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THE USE OF A NEW MATHEMATICS TEXT BOOK SCHEME – SUPPORT OR IMPEDIMENT

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School mathematics textbooks are used in varying ways and to varying degrees by teachers and schools. The textbook materials of focus in this study were designed in accordance with current curriculum reform principles, advocating a student-centred approach that emphasises conceptual understanding and fostering of students' thinking and mathematical communication. The purpose of this study was to investigate the impact of a new reform-based mathematics textbooks series on teachers' classroom practices. Observations were conducted in six primary teachers' mathematics classrooms as they implemented the new textbook series. The observations were combined with interview data to explore the impact of the textbook upon teachers' classroom practice. Through combining interview data with classroom observations, this study provided a snapshot of various teachers' use of new curriculum materials. It was apparent from this study that the materials were used to varying degrees of effectiveness by individual teachers. Results suggested that when the textbook was regarded as a resource, quality pedagogy was enacted. Conversely, if teachers felt challenged by the new reforms evidenced in the textbook they tended to follow the textbook in a prescriptive manner, resulting in teacher-directed pedagogy.

INTRODUCTION

School mathematics textbooks are used in varying ways and to varying degrees by teachers and schools. The influence of the mathematics textbook upon what is taught in school mathematics classes has consistently been highlighted in research into teachers' use of curriculum materials (e.g., Reys, Reys, & Chávez, 2004). In general, mathematics textbooks can be viewed from two divergent perspectives. They can be regarded as either a resource to support the planning and teaching of school mathematics, or perceived as a mandate, prescribing and directing the teaching of school mathematics.

Teacher knowledge and beliefs and textbook use

In a study of two experienced classroom primary teachers' use of curriculum materials, Collopy (2003) reported on the similarities and differences between the teachers' use of materials. Differences were related to teacher beliefs and mathematics knowledge. One teacher was very confident in her mathematics content knowledge and the mathematics program that she implemented with her students. She used the new materials quite infrequently, and not in the way intended by the curriculum writers. This teacher did not encourage students to engage in extended conversations about mathematics, and often omitted activities that were deemed to take too much time, or required too much organisation of equipment and materials. She also judged the new materials as de-emphasising written computational procedures, so she spent considerable time supplementing the new materials with usual lessons on computation. This teacher felt it was expected that her students would know how to perform particular written computations by the end of the year, and this was her reason for continuing with her usual program.

The second teacher, although an experienced classroom teacher (11 years), was not overly confident in her mathematics content knowledge. Her implementation of the new materials was gradual and she often pre-judged the suggested activities as of little value in promoting student

learning of mathematics. However, following suggestions in the textbook, she allowed time for students to conduct the suggested investigations and to discuss their solution strategies and thinking. It was the students' responses that encouraged this teacher to continue with the materials, with the teacher noting the growth of students' conceptual understanding, which in turn, promoted her own conceptual knowledge of mathematics.

In a similar study, Remillard (2000) studied two primary school teachers' implementation of a new school textbook that had an emphasis on problem solving. The change in the teachers' approaches was described in terms of their 'reading': reading of the text; reading of their students; and reading of the tasks. In terms of reading the text, over the course of the year, both teachers implemented the tasks as suggested in the textbook and through this reading, they become more aware of the connections between topics in mathematics. However, it was the teachers' lack of awareness of directions in curriculum reform that resulted in missed opportunities in the classroom. The teachers read the textbook selectively, and often omitted tasks and activities that they deemed to be irrelevant. And yet, often, such activities embodied the philosophy of curriculum reform in mathematics.

In terms of reading the students, implementing the textbook activities provided these teachers with an opportunity to watch students struggle with particular mathematics concepts in ways that practising routine procedures did not. This deepened the teachers' understanding of mathematics and students' thinking.

In terms of reading of the tasks, the teachers became more aware of tasks and how particular tasks prompted students to think and respond in ways that they had not anticipated. The most learning from the textbooks by these teachers occurred when teachers took the ideas presented in the textbook and allowed students time to engage and explore the mathematical ideas, as per the advocated approach in the textbook. The tasks were implemented as intended. The least learning occurred when the teachers actually implemented the activities 'verbatim', that is, by using the textbook as a script and not fully interacting and engaging with the intention of the tasks. It was students' unanticipated responses to new and unfamiliar tasks that prompted the most reflection by the teachers, with familiar tasks and routines resulting in very little reflection.

In this study, the two teachers approached the textbook in slightly different ways, with one teacher using the suggestions in the textbook to design her own learning tasks, and the other teacher implementing tasks that were unfamiliar to her and closely observing students' responses to these tasks. The two teachers in this study actively made decisions about implementing the materials, and this was based on their beliefs. However, in using the materials, the teachers "read the text, their students, or tasks as students worked on them...This process of reading and decision making caused the teachers to re-examine their beliefs and understandings, which in turn, influenced the curriculum they enacted" (p. 343).

Teachers' experience and confidence

Primary school teachers are predominantly generalist teachers with little specialist expertise in mathematics education. For many primary teachers, preparation for teaching mathematics is confined to their undergraduate teacher education program and various ad hoc professional development in-service programs during their career. Many pre-service primary teachers enter teacher preparation programs with negative attitudes towards mathematics and openly express fear and anxiety about teaching mathematics (Dole & Beswick, 2002). Once teachers have graduated from their initial teacher education program, the chances of participating in extended programs of study in mathematics curriculum and pedagogy are often minimal. As seen in the study by Collopy (2003) detailed above, one of the teachers expressed a lack of confidence in her mathematics knowledge, and this is not an uncommon response by primary school teachers about their own

mathematics background. Teachers' experience and confidence in their mathematics knowledge is a major factor in how textbooks are used by teachers (Collopy, 2003). As stated by Reys, Reys, and Chávez (2004),

[g]iven the limited preparation in mathematics of most primary teachers and the shortage of teachers certified to teach mathematics at secondary schools, the mathematics textbook becomes the mathematics program for a large segment of the teaching corps. (p. 64)

For many teachers, the mathematics textbook is a valuable support document to assist in planning and sequencing the teaching of mathematics. According to Reys et al. (2004), the textbook has a direct impact on what schools teach and what students learn. The three roles that textbooks play, as suggested by Reys et al. are that: (1) they dictate the sequence of instruction and presentation of topics, as teachers follow the suggested sequence; (2) they suggest the content that should be taught; and (3) they provide the activities, exercises, tasks, examples for each topic for teachers to implement. These three roles, however, when analysed in terms of research by Remillard (2000) and Collopy (2003) above, the implementation of the curriculum materials is also mediated by teachers' experience and beliefs. Textbooks are used by different teachers in different ways, and for some teachers, the textbooks support their own knowledge development of mathematics, which thus supports the development of their confidence in teaching mathematics. For other teachers, who may have high confidence levels in their own mathematics knowledge, material in the textbook may prevent them from enacting the intended curriculum as they have had little opportunity to engage with the issue of curriculum reform (Remillard, 2000). It appears too simplistic a notion that textbooks directly influence what is taught, although analysis of larger bodies of data, such as that gathered through international assessments such as TIMSS [Trends in International Mathematics and Science Study] (The National Institute on Educational Governance, 1997) show that the majority of mathematics teachers in secondary schools generally follow the prescribed textbook when planning and implementing their program (Thomson & Fleming, 2004). As stated by Robitaille and Travers (1992), the influence of the textbook is

more characteristic of the teaching of mathematics than of any other subject in the curriculum. Teachers decide on what to teach, how to teach it, and what sorts of exercises to assign to their students largely on the basis of what is contained in the textbook authorized [sic] for their course. (p. 706)

Because of the relatively limited extent of their teacher preparation for mathematics teaching, the school mathematics textbook frequently becomes the mathematics program for many primary teachers (Reys, 2004). Although teachers' use of the textbook has been shown to be selective (Remillard, 2000), lesson dimensions such as sequence, practical activities and exercises are almost exclusively governed by the format and order of material contained within texts (Reys, 2004).

Curriculum materials

The relationship between textbook adoption and curriculum reform is not a linear process. Research shows how this relationship is impacted on by such variables as; teachers' self-efficacy and resistance to change (Collopy, 2003); professional development and support opportunities (Remillard, 1999); and, the extent to which differences in context cause teachers to adapt textbook material (Remillard, 2000). Although textbooks may be designed to align the principles of curriculum reform in school mathematics, Remillard (1999) reminds us that research in this field raises questions about the power of revised textbooks to foster changes required by these reforms. Further, as noted by Collopy (2003)

...teachers may enact lessons in very different ways than how curriculum developers or educational reformers intended. This great variation in curriculum use can affect the opportunities teachers have to learn through curriculum materials. (p. 228)

THE STUDY

This study is part of a larger study that aimed to explore how the teaching of mathematics, student learning of mathematics, and mathematics textbook use interact in primary classrooms to impact on student learning outcomes. The study reported here focuses on the investigation of the impact of a new primary school mathematics textbook series upon teachers' classroom practices. The textbook materials include teacher sourcebooks containing detailed lesson plans of all mathematics to be taught, a student journal (workbook), a computation practice book for each student, and a student check/test book. Lesson plans are contained in units which detail the mathematical background of the topic, the language needed, the materials required for each lesson, and include detailed descriptions of the activities. On face value, the materials have the potential to provide a great deal of support in both mathematics content and pedagogy.

This aspect of the study was guided by the following research goals:

- To investigate the impact a new reform-based mathematics textbooks series has upon teachers' classroom practices;
- To investigate the extent to which the new curriculum materials influence pedagogical practice and foster sustained change in accordance with principles of mathematics curriculum reform.

METHODOLOGY

The methodology was a qualitative interpretive study of classrooms (Burns, 2000), using interviews and classroom observations. Individual interviews were conducted with each of the 6 participating teachers, and classroom observations were undertaken in each class. By referring to the intended material of the textbook series, the interviews enabled teachers' interpretation of the intention of the curriculum materials to be determined, and classroom observations enabled viewing of how the curriculum was enacted. Thus, the teacher interviews and observations served to complement each other.

Participants

The participants were six (1 first grade, 2 second grade, 2 third grade, and 1 fourth grade) teachers from three Brisbane (a capital city in Australia) schools. The schools represented populations of middle socio-economic status.

Instruments

A semi-structured interview was conducted with the 6 teachers. The aims of the interview were to determine teachers' perceptions of the text, instructional decisions relating to the implementation of the materials, how they used the text in the classroom, and what modifications, if any, they incorporated. The classroom observation schedule identified how the textbook materials were used in the classroom by the teacher and students, the influence the textbook had on the content or presentation of the lesson, the use of other supplementary materials, and the interactions in the classroom. The schedule was derived from the Middle School Mathematics Study Observation Tool (University of Missouri; see Chávez, 2003), selected specifically due to inclusion of descriptors for classroom events that aligned the intention of the textbook in this study. The descriptors related to supporting student conjectures, promoting conceptual understanding, making connections, linking to students' daily lives, student explanations, multiple perspectives, student communication, inquiry, and reflection (see Table 1). For further discussion, see Chávez (2003).

Procedure

Each teacher was interviewed once in the second term of the four term year. A classroom observation was undertaken in each teacher's mathematics class in term 3. Two research assistants observed the classroom interactions, and completed the Observation Tool in each classroom.

Analysis

Teacher interviews were audio recorded and transcribed. The content of each teacher's interview was summarised according to what they perceived as being positive and negative (or areas in need of improvement) with regard to the materials, what they did or would do to remedy perceived shortcomings, and how effective they believed the materials to be in supporting students' mathematical learning. The classroom observations were analysed for effective teaching in relation to the 9 descriptors (see Chávez, 2003), the primary emphasis of the lesson (e.g., procedures, conceptual development, problem solving), and engagement of students in significant mathematical learning. The comments made by the teachers in the interviews were compared with what was observed in the lessons.

RESULTS

The results are presented as a summary of what was observed in each teacher's classroom. Each summary provides an overview of the lesson focus and key events during the lesson. The results of classroom observations in accordance with the 9 descriptors are summarised in Table 1. For each descriptor an observational score for each teacher is also included with 1 representing a low rating and 3 a high rating. The six teachers are labelled with letters (A-F). The grade levels taught are also included.

Table 1

Observational Rating for each of the 9 Descriptors (1 – low rating; 3 – high rating)

	Teacher	A	B	C	D	E	F
Grade level taught		1	2	2	3	3	4
Descriptors	Observational Score						
1. The lesson provided opportunities for students to make conjectures about mathematical ideas		1	3	2	3	2	1
2. The lesson fostered the development of conceptual understanding		2	3	3	3	2	1
3. Connections within mathematics were explored in the lesson		1	3	2	3	1	1
4. Connections between mathematics and students' daily lives were apparent in the lesson		2	3	2	3	2	1
5. Students explained their responses or solution strategies		1	3	2	3	2	1
6. Multiple perspectives/strategies were encouraged and valued		1	1	2	3	3	1
7. The teacher valued students' statements about mathematics and used them to build discussion or work toward shared understanding for the class		2	3	2	3	2	1
8. The teacher used student inquiries as a guide for instructional decisions or as a guide to shape the mathematical content of the lesson		1	1	1	3	1	1
9. The teacher encouraged students to reflect on the reasonableness of their responses		1	3	1	3	1	1

From the table, it can be seen that Teacher F was rated low on all descriptors, and Teacher D was rated high on all descriptors. Ratings for Teachers C and E varied from high to low across the descriptors; whereas, Teacher A was rated medium to low with no high ratings. Teacher B was rated high on seven of the nine descriptors, with low ratings for descriptor 6 (Multiple perspectives/strategies were encouraged and valued) and descriptor 8 (The teacher used student inquiries as a guide for instructional decisions or as a guide to shape the mathematical content of the lesson).

It appears that the last two descriptors that relate to student inquiry and reflection were rated lower for most of the participating teachers. There is no clear indication from the data to suggest why this was so, but we raise the question: is it more difficult for textbook writers to document these aspects, rather than the other aspects, into lesson plans?

The next section presents some key classroom observations that support the above ratings for each of the descriptors and comments by the teachers in their interviews.

Teacher A. Lesson Focus: Time – associated vocabulary (e.g., today, tomorrow, long, short). The teacher used questions from the Teacher Sourcebook as a focus for the lesson. She followed the Sourcebook very closely; in fact, the lesson was totally teacher directed; although, in her interview, she criticised the materials for being too teacher-directed. When students offered answers she did not agree with, she did not invite individuals to justify or invite comment from the class. Students were encouraged to respond to her questions, but the students' responses did not form the basis of any further discussion. Different perspectives were not explored. Student responses that were ambiguous were not pursued or acknowledged. Whilst this teacher criticised the text for insufficient hands-on learning, she did not provide any hands-on learning in the lesson. However, there may have been little opportunity to do so in this particular lesson.

Teacher B. Lesson Focus: Time – o'clock, half past, quarter past and to. The teacher developed conceptual understanding by relating mathematics concepts to other mathematics concepts (e.g., division of whole numbers into equal groups and dividing objects into equal parts) and familiar contexts from children's lives (e.g., "past" – running past in a race, quarter – cutting pizza into quarters). She used additional concrete material from that suggested by the Teacher Sourcebook. In her interview, she stated that she often used concrete aids to enhance children's understanding, in preference to confusing pictures that were presented in the Student Journal. Further, she stated that she often changed the order of presentation of topics, to ensure links between topics would be likely to occur. In the observed lesson, students were asked to justify answers and class discussion of answers was encouraged. For example, the teacher continually asked questions such as "Is he right? Why is he right? How do you know he's right?"

This was a first year teacher; she was enthusiastic about the program and she was comfortable modifying lessons in response to observed needs of students. In her interview, she stated that she often developed additional extension activities, and modified activities to suit the students. The lesson observed focused on facilitating conceptual understanding through real life examples and practical activities.

Teacher C. Lesson Focus: Multiplication – set model and symbols. The lesson involved individual and group work. The students were observed using different strategies to count and group, but these strategies were not fully explored during class discussion. In fact, the teacher encouraged counting strategies; yet, some students were using more advanced strategies; for instance, skip counting or working from a known fact. Rather than challenging students' thinking when the opportunities arose, the teacher's focus was on every group having a turn and answering the same question; an emphasis on procedures, rather than on conceptual development. In her interview, this teacher appeared to focus more on narrow interpretations of maths vocabulary than on meaning; for instance, she preferred the word "group" to "loop" ("loop" is used in the text to indicate

“groups of” / “sets of”) when talking about a multiplication concept. Overall, there appeared to be an emphasis by the teacher on correcting mistakes rather than exploring strategies.

Teacher D. Lesson Focus: Measurement: mass (kilogram). During the daily number sense activity, students were encouraged to demonstrate and explain their strategies. Each student was provided with laminated number lines to support their calculations. In her interview, this teacher stated that she had supplemented the activities with additional hands-on activities. She also suggested that the concepts of measurement and patterning were not well covered in the text. During the measurement lesson, the teacher passed around one kilogram weights for students to feel and open discussion was encouraged:

Student 1: It's not as heavy as a shot put.

Teacher D: No, you put two kilograms together to get a shot put.

Student 2: Can I have a feel of two kilograms?

Teacher D: [Student's name], would you like to share your story about scales?

Student 3: I saw some scales in the supermarket.....

Student 4: We've got scales in our bathroom to weigh us.

Student 5: I was watching the animal show and I saw an anaconda being weighed. It was 103 kg. They had a big hook and put the anaconda in a bag.

The discussion continued for several more minutes, as students described a variety of scales for measuring mass. The teacher used student comments to generate further exploration, discussion and activity. Answers in Student Journals were used to modify the lesson (e.g., writing weights on objects such as rice containers, rather than just a label in the text). Overall the teacher followed the lesson plan closely, but built on student observations, strategies and conjectures throughout the lesson. The students were challenged, engaged and enthusiastic.

Teacher E. Lesson Focus: Number – money (notes and coins). When discussing the selection of money for purchases in the lesson, the teacher drew answers on the white board; for instance, “\$10 \$10 \$10 \$5” to pay for an item costing \$35. No play money was used, nor was it available for students experiencing difficulties when completing their Student Journal. In her interview, the teacher complained that there was insufficient time to produce the concrete materials required for the activities. She also suggested that there were insufficient hands-on activities suggested in the materials. Towards the end of the lesson, a number facts test was conducted, and the number facts were presented on the board. Fast finishers waited for others to finish. The facts were simply marked correct or incorrect. There was no discussion about the different strategies students used to reach their answers. During the remainder of the lesson, students who finished the exercises in the Student Journal earlier than others were provided with additional exercises at the same level as the ones they had already completed. The teacher closely followed the lesson plan. However, she was the only teacher to admit to omitting some aspects of the lessons (because of lack of time). She believed that the program did not provide sufficient flexibility to extend or support children's learning. In the interview, she was very negative about the program. Overall the lesson tended to be very teacher directed and procedural without the inclusion of concrete materials or any concluding reflective discussion (which no teacher in any of the observations included in any lessons).

Teacher F. Lesson Focus: Division – array model. Although the lesson was introduced by investigating the relationship between multiplication and division, there was no evidence that students understood this relationship throughout lesson. When asked to rewrite a multiplication problem $4 \times 10 = 40$ as a division problem, the students merely guessed where to place numbers. In her interview, teacher F stated that she focused on “what they needed to know”, encouraged

interaction, and provided more visual supports and concrete materials than those suggested in the Teacher Sourcebook. She commented that there was insufficient time to make all the additional resources required for student learning. She stated that she modified the activities to suit the needs of this group. Her focus was on developing their confidence and providing opportunities for the students to experience success. In this lesson some modifications were observed, including the provision of a challenge question (although unrelated to the lesson) for early finishers. Overall, the students struggled with many of the concepts, eventually resorting to guessing answers, but the teacher chose to continue the lesson rather than modify it in any way to promote student learning.

Summary

The ratings for each teacher according to descriptors for classroom events mirrored to a degree particular teacher's implementation of the curriculum materials (see Table 1). Teacher B and Teacher D rated highly on the majority of nine descriptors, with Teacher D receiving the highest rating on each descriptor. These teachers were observed to actively provide opportunities for students to make conjectures about mathematical ideas; to promote conceptual understanding and connections; to link the mathematics to the daily lives of the students and to encourage students to explain their thinking strategies. In contrast, Teachers A and F in particular scored very low on each of these descriptors and both tended to 'close down' the lesson providing minimal classroom discussion and showing little awareness of, or response to, student learning. From analysis of the data here, it appeared that effective teachers used the materials in a selective and highly effective manner; ineffective use resulted in ineffective practice. Teachers, rather than the text were determining practice.

DISCUSSION AND CONCLUSIONS

Although all six teachers in this study were using the new textbook materials, classroom and interview data revealed the differences in implementation of the materials. The observed lessons were directly taken from the textbook and the suggested sequence followed by all six teachers. What was notable was the varying extent to which the teachers followed the lesson 'to the letter' and particularly how they responded to students' answers to their questions. Teacher A was seen to dismiss student responses that did not follow the focus of the lesson, and to take a very direct teaching approach. Teacher C was seen to stifle student discussion of their thinking and solution strategies by asking each group the same question and all students listening to the response. Teacher E, who expressed her dislike of the textbook and associated materials and who admitted to omitting suggested aspects of the lesson, was seen to follow the lesson sequence as prescribed and to merely omit inclusion of the use of materials to assist student conceptual knowledge development. These three teachers gave the impression of feeling confined by the material in the textbook, with the focus being on completing the lesson, rather than considering children's thinking about the focus of the lesson. In contrast, Teachers B and D in particular were seen to take time to listen to students' responses, and to engage students in discussion to expand their thinking about the topic of study. Teacher D, although clearly following the suggested sequence of the lesson, also was mindful of students' responses, looking for opportunities to assist students make connections between their own knowledge and new material presented in the lesson.

In this study, implementation of the prescribed lessons was mediated by the amount of freedom the teacher felt the textbook afforded them. Teachers who felt constricted by the textbook were seen to teach in a teacher-directed manner, closely following the suggested sequence and moving students forward, regardless of whether students understood the material presented. Teachers who saw the textbook as a guide were seen to take a more student-centred approach, adapting the lesson and supplementing the lesson with other materials and activities. Of course, they may have already practised this in their classrooms, before implementing the materials. The textbook did delineate the types of questions that could be utilised to afford classroom discussion. However, some

teachers did not build on student responses. While each lesson outline contained a reflective section, all teachers failed to implement this. It seems that the main impact that the new reform-based mathematics textbook series had upon teachers' classroom practices was that each teacher ensured the content was covered.

The textbook materials of focus in this study were designed in accordance with current curriculum reform principles, advocating a student-centred approach that emphasises conceptual understanding and fostering of students' thinking and mathematical communication. Results reported here echo the words of Remillard (1999) in that it is the teachers, rather than the texts that influence curricular change. This study also supports findings by Collopy (2003) that teachers "may enact lessons in very different ways than how curriculum developers or educational reformers intended" (p. 228).

Through combining interview data with classroom observations, this study has provided a snapshot of various teachers' use of new curriculum materials. It was apparent from this study that the materials were used to varying degrees of effectiveness by individual teachers. As a new resource, the materials may have been suggesting teaching approaches which were quite new to particular teachers. This raises the question of the role that teachers' confidence and understanding of the material play in how these learning activities were implemented in the classroom context? Further, as teachers' confidence and knowledge of new reforms in mathematics increases, do the new curriculum materials have greater influence on pedagogical practice? Further research will assist us in answering such questions.

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