2007). Randy used lower level problems as an example and student practice in his teaching.

Indeed, the conventional textbook Randy uses also provides several word problems which contain "real-world" context in "problem solving" section. During an interview, Randy mentioned that he would use "problem solving" section later to prepare their students for assessments since word problems are one type of problems in assessments. However, even word problems presented in the textbook require only the use of a well-established procedure for finding sum or difference between two mixed numbers, which can be categorized as one lower level task, *procedure without* *connections*, based on Stein and Smith's framework (2000).

Teacher Questions Randy asked almost all the questions, and students typically articulated the procedures that led to an answer and/or the answer itself by way of responding. Further discussion was rare. The interview confirmed this pattern. During an interview, I asked Randy about typical questions he would often use in his lessons. Randy said "I'll pose questions that have detailed answer and sometimes students will do part of that answer" (interview, 01/23/2007). His remark "detailed answer" implies lower level of student thinking required. Randy neither asked students to generate their own algorithms nor to explain how or why procedure worked. Randy's questions were procedure-oriented. There was little or no questions that asked students to conceptualize or think about the content.

Indeed, the conventional textbook Randy uses does not provide many teacher questions he could use. One teacher question suggested in the lesson guide was "ask students which steps could be skipped if the fractional parts of each mixed number had like denominators" (p. 328). This question requires students to compare different problem situation between mixed numbers with like denominator and those with unlike denominator, which at least require more cognitive efforts than following the procedure. Yet, Randy did not use this question. Overall, the textbook provides lower level problems and teacher questions and Randy maintained the cognitive level when using problems and teacher questions.

Influential Factors on the Transformation Pattern

One noticeable feature is that Randy used "a conventional textbook". However, it is not the use of conventional textbook alone that sets Randy apart from teachers in other patterns. The conception of knowing and doing mathematics represented in lower level problems and maintained by lower level teacher questions also set him apart from teachers in other patterns. Similarly, the other two teachers in this pattern used problems and questions in their teaching in ways that matched with the notion of doing mathematics embedded in their conventional textbooks, which is mathematics as a set of procedures that students needed to master in order to solve exercises involving addition, subtraction, multiplication, and division of fractions.

What factors account for these teachers' textbook transformation pattern? Open about their choice, teachers in this pattern named thee causes: assessment, their students, time. In addition to these factors, teachers' notion of how students learn can be an indicator of this pattern.

The pressure of assessment from the GLCEs Teachers in this pattern commonly remarked that the press to get high test scores on tests also limited their ability to teach for deeper understandings. Similar to teachers in other patterns, teachers in this pattern felt obligation to the Grade Level Content Expectations (GLCE). However, teachers in this pattern seemed more concerned about assessment than the GLCEs. During an interview, Randy said that

> Assessment drives the curriculum. That's what our administration expects that we are doing. The curriculum and the assessments because of the amount of work that we have to get exposed to the kids it drives it and it is too much (interview, 01/23/2007).

Randy mentioned repeatedly how much assessment constrained his use of problems. Even when he answered why he did not include certain problems in his lesson, he simply said that "Just it's not on the assessment so I skipped it". Indeed, In Randy's case, assessment dictates what is taught. Randy was working on a district that bought an assessment program, which is now the curriculum of a small county. He described his use of the textbook as follows:

> I use the book based on whatever my assessment is. If the book meets the criteria for the student to do in the assessment then I use the book. If I can do *Investigation* and it meets those same criteria then I'll do it. If it means drawing pictures then I'll use that. If it means coming up with constructive responses in small groups then that's what gets you. It just depends; I'm not totally textbook driven. It just depends on the resources that I have and how that it fits the assessment that I am trying to teach or that I'm trying to get the kids ready for (interview, 01/23/2007).

He, therefore, would skip some contents that are not on the assessment and delete examples and problems that do not fit with assessment.

The Pressure of Time Teachers in this pattern also pointed out their limited time for covering all contents to be taught. Randy believes that with his limited time, he can only work on the basic foundation—the rules and procedures. During the interview, I asked him why he skipped certain problems presented in his textbook. Randy simply found his decision from "time". He said, "When do I have the time to teach? Definitely I will cover. But when?" (interview, 01/23/2007). In addition to time constraint, he provided the rationale for why he did not include certain type of problem in that those problems are not tested in assessment. He said that,

> I skipped it because there wasn't, there wasn't on assignment where the students had to round off the mix numeral to the nearest whole and then add....It's not on the assessment (01/23/2007).

Taken together with Randy's obligation to assessment, time factor seems to constrain his use of textbook problems that require higher level.

Students' Diverse Ability Students' diversity in terms of mathematics ability is another commonly perceived factor by teachers in this pattern. Teachers in this pattern commonly mentioned that their students' low economic level and achievement in mathematics influenced their use of textbooks. For example, during the interview, Randy mentioned that:

> What comes into play is the ability of the students and some students are going to get done a lot faster than others which then allow me more time to do with students that need more help. That comes into play (interview, 01/23/2007).

Indeed, student ability is one commonly referred factor by teachers to describe their students' low achievement (Wilson, 1990). Although analyses of overall MEAP test results in these schools show that a slightly higher percentage of students in the school

(78 or 79%) met standards for mathematics of the 2007 Michigan Educational Assessment Program (MEAP) that that of the state average (76%), teachers in this pattern commonly mentioned that because of their students' diversity in mathematics achievement, they focused on practice problems.

Procedural fluency as a Teaching Goal Furthermore, even though teachers in this pattern did not point out their view on fractions and his goal as influence on his textbooks, their teaching goal is possible factor that influences their use of textbooks in terms of cognitive demands. In particular, Randy's notion of how students learn, as evidenced by the focus of his questions on procedures—on *how* rather than *why*—matches the category 'procedural-fluency oriented' developed by the present study to describe teaching which favored the more traditional transmission perspective than constructivist approach.

Summary

This chapter presents the findings from the case studies that explored what textbook transformation patterns exhibit when teachers move content from text to teaching and what factors influence these transformation patterns. More specifically, this study explored: (1) What are the similarities and differences between the textbook and taught lesson in terms of cognitive demands of lesson's goals, problems, and questions?

and (2) What factors teachers perceived influence their use of textbooks?

Three transformation patterns were identified in terms of the cognitive demand of problems and teacher questions—(1) H-H pattern, (2) H-L pattern, and (3) L-L pattern. First, when teachers used standards-based curriculum that provides higher level cognitive demand of problems and teacher questions, some teachers closely follow their textbooks and thereby maintain the higher level cognitive demand of student thinking in their teaching. This pattern is called the H-H pattern. In this pattern, mathematical problems were set up to help students explore concepts, meaning, and underlying ideas of the procedure. Teacher questions sustained the cognitive level of problems by demanding students conjecturing, problem-solving, and justification of ideas.

However, some teachers with standards-based curriculum lowered the cognitive demand level of the textbook lessons by using teacher questions that focus on procedure and finding *the* answer. This pattern is called as the H-L pattern. In this pattern, while mathematics problems in these classrooms were presented in ways that highlighted meaning and sense-making, teacher questions focused students' attention on procedures rather than meaning.

One of the big differences between teachers in the H-H pattern and those in the H-L pattern was different emphasis of student learning. Teachers in the H-H pattern emphasize the importance of understanding, meaning, and sense-making over procedure and computation, whereas teachers in the H-L put more emphasis on proficiency (or knowing procedure). This finding is consistent with the findings from the survey.

Two teachers categorized as the H-L pattern in the case studies were categorized as the H-H pattern in the survey. For example, Karen and JoAnne both reported that they often used teacher questions that require explanation, multiple representations, and students' justification. They were, therefore, categorized as the H-H, representing teachers who have textbooks presenting higher level teacher questions and use higher level teacher questions in their teaching. Yet, in the case analysis, these teachers were identified as using lower level cognitive demand of teacher questions.

Indeed, Karen and JoAnne asked students to use representations, explain their answer, and justify their answer in their classroom. However, interestingly, "explaining," in the context of her lesson was a tool to restate the processes of how to get the answer, which involves a lower level application of rule and procedure. This may explain why discrepancies occur between teachers' responses on the survey and the case studies.

Second, all teachers who used conventional textbooks were considered as presenting lower level of problems and using lower level of teacher questions, which were firmly grounded in procedural mathematical knowledge and computational skills.

This pattern was called the L-L pattern. Although teachers in this category selectively used problems and questions presented in the textbooks, most of problems and questions presented in the lesson plan lend themselves requiring lower level of thinking, which require students to memorize and follow the rule to solve problems. Teachers in this category commonly put more emphasis on knowing procedures and algorithm than meaning and sense-making. Even though these teachers also recognize the importance of having students opportunity to experiences related to underlying ideas (e.g., using manipulative, game, etc), these teachers put more emphases on the ability required on the assessment when selecting problems and using teacher questions. These teachers commonly reported their rationales for why they did not include problems requiring higher level cognitive demand from the assessment, time, and their students' low mathematics ability.

Chapter 7

SUMMARY, DISCUSSIONS, AND IMPLICATIONS

This chapter is comprised of four sections. In the first section I summarize the findings from the survey and the case studies, and in the second section I discuss the theoretical and practical contributions of this work and clarify its limitations. In the third section, I provide implications of the findings from this study by considering what they illuminate about teachers' textbook use and the role that textbooks and practical and curricular support for teachers might play. In the fourth and last section, I conclude this study by providing final thoughts about changing teachers' practices using textbooks.

Summary

This study was prompted by the current curriculum policies that use textbooks as an important strategy to regulate mathematics practice and align instruction with the reformers' ideas. The purpose of this mixed method study was to examine teachers' textbook use and its influential factors from a different angle, that of the cognitive demand of mathematical problems and teacher questions, and to provide both depth and breadth of analysis with respect to teachers' textbook use and its influential factors.

I sought to answer the following research questions: (1) What transformation patterns do elementary teachers exhibit as they move content from text to teaching if the transformation is looked at in terms of cognitive demands of problems and questions? (2) What factors are associated with various textbook transformation patterns?

This study began with four hypothetical textbook transformation patterns that describe the relationship between the cognitive demand of problems and questions presented in textbooks and that of problems and questions used by teachers in teaching—(1) H-H, (2) H-L, (3) L-L, and (4) L-H. The H-H pattern refers to teachers who had a textbook categorized as providing "higher level" problems and teacher questions (e.g., problems and questions requiring students' mathematical thinking or justification) and who maintained this higher level in their teaching. The H-L pattern means teachers had textbook problems and teacher questions that required higher level student thinking but decreased the cognitive level in their teaching. The L-L pattern refers to teachers who had textbook problems and teacher questions requiring a lower level of student thinking (e.g., problems and questions requiring students merely to follow the rules and procedures) and who maintained the low cognitive level in their teaching, whereas the L-H pattern means that teachers increased the low cognitive level textbook problems and teacher question in their teaching.

I used the term "high" and "low" not only to imply cognitive demands for student thinking required when working on problems and questions, but also to suggest the extent to which problems and questions represented the conception of knowing and doing mathematics in ways that corresponded to reform ideas. At the core of the mathematics reforms (NCTM, 1989, 1991, 2000) is an attempt to revise what counts as mathematical knowledge and doing mathematics in school. Reformers and educators argue that students should come to understand mathematics as involving more than manipulating numbers to compute right answers and should develop mathematical thinking, reasoning and problem-solving (Cobb, 1988; Lampert, 1990; NCTM, 1989, 1999, & 2000; Schifer & Fosnot, 1993; Simon, 1986). In this study, problems and questions categorized as "high level" were perceived as more likely to foster the conception of doing mathematics and knowledge mathematics supported by the NCTM reform ideas than problems and teacher questions categorized as "low level." By exploring changes between the cognitive demand of textbook problems and teacher questions and the cognitive demand of problems and teacher questions used by teachers in their lessons, this study attempted to understand whether and how teachers use their textbooks to provide students' learning opportunities supported by the NCTM (1989, 1991, & 2000) ideas. This study also sought to understand whether the type of textbook (e.g., standards-based vs. conventional textbook) influenced these transformations and what other factors supported or constrained teachers' use of textbooks. Thus, this study was concerned with exploring how teachers' use of textbooks relates to students' opportunities to learn mathematics in ways considered meaningful by the field/professionals in this domain.

A survey was used for the quantitative aspect of the research, along with interview and observation for the qualitative part. Among 169 teachers who participated in the survey, eight teachers were observed and interviewed in order to establish the validity of the written survey and to provide additional details about teachers' transformation patterns that can't be obtained from the survey. In the following section, I summarize the findings from the survey and the case studies.

Transformation Patterns in Terms of Cognitive Demands

Transformation patterns in terms of cognitive demands were explored in relation to both the text phase and the enactment phase of instruction. Within the text phases, I examined transformations of textbook problems in teaching and transformations of textbook teacher questions in teaching. Within the enactment phase, I examined the enactment of problems along with teacher questions. It is important to note that, while all transformation might be considered 'enactment,' I use this word here to describe how the problems in teaching were repeatedly enacted by teacher questions in teaching.

Transformation Patterns of Textbook Problem

First, in the *problem-problem* phase, this study explored how problems presented in textbooks were changed in terms of the cognitive demand when teachers selected problems and used them in their teaching. Figure 7.1 presents the transformation patterns from text to teaching in terms of the cognitive demand of problems identified after combining the findings from the survey and the case study.

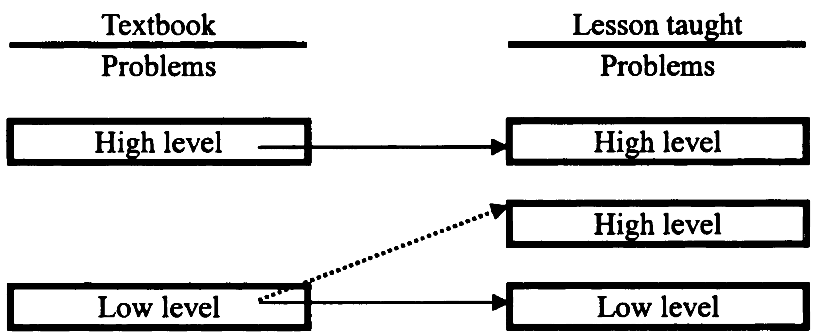


Figure 7. 1 Textbook Transformation Patterns Identified in Terms of Cognitive Demand of Problems

The solid line represents the pattern identified from both the survey and the case study. The dashed line represents the patterns identified from either only the survey or only the case study. The H-H pattern and the L-L pattern appeared both in the survey and the case study. When teachers used textbooks that presented higher level problems (standards-based curriculum), they used higher level problems in their teaching. When teachers used textbooks presenting lower cognitive demand problems (conventional curriculum), teachers used lower cognitive demand problems in their teaching even when they selectively used textbook problems.

This finding indicates that teachers report that they *maintain* the cognitive demand of textbook problems when they use *problems* in their teaching. This implies that the cognitive demand of problems presented in textbook plays an important role in deciding the cognitive demand of problems used by teachers in teaching. In particular, because standards-based curricula portray mathematics as a process of exploring relations, which requires students' high cognitive demand (Stein & Kim, 2007), teachers' use of standards-based curriculum might increase the likelihood that students would engage with these mathematical concepts and do mathematics involving developing conjectures, explaining and justifying their solutions rather than following rules.

This inference can also be supported by previous studies. For example, Star and Hoffmann (2005) examined whether and how students who worked with standards-based curricula perceived the conception of mathematics and doing mathematics differently from students who worked with non-standards-based curricula (in this study, conventional curricula). They reported that students at the standards-based site expressed more sophisticated conceptions of knowing and doing mathematics than the students from the non-standards-based site. Since teachers in this study who used standards-based curricula were found to be maintaining the cognitive demand of textbook problems, which means that teachers used problems that required student thinking and reasoning, it is plausible that students in these teachers' classrooms had more opportunities to work on mathematical problems that required exploring mathematical concepts and underlying ideas through representations, communications, and reasoning and were able to do so more than students whose teachers used conventional curricula.

Due to the selection of teachers in the case study, the L-H pattern in the problem-problem phase did not appear in the case studies (all participants in the case studies were either the H-H pattern or the L-L pattern in the survey). However, the analysis of a lesson plan and the survey suggest the possibility of teachers who fit into the L-H pattern when they use problems in their teaching. The fact that this possibility was not represented here suggests the need for future studies that investigate this pattern and teaching practice in relation to textbooks.

Transformation Patterns of Textbook Teacher Questions

In the *teacher question-teacher question* phase, this study examined how teacher questions presented in textbooks were changed in terms of cognitive demands when teachers selected them from textbooks and used them in their teaching. Figure 7.2 presents the transformation patterns in this phase exhibited in the survey and the case study.

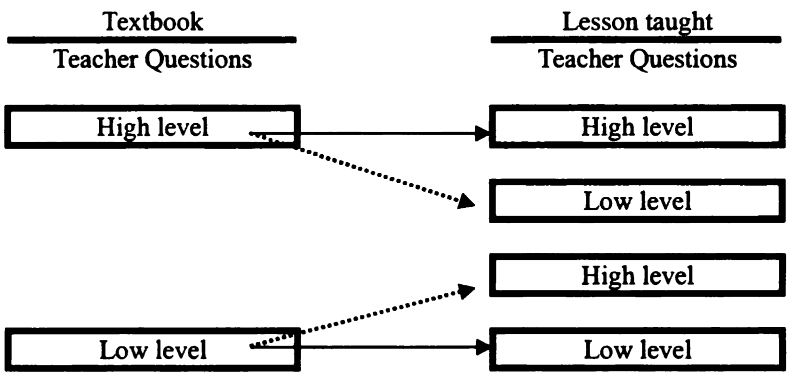


Figure 7.2 Textbook Transformation Patterns Identified in Terms of Cognitive Demand of Teacher Questions

Four patterns appear when combining the findings from the survey and the case studies in the question-question phase. The H-H pattern and the L-L pattern were exhibited both in the survey and the case study. The L-H pattern emerged from the survey while the H-L pattern emerged only from the case study. These patterns show interesting trends.

First, the confirmation of the H-H pattern and the L-L pattern from the case study suggests that, as in the problems-problem transformation phase, the cognitive demand of textbook questions plays an important role in deciding the cognitive demand of questions used by teachers in teaching. If teachers use textbooks that present higher level questions, then some teachers use higher level questions in their teaching. This relationship between text and teaching suggests the possibility that textbooks that require higher cognitive demand of problems may contribute to change teaching in ways that reformers intend to.

However, the appearance of the H-L pattern and the L-H pattern, in particular the H-L pattern, reveal that there are other factors that influence teachers' decision making when teachers use questions in their teaching. In terms of the cognitive demand of problems, some teachers at least maintained the cognitive level of textbooks in their teaching. However, as far as teacher questions are concerned, some teachers decreased in their teaching the cognitive level of teacher questions presented in textbooks. In the case studies, two teachers, Karen and JoAnne, used standards-based curriculum that presented higher level questions, but they lowered the cognitive level by changing the emphasis from exploring mathematical concepts and meaning to applying the rules to solve the problems and using the questions that focused on following the procedures.

This finding provides important suggestions to understand better the text-teacher relationship, in particular in terms of teacher questions. For example, the implication is that although the cognitive demand of questions presented in textbooks is important, teachers are influenced by various factors when using questions in their teaching. This recognition suggests that we need to consider other factors, including teachers' individual characteristics, to understand teachers' textbook use.

Transformation Patterns in Problem–Questions Enactment Phase

In the problem-teacher question enactment phase, this study explored whether and how the cognitive demand of problems used in teaching was maintained or decreased by the questions used by teachers in teaching. Even though the transformation patterns explored in this phase did not explain directly the text-teacher relationship, without understanding the change in this phase we do not know which level of learning opportunities are provided for students. Since teacher questions can fundamentally transform the manner in which a particular problem is enacted by the teacher and students, this study explored transformation patterns in this phase. Transformation patterns that appeared in the problem-teacher enactment phase can be used as an indicator that implies the students' level of cognitive engagement.

Four transformation patterns were observed—(1) H-H, (2) H-L, (3) L-H, and (4) L-L pattern. Among teachers who reported using mathematical problems that required higher cognitive demand, some teachers reported using teacher questions that sustained the cognitive demand of the mathematical problems. However, other teachers like Karen and JoAnne in the case study, set up problems that required students' mathematical thinking and relationship, but used teacher questions that lowered the cognitive demand of the problems by changing the emphasis from understanding to knowing procedures. Some students in the H-L pattern may know and do mathematics as involving more than manipulating numbers since they worked on higher level problems that required mathematical thinking, reasoning, and explanation. However, many students in this pattern may perceive mathematics as just involving following predetermined steps to compute correct answers because of the way the teacher posed the questions.

In contrast, among the teachers who used mathematical problems that required lower cognitive demand (e.g., following the rule to compute correct answers), some teachers, like Randy in the case study, used teacher questions that sustained the low cognitive demand of the problems. Yet, other teachers might increase the cognitive demand of the mathematical problems by using higher level questions requiring that students develop conjecture, explain, justify, and defend their solution and thereby provide higher level of students' cognitive engagement. Although the L-H pattern did not appear in the case study, this pattern might be possible (e.g., Martin, 1997). For example, Deborah Ball began her class with a low level problem (e.g., compare two fractions, ½ and ¼). However, by using questions that require students to explain and justify their answer, or defend their solutions with various representations, she ultimately increased the cognitive demand of the problem and led her students to learn mathematics in ways that not only manipulate numbers but also develop mathematical concepts and relationships.

To understand teachers' enactment of problems and teacher questions in relation to textbooks, I connected transformation patterns that appeared in the problem-problem phase with those in the problem-teacher questions phase, according to teachers' response on the survey. Figure 7.3 presents the transformations from text problems to problems used in the lesson to questions used by teachers in teaching in terms of the cognitive demand.

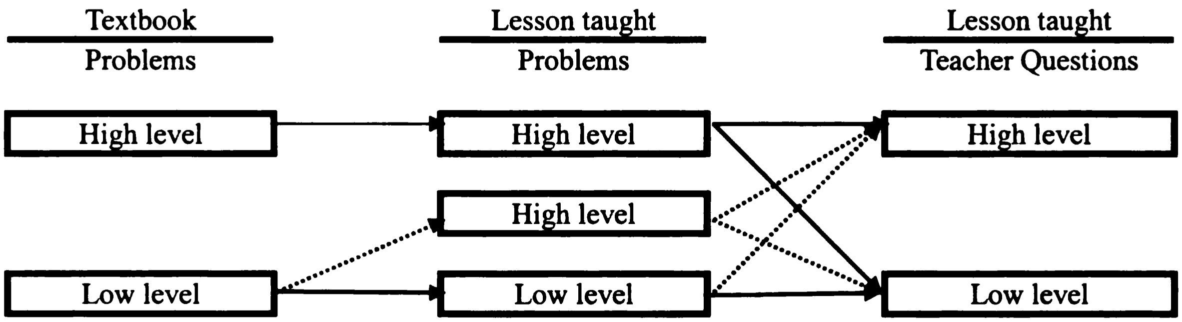


Figure 7. 3 Transformation Patterns Identified in Terms of Cognitive Demands of the Lesson Taught

When teachers used problems in their lesson from their textbooks, there was not much variation between the cognitive demand of textbook problems and the cognitive demand of problems used by teachers in teaching. However, when the problems were enacted by teachers with students in teaching, there was much more variation between the cognitive demand of problems and that of questions used by teachers in teaching. Table 7.1 shows the frequencies of teachers in each pattern.

Table 7. 1 *Frequency of Teachers in Each Pattern*

Textbook Problems	Lesson taught Problems	Lesson taught Teacher questions	Frequency (N=169)
High	High	High	117
High	High	Low	8
Low	High	High	19
Low	High	Low	13
Low	Low	High	6
Low	Low	Low	6

Among teachers who had textbook problems that required higher level, eight teachers reported lowering the cognitive demand of problems in teaching by using lower level teacher questions. Among teachers who increased the cognitive demand of textbook problems to a higher level, thirteen teachers reported lowering the increased cognitive level of problems used in teaching by using lower level teacher questions.

The tracking from textbook problems through teaching problems to teacher questions used in teaching suggests two important aspects to consider. First, comparatively, the simple relationship between textbook problems to problems used in teaching in terms of the cognitive demand suggests that whether textbooks provide higher level problems or lower level problems may be one indicator that describes what problems teachers use in their teaching in terms of the cognitive demand and therefore what learning opportunities students might be provided to students.

However, the complicated relationship between the cognitive demand of problems and teacher questions used in teaching in the problem-question enactment phase suggests that we need to explore learning opportunities for students by looking not only at the problems written in a textbook or the problems set up by teachers, but also at the ways in which the problems used by teachers are actually carried out by the questions teachers pose for students to work on. In addition to that, the teachers are influenced by not only the cognitive demand of textbook problems and questions but also teachers' individual characteristics (e.g., teaching goals) as their learning opportunities (e.g., PD experiences).

This study expanded upon previous research in that it attempted to explore teachers' transformation patterns from a different angle, in order to understand what learning opportunities for students teachers provide with their textbooks. This study also attempted to consider this topic based on what teachers report on the use of their textbook and on how they actually use them in practice. This study suggests the importance of the cognitive demand of problems and teacher questions presented in textbooks and argues that if teachers have textbooks that provide higher level problems and teacher questions, they are likely to more frequently provide problems and questions that require students to think mathematically, and to reason out solutions and explain and justify their answers with various representations, than teachers who have textbooks that provide lower level problems and teacher questions. Students in this class are thereby more likely to be provided learning opportunities for knowing and doing mathematics that foster their mathematical thinking, reasoning and problem solving. Conversely, if teachers have textbooks that provide lower level problems and teacher questions, they are less likely to use problems and teacher questions that require higher level cognitive demand, and thereby provide students with learning opportunities that involve following predetermined steps to compute correct answers and chiefly manipulating numbers without connections to underlying ideas or meaning.

However, the previous statements are not meant to suggest that textbooks that require a higher level of student thinking are a panacea. I pointed out earlier that various factors are associated with teachers' decisions--in particular, teachers' use of questions, factors that decide the ultimate fate of the cognitive demand of problems students work on (Henningsen & Stein, 1997; Stein et al., 1996). Next, I discuss what factors influence these various transformation patterns, by synthesizing the findings from the survey and the case study.

Influential Factors Associated with Various Transformation Patterns

Using the survey of in-service teachers (n=169 teachers), this study first examined the factors that influence the transformation patterns in three phases and then, using the case study data (8 teachers), I examined that what teachers actually perceived constrained or supported their use of textbooks.

Several factors were commonly identified that distinguish the H-H pattern from the L-L or from the L-H pattern in three phases of transformations as well as in the case study. For example, the type of textbook (standards-based vs. conventional curriculum) was the most critical factor that distinguished teachers in the H-H pattern from teachers in the L-L pattern (see Odds in Table 5.11 and Table 5.14 of Chapter 5). Teacher teaching goals (use of understanding-oriented student objectives) and teacher fidelity to textbooks were also found to be important factors that characterized teachers in the H-H pattern compared to teachers in other patterns. In addition, teacher view on textbook was a commonly identified factor that distinguished L-H pattern from the L-L pattern. The type of textbook (conventional curriculum) was found to be an insignificant factor in distinguishing teachers in the L-H pattern from teachers in the L-L pattern. Using the H-H and L-L patterns as a reference, I next summarize which factors characterize each individual transformation pattern

Factors Distinguishing H-H Pattern from L-L Pattern

Four factors were identified as distinguishing teachers in the H-H pattern from teachers in the L-L pattern: standards-based curriculum, teacher fidelity to the standards-based curriculum, understanding-oriented teaching goals, and teacher knowledge.

Influences of standards-based curriculum The type of textbook was the most critical factor that distinguished teachers who used higher levels of problems and teacher questions in their teaching from teachers who used lower levels of problems and teacher questions in their teaching. When teachers used standards-based textbooks, they were more likely to use higher cognitive demand of problems and teacher questions in their teaching, thereby providing the potential for high levels of student thinking. Conversely, when teachers used conventional textbooks, they were more likely to be using lower cognitive demand of problems and teacher questions in their teaching. This conclusion was drawn not only from the survey but also the case study and is consistent with findings in previous studies (e.g., Remillard, 2004) as well as current textbook adoption policies. I argue that the teachers can "develop a vision of reform instruction" through the use of the standards-based textbooks (Drake & Sherin, 2002; Lloyd & Behm, 2002; Remillard & Bryans, 2003).

Influence of teacher fidelity to textbook Teacher fidelity to textbook was also an important factor that characterized teachers providing higher levels of problems and teacher questions compared to teachers providing lower levels of problems and teacher questions in their teaching. Taken together with the type of textbook, when teachers closely use standards-based curriculum, they are more likely to be categorized as being in the H-H pattern and are more likely to provide learning opportunities for students that know and do mathematics by fostering mathematical thinking, reasoning, and problem solving (Star & Hoffman, 2005). Conversely, teachers in the L-L pattern who provided lower level problems and teacher questions in teaching were more likely to use conventional textbooks and less likely to report that they followed their textbooks.

The analysis of case studies confirmed this finding. For example, Brad, categorized in the H-H pattern said that "as long as the lesson matched with the grade level content expectations, I closely follow[ed] the textbook." On the contrary, Randy, categorized in the L-L pattern, said that he usually skipped some activities and problems presented in a textbook because of "assessment."

The influence of teacher fidelity to textbooks on teachers in the H-H pattern extends previous studies in two important ways. First, consistent with previous studies (e.g., Freeman & Porter, 1989), this finding questions the long-held conviction that teachers who closely follow the textbook do not serve their students. This study argues that the teachers who deviated most from the standards-based textbook were likely to place an emphasis on drill and practice of computational skills, while those who followed the text more closely were likely to emphasize applications and conceptual understanding.

Second, although teachers' fidelity to their textbook is often criticized by reformers or educators (e.g., Apple & Jungck, 1990), the findings of this study suggest that teachers' fidelity to their textbooks itself should not be considered the indicator to gauge teachers' practice, but should be considered in conjunction with the type of textbook teachers use and how they see their textbook. In addition to statistical results from the survey which showed that the type of textbook and teacher fidelity to text were crucial ingredients in deciding teachers' textbook transformation patterns, case studies of the H-H pattern also confirmed the influence of these factors. Moreover, I argue that these factors should be considered with teachers' individual characteristics such as teachers' notions of how students should learn (Barr, 1988; Stodolsky, 1989; Schmidt, et al., 1987).

Influence of well-aligned teaching goals with the goals of standards-based curriculum Teachers' teaching goals were also found to be a significant factor in characterizing teachers who provided higher level problems and teacher questions compared to teachers who provided lower level problems and teacher questions (Ball & Feiman-Nemser, 1988; Freeman, & Porter, 1989). Taken together with type of textbook and fidelity to textbook, teaching goals constituted a critical factor that led teachers to sustain high level cognitive demand in their teaching. First of all, all teachers in the case study who were identified as using higher level problems and teacher questions said that their notion of how students learn mathematics matched the notion of teaching and learning embedded in standards-based curricula, which are designed to help students develop conceptual understanding, problem-solving, and mathematical reasoning (Remillard, 2005).

Moreover, comparison between teachers who maintained the cognitive demand of problems and those who didn't suggests that teachers' teaching goals for student learning was a critical ingredient in the ultimate fate of high level problems when teachers use standards-based curriculum. For example, although Brad and Karen used the same standards-based curriculum, Brad maintained the cognitive demand of the textbook problems by using higher level teacher questions, whereas Karen decreased the level by using lower level teacher questions. The reason behind this different use of the textbook is the difference in their teaching goals for student learning. While Brad wanted students to develop the underlying ideas between equivalent fractions, generate the rule and apply the rule to find equivalent fractions, Karen wanted students to follow the rule to find equivalent fractions. Different teaching goals led them to use the same textbook in different ways, which in turn provided different notions of knowing mathematics and doing mathematics to students. In keeping with previous studies, this study argues that the extent to which teachers' ideas about how mathematics is learned matches the teaching and learning philosophies of standards-based curricula contributes significantly to their use of curriculum (Lloyd, 1999; Remillard, 1999; Sherin & Drake, 2004; Stodolsky, 1989).

Influence of teacher knowledge Teacher knowledge, in particular pedagogical content knowledge, was also found to be significant in characterizing teachers who provided higher level cognitive demand problems and teacher questions, compared to teachers who used low cognitive demand problems and teacher questions in their teaching. In the survey, teachers categorized in the H-H pattern rated their knowledge higher than teachers in the L-L pattern. This finding is consistent with previous studies, in particular those that emphasize the importance of teacher knowledge (e.g., Shulman, 1986).

Standards-based curricula are much more challenging for teachers to use because they include many more high-level tasks than teachers typically encounter in the conventional curricula to which they are accustomed (Stein & Kim, 2007). Specifically, because with the standards-based curriculum teachers are asked to teach in ways that are unfamiliar to them and they did not experience as students, it is plausible that teachers with better understanding of mathematics and how students learn mathematics maintain higher level problems in their teaching (Wilson, 1999; Remillard, 2000). Based on this study, I suggest that if teachers have deeper understanding of content and students' ways of thinking, they will be more likely to provide higher level problems and teacher questions, thus helping students learn mathematics through mathematical thinking, conjectures, explanations, and justification as opposed to the way teachers in the L-L pattern would approach teaching.

Factors Distinguishing H-L Pattern from H-H Pattern

The significant factor that distinguished teachers in the H-L pattern from teachers in the H-H pattern was teachers' notions of how students best learn, notions that were embedded in their teaching goals.

Influence of competing conceptions of learning and teaching mathematics to those of standards-based curriculum Only one factor, teachers' teaching goals, was found to be significant in distinguishing teachers in the H-L pattern from teachers in the H-H pattern. The degree of emphasis on understanding-oriented student objectives differs between teachers in the H-H pattern and teachers in the H-L pattern. The findings from the survey revealed that teachers in the H-H pattern were more likely to report heavier emphasis on understanding-oriented student objectives than teachers in the H-L pattern. The case study supported this conclusion. For example, although Brad and Karen used the same standards-based curriculum emphasizing mathematical thinking and understanding, Karen changed this understanding-oriented goal into a procedural fluency-oriented goal, such as following the rules and getting the correct answer. This difference in her teaching goals for student learning led her to lower the cognitive demand of problems. This trend set her apart from teachers in the H-H pattern, for example, Brad. Indeed, her teaching goals came from her notion of how students learn mathematics best. She believed that practice makes perfect. This difference in belief about student learning provides a possible explanation for why teachers in the H-L pattern emphasized understanding less than procedural fluency when using teacher questions in their teaching.

Factors distinguishing L-H pattern from H-H pattern

Even though the L-H patterns only appeared in the survey, there is a possibility that teachers begin with low cognitive demand problems but end up with high level cognitive demand of student thinking by using high level teacher questions in actual classrooms (consider the video clips of Deborah Ball teaching third graders). Several factors significantly distinguished the teachers categorized as an L-H pattern from teachers in other patterns. For example, in the survey, these teachers reported using conventional textbooks and less reliance on their textbook than teachers in the H-H pattern.

Influence of teacher perception of student achievement Interestingly, teachers in L-H pattern perceived their students' mathematics achievement to be higher than teachers in other patterns. This study revealed that teachers in this pattern indicated their students' mathematics achievement level as mostly high more often than teachers in other patterns.

This factor provides a plausible reason why teachers in this pattern increased the lower cognitive demand of textbook problems into higher levels by using questions that required students to reason out solutions and explain and justify their answers. In contrast to teachers in the L-H pattern, the case study revealed that teachers in the L-L pattern, like Randy, attributed their emphasis on low cognitive demand of tasks and low cognitive demand of problems to their students' diversity in terms of mathematics achievement. This finding is consistent with previous studies (e.g., Remillard, 2005; Saracho, 2003), implying that teachers' use of textbooks was also shaped by students, since teachers do not implement their plans in a vacuum, but in a classroom with students. I argue that teachers who perceive their students as mostly high-achieving are more likely to enact lower level textbook problems in ways that increase the cognitive level by using questions that require students' higher mathematical thinking.

Factors Distinguishing L-H Pattern from L-L Pattern

Three factors significantly distinguished teachers in the L-H pattern from teachers in the L-L pattern—teacher views on conventional textbook, understanding-oriented teaching goals, and observation of experts' teaching during professional development programs.

Influence of teacher view on conventional textbooks Both teachers in the L-H pattern and teachers in the L-L pattern were found to be using the same type of textbook (conventional textbooks). Teacher views on conventional textbook were the critical factor in distinguishing teachers in the L-H pattern from those in the L-L pattern. The findings from the survey revealed that teachers in the L-L pattern are more likely to agree that they were pleased with their textbook than teachers in the L-H pattern; these teachers moreover are more likely to use closely the conventional textbook than teachers in the L-H pattern.

Influence of different teaching goals from the goals of conventional textbooks Teachers' teaching goals were also an important factor that distinguished teachers in the L-H pattern from teachers in the L-L pattern. Teachers in the L-H pattern were more likely to report heavier emphasis on understanding-oriented teaching goals than teachers in the L-L pattern. In conjunction with dissatisfaction with conventional textbooks, this difference in emphasis on student learning provides a possible explanation for why teachers in the L-H pattern increase the lower level cognitive demand of the conventional textbooks to higher level in their teaching. Because teachers were dissatisfied with their textbooks and believed their students were more capable, they were more likely to modify the level of cognitive demand.

Influence of lesson observation experience in professional development opportunities Teachers' lesson observation experience during PD was also found to be significant in distinguishing teachers in the L-H pattern from teachers in the L-L pattern. Analyses of the survey revealed that teachers in the L-H pattern were more likely to report their frequent opportunities to observe expert teachers and to be observed teaching during their professional development programs than teachers in the L-L pattern. Consistent with previous studies (Carey & Frechtling, 1997; Darling-Hammond, 1997; Lieberman, 1997), teachers in this study who had more opportunities to observe expert teachers and to be observed teaching in their own classrooms and had more opportunities to obtain feedback were more likely to increase the lower level problems and questions in ways that allow students learn mathematics through mathematical thinking, conjecture, explanations, and justification than teachers in the L-L pattern.

Other Important Findings to Consider

I have summarized thus far findings from the survey and the case studies, which associated directly with the text-teacher relationship (i.e., whether and how teachers change the cognitive demand of *textbook* problems and questions in their t*eaching* and what factors influence their transformations). In addition, there are several other aspects that we need to consider in order to understand better the relationship between texts, teachers and teaching. First, consistent with findings from previous studies, this study found that textbooks did not dictate what to teach. Rather, it was the Michigan grade-level content expectations (or assessment derived from the GLCEs) that determined what was to be taught. Therefore, the first thing for teachers to do when planning lessons is to determine whether their textbooks provide mathematics content "they should cover." This suggests that we also need to consider the text-teacher relationship in relation to content framework.

Second, textbooks were the primary sources for teachers to make plans and create their lessons. As long as the textbooks provided the lessons teachers are required by the GLCEs to cover, some teachers closely followed the textbook whereas other teachers selectively used problems and activities presented in textbook lessons. However, when textbooks did not provide the content they needed to cover, teachers tended to refer to available sources such as the Internet, other textbooks that contain the contents, or to create their lessons based on their own experience or their knowledge.

Third, this study did not consider "time" as an influential factor that distinguished teachers in one pattern from teachers in other patterns. However, teachers in the case study referred most frequently to time pressures as influencing their use of textbooks (or teaching). For example, in keeping with previous studies (e.g., Wilson, 1990), teachers in the L-L pattern mentioned that they could only work on the basic skills—rules and procedures. Teachers also commonly mentioned that they adapted their textbooks according to student needs.

Discussion

This study looked at two dimensions of teachers' textbook use in terms of cognitive demands (i.e., problems and teacher questions) and provided interesting findings. For example, this study suggested that when teachers used problems from their textbooks, they at least maintained the cognitive demand of textbook problems. However, this study also suggested that the enactment of mathematical problems was a multi-dimensional practice. As mathematical problems are enacted in the mathematics class, they become intertwined with teachers' goals, intentions, and questions, as well as interactions among teachers and students, and are thereby transformed into different cognitive levels. Although teachers used the higher level of textbook in their teaching, they decrease its cognitive demand by using a lower level of teacher questions. These findings suggest the importance of the ways in which the problems are carried out by the questions teachers use for students to work on as well as the importance of examining these two dimensions (problems and teacher questions) in understanding the text-teaching relationship. Some researchers examined only the enactment of problems to understand teaching practice in terms of the cognitive demand (e.g., Stein & Smith, 2000) whereas other researchers explored only the use of teacher questions in teaching (e.g., Nicol, 2006). By investigating these two dimensions together, this study expanded research in the areas of teachers' use of textbook in mathematics education.

In addition, this study identified influential factors on elementary teachers' textbook use that need to be considered in order to change teaching practices in ways that promote students' understanding and sense-making. This study illustrated the factors that influence teachers who decrease the higher level text into lower level cognitive demand: teachers' conflicting conception of learning and teaching mathematics and teachers' frequent use of procedural-oriented teaching goals. For example, in keeping with previous studies (e.g., Remillard, 2005), this study revealed that teachers who decreased the higher level textbook problems and questions have a competing conception of learning and teaching mathematics with those of standards-based curriculum designed to help students develop conceptual understanding, problem-solving, and mathematical reasoning. These teachers put more emphasis on procedural aspects of the mathematics (i.e. how) rather than conceptual aspects (i.e., why). Although these teachers use the higher level problems presented in standards-based curriculum, they decrease the cognitive demand of the higher level problems by using teacher questions that emphasize the procedure of "how to get an answer".

In a similar way, this study also identified the factors that influence teachers who increase the lower cognitive demands of the text into higher level: teachers' dissatisfaction with conventional textbooks, high-achieving students, and experts' lesson observations in professional development. For example, this study revealed that teachers who increased the lower level textbook problems and questions have a competing conception of learning and teaching mathematics with that of conventional textbooks so that these teachers put more emphasis on conceptual of the mathematics (i.e. why) rather than procedural aspects (i.e., how). In particular, these teachers perceived their students as mostly high-achieving and had more opportunities to observe expert teachers and to be observed teaching in their own classroom in professional development than teachers who maintained or decreased the lower cognitive demand in teaching.

Among three-level factors—individual-level, contextual-level, and teachers' opportunity-to-learn, this study revealed that contextual-level factor, type of textbook (standards-based curriculum) is the most significant factor that plays an important role in deciding the cognitive demand of problems and questions in teaching. However, this study also revealed that the enactment of mathematical problems is a multi-dimensional practice intertwined with contextual-level factors (type of textbook and student mathematics achievement), individual-level factors (teachers' goals, intentions, and their knowledge), and teachers' opportunity-to-learn factors (observation of experts' teaching in PD). This understanding is essential when curriculum materials are considered the primary strategy for improving practice. These findings will help reformers, school administrators, and teacher educators to consider in what ways they can support teachers when teachers attempt to revise their practices according to reform ideas. Therefore, this study will contribute to current reform efforts that change teaching practices in ways that promote students' understanding.

Furthermore, this study developed the framework that describes teachers' modifications in four components of a lesson plan--student objectives, classroom activities, mathematical problems, and teacher questions of a lesson, which is associated with maintenance or change in the level of cognitive demand. This framework was developed based on the revised Bloom's Taxonomy (2001) and Stein and Smith (2000) and was utilized in this study to minimize methodological limitations of the survey and to provide valid findings. In particular, this framework helped me not only to analyze teachers' lesson plan modification but also to examine analytically teachers' actual teaching in terms of cognitive demand. Many perspectives on the text-teacher relationships tend to place the teacher and the text at odds with one another, each vying for the same authority over curriculum-decision (cf. Russell, 1994). This perspective is likely to be emphasized in teacher education program (Ball & Feiman-Nemser, 1988). Instead, preservice teachers should be encouraged to develop an interactive relationship with textbooks and curriculum guides rather than antagonistic relationship. Teacher education programs should provide aspiring teachers with opportunities to critically analyze, to examine the mathematical and pedagogical assumptions embedded in curriculum materials, and to revise their lesson in ways that increase student understandings. In conjunction with such efforts, this framework can be a useful tool for helping pre-service and in-service teachers be aware of the cognitive demand of their lesson plans and analyze the cognitive demand of their textbooks. In addition, this framework can be a validation tool to minimize methodological limitations of future research that will use a survey in examining teachers' use of textbooks in terms of the cognitive demand.

However, despite these theoretical and practical contributions of this study, there are several caveats that should be carefully considered: First, in contrast with previous studies (e.g., Stigler & Hiebert, 2006), a large number of teachers in this study were categorized in the H-H pattern. In addition, none of teachers were categorized as the H-L pattern, most frequently identified by other researchers (e.g., Cohen, 1990; Cohen, McLaughlin, & Talbert, 1993; Darling-Hammond, & McLaughlin, 1995; Kennedy, 2006; Porter & Brophy, 1988; Stigler & Hiebert, 2006), in describing the text-teaching relationship. Why do the findings in this study differ from those of other researchers?

One possibility is that the use of the code of 3 as the cut off score is too generous to classify an individual teacher's average frequency rating of high-level problems presented in textbooks and those used by teachers in teaching into either higher cognitive demand level or lower cognitive demand level. What would happen if a code of 4 was used? We might have seen the H-L pattern and a smaller number of teachers in H-H pattern.

However, the cut off score chosen in this study was based on previous studies (e.g., Sanders, 1966). The accuracy of this cut off score was tested in two ways: (1) examining the type of textbook as an influential factor distinguishing H-H and H-L patterns from L-L and L-H pattern; (2) examining group membership among transformation patterns. First, this study used the type of textbook (standards-based textbooks and conventional textbooks) as an indicator that distinguishes teachers in the H-H pattern and the H-L pattern from teachers in L-L pattern and L-H pattern. If the cut off score is accurate, the type of textbook should be an indicator of different transformation patterns. The findings from multinomial logistic regressions revealed that teachers in the H-H and H-L patterns were more likely to use the standards-based curriculum whereas teachers in the L-L and L-H patterns were more likely to use the conventional textbooks.

In addition, multinomial logistic regressions allowed me to examine group membership among transformation patterns exhibited. In particular, the classification results from multinomial logistic regression reveal whether transformation patterns exhibited in each phase are correctly classified in the analysis. The overall rate of correct classification is 78.5% for the analysis of group membership among transformation patterns in phase 1; 73.9% for the analysis in transformation phase 2; and 81.6% for the analysis in phase 3. Although these overall rates of correct classification do not directly examine whether the use of the code of 3 is accurate, they provide me a rationale for using a code of 3 as the cut off score.

In conjunction with the cut off score, another possible explanation for the absence of the H-L pattern results concerns the methodological limitation of the survey as a research tool. In the survey much of the data are self-reported by teachers. One limitation of self-report for this study is the potential for teachers to provide biased responses to the survey because they feel that they should (for a variety of reasons) respond to the questions in "acceptable" or "socially desirable" ways; or teachers might unknowingly provide misleading responses to the survey questions. Researchers reported that teachers sometimes truly believe they are embracing pedagogical reforems although their teaching does not, in fact, match the vision of the reformers (Cohen, 1990; Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1996).

Further, convenience samples of this study which do not represent the entire population of teachers might lead to different results from previous studies. Participants were recruited among teachers who were taking Master's courses at a large suburban Midwestern University or those who were registered for professional development programs. Given their participation, these teachers might be very familiar with reform ideas (e.g., NCTM standards) or might be influenced by these programs and might thereby show different transformation patterns from those identified by other researchers (e.g., Cohen, 1990; Stein & Smith, 1998; Stigler & Hiebert, 2004).

There is an alternative way of examining transformation patterns in the survey that may avoid teachers' overestimation of their teaching. This study used high-level cognitive demand problems and questions (which often cause teachers' embracing of theoretically fashionable terms). If one compared teachers on their frequency of using the low-demand options in questions 18 and 19, one might have different results. Due to the small number of survey items measuring the low-demand options, in particular, relatively low reliability, high-level cognitive demand problems and questions were selected and used. Future research should explore transformation patterns using both high-and low-level problems and questions in a survey in order to capture a more accurate portrait of what teachers do in their classrooms and how they trasnform their textbook in their classroom. This limitation calls for future research that avoids each of the above potential criticisms (e.g., to address the recruitment issue, teachers could be recruited from a more representative pool, perhaps a national survey).

The second caveat is that the case studies focus on only one specific topic (fractions units) and the findings from the case studies are short-term observation. After analyzing the survey, in order to examine how teachers actually use their textbooks in the classroom, I observed eight teachers at least once (in most cases, twice) when they were teaching fraction units. This limited observation might not capture an accurate portrait of what these teachers do in their classrooms and how they intract with the students using their textbook in their classroompractice. Or a limited observation might produces a pattern that may or may not hold true for that teacher over time.

The third and final caveat is that there are inconsistencies regarding transformation patterns between some findings from the survey and the case studies. Among the eight teachers whose lessons were observed for the case study, two teachers showed inconsistencies between their reports on the survey and their actual teaching. This implies that there might be more cases that show inconsistencies between reports on the survey and actual teaching. Yet, there are six cases in this study confirming what the survey results suggest about transformation patterns as well as influential factors. In addition, combining the results from both the survey and the case study helped me infer a possible reason for the discrepancies between teachers' responses on the survey and their actual teaching. In light of these explanations, the findings of this study seem credible and plausible and allow me to provide implications for policy makers, curriculum developers, professional developers, and teacher educators.

Implications

Implication for Policy Makers

As many policy makers assume, teachers use their textbooks as primary resources. A textbook can be a reasonable candidate for communicating and providing guidance for change. In particular, this study showed that, in contrast to conventional textbooks, standards-based curriculum has the potential to influence teaching practice in ways that emphasize students' mathematical thinking, reasoning, and sense-making.

There are various textbooks available on the market. In the selection of new textbooks or new curriculum, policy makers and reformers need to first consider whether the selected textbook can provide a vision for teachers to take on new roles in helping children to construct knowledge in ways that they intend.

However, textbooks alone do not guarantee different practice. Policy makers and reformers need to consider various factors that affect teachers' use of textbooks, such as teachers' conception of learning and teaching mathematics and provide systemic support and resources for teachers to use textbooks. All teachers need support. In particular, teachers in the H-L pattern and the L-L pattern need to teach about mathematics as a field of inquiry, not as a body of procedures. They need to learn to think about the goals of learning mathematics as greater than the mastery of computational skills. Teachers cannot make fundamental changes in their teaching without several kinds of support, such as time and assistance in examining and evaluating their own assumptions about how children learn mathematics and comparing their assumptions to those represented in standards-based curriculum. This study revealed that the extent to which teachers' ideas about how mathematics is learned matches the teaching and learning philosophies of standards-based curricula contributes significantly to their use of curriculum. Reformers and policy makers must find ways to communicate about change in a way that makes sense and respects where teachers are, while still helping them realize that they are being asked to rethink what they do, and in a way that provides guidance for that change.

Moreover, policy makers need to help teachers have a clear understanding of what their goals are. This study showed that the vision of learning and teaching mathematics presented in the curriculum framework was seen by teachers as subtly contradictory, due to the ambiguities of the term "mastery." For example, since the term "mastery" can be interpreted in multiple ways, Karen, one of the case participants, perceived its meaning from a procedural standpoint. Her conception of "mastery" of procedures hindered her from sustaining higher levels of student thinking in her class. Schmidt et al. (1987) pointed out that teachers are often confronted with the ambiguities and weaknesses of curriculum policies in practice. Even in the situation that curriculum frameworks are provided, teachers must still choose the content and methods of their instruction. Karen's case shows that such mismatch or miscommunication about the intentions of the framework may function as a constraint for teachers' use of higher level problems and teacher questions from their textbooks. Policymakers and reformers may need to clarify what they intend by "mastery" and find ways to communicate with teachers.

Furthermore, policy makers should provide systemic support and resources for teachers' use of textbooks through professional development activities. Teachers need to learn about the range of methods, including their respective strengths and weaknesses, because their lack of knowledge about alternative methods constrains their ability to implement the textbooks adopted by district or states

Implications for Curriculum Developers

One hallmark of standards-based reform is its attempt to build on student thinking in meaningful ways as opposed to teaching algorithms that often don't connect with students' prior understandings. Research has documented the challenges that many teachers face when they try to conduct lessons that take into account and productively build on student responses (e.g., Ball, 2001; Brown & Campione, 1994; Chazen & Ball, 2001; Lampert, 2001; Leinhardt & Steele, 2005; Schoenfeld, 1998; Sherin, 2002). For example, during whole-class discussions that typically follow exploratory group work, teachers must make rapid assessments of students' understandings, compare them with the desired response, and then fashion a response that will simultaneously help move both the responding student and the rest of the class towards a more sophisticated understanding of the mathematics in question.

To help teachers make better use of their textbooks, curriculum developers need to be aware of these teachers' difficulties when using standards-based curriculum and consider including more detailed information about how to use their textbooks. Ball & Cohen (1996) have identified ways in which curriculum materials can be educative for teachers, two of which I have identified as particularly relevant implications for curriculum developers: (a) making visible developers' rationales for including particular tasks in terms of the mathematical understandings to be gained; and (b) helping teachers learn how to anticipate what learners may think about or do in response to instructional activities. In addition, curriculum developers might suggest a range of pedagogical options that teachers could use to address the particular mathematical idea along with sample student work or responses including the correct and incorrect student thinking.

Implications for Professional development

Teachers, like their students, are learners who need to be taught in innovative, flexible ways. Teacher should have opportunities to learn and participate with their textbooks in professional development. First, professional development activities should provide teachers with opportunities to change their notions of learning and teaching mathematics. As Brad's case shows, matching a textbook with the teacher's own philosophy has important consequences. Professional development supporting textbook adoption has focused on fidelity of implementation. If teachers can reconcile their own views with those advocated by the developers, frequent adaptations by the teacher will change the content being taught. A more flexible understanding of what a textbook is might enrich the possibilities of professional development activities. By acknowledging that teachers might not change radically their own views, middle ground solutions can be a better strategy for promoting teacher change. Professional development can focus more on understanding the particular needs of a community of teachers, rather than trying to impose an implementation.

Second, professional development activities should help teachers become consciously aware of the cognitive demand of activities, problems, and questions presented in curriculum materials and examine and reshape textbook suggestions to fit their classroom needs. Content in professional development activities should be also specifically designed for improving teachers' pedagogical content knowledge (e.g., Specific ways of teaching strategies/methods; specific ways of improving students' conceptual understanding).

Furthermore, professional development activities should provide the opportunities for teachers to work with other teachers in forming collaborative-inquiry partnerships. Those facilitating teacher groups that involve examining students' thinking and classroom discourse using textbooks have found that such activities can enhance teachers' mathematical knowledge (Russell et al., 1995; Smith & Featherstone, 1996) and their ideas about pedagogy (Hammerman, 1995). Collaborative analysis in professional development activities would be identifying the mathematical roots of students' activities, assessing their understanding with respect to mathematical concepts and exploring possible curricular actions. In those activities, teachers need to have opportunities to critique other lessons and explore alternative possibilities with others.

Implications for Future Study

Limitations and findings from this study lead me to several implications for future research. First, this study focused on the topic of fractions. Future studies might consider other topics and examine how teachers use their textbooks in terms of cognitive demands across different topics. It is possible that different topics require different opportunities for student learning, which lead teachers to use different types of activities and problems. For example, learning and teaching geometry involves more work for students and teachers to use representations and concrete materials than learning and teaching the operations for whole number and fractions. Comparisons of teachers' use of textbooks across different topics would shed light on the role that the specific topics play in this process.

Second, due to the lack of participants categorized as the L-H pattern, this study could not fully describe why and how these teachers modify their textbooks when using problems and teacher questions from their textbooks. The analyses from the survey revealed three factors that distinguish teachers in the L-H pattern from teachers in the L-

L pattern—(1) Participations of profession development programs that provide opportunities to observe expert's lesson, (2) teachers' perception of students as high-achieving, and (3) teachers' frequent use of understanding-oriented teaching goals. However, these findings do not tell how teachers in the L-H pattern modify the lower level of textbooks into higher level. This finding calls for more future research that examines how these factors influence teachers' decision-making in the selection and use of problems and questions in their teaching.

Third, one suggestion from the findings of this study is that the type of textbook plays an important role in deciding student learning opportunities. This study revealed that when teachers use standards-based curriculum, they are likely to provide questions leading to higher level of student thinking whereas when teachers use conventional textbooks, they are less likely to provide higher level of student thinking. However, this study does not examine relationship among student mathematics achievements, type of textbook teacher use, and teachers' use of textbooks. Findings of this study call for future research that examines these relationships.

Fourth, this study focused on in-service teachers' textbook use and influential factors. Teachers in different stages require different need and support in order to help them teach better. Future comparative studies of experienced teachers and novice teachers (including student teachers) using standards-based curriculums and/or conventional textbooks could contribute to research on teacher development and its role in current reform efforts that change teaching practices in ways that promote students' understanding.

Fifth and finally, this study developed a framework that illustrates teachers' modifications in student objectives, classroom activities, mathematical problems and teachers questions of a lesson, which is associated with maintenance or change in the level of cognitive demand. This framework can be a useful tool for helping pre-service and in-service teachers be aware of the cognitive demand of their lesson plans and analyze the cognitive demand of their textbooks. This framework could be utilized in teacher education programs designed to prepare teachers to be skilled in curriculum development (Ball & Feiman-Nemser, 1988) and in professional development programs. Future research needs to examine the effectiveness of this framework in teacher education programs and profession development programs.

Concluding Remark

This study shows the complexity of the relationship between texts, teacher and teaching. If policy makers and reformers intend to change practice by using new curriculum materials, they need to first choose a textbook that can provide a vision and guide for teachers to take on new roles in helping children to construct knowledge in ways that the change was intended. In addition, they should consider adding scaffolding systems to help teachers make better use of their textbooks. Teachers are affected by both contextual-level factors and individual-level factors (Johnston & Woodbury, 2003; Knapp, 2002; McLauglin, 1991). Teachers need time and assistance in examining and evaluating their own assumptions about how children learn mathematics and comparing these assumptions to those represented in standards-based curriculum. Through professional development activities, teachers should be provided with learning opportunities for new methods and pedagogy. Working together with fellow teachers for specific tasks that are closely related to their curriculum materials, teachers can be given relearning opportunities for how to teach mathematics. Policy makers and reformers, curriculum developers and professional developers should work together to provide the systemic support described above and resources for teachers to make better use of their textbooks.

APPENDICES

Appendix A

Survey

A. Background

1. Gender: ______ Male ______ Female

2. Please mark ALL teaching certifications that you hold.

______ Certified in K-8 grade education: If you have elementary certification, do you have an endorsement for teaching 6-8 grade mathematics?____Yes, _____No.

______ Certified in 7-12 grade education. If yes, in what subject? ________________

______ Other certification (Please specify): ________________________________

______ None

3. How many years have you taught each of the following grade bands in schools? Please include this year.

- K-2 ________________Year(s)
- 3-5 ________________Year(s)
- 6-8 ________________Year(s)
- 9-12 ________________Year(s)
- Others (describe);_______ ________________Year(s)

* Did you teach in 2005-06? Yes ____ No _____

4. Grade level(s) you taught in 2005-06. Please specify: ______________________

5. Type of School:___Public____Private, non-religious___ Private, religious __Other (Specify);____

6. School Size (# of classes in your school):_____; approximate number of students: ____

7. Number of students in your classroom: ________________

8. Mathematics achievement level of students in your classroom in 2005-06. Check one.

_____ Mostly high achieving

_____ Mostly average achieving

_____ Mostly low achieving

_____ Students at a range of achievement level

9. Which of the following best describe your district's policy regarding the use of the school mathematics textbooks? Please mark (v) one.

_____ a. All teachers in the building are expected to use the same mathematics textbook series.

_____ b. All teachers at the same grade level are expected to use the same mathematics textbook; different series are allowed across grade level.

_____ c. Each school can adopt its own textbook series; different schools may adopt different series.

_____ d. The district has no policy, None of the above

_____ e. The district has a policy but it is different from those listed above (Please explain):

____

10. Do you generally use the textbook assigned to you by your district or school?

_______Yes _______ No

11. Do you use any other textbooks? _______ Yes _______ No

12. List the textbook(s) students used in your class in 2005-06. Write it down in detail, such as, the title of textbooks, year, and edition (e.g., Everyday Mathematics, Grade 3, 2001, 2nd edition.). Mark (v) which one of these was your main resource.

Title & Publisher	**Grade**	**Year of publication**	**Edition**

13. Think about the main textbook you used as a resource in planning lessons for your mathematics classes. Indicate how much you agree or disagree with each of the following statements.

1= Strongly disagree, **2**=Disagree, **3**=Neither agree nor disagree, **4**=Agree, **5**=Strongly agree

a. You are pleased with the textbook	1	2	3	4	5
b. The textbook adequately covers the topics on the state tests	1	2	3	4	5
c. The textbook series matches what you think is important in mathematics	1	2	3	4	5
d. The textbook reflects NCTM principles and standards for school math.	1	2	3	4	5
e. The teacher's manual of the textbook helps you learn new methods to use in planning lessons	1	2	3	4	5

* Are you planning to teach the same grade you taught last year in the 2006-2007 academic year?

____Yes, _____No.

* Would you be willing to be interviewed in <u>a follow up study</u> (Part II of this study)?

____Yes, _____No.

If yes, please provide your contact information below.

Name	
District	
School	
Email Address	

B. Textbook Use on Rational Numbers

The questions in this section are about the main textbook you used as a resource when you planed lessons on rational numbers in the 2005-06 academic year.

- Did you teach anything about fractions during the 2005-2006?

Yes ____ No _____

If yes, go to next question.
If no, go to Question 20.

14. Think about the main TEXTBOOK YOU USED in planning and teaching fraction lessons. Indicate how much you agree or disagree with each of the following statements.

1 = Strongly disagree, **2** = Disagree, **3** = Neither agree nor disagree, **4** =Agree, **5** = Strongly agree

a. You used the textbook as a primary resource	1	2	3	4	5
b. Your planned in-class learning activities came directly from the textbook	1	2	3	4	5
c. Your planned problems came directly from the textbook	1	2	3	4	5
c. Most of the homework assignments were typically drawn from the textbook.	1	2	3	4	5
d. Most of examples you planned to use to explain content came directly from the teacher's manual of the textbook.	1	2	3	4	5
e. Most of questions you planned to use came directly from the teacher's manual of the textbook.	1	2	3	4	5

15. Think about the fraction unit(s) you taught in 2005-06. Which of the following SOURCES, if any, did you mainly depend on when planning lessons about the topic of fractions? Indicate what percentage of the following sources you used when you planned your lessons. (The sum of the percentage in 1.-7. below should be 100%).

Percentage	Sources you used
________%	1. Textbook assigned to me by district or school
________%	2. Other textbooks (specify; ______________________)
________%	3. Other commercial prepared supplementary materials
________%	4. Worksheets or other materials prepared by me or my colleagues
________%	5. MEAP-test questions
________%	6. Internet materials
________%	7. Others non-textbook teaching materials (specify; ______________)
= **100%**	**Total**

16. Think about STUDENT OBJECTIVES in your lesson plans for teaching fractions in 2005-06. How much emphasis did each of the following student objectives receive? Please circle one in each row.

1= No Emphasis, **2**= Minimal Emphasis, **3**= Moderate Emphasis, **4**= Heavy Emphasis

a. Learn mathematical concepts	1	2	3	4
b. Learn mathematical algorithms/procedures	1	2	3	4
c. Develop students' computational skills	1	2	3	4

d. Learn to reason mathematically	1	2	3	4
e. Increase students' interest in mathematics	1	2	3	4
f. Learn to perform computations with speed and accuracy	1	2	3	4
g. Learn to explain ideas in mathematics effectively	1	2	3	4
h. Learn how mathematics ideas connect with one another	1	2	3	4
i. Prepare for standardized tests	1	2	3	4
j. Learn how to solve problems	1	2	3	4

17. When you planned lessons for fraction units, how often did you do the following?

1=Almost never, **2**=Rarely (about once a week), **3**=Sometimes (2-3 times a week), **4**= Often (4 times a week), **5**= (Almost everyday)

a. Use the questions in the textbook exactly as they are phrased.	1	2	3	4	5
b. Modify difficult questions in the textbook to make them easier for students.	1	2	3	4	5
c. Modify easy questions in the textbook into more challenging for students	1	2	3	4	5
d. Omit questions or activities.	1	2	3	4	5

18. Think about the fraction PROBLEMS presented in your main textbook and those you used in your planning and teaching. Indicate frequency of the following types of problems in textbook and in your teaching. **1**= Never, **2**= Rarely (once a unit), **3**= Sometimes (2-3 times a unit), **4**= Often (4-5 times a unit), **5**= Almost all lessons

	In TEXTBOOK					In TEACHING				
a. Problems/activities that require students to use methods of inquiry (e.g. collecting and analyzing data).	1	2	3	4	5	1	2	3	4	5
b. Problems that allow students to explain and justify their ideas.	1	2	3	4	5	1	2	3	4	5
c. Problems involving communication with peers and teachers.	1	2	3	4	5	1	2	3	4	5
d. Problems that require students to develop their own methods.	1	2	3	4	5	1	2	3	4	5
e. Problems that emphasize relationships among math concepts.	1	2	3	4	5	1	2	3	4	5
f. Problems that require using various representations (e.g., writing, tables, & graphs).	1	2	3	4	5	1	2	3	4	5
g. Problems that require students to apply math concepts to real world problems.	1	2	3	4	5	1	2	3	4	5

19. Think about the QUESTIONS in the fraction unit(s) presented in your main textbook and those you used in your planning and teaching of fractions. Indicate frequency of the following types of questions in textbook and in your teaching.

1= Never, **2**= Rarely (once a unit), **3**= Sometimes (2-3 times a unit), **4**= Often (4-5 times a unit), **5**= Almost all lessons

	In TEXTBOOK					In TEACHING				
a. Pose open-ended questions	1	2	3	4	5	1	2	3	4	5
b. Require students to explain their reasoning when giving an answer	1	2	3	4	5	1	2	3	4	5
c. Ask students to explain concepts to one another	1	2	3	4	5	1	2	3	4	5
d. Ask students to consider alternative methods for solutions	1	2	3	4	5	1	2	3	4	5
e. Ask students to read from a mathematics textbook in class.	1	2	3	4	5	1	2	3	4	5
f. Ask students to answer questions about what they have read.	1	2	3	4	5	1	2	3	4	5
g. Ask students to evaluate each other's ideas	1	2	3	4	5	1	2	3	4	5

20. Suppose that you are planning to teach the concept of equivalent fractions to fourth graders. The next page shows a daily lesson. Would you use this lesson plan exactly as it is presented? _______ Yes _______ No

If no: Please describe <u>in detail</u> the modification(s) you would make including your student objectives, classroom activities, problems, and questions you would use.

12-11 Daily Lesson Plan   Objective: Write equivalent fractions.

Introducing the Lesson

Manipulatives: fraction bars

Display 2 fraction bars, one showing $\frac{1}{2}$ and the other $\frac{2}{4}$.

Ask, **What can you say about these two fraction bars?** (They are equivalent fractions, $\frac{1}{2}=\frac{2}{4}$)

Write on the chalkboard: $\frac{2}{3}=\frac{(\ )}{9}$

What number do you multiply by 3 to get 9? (3) **The next step is to multiply by 1 what number?** (3)

$$\frac{1\text{x}3}{3\text{x}3}=\frac{3}{9}$$

Repeat the questioning for the following questions.

$$\frac{1}{7}=\frac{(\ )}{14}(2) \qquad \frac{1}{4}=\frac{(\ )}{16}(4)$$

Using the Pages

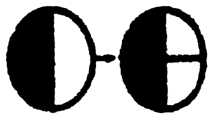
Share with the students, **We all know that** $\frac{3}{3}=1$, $\frac{4}{4}=1$, $\frac{5}{5}=1$, **etc. You can find many equivalent fractions by multiply any fraction by** $\frac{2}{2}$, $\frac{3}{3}$, $\frac{4}{4}$, $\frac{5}{5}$, **etc. So** $\frac{1}{2}=\frac{1\text{x}3}{2\text{x}3}=\frac{3}{6}$, $\frac{1}{2}=\frac{1\text{x}4}{2\text{x}4}=\frac{4}{8}$, **etc.** The diagram at the top of page 350 helps students see that when you double the number of pieces (multiply the numerator and denominator by 2) you have equivalent fractions: $\frac{1}{2}=\frac{2}{4}$. Go over each equivalent fraction given for $\frac{1}{2}$. Make sure students understand the procedure for multiplying by fractions that equal 1, for example, $\frac{1}{2}=\frac{1}{2}\text{x}1=\frac{1}{2}\text{x}\frac{2}{2}=\frac{2}{4}$.

The **Class Exercise** should be completed orally. Call on various students to respond, noting those who may need further help.

Source: Burbank, I.K. et al. (1987). *Houghton Mifflin Mathematics Teacher's Edition, level 4,* Houghton Mifflin Canada Ltd..

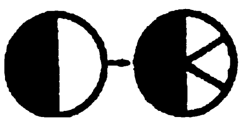
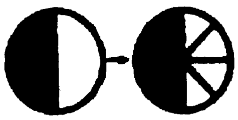
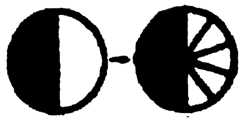
EQUIVALENT FRACTIONS

You can write an equivalent fraction by multiplying the numerator and the denominator by the same number.



$$\frac{1}{2}=\frac{1\text{x}2}{2\text{x}2}=\frac{2}{4}$$

You can write other equivalent fractions for $\frac{1}{2}$.

$$\frac{1}{2}=\frac{1\text{x}3}{2\text{x}3}=\frac{3}{6} \qquad \frac{1}{2}=\frac{1\text{x}4}{2\text{x}4}=\frac{4}{8} \qquad \frac{1}{2}=\frac{1\text{x}5}{2\text{x}5}=\frac{5}{10}$$

A calculator is handy for finding equivalent fractions with large denominators.

$$\frac{5}{9}=\frac{?}{261}$$

Think: How many nines are in 261? 261 ÷ 9 = 29

$$\frac{5}{9}=\frac{5\text{x}29}{9\text{x}29}=\frac{145}{261}$$

CLASS EXERCISES

Complete.

1. $\frac{1}{2}=\frac{1\text{x}2}{2\text{x}2}=\frac{(\ )}{4}$ 2. $\frac{1}{2}=\frac{1\text{x}3}{2\text{x}3}=\frac{(\ )}{6}$ 3. $\frac{1}{2}=\frac{1\text{x}4}{2\text{x}4}=\frac{(4)}{(8)}$

By what number is the denominator multiplied? Complete the equivalent fractions.

4. $\frac{1}{3}=\frac{(\ )}{6}$ 5. $\frac{1}{4}=\frac{(\ )}{12}$ 6. $\frac{1}{5}=\frac{(\ )}{10}$ 7. $\frac{2}{7}=\frac{(\ )}{21}$ 8. $\frac{3}{4}=\frac{(\ )}{16}$

PRACTICE

Complete.

9. $\frac{1}{8}=\frac{(\ )}{24}$ 10. $\frac{1}{5}=\frac{(\ )}{20}$ 11. $\frac{2}{4}=\frac{(\ )}{24}$ 12. $\frac{1}{7}=\frac{(\ )}{21}$ 13. $\frac{3}{8}=\frac{(\ )}{16}$

350 LESSON 12-11

Source: Burbank, I.K. et al. (1987). *Houghton Mifflin Mathematics Teacher's Edition, level 4,* Houghton Mifflin Canada Ltd..

C. Factors Influencing Your Lessons

21. How would you rate your knowledge about each of following? Please circle only one in each row.

1 = Very poor, **2** = Poor, **3** = Adequately, **4** = Good, **5** = Excellent

a. Mathematics content knowledge on whole numbers	1	2	3	4	5
b. Mathematics content knowledge on rational numbers	1	2	3	4	5
c. Mathematics content knowledge on geometry	1	2	3	4	5
d. Mathematics content knowledge on measurement	1	2	3	4	5
e. Mathematics content knowledge on data analysis and probability	1	2	3	4	5
f. General classroom management	1	2	3	4	5
g. Knowledge of how students learn (e.g., common mistakes/confusion)	1	2	3	4	5
h. Specific ways of teaching strategies/methods (e.g., cooperative groups)	1	2	3	4	5
i. Specific ways of improving student basic skills	1	2	3	4	5
j. Specific ways of improving student's conceptual understanding	1	2	3	4	5
k. Specific ways of improving students' problem solving in mathematics	1	2	3	4	5
l. Specific ways of using curriculum materials (e.g., new textbooks)	1	2	3	4	5
m. Specific ways of modifying difficult questions in the textbook to make them easier for students.	1	2	3	4	5
n. Specific ways of modifying easy questions in the textbook to make them more difficult for students.	1	2	3	4	5
o. Specific ways of developing higher order thinking skills	1	2	3	4	5

22. The followings are the statements of your school district and/or state curriculum frameworks and test. Indicate your degree of agreement or disagreement by circling one in each row.

1 = Strongly disagree, **2** = Disagree, **3** = Neither agree or disagree, **4** = Agree, **5** = Agree

a. District teachers have an obligation to follow district curriculum frameworks	1	2	3	4	5
b. District curriculum frameworks match my beliefs about what is important in mathematics.	1	2	3	4	5
c. District curriculum frameworks reflect adequately NCTM reform ideas.	1	2	3	4	5
d. District teachers have an obligation to teach the content of and state-wide tests.	1	2	3	4	5
e. The state-wide MEAP tests match my beliefs about what is important in math.	1	2	3	4	5
f. The state -wide MEAP tests reflect adequately NCTM reform ideas.	1	2	3	4	5

23. Different teachers have different philosophies. For each of the following pairs of statements, check the box that best shows how closely your own beliefs are to each of the statements in a given pair. The closer your beliefs to a particular statement, the closer the box you check. Please circle only one for each set.

a. "I mainly see my role as a facilitator. My job is to provide opportunities and resources for my students to discover or construct concepts for themselves."	1	2	3	4	"Students won't learn the subject unless you go over the material in a structured way. It's my job to explain, to show students how to do the work, and to assign specific practices."
b. "The most important part of instruction is the content of the curriculum. That content is the community's judgment about what children need to be able to know and do."	1	2	3	4	"The most important part of instruction is that it encourages thinking among students. Content is secondary."
c. "It is useful for students to become familiar with many different ideas and skills even if their understanding, for now, is limited"	1	2	3	4	"It is better for students to master a few complex ideas and skills well, and to learn what deep understanding is all about, even if the breadth of their knowledge is limited until they are older."
d. "It is a good idea to have many activities going on in the class at the same time. Students learn by doing different activities"	1	2	3	4	"It's more practical to give the whole class the same assignment, one that has clear directions, and one that can be done in short intervals that match students' attention spans and the daily class schedule."
e. "Students learn more when the teacher give background and directly teach concepts."	1	2	3	4	"Students learn more when the teachers use active approaches like student discussion, projects, and presentations."

24. Approximately how many total hours have you spent on professional development (PD) in the last 24 months? (Include attendance at professional meetings, workshops, conferences, and formal courses for which you received college credit.)
__________________Hours

* Please indicate how much time you have spent on PD activities on the following content areas in the last 24 months?

1= Never, 2=Less than 6 hours, 3=6-15 hours, 4=16-35 hours, 5=35-65 hours

a. Mathematics content knowledge on whole numbers	1	2	3	4	5
b. Mathematics content knowledge on rational numbers	1	2	3	4	5
c. Mathematics content knowledge on geometry	1	2	3	4	5
d. Mathematics content knowledge on measurement	1	2	3	4	5
e. Mathematics content knowledge on data analysis and probability	1	2	3	4	5
f. General classroom management	1	2	3	4	5
g. Knowledge of how students learn (e.g., common mistakes or confusion)	1	2	3	4	5
h. Specific ways of teaching strategies/methods (e.g., grouping methods)	1	2	3	4	5
i. Specific ways of improving student basic skills	1	2	3	4	5
j. Specific ways of improving student's conceptual understanding	1	2	3	4	5
k. Specific ways of improving students' problem solving in mathematics	1	2	3	4	5
l. Specific ways of using curriculum materials (e.g., new textbooks)	1	2	3	4	5
m. Specific ways of modifying questions in the textbook to make them more appropriate for the level of the students.	1	2	3	4	5
n. Specific ways of developing higher order thinking skills	1	2	3	4	5

25. Indicate how often you did the following during the professional development. Please circle only one per row.

1 = Never, **2**= Rarely (Less than 20%), **3**= Sometimes (21-59%), **4**=Often (60-80%), **5**= Almost (More than 80%)

a. Presentation	1	2	3	4	5
b. Listen to a lecture	1	2	3	4	5
c. Observe a demonstration of a lesson or unit	1	2	3	4	5
d. Observing an expert teachers' teaching	1	2	3	4	5
e. Being observed teaching in classroom & obtaining feedback	1	2	3	4	5
f. Planning and designing classroom implementation	1	2	3	4	5
g. Examining and discussing student work	1	2	3	4	5
h. Leading a whole-group or small-group discussion	1	2	3	4	5
i. Demonstrating a lesson, unit, or skill	1	2	3	4	5

"THANK YOU so much for completing this questionnaire."

Appendix B

Interview Protocol

I. Post-observation interview

This is the copies you gave me before I observed your class.

1. Is there anything you changed while you were teaching this lesson?

If yes:

- What changes were made?
- What caused the changes? Why?
- Did that change made things more or less complex?

If no: ask Q2

2. How did you use your textbook when planning this lesson? Looking at your textbook lesson, there are things you seem to have kept the same and some things you changed. Can you tell me how you think about this?

- What did you add or delete from textbook? Why?
- What made you decide to use them?
  Probe: Did you think that modification changed the level of difficulty/complexity? Why?
- What were the particular activities/examples/problems you included and emphasized in your planning? Why?
- How did you teach and lead these activities/examples/problems? Please step me through your activities and problems—before, during, and after.
- What questions did you pose to have students get involved with these activities?
- What was your goal in this lesson? What did you expect your students to achieve or accomplish in this lesson? Is your goal the same with the goals provided in this textbook?

II. Planning for next lesson

This is the copies of planning for the next lesson.

1. Could you tell me how you prepared this lesson with your textbook? Is there anything you would like to do differently from the textbook? Why?
2. Please step me through your activities and problems—before, during, and after.
   - Is there any particular activity, problems, or example in this lesson you would like to include and emphasize? What are they? Why?
3. For this lesson, how would you teach and lead the classroom activity?

   Probe: What kinds of questions would you use?
   Can you illustrate questions you would like to use in each activity?
4. What would be student difficulties/errors when learning this lesson?
5. What was your goal in this lesson?

III. Factors

1. What are the big idea(s) in this unit?
2. What is the hardiest concept to teach here? Why?
3. What is the hardiest concept for students to learn in this particular unit? Why?
4. How does the textbook help you to teach this content?

   Probe:
   - How helpful is your textbook in helping you address what is hard about this content?
   - In what ways is your textbook is not helpful?
   - Are there parts of the book you find particularly helpful?
5. In general, what do you want your students to learn/accomplish by studying mathematics?
6. I am also interested in the possible factors which influence your planning with textbooks. Is there anything else you would like to say about some factors influencing your use of textbooks?

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