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Middle Grade Teachers' Use of Textbooks and Their Classroom Instruction

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This study focuses on the relationship between teachers' use of textbooks and their attempts to create a learning environment that cultivates deep conceptual understanding of middle school mathematics. Classroom videos (n = 58) were filmed of 14 purposefully selected sixth-grade teachers, who used three unique middle school textbooks which served as one of the lens for video analysis. Additionally, the nature of instruction was analyzed in terms of developing ideas in depth, promoting sense making, and engaging students in learning fractions with multiple representations. The study revealed that teachers using standards-based textbooks were more likely to use teaching strategies that engaged students and facilitated student thinking. Less student engagement and use of effective representations occurred when teachers used lower-rated textbooks.

Key words: standards-based instruction, representation, questioning.

Introduction

The publication of the National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989) called for alignment of high quality curricula with national standards. This focus on standards resulted in the development of several series of middle school mathematics curricula, which opened the age of the standards-based curriculum movement in this country. The notion of standards-based curriculum has become a popular topic within the mathematics education community, but how "traditional" and standards-based textbooks differ and the characteristics and outcomes of standards-based instruction requires further development and research. Some characteristics of standards-based curriculum are revealed in several National Science Foundation (NSF) sponsored projects aimed at developing high quality middle school curriculum materials, e.g., *Connected Mathematics* Project at Michigan State University, *Mathematics in Context* developed in Wisconsin, *Seeing and Thinking Mathematically* (MathScape) developed by the Educational Development Center. Trafton, Reys, and Wasman (2001) proposed that a standards-based curriculum contained six characteristics: comprehensibility, coherence, development of ideas in depth, promotion of sense-making, engagement of students, and motivation for learning.

Many mathematics educators tend to view curriculum as the experiences that students encounter in an educational setting, including national/state standards, textbooks, lesson plans, classroom instruction, and school sponsored programs and services (Oliva, 2001). Researchers have claimed that the textbook is still the major curriculum resource in not only planning but also implementing classroom instruction (American Association for the Advancement of Science [AAAS], 2000; Chandler, 1995; McKnight et al., 1987; Reys, Reys, & Chavez, 2004). However, the alignment between the national/local mathematics standards and many textbooks diverge substantially (Goodlad & Su, 1992; Oliva; Trafton et al., 2001). Moreover, the quality of middle school textbooks vary significantly according to research conducted by Project 2061 (AAAS). Given the differences of textbook quality, how does this discrepancy affect the classroom instruction? More specifically, how do textbooks affect classroom instruction? Some research has explored factors that influence how teachers use textbooks and other curriculum materials, however, little has been done to provide close examination of the strategies that teachers who use different textbooks use in order to teach specific mathematics topics (Remillard, 2005). We used three different textbooks, *Connected Mathematics* (CMP) (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1998), *Middle Grades Math Thematics* (MGMT) (Billstein, Lowery, Montoya, Williams, & Williamson, 1999), and *Mathematics: Applications and Connections* (MAC) (Collins, Dristas, Frey-Mason, Howard, McClain, Molina, et al., 1999) in this study, among which CMP and MGMT are standards-based textbook, while MAC is a non standards-based textbook. The study focused on providing detailed examination of teachers' instruction of the same sixth-grade mathematics objective across different textbooks. The study analyzed individual teachers' instruction using three criteria proposed by Trafton et al. (2001): "developing ideas in depth," "promoting sense-making," and "engaging students" In particular, the following research questions were addressed:

1. How effective are the three criteria proposed by Trafton et al. in determining whether classroom instruction is standards-based or not?
2. How did sixth-grade teachers use different textbooks to teach the same mathematics objective?
3. How did high quality standards-based textbooks influence instruction?

Theoretical Framework

Standards-based Instruction

Researchers have described several characteristics of standards-based instruction as developing ideas in depth, promoting sense making, and engaging students (Kulm, Capraro, & Capraro, 2007; Trafton et al., 2001, Van de Walle, Karp, & Bay-Williams, 2009). The criterion to identify whether teachers or textbooks "develop ideas in depth" is to examine whether the ideas were presented with different representations and connected in a meaningful way (Behr, Lesh, Post, & Silver, 1983; Hiebert, 1990; Trafton et al.). Multiple representations, real world applications, manipulatives, pictures, and the use of written and spoken symbols were suggested as ways to develop math ideas and ensure understanding (Lesh, 1979; Van de Walle et al.; Zhang, 1997). Thus, classroom instruction that uses multiple representations and connects them in a meaningful way was used to identify the criterion of developing ideas in depth.

Trafton et al. (2001) also defined promoting sense making as opportunities provided for students to think reflectively. In the process of learning, students can be at the "zone of proximal development" according to Vygotsky (1978), who indicated that students need assistance from the teacher to facilitate the learning process when they are at the verge of understanding and may have misconceptions, encounter confusions and cognitive conflicts, or become discouraged. At this point, teachers are encouraged to step in by asking guiding/probing questions to "scaffold" students' thinking and learning. The scaffolding that teachers provide may be called "discourse" (Brophy, 2000), "discussion" (Grouws & Cebulla, 2000), "(students) reflective thinking" (Trafton et al.), or "probing/guiding questions" (Kawanaka & Stigler, 1999; Moyer & Milewicz, 2002). All of these actions convey an important idea about using strategies to promote students' sense making through thinking, digesting, and further understanding of the concepts and relationships developed (Brophy, 2000; Grouws & Cebulla; Kawanaka & Stigler; Moyer & Milewicz).

The third characteristic of standards-based curriculum, "engaging students" was analyzed according to students' participation and responses to teacher's questions, for example, whether students were involved in group work or class discussion. Engagement often is promoted if the instruction or content is interesting or relevant to students' daily lives. Participation in hands-on or real-world activities that enhance making connections to more abstract ideas is important. Interaction with peers in exploring and discussing mathematical ideas can enhance students' engagement and interest (Hiebert, 1990; Trafton et al., 2001; Van de Walle et al., 2009).

Relationship between Instruction and Textbooks

Research on the relationship between instruction and textbooks indicated that the way teachers read and used the textbooks varied substantially (McCutcheon, 1981; Remillard, 2005; Smith, 2000; Sosniak & Stodolsky, 1993; Wilson, 2003). The relationship between teachers and textbooks is largely depended on the curriculum and the teacher in particular, how the teacher interprets and reacts to students in the context of classroom setting (Remillard). Often researchers refer to classroom instruction as "enacted curriculum" as a comparison to the "intended curriculum" (lesson planning), since both teachers and students construct the curriculum. Some researchers agree that fidelity between textbooks and instruction is possible even though teaching often reflects diverse fidelity with standards, while others stated that fidelity is not possible since teachers interpret textbooks differently, therefore a "participant" relationship between textbooks and classroom instruction is proposed (Remillard). Teachers "drew on" or "interpreted" or "participated with" textbooks by using/redesigning the tasks based on their beliefs, knowledge, and experiences about specific math topics or pedagogy (Remillard).

Methods

This study was part of a larger study funded by the Interagency Educational Research Initiative through a grant to the American Association for the Advancement of Science (AAAS). The study analyzed the classroom implementation of three different middle grades mathematics textbooks. These textbooks were: CMP, (Lappan et. al., 1998), MGMT (Billstein et al., 1999), and MAC (Collins et al., 1999). The ratings of the instructional quality of these textbooks were high, medium, and low, respectively, according to an analysis by Project 2061 of the AAAS. The study used the data collected from the year 2002-2003. One of the authors actually visited the classrooms and videotaped all lessons. Before the actual videotaped data collection, a workshop aimed at multiple representations was held for the participating teachers.

Participants

The participants in this study were 14 sixth-grade mathematics teachers with teaching experiences ranging from one year to twenty three years. These four males and ten females were employed at five different public schools who participated in the larger project aimed at examining the effects of professional development on teaching for understanding. For the current study, purposeful sampling (Gay, Mills, & Airasian, 2009) was applied to select teachers who had volunteered to be part of the larger project. The textbooks adopted in each school district were MGMT, MAC, and CMP respectfully because we choose a purposeful sampling. For data coding, each teacher was assigned a number from one to 14.

Two teachers in a small rural district used the MAC textbook, a commercially successful textbook that had been used by the teachers for several years. The textbook introduced mixed numbers by providing the definition of the concept of "mixed numbers and improper fraction" in a real world situation—the need to measure the grip size of a tennis racket—followed by a graphical representation of five-fourths, and how to read and write it as an improper fraction and mixed number (Collins et al., 1999). Five teachers from a diverse suburban district used the MGMT textbook. The textbook uses manipulatives (called pattern blocks) to illustrate 4/6 equals to 12/18 (See Figure 1). Students work with the pattern blocks to represent other equivalent fractions.

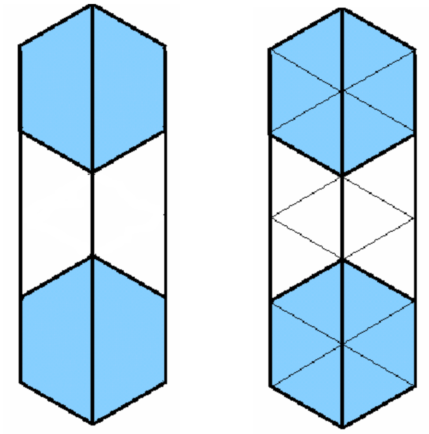

Figure 1. **An example from Middle Grades Math Thematics, illustrating that 4/6 equals to 12/18.**

Seven teachers from a suburban district used the CMP textbook. The lessons that we studied was part of a unit named Bits and Pieces. A real world context involved a survey on how much money they would pay as a ransom for a kidnapped cat. Students apply their knowledge to translate among fractions, decimals, and percents (Lappan et al., 1998).

Video Data Collection and Analysis

Each teacher was observed and videotaped five times per semester. However, some videotapes had quality problems, thus, only 58 of the 70 videotaped lessons were used in the analysis. Analysts, including the authors, were trained by project leaders from AAAS to identify the criteria of “develop ideas in depth,” “promote sense making,” and “engage students.” Video segments from each of the 58 lessons that contained one or more of these three criteria were then identified for analysis. The first and third authors watched and coded the extent to which each lesson met each of the three criteria. When there were disagreements among raters, we watched the videotape together, discussed it and reached agreement to ensure the credibility (Lincoln & Guba, 1985). Triangulation was applied by using information from observations, videotapes, and researcher notes to guarantee dependability (Anfara, Brown, & Mangione, 2002).

Qualitative analyses methods were used to examine the three research questions. Table 1 shows the categories and codes of these characteristics of standard-based instruction.

Results

Classroom Instruction Using Three Different Textbooks

Five teachers (1, 5, 6, 7, and 9) did not meet all three of the characteristics of standards-based instruction, while nine teachers (2, 3, 4, 8, 10, 11, 12, 13, and 14) did. For teachers who followed the textbook, instructional variations were observed even within the same textbook. None of the teachers who used the MAC textbook followed it. Instead of using a graphical representation of 5/4 to introduce mixed numbers and improper fraction as suggested by the textbook, MAC teachers used their own materials, such as pattern blocks or symbolic representations. Most teachers who used the MGMT textbook and teachers who used the CMP textbook did follow the textbook. Among teachers who did not follow the MGMT or CMP textbooks, the instruction looked very similar regardless of the textbook. Those lessons usually employed practice worksheets, lecture as the primary mode of instruction, and limited discussion or questions aimed at checking for students' understanding. When questions were posed, teachers tended to supply the answer without waiting for students to respond.

Development of Ideas in Depth

All teachers who were successful in developing ideas in depth assigned students to work in cooperative learning groups followed by whole class discussions. They also used multiple representations to connect the mathematical ideas in a meaningful way.

Table 1

Criteria of Standards-based Instruction Used by Followers and non-Followers of Each Textbook

Criteria	Indicators	Types	MGMT	MAC	CMP	T
	Setting	Textbook Followers	3	0	6	9

Develop ideas in depth		Non-textbook Followers	2	2	1	5
	Use of Represe-ntations	Textbook Followers	3	0	6	9
		Non-textbook Followers	2	2	1	5
Promote sense making	Question Posing	Textbook Followers	3	0	6	9
		Non-textbook Followers	2	2	1	5
Engaging students	Wait time & Students' response	Textbook Followers	3	0	6	9
		Non-textbook Followers	2	2	1	5

Note. CMP= *Connected Mathematics Project*. MGMT=*Middle Grades Math Thematics*. MAC= *Mathematics: Applications and Connections*. Both MGMT and MAC are standards based textbooks. T=Teachers. Numbers refer to lesson frequency.

Sample MGMT and CMP followers of the textbook

Textbook followers usually adopted the activity from the textbooks, using the books' representations, assigned group work, followed by a whole class discussion. MGMT textbook followers explored equivalent fractions using the pattern blocks (manipulatives), especially focusing on making connections between the manipulatives, graphic representations, and the mathematics symbols. CMP textbook followers guided students to explore the strategies of translation from fractions, decimals and percents. Multiple representations including real world examples, pictures, hundredth grids, and verbal representations were used to develop the mathematical ideas.

Teacher 11 first allowed students to work in groups on an activity using a hundredth grid from the textbook. She then led a class discussion.

T11: Does 1/4 look like it is equal to 25/100?

S: Some said yes, some said no.

T11: Can anyone show me why? If you say they are equal, why? If you say are not, Why?

S: They are different because they look different.

T11: OK. Anyone else?

S: I think they are same, because you can divide 4.

T11: What do you mean? Can you come to the board to show us?

A student simplifies 25/100 to 1/4.
T11: Now does this (1/4) look like it is equal to this (25/100)? Are they equal?
S (all): Yes!
. . . .
T11: Can anyone show me another way using hundredth grids?
Student further worked on the problem to change the fraction to decimal and then percent using the grids.
. . . .
T11: Now you have graphed (percent), fraction, and decimal, three different ways of showing me the same thing.

Sample MGMT, CMP and MAC non-followers of the textbook

Non-followers of the textbook exhibited a very similar pattern, often using worksheets for independent seatwork and the textbook as a reference for in-class exercise practice or homework. They either ignored the sequences of activities and the multiple representations suggested by the book, or they asked their students to read the textbook, followed by more worksheets. With the exception of one MAC teacher who used manipulatives in one lesson, the main instructional approach was lecture or question-answer, as in the following brief example.

Teacher 1 omitted the part of using manipulatives to build the hexagonal window. She asked her students to read the textbook instead. She wrote 4/6=?/18 on the blackboard.

T1: How could I do that?
S: Quiet.
T1: What can I multiply to do that?
S: Quiet
T1: (I multiply by) 3.

Promote Sense Making

Most teachers tried to use questions to promote sense making, especially when the students were at the verge of understanding, when they were demonstrating misconceptions, showing confusion, or becoming discouraged. Those teachers provided appropriate "scaffolding," using guiding and probing questions to facilitate these students' thinking to the next level. The MGMT teachers and CMP teachers all made attempts to provide a learning opportunity for their students.

Sample MGMT and CMP Textbook Followers

Teacher 4 grasped the opportunity when students made mistakes to make it a teachable moment by challenging their thinking.

T4: What fraction of the original window is replaced with the green triangles?

One student: four-twelfths (Figure 2).

T4: "How did you get four-twelfths? But is this four-twelfths (pointing to the trapezoids)? Four of these pieces (trapezoids), will twelve of them (trapezoids) make up the whole thing? That would mean four trapezoids out of twelve trapezoids,"

S: Uh…

T4: "We have to use the same unit, so changing your unit will work, which one do you want to use, you can leave your 4 (trapezoids)or you can leave your 12 (triangles), it is up to you, which one do you want to use?

S: Uh… four trapezoids…..inaudible

T4: Say with the trapezoids, four trapezoids changed out of … (how many trapezoids)?"

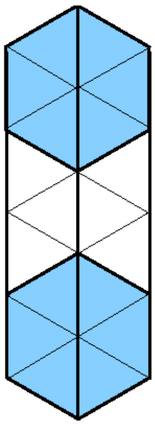

Figure 2. **An example of a student's misconceptions (Note: Four trapezoids equal to twelve triangles so one student thought the shaded area represent 4/12 rather than 4/6).**

Sample MGMT, CMP and MAC non-followers of the textbook

Non-followers all failed to promote sense making. They used lecture without checking on students' understanding, or they asked questions but did not provide enough time for students to respond, or they corrected students' mistakes without discussion of justifications of the correct answer. The follow sample dialogue illustrates a typical approach.

T6: We have a problem here, change $3\frac{2}{3}$ *into an improper fraction.*

S: Use 3, multiply 2, and then add 3 (the teacher wrote $\frac{9}{3}$ *on board).*

T6: No, no, no.

T6: Let us see if this is right…so if there are three on each one (hexagon), and we have two left over, I am not going to have enough blue (rhombuses) to go in these (hexagons), but if there are three in this one, how many are there that went in here? (pointing to the second hexagon), How many are there that went in here? (Pointing to the third hexagon), and we have two left over. Three plus three plus three is nine and plus that two is eleven. Eleven thirds, does that make sense? (Figure 3)

S: (a student disagreed) "Multiply three and two first, and then add three.

T6: I think you got confused with something else because that won't work at all. I think you got confused on that one.

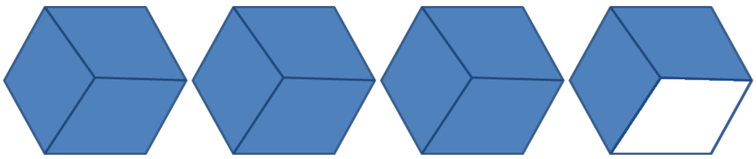

Figure 3. **An example of a student's misconceptions (Note: students thought** $3\frac{2}{3}=\frac{9}{3}$ **using** $3\frac{2}{3}=\frac{3\times2+3}{3}=\frac{9}{3}$ **algorithm, while teacher 6 failed to address).**

Engaging Students

Most teachers tried to engage students by assigning group work, and posing questions. Those teachers who failed to engage students lectured or did not give time for students to answer questions.

MGMT and CMP Textbook Followers

MGMT textbook followers assigned group work first, and then observed students in their group work using manipulatives to build hexagonal windows with hexagons. Students were involved in small group discussion first and then moved to a whole class discussion led by the teacher. Most CMP teachers let students work on the cat ransom problem first in groups, followed by a whole class discussion. Students' responses to the questions and activities are presented as indicators of engagements. The following is a brief example of student engagement.

T11: What do we know about that? What do we know about these three different representations?
S (in chorus): They are the same.
. . . .
T13: What is percent?
S1: Out of one hundred.
T13: What do you think about Amy's answer?
S2: I agree.
T13: What do you think about Amy's answer, John?
S: . . . .

Non-followers of the Textbook. Teachers who did not follow the textbook were seldom observed encouraging student engagement. Students listened to the lecture without indication of verbal or physical involvement. The teachers often asked a question and responded themselves without waiting for students to answer. The following is an example.

T9: What do we do when we change percents to decimals?
S: No response
T9: What do we do?
S: No response
. . . .
After several attempts failed to get students to answer, teacher 9 went on.

. . . .

T9: Come on, talk to me. When we have a percent sign, what do we do? We move into the what? Into the left, and we take out what? Our percent sign, let us move to the left and take out our percent sign."

Table 2

Summary of Instruction and Textbook

	Textbook Followers			Non Textbook Followers		
	MGMT	MAC	CMP	MGMT	MAC	CMP
Non Standards -based Instruction				1,5	6,7	9
Standards-based Instruction	2,3,4		8,10, 11,12, 13,14,			

Note. CMP= *Connected Mathematics Project* . MGMT=*Middle Grades Math Thematics*. MAC= *Mathematics: Applications and Connections*. Both MGMT and MAC are standards based textbooks. Numbers refer to teacher code.

Standards-based Instruction and Textbook Quality

We found out that standards-based instruction occurred when teachers followed high or medium rated textbooks. The lower-rated textbook was not followed by the teachers in this study. Most of the teachers who used high or medium quality textbook used standard-based instructional strategies (Table 2).

Discussion

We used "develop ideas in depth," "promote sense making," and "engage students" as criteria to identify standards-based instruction (Trafton et al., 2001), and found that these three themes were inter-related in that the use of higher-rated standards-based textbooks are associated with student use of manipulative representations, and student engagement through guiding and probing questions, while the use of non standards-based textbook was associated with whole class lecture, less student engagement and less guiding and probing questions.

How did sixth-grade teachers use different textbooks to teach the same standards? This study found that teachers' instruction on the same objective varied even though they used the same textbook representation. Some of them arranged the teaching environment differently, some of them developed mathematical ideas beyond what the textbooks suggested as a result of classroom discussion, and some of them made extra effort to address students' misconceptions. This is consistent with the previous findings that the implementation of national standards in the classroom reflects "varying degrees of fidelity" (McCutcheon, 1981; NCTM, 2000; Smith, 2000; Sosniak & Stodolsky, 1993; Wilson, 2003). The fact that these teachers use textbooks differently reflected that these teachers are enactors of mathematics instruction, and teachers have agency over the textbooks (Remillard, 2005). The factors that influenced these teachers' instruction might be due to several issues that are beyond the scope of this study, for example, teacher beliefs and teaching experiences, teachers' knowledge about students and knowledge about the content of rational numbers (Remillard).

The findings of this study revealed a complicated relationship between standards-based textbook and standards-based instruction, which supported the view proposed by Remillard (2005) that teachers "drew on" or "interpreted" textbooks by using/redesigning the tasks based on their beliefs, knowledge, and experiences about specific math topics or pedagogy. A majority of the teachers (nine out of 14) followed the suggestions of their textbooks, using them as their primary, if not only, resource for instruction. This confirms previous findings that mathematics instruction in the U.S. is textbook driven (AAAS, 2000; Chandler, 1995; McKnight et al., 1987; Reys et al, 2004). The result is different from the TIMSS videotape study (Stigler, Gonzales, Kawanka, Knoll, & Serrano, 1999), which stated that teachers who implemented standards-based curriculum were less likely to follow the textbook approach than those who taught from a non standards-based curriculum. A time lag between the publication of standards-based textbooks and the TIMSS study could result in the differences. Specifically, CMP was published in 1998, and MGMT was published in 1999, while the TIMSS video study was conducted from 1994 to 1995. A substantial amount of research conducted at that time advocated teachers not following textbooks, rather teachers were encouraged to use a variety of materials as supplementary resources. Another possible reason is that standards-based textbooks provide extra resource and support for teachers to develop a standards-based learning environment, while popular commercial middle school textbooks did not provide enough guidance to promote a standards-based learning environment (AAAS, 2000; Battista, 1999; NCTM, 2000; Remillard, 2005; Ward, 2001).

The current study also points to the importance of high quality textbooks in supporting a standards-based learning environment by providing activities that aim at developing deep conceptual understanding, which is in line with the textbook evaluations conducted by Project 2061 (AAAS, 2000). The mathematics teachers who implemented the high or medium rated quality standards-based textbooks (AAAS) tended to engage more students in learning, asked more probing questions to promote thinking, and developed a deeper conceptual understanding. In contrast, teachers who did not use standards-based textbooks tended to enact non standards-based classroom practices. The reasons why these teachers made the decisions to deviate from textbooks' tasks and pedagogy might be due to several factors that are beyond the scope of this study. One is that they possess limited knowledge of teaching fractions, decimals and percents. Without guidance from a textbook to suggest more student-centered strategies, they use a more traditional approach. Again, a divergence from the textbooks' approach does not promise good instruction. On the contrary, in this study, teaching which diverges from a standards-based textbook lacks strategies and resources to engage students in thinking about the mathematics. Thus, deep conceptual development is inhibited, which further prevents instruction from being characterized as standards-based. This result again confirms the previous research that the high-quality textbooks provide opportunities for instruction that build on understandings (AAAS, 2000; Sun & Kulm, 2003). Increased professional development as well as training in using standards-based teaching materials may be necessary for teachers who use lower-ranked textbooks.

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