THE EFFECT OF CURRICULUM TYPE ON MIDDLE GRADES INSTRUCTION

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In this article, we discuss differences between the mathematics instruction of CMP and non-CMP teachers in the LieCal project. There are three aspects of instruction that 200 6th grade urban classroom observations showed were strongly and differently related to the type of curriculum that teachers were using. These three aspects relate to the teachers' use of (1) group and individual work, (2) written narratives and worked-out examples, and (3) conceptually- and procedurally-focused instruction.

Introduction

Historically, curriculum has played a central role in educational reform. In all of the reform movements since the 1960s, curriculum has been used as a means to convey what and how teachers should teach (NCTM, 1989, 2000), and it has also been used to serve as an agent for instructional improvement (Ball & Cohen, 1996). While curriculum does not always dictate the content of instruction (Freeman & Porter, 1989), research has consistently shown that curriculum has a strong influence on the ways mathematics is taught (Remillard, 2005; Robitalle & Travers, 1989; Schmid et al., 2002). In fact, teachers often base their teaching approaches primarily on the ways the curricular materials are presented (Cai, 2005; Robitalle & Travers, 1989; Tarr et al., 2006). However, research has not documented specifically how curriculum materials actually influence classroom instruction.

The current discussion of how curriculum materials actually influence classroom instruction habitually has focused on differences between the use of *Standards*-based curricular materials developed through the support of the National Science Foundation (NSF) and the use of more traditional curricular materials developed through the support of commercial publishers (Hirsch, 2007; Reys, Robinson, Sconiers, & Mark, 1999; Tarr et al., 2006). *Standards*-based NSF-funded curricula claim to build students' understanding of important mathematics through explorations of real-world (or sometimes fanciful) situations and problems. These curricular materials are intended to align with the recommendations in the NCTM *Standards*, with a focus on the importance of thinking, understanding, communicating, representing, making connections, reasoning, and problem solving (e.g., NCTM, 1989, 1991, 2000). This view stands in contrast to a more conventional approach to curriculum that emphasizes the application of well-rehearsed procedures to solve problems, and stresses the memorization, recitation, and use of decontextualized facts, rules, and procedures. In this article, we report initial findings from our investigation of differences between the mathematics instruction of CMP and non-CMP teachers.

LieCal Project

This research for this article was done as part of our LieCal project. LieCal (Longitudinal Investigation of the Effect of Curriculum on Algebra Learning) is a project that investigates

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differences between the effectiveness of the Connected Mathematics Program (CMP) and the effectiveness of more traditional middle school curricula (non-CMP) on students' learning of algebra. CMP is one of four *Standards*-based middle school curricula developed with funding from NSF (Lappan et al., 2002). In the LieCal project, we are studying the algebra-related teaching and learning of about 1400 students in 16 urban middle schools as they progress from sixth through ninth grades. Our overall goal for the LieCal project is to provide: (1) A profile of the intended treatment of algebra in the CMP curriculum with a contrasting profile of the intended treatment of algebra in the non-CMP curricula; (2) a profile of classroom experiences that CMP students and teachers have, with a contrasting profile of experiences in non-CMP classrooms; and (3) a profile of student performance resulting from the use of the CMP curriculum, with a contrasting profile of student performance resulting from the use of non-CMP curricula. In order to provide a profile of CMP classroom experiences and a contrasting profile of experiences in non-CMP classrooms, we are collecting data on how teachers use CMP and non-CMP curricula. In this article, we discuss differences in CMP and non-CMP classrooms in the LieCal Project.

Method

The LieCal Project is being conducted in 16 middle schools in a district serving a diverse student population. When we began the project, 27 of the 51 middle schools in the school district had adopted the CMP curriculum while the remaining 24 middle schools used other more traditional curricula. Eight CMP schools were randomly selected from the 27 schools that had adopted the CMP curriculum. After the eight CMP schools were selected, eight non-CMP schools were chosen based on the comparable ethnicity, family incomes, accessibility of resources, and state and district test results.

An important part of the LieCal Project's examination of the fidelity of curricular implementation is classroom observations. The observations upon which this article is based were conducted in the 6th grade of the 16 middle schools. Subsequent observations in grades 7 and 8 yielded similar results. Using a pre-developed observation instrument[1], two trained research specialists observed each of the 50 participating classes (24 CMP classes and 26 non-CMP classes) 4 times a year, twice in the fall and twice in the spring. Due to space limitations, we have chosen to report only on the data from the 6th grade observations.

The LieCal observation instrument is designed to provide a comprehensive analysis of the instruction that transpires during each class. Two retired, highly experienced mathematics teachers were hired as research specialists to conduct the classroom observations. Over the course of the year, we checked the reliability of the specialists' coding three times. These three sessions revealed that the reliability of the coding done by the two specialists was quite high. The reliability achieved during the three sessions averaged 79% perfect agreement using the criterion that the observers' coded responses were considered equivalent only if they were identical (i.e., perfect match). The reliability averaged 95% using the following criteria: (a) If an item or sub-item was "scored" using an ordinal scale, then the specialists' coded responses were considered equivalent if they differed by at most one unit; (b) If an item or sub-item (e.g. representation) was "scored" by choosing from a list of alternatives all the words/phrases that characterize it, then the specialists' coded responses were considered equivalent if they had at least one choice in common (e.g. symbolic and pictorial vs. pictorial).

Results

There are three aspects of instruction that our classroom observations showed were strongly and differently related to the type of curriculum that teachers were using. These three aspects relate to the teachers' use of (1) group and individual work, (2) written narratives and worked-out examples, and (3) conceptually- and procedurally-focused instruction. Our findings regarding these three instructional aspects are presented next.

Teachers' Use of Group and Individual Learning

The CMP curriculum is composed, to a large extent, of extended contextual tasks, called investigations. The teachers' edition of the CMP curriculum encourages teachers to organize their students in small groups to work on the investigations, which guide the students to explore important mathematical ideas and ways of thinking as they try to understand and make sense of real-world situations. Using the observation instrument of the LieCal Project, we documented ways that teachers organized students to engage in lesson activities. Two of the ways we documented were the use of small-group and individual learning. Nearly half of the CMP lessons (47 out of 100) involved students learning in small groups, but only 7.4% of the non-CMP lessons (7 out of 95) involved group learning (See Table 1). Accordingly, the CMP students also spent a larger percentage of lesson time engaged in group learning than non-CMP students. In particular, on average 15.4% of the total CMP lesson time was used for group learning, but only 2.3% of the total non-CMP lesson time. This means that, overall, CMP students spent about six times longer than non-CMP students on group learning.

What is surprising, however, is that when group learning was used in non-CMP classrooms, the time students spent in small groups was similar to the time spent in CMP classrooms. In fact, in the 47 CMP lessons that used group learning, the average number of minutes students spent in groups was 18.9 minutes, which is very close to that for the seven non-CMP lessons, 16.4 minutes. This result suggests that once teachers decide to use small-group learning, both CMP and non-CMP teachers engage their students in small group learning for about the same amount of time per lesson.

Table 1. *Group and Individual Learning in Both CMP and Non-CMP Lessons*

	CMP Lessons (n=100) Minutes (n=5724)	Non-CMP Lessons (n=95) Minutes (n=4980)	Z	
Group work				
% of Lessons	47.0	7.4	6.02	$p < .01$
% of Minutes	15.5	2.3	22.75	$p < .01$
Individual work (not on homework)				
% of Lessons	32.0	51.6	2.69	$p < .01$
% of Minutes	10.7	12.6	3.15	$p < .01$
Individual work (on homework)				
% of Lessons	9.0	27.4	3.09	$p < .01$
% of Minutes	1.4	6.5	16.15	$p < .01$

From the opposite point of view, the relatively little use of group learning in non-CMP lessons implies that individual student work occurred in many more non-CMP lessons than in

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CMP lessons. There are two types of individual work. One is on homework, and the other is on non-homework activities. About half of the non-CMP lessons included individual learning that was on non-homework activities, but only about one third of the CMP lessons included individual learning that was not on homework.

CMP students worked individually on homework in 9 of the 100 observed lessons (9%), but non-CMP students worked individually on homework in 26 of the 95 observed lessons (27.4%). Both CMP teachers and non-CMP teachers assigned homework in about one third of their lessons. Therefore, in our study non-CMP students worked individually on homework in about 81% (26/32) of the classes in which homework was assigned. However, CMP students worked individually on homework in only about 27% (9/33) of the classes in which homework was assigned. So, non-CMP lessons were three times more likely than non-CMP lessons to have students working individually on homework.

Teachers' Use of Written Narratives and Worked-Out Examples

Even a cursory comparison of the CMP mathematics curriculum with non-CMP mathematics curricula reveals major differences between them. Customarily, the sections of non-CMP curricula are organized around worked-out examples of mathematics problems similar to the beginning exercises that appear at the end of the sections, rather than the application problems that appear later. The worked-out examples generally are connected by short narrative paragraphs that explain the worked-out examples, or that provide definitions, generalizations, and formulas that are based on the examples. On the other hand, the CMP curriculum contains very few worked out examples and almost no formulas. Instead, the curriculum is composed of a series of investigations that the students are expected to explore, often in groups. Each investigation comprises multiple paragraphs of written narrative interspersed with diagrams, tables, and unworked problems that the students are asked to analyze, solve, and discuss. In our study, we found that these two types of curricular presentations lead to very different patterns of textbook use by teachers and students.

Table 2. *The Purpose of Textbook Use**

	% of CMP Lessons (n=100)	% of Non-CMP Lessons (n=95)	Z	
Students looked for problems in the text	63	64	0	NS
Students reviewed diagrams, charts or pictures	28	1	5.10	p<.01
Students reviewed examples or find formulae	5	16	2.30	p<.05
Students read from text	49	14	5.09	p<.01
Students do not use text	3	16	2.89	p<.01
Teachers drew examples from text	17	47	4.34	p<.01

*Student percents total more than 100 because textbooks can be used for multiple purposes in a lesson.

Table 2 shows ways that students used both CMP and non-CMP textbooks. The students' most frequent use of both the CMP and non-CMP texts was to look for problems in the text. These problems generally formed the basis for their instruction or their practice. This type of usage occurred in almost equal frequencies in the CMP lessons (63%) and the non-CMP-lessons (64%). We have shown elsewhere (Cai et al., 2009), however, that the overall cognitive level of the tasks posed by the CMP teachers was significantly higher than that of the tasks posed by non-CMP teachers. Therefore, opportunities to think conceptually and make connections were much different in the CMP classes, even though the frequency of use of problems from the text was the same in both types of mathematics classes.

The investigation of the other three purposes for which students used their textbooks revealed large and significant differences between the CMP and non-CMP classrooms. In particular, the CMP students in our study used their textbooks to review diagrams, charts or pictures in 28% of the CMP lessons we observed, while the non-CMP students used the textbook for this purpose in only 1% of the lessons. However, the percents were reversed when students used their textbooks to review examples or find formulae (5% of the CMP lessons and 16% of the non-CMP lessons). Also, the students read their textbooks in about half of the CMP lessons we observed, but students read textbooks in only about 14% of the non-CMP lessons.

These last three findings may be due, in part, to the fact that the CMP curriculum contains more written text and more diagrams and charts than the non-CMP curricula. It may also be due, in part, to the fact that teachers of non-CMP curricula presented and discussed the textbook's worked-out examples (or ones like it) much more often than teachers of the CMP curriculum (17% of CMP lessons and 47% of non-CMP lessons). This may have helped obviate the need for the non-CMP students to read the text. These two arguments are especially compelling when one considers that the brunt of the learning from non-CMP texts is often based on the worked-out examples and the subsequent practice problems. This is in stark contrast to CMP texts, in which the burden of learning usually resides in the students' own work on un-worked problems in the text, many of which are integrally dependent for their solutions on accompanying diagrams, charts, and pictures. Similar arguments can be made to explain why non-CMP students did not use their textbooks in 16% of the lessons we observed, but CMP students failed to use the their textbooks in only 3% of the lessons.

Teachers' Use of Conceptually- and Procedurally-Focused Instruction

CMP can be characterized as a problem-based curriculum. The focus is more on conceptual understanding than on procedural knowledge. It is expected that students will learn algorithms and master basic skills as they engage in explorations of worthwhile problems. On the other hand, the non-CMP curricula in our study include extensive sets of practice exercises, and the focus is more on procedural knowledge and basic skills than on conceptual understanding. Take the introduction to equation solving as an example, in the Non-CMP curriculum, equation solving was introduced symbolically by using additive property (add or subtract the same quantity on both side of the equation, the equality holds) and multiplicative property (multiple or divide a non-zero quantity on both sides of an equation, the equality holds). On the other hand, in the CMP curriculum, real-life contexts are used to help students understand the meaning of each step of the equation solving, as shown in Table 3 below (Nie, Cai, & Moyer, 2009).

Table 3. *Introduction of Equation Solving in CMP*

Thinking	Manipulating the Symbol
"I want to buy a CD-ROM drive that costs $195. To pay for the drive on the installment plan, I must pay $30 down and $15 a month."	195 = 30 + 15N
"After I pay the $30 down payment, I can subtract this from the cost. To keep the sides of the equation equal, I must subtract 30 from both sides	195 – 30 = 30 – 30 + 15N
"I now owe $165 which I will pay in monthly installments of $15."	165 = 15N
"I need to separate $165 into payments of $15. This means I need to divide it by 15. To keep the sides of the equation equal, I must divide both sides by 15."	$\frac{165}{15}=\frac{15N}{15}$
"There are 11 groups of $15 in $165, so it will take 11 months."	11 = N

Table 4. *Sample Conceptual and Procedural Scales in the LieCal Observation Instrument*

1. Example of Measuring Conceptual Understanding

The teacher's questioning strategies were likely to enhance the development of student conceptual understanding/problem solving (e.g., emphasized higher order questions, appropriately used "wait time," identified prior conceptions and misconceptions).

1	2	3	4	5
Does not ask questions	Asks low level questions or answers his/her own questions	Asks low level questions that lead to a dialogue between teacher and students	Asks high level questions but does not pursue the answers	Asks high level questions, and pursues their answers

2. *Example of Measuring Procedural Knowledge*

The teacher worked out examples to demonstrate the steps of a mathematical procedure or solution process.

1	2	3	4	5
Not at all		Moderate Demonstration		Extensive Demonstration

The classroom observation instrument of the LieCal Project includes twenty-one 5-point Likert scale questions, which are designed to rate the nature and quality of instruction in a lesson. A factor analysis of the 21 questions revealed that five of the 21 questions rate the extent to which the lesson fosters students' conceptual understanding of mathematical knowledge, and another five questions rate the extent to which the lesson fosters students' ability to carry out mathematical procedures. The first question in Table 4 is an example of the type of Likert scale that was used to rate the likelihood that the teachers' instruction would help develop students' conceptual understanding of math knowledge. The second question in Table 4 is a detailed example of the type of Likert scale that was used to rate the likelihood that the teachers' instruction would help develop students' procedural knowledge.

The mean of the sum of the scores on the five questions that measure the likelihood that the teachers' instruction would help develop students' conceptual knowledge was 17.99 for CMP classes and 12.33 for non-CMP classes, which is statistically significantly higher for CMP classrooms than for non-CMP classrooms: $t(193)=10.05$, $p<.0001$.

The mean of the sum of the scores on the five questions that measure the likelihood that the teachers' instruction would help develop students' procedural knowledge was 14.70 for CMP classes and 17.16 for non-CMP classes, which is statistically significantly higher for CMP classrooms than for non-CMP classrooms: $t(193)=4.25$, $p<.0001$.

Conclusion

In this article, we discuss differences between the mathematics instruction of CMP and non-CMP teachers in the LieCal project. There are three aspects of instruction that our classroom observations showed were strongly and differently related to the type of curriculum that teachers were using. These three aspects relate to the teachers' use of: (1) group and individual work, (2) written narratives and worked-out examples, and (3) conceptually- and procedurally-focused instruction. This article shows that the use of different types of curriculum materials in the LieCal project corresponds to major differences in teachers' classroom practice as it relates to these three aspects of instruction.

Based on findings from the LieCal Project, this article shows that the use of CMP and non-CMP curriculum materials can impact teachers' classroom practice in very different ways. Regarding group versus individual learning in classroom instruction, CMP teachers dedicate more time to group learning than non-CMP teachers, while non-CMP teachers use more individual learning. Because students in CMP classrooms more often work in small groups to perform cognitively demanding tasks, it is likely that CMP students are given more opportunities to interact and digest math concepts and ideas than non-CMP students. On the other hand, students in non-CMP classrooms have more opportunities to practice basic mathematical skills individually. Our classroom observations also revealed that teachers who use the CMP curriculum provide more opportunities for students to use diagrams, charts, and pictures than non-CMP teachers. For non-CMP lessons, both students and teachers are much more likely to use the curriculum materials to study worked-out examples. Finally, CMP classroom instruction is more likely to enhance students' conceptual understanding of mathematical knowledge while non-CMP classroom instruction focuses more frequently on mathematical procedures.

The data in our study do not establish a causal relationship between the different instructional practices we analyzed and the use of CMP and non-CMP curricula. Nonetheless, the differences that we highlighted between CMP and non-CMP teachers' classroom practices are closely related to the nature of CMP and non-CMP curriculum materials. Thus, there is good reason to believe that the choice of curriculum materials by a school or district is an important decision that should be made with the utmost care. When all is said and done, our study confirms that teachers tend to teach their lessons in ways that are compatible with the nature of the texts they use. Therefore, deliberate and close attention should be paid to the compatibility of potential curricula with the teachers' beliefs about the nature of mathematics instruction, and with the goals they have for their students.

Endnotes

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[1]In developing the instrument, we adopted ideas from the QUASAR project, the Middle School Mathematics Study, the Evaluation Study of Mathematics in Context, and from Horizon Research, Inc.

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