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A Case Analysis of Fourth-Grade Subtraction Instruction in Basal Mathematics Programs: Adherence to Important Instructional Design Criteria

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This study evaluates the extent to which 7 mathematics basal programs adhered to salient instructional design criteria when teaching the mathematics skill, subtraction across zeros. The programs represented middle and late 1990s editions of 4th-grade mathematics textbooks widely adopted in schools. Results of the analysis indicated that across the 1994 through 1995 mathematics series, only Silver Burdett & Ginn (Champagne et al., 1994) satisfied most (7 out of 9) criteria. Also, Scott Foresman–Addison-Wesley (Charles et al., 1998), the most recent edition, was equally effective in satisfying 8 out of the 9 criteria. This program incorporated the most effective features of its 2 earlier programs—Addison-Wesley (Eicholz et al., 1995) and Scott Foresman (Bolster et al., 1994)—and added information (e.g., effective feedback) to improve its overall quality. In contrast, the 1998 Silver Burdett Ginn program (Fennell et al., 1998) was less effective than its 1994 edition in adhering to the 9 criteria. Implications of results relative to curriculum selection and use are discussed.

Changing demographics in American schools have resulted in general education teachers being responsible for increasing numbers of diverse learners. The percentage of students with learning disabilities (LD) served in general education classrooms has increased significantly in recent years (Tomlinson et al., 1997). With the advent of the regular education initiative and the inclusive schools movement, most general education teachers are asked to meet the needs of students with LD in their classrooms by providing individualized educational programs. These teachers are expected not only to modify and differentiate the general education curricula and instruction in ways that extend the learning and performance of students with LD, but also to address the needs of all learners in the classroom (D. Fuchs & Fuchs, 1994; L. S. Fuchs, Fuchs, Hamlett, Phillips, & Karns, 1995; Tomlinson et al., 1997).

Mathematics instruction in particular presents unique challenges to general educators. The poor mathematics performance of students in the United States when compared to students from other countries is well documented (Anrig & LaPointe, 1989; Gray & Kemp, 1993; LaPointe, Mead, & Phillips, 1989; Stedman, 1994). In an effort to reform and improve the field of mathematics, the National Council of Teachers of Mathematics (NCTM; 1989) developed specific curriculum and evaluation standards (Woodward & Baxter, 1997). As a result, all students, including those with LD, are required to meet the high levels of academic goals (Woodward & Baxter, 1997). However, students with LD experience difficulty in most aspects of mathematics (Mastropieri, Bakken, & Scruggs, 1991; Mastropieri, Scruggs, & Shiah, 1991) and lag considerably behind their normally achieving peers (Englert, Culatta, & Horn, 1987; Harris, Miller, & Mercer, 1995; Parmar, Cawley, & Frazita, 1996; Zentall, 1990; Zentall & Ferkins, 1993). These students have difficulty with mathematics skills, such as basic concepts (Barron, Bransford, Kulewicz, & Hasselbring, 1989), problem solving (Jitendra & Xin, 1997; Parmar, Cawley, & Miller, 1994), fractions (Baroody & Hume, 1991; Kelly, Gersten, & Carnine, 1990), mathematics analysis and measurement skills (Algozzine, O'Shea, Crews, & Stoddard, 1987), and calculations and applications (Cawley & Miller, 1989;

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Cawley, Parmar, Yan, & Miller, 1998). Often, problems with basic mathematical skills (e.g., subtraction) seem to interfere with the ability to solve more complex problems. For example, in the area of subtraction, students with LD may evidence difficulties in regrouping (e.g., renaming across zeros, renaming from the correct place; Cawley, Parmar, Yan, & Miller, 1996; Sugai & Smith, 1986), identifying place values, and selecting the correct operation (adding instead of subtracting; L. P. Case, Harris, & Graham, 1992; Kirby & Becker, 1988). The lack of proficiency in basic understandings of arithmetic concepts and skills may have serious implications for inclusion of students with LD at later grades when they are responsible for learning higher level math content.

Given that mathematics curricular materials account for about 75% of what occurs in mathematics instruction, textbooks primarily affect instruction and learning in the classrooms (Porter, 1989). Textbooks also represent the primary means of presenting new information (Parmar, 1992). Traditionally, basals mathematics programs have been criticized for poorly designed instructional features (Carnine, Jitendra, & Silbert, 1997; Jitendra, Carnine, & Silbert, 1996; Stein, Silbert, & Carnine, 1997). For example, Jitendra et al. (1996) examined division instruction in fifth-grade mathematics basal series published before and after the NCTM standards were in effect. The analysis revealed that the 1990s basal series made some improvements by eliminating potentially confusing or time-consuming activities. However, the basal series did not make significant changes to ameliorate problems (e.g., lack of practice, rapid rate of introduction) prevalent in the 1980s editions. In addition, an analysis of three 5th-grade mathematics basal series identified several areas of concern related to teaching adding and subtracting fractions (Carnine et al., 1997). Big ideas were rarely identified, introduced, or integrated; content was introduced too rapidly; teaching demonstrations were often not explicit; manipulative activities were open ended and ineffective; and review was often inadequate. Results of both studies indicated that traditional basals continue to inadequately meet the needs of most students. This, in conjunction with higher standards, may widen the gap between students with mathematics disabilities and their normally achieving peers.

In summary, effective solutions to achieve the standards and improve students' mathematics performance may require modifying mathematics basal programs or instructional practices. General educators, for various reasons, do not readily adapt or modify their curricula or instructional methods for students with LD (Baker & Zigmond, 1990; L. S. Fuchs, Fuchs, & Bishop, 1992; Kagan & Tippins, 1991). For successful inclusion of students with LD, it may be critical to provide teachers with the knowledge needed to modify mathematics curriculum (Carnine et al., 1997). As such, an in-depth examination of how instruction is designed to meet the needs of all learners may be necessary to effectively modify or adapt instruction, and thus enhance student learning. In this article, salient pedagogical variables gleaned from effective teaching practices are presented (Dixon, 1992). These include (a) specification of objectives, (b) number of additional concepts taught, (c) prerequisite skills knowledge, (d) explicit explanations, (e) instructional efficiency, (f) appropriateness and adequacy of teaching examples, (g) adequacy of practice, (h) appropriateness of review, and (i) effective feedback. Instructional programs that incorporate all of these variables have direct implications for mathematics instruction and are associated with successful student achievement (see Carnine, Engelmann, Hofmeister, & Kelly, 1987; Darch, Carnine, & Gersten, 1984; Gleason, Carnine, & Boriero, 1990; Moore & Carnine, 1989; Stein et al., 1997; Woodward et al., 1985).

The purpose of our study was to evaluate the teaching of a basic mathematics skill (subtraction across zeros) in mathematics basal programs following the adoption of the NCTM standards. Specifically, the intent was to examine the extent to which mathematics basal programs adhered to the nine components of instructional design.

METHOD

Curriculum Program Selection

Seven basal mathematics programs—Addison-Wesley (Eicholz et al., 1995), Harcourt Brace Jovanovich (Burton et al., 1994), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman (Bolster et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), Silver Burdett & Ginn (Champagne et al., 1994), and Silver Burdett Ginn (Fennell et al., 1998)—were evaluated. The most recent and earlier editions of mathematics textbooks widely adopted in schools in eastern Pennsylvania were selected. For example, the most recent editions in this analysis included Harcourt Brace Jovanovich (Burton et al., 1994), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), and Silver Burdett Ginn (Fennell et al., 1998). The sampling of middle and late 1990s editions of mathematics textbooks served to determine whether publishers made changes to their programs based on pedagogy and previous research findings. According to teacher's editions of the programs analyzed, subtraction of whole numbers is taught during the early part of the fourth-grade program. Thus, we scrutinized the fourth-grade levels of the four mathematics series to examine subtraction across zeros. The subtraction skill was chosen, because it requires the knowledge and integration of a number of important preskills. In addition, given that regrouping across zeros in subtraction presents consistent difficulties for most students, the importance of effective instruction in this area is underscored.

Data Analysis Procedures

In this analysis, instructional design criteria were applied to the teaching sequences of the target skill (subtraction across zeros) in the four basal mathematics programs. The teaching procedures in the four basal programs were evaluated according to the following nine instructional design criteria. For each category, Asha K. Jitendra and Mary M. Salmento independently examined the target lesson in the teacher manuals of the basal mathematics programs and assigned a rating (from 0 to 2 points) based on various levels of satisfaction of the criterion. When appropriate, the number of instances of the criterion (e.g., practice examples) that occurred in the lesson also was computed.

Criterion 1: Clarity of objective. An objective describes a direction for instruction by identifying and delineating the content and necessary learning experiences (Ornstein & Levine, 1993). Objectives that indicate what students will do should be stated as behaviors that are observable, clear, and complete. Setting objectives is one of the critical aspects of effective instruction (Stein et al., 1997). When objectives are clearly specified, students know exactly what is expected. As Carnine, Silbert, and Kameenui (1990) pointed out, "the more specific the teacher is in specifying what the students will be expected to do, the better the teacher can construct a program to teach the skill and help students encounter success in the learning process" (p. 276). Objectives also serve as performance indicators to evaluate student performance (Stein et al., 1997).

For this criterion, we examined the subtraction lesson in which the target skill (subtraction across zeros) was introduced. Typically, objectives were listed at the beginning of the lesson. We noted a score of 0 if the lesson did not present an objective. A score of 1 was awarded if an objective was present but stated globally (e.g., subtraction) or incompletely, whereas a score of 2 required that the objective was complete and stated in specific terms (e.g., subtraction across zeros with regrouping).

Criterion 2: Additional concepts and skills taught. Because adequate resources of working memory are necessary for acquisition of new skills and solving complex problems, teaching one new concept or skill at a time is recommended (Ashcraft, 1985; Carnine, Jones, & Dixon, 1994; Dreher & Singer, 1989; Klausmeier, 1992; Porter, 1989). For students with LD, teaching the new concept or skill to mastery before additional new information is presented is deemed important. This allows errors to be identified and associated with the single concept being taught. When more than one concept is taught in the same lesson, discerning the cause of the error becomes difficult.

The researchers identified the number of additional concepts presented in the lesson that the target skill was introduced. For this criterion, the number of concepts, other than the target skill, listed in the objectives for the lesson was computed. Skills that were taught earlier, but were reviewed and listed in the lesson objectives, were not counted. A score of 0 was noted if the program introduced more than one additional concept or skill. In contrast, a score of 1 indicated that an additional concept or skill was introduced, whereas a score of 2 was awarded if no additional concepts or skills were presented.

Criterion 3: Prerequisite skills taught. An adequate and appropriate review of background knowledge (prerequisite skills) in mathematics instruction is important for learning higher order skills (Barron et al., 1989; Carnine, Dixon, & Silbert, 1998; R. Case, 1975; Leinhardt, 1987; Nickerson, 1985). As Gagne and Driscoll (1988) noted, "skills typically require the prior learning of simpler component skills" (p. 13). For example, preteaching of problem-solving component skills is seen to be effective in improving student performance (Darch et al., 1984). Carnine (1980) indicated that when component skills (e.g., counting by series, decoding facts, and applying a count-by strategy) of multiplication problems were pretaught, children learned to solve a set of multiplication facts in less time than children who learned the components and the procedure at the same time.

We checked the lesson and prior lessons within the fourth-grade program for the teaching of prerequisite skills necessary for applying the target skill. Preskills for subtraction across zeros entailed knowledge of place value, subtraction facts, and regrouping. A score of 0 was awarded if the required preskills were not taught or reviewed in the program. In contrast, a score of 1 indicated that some but not all prerequisite skills were taught, whereas a score of 2 was noted if the program addressed all prerequisite skills.

Criterion 4: Explicit teaching explanations. When learning a cognitive skill, explicit explanations are necessary to facilitate learning (Rosenshine, 1995). This notion of explicit explanations contrasts with the NCTM standards and pedagogical principles of discourse intensive, discovery learning in mathematics. However, such practices have not been widely accepted by teachers in classrooms because they present numerous challenges (Ball, 1993). Gersten and Baker (1998) noted that an important goal of mathematics instruction is facilitating children's thinking, and that "*highly structured* [italics added] teaching of core mathematical concepts" (p. 27) is necessary before having students with disabilities engage in ambiguous, open-ended problem solving. Webster (1989) defined *explicit* as "fully and clearly expressed; leaving nothing merely implied; unequivocal" (p. 502). According to Stein et al. (1997), "instructional programs should teach explicit strategies designed to enable students to work a broad set of examples. The strategies need to be explicit as well as generalizable" (p. 4). Explanations should result in clarifying concepts and procedures and helping students understand them (Leinhardt, 1989). Complete, consistent, and logical explanations are deemed important to provide a firm conceptual base that is necessary for students to be successful and confident in mathematics (Darch et al., 1984; Gleason et al., 1990; Kameenui, Carnine, Darch, & Stein, 1986; Leinhardt, 1987, 1989).

Teaching explanations for both symbolic and manipulative activities should be explicit. Manipulative activities are those that "involve the use of concrete objects that children manipulate to find answers to the teacher's questions" (Resnick & Ford, 1981, p. 106). In the case of subtraction, manipulatives may involve counting sticks and place value charts. The purpose of manipulative activities is to promote understanding and meaning of mathematical concepts (Resnick & Ford, 1981). This would entail making explicit the connections between the activity and the concept. That is, "symbols need to be attached to the concepts" (Resnick & Ford, 1981, p. 117). As Mayer, Sims, and Tajika (1995) pointed out, the "role of meaningful explanation rather than unguided hands-on symbol manipulating activities [is critical] in promoting problem-solving competence" (p. 447). Numerous studies provide support for the effectiveness of explicit teaching in promoting learning (Carnine & Stein, 1981; Darch et al., 1984; Wilson & Sindelar, 1991).

For this criterion, teacher explanations for symbolic or manipulative activities in the target lesson were examined to evaluate their explicitness in promoting understanding. Generally, teaching was examined in sections entitled, "Motivate and Teach," "Teach," "Build Understanding," and "Developing the Lesson." We recorded a score of 0 if the lesson did not include teacher explanations. A score of 1 was awarded if an explanation was present but not clear, whereas a score of 2 required that an explanation was clear in promoting understanding and linkage.

Criterion 5: Efficient use of instructional time. Instructional efficiency may be defined in terms of learning outcomes. Program design should involve carefully constructed lessons that lead to maximum student achievement. The use of instructional time, especially adequate academic-engaged time, has been linked to student success (Carnine et al., 1997; Carnine et al., 1990; Greenwood, 1991; MacArthur, Haynes, & Malouf, 1986; Park & Tennyson, 1980; Rosenshine & Stevens, 1986). A lesson that includes a balance of teacher-directed interaction and independent work may be deemed more efficient than one in which the majority of the instructional activities involve manipulatives or independent seat work (Evans & Carnine, 1990; Stein et al., 1997). Efficiency is particularly an issue with a discovery approach that uses manipulatives. Furthermore, several researchers have noted problems related to use of concrete objects, because simply interacting with particular manipulatives does not automatically lead to understanding (Ball, 1992; Baroody, 1989).

Evans and Carnine (1990) compared two sequences for introducing manipulatives and an algorithm to solve subtraction problems that required borrowing. In one sequence, first graders were instructed initially to solve subtraction problems using manipulatives. Next, they were taught an algorithm and applied it to solve subtraction problems. The second sequence introduced the algorithm first and followed it by having students use manipulatives to solve subtraction problems. Results indicated that the manipulatives first sequence group required an additional 90 min of instruction on average when compared to the group that received instruction in an algorithm first. This difference in instructional time was statistically significant. However, the two groups did not differ in terms of correctly solving subtraction problems using either manipulatives or an algorithm.

We examined the explanation portion of the lesson only and indicated whether instruction was efficient. A score of 0 was awarded if the lesson included a discovery approach only and the use of manipulatives. The lesson received a score of 1 if it included a guided discovery approach (facilitative questioning) and manipulatives and a score of 2 if it entailed guided discovery without manipulatives or explicit teacher-mediated interactions (modeling and explanation of necessary steps) with or without manipulatives.

Criterion 6: Sufficient and appropriate teaching examples. The number of examples (i.e., 3–5) employed should provide students with increased knowledge of the strategy before moving on to the guided practice portion of the lesson (Cawley et al., 1996). It is also important to present a range of examples representing the problem type to allow learners to generalize to new examples of the problem type. Effective skill explanations should in effect demonstrate application of a strategy using sufficient examples (Gagne, 1985). In addition, guidelines for selecting and sequencing examples include (a) employing examples that are consistent with a strategy before introducing exceptions, (b) sequencing easy to difficult examples, and (c) selecting examples that avoid teaching misrules (Cawley et al., 1996; Jones, Krouse, Feorene, & Salerstein, 1985; Stein et al., 1997). Trafton (1983) identified several problems students may encounter when insufficient instructional examples are presented. In particular, problems with zeros in the subtrahend or quotient of subtraction and division problems, respectively, present consistent difficulties for most students.

We evaluated the explanation portion of the lesson to determine the number of examples presented to introduce the target skill. In addition, a score of 0 indicated insufficient (i.e., less than 3) and limited range of teaching examples. A score of 1 was awarded if the lesson included sufficient (i.e., greater than or equal to 3) but limited range of examples and a score of 2 if sufficient and adequate range of examples was present.

Criterion 7: Adequate practice. Practice leads to *automaticity*. According to Resnick and Ford (1981), *automaticity* refers to

> the ability to respond automatically to certain components of complex computations and may reduce the processing load of the human memory system and thus contribute to its efficient functioning. A conventional notion in mathematics is that practice makes perfect. The development of automaticity, or automatic responding, through drill and practice leads to efficiency, speed, and accuracy. (p. 35)

Automaticity research has yielded programs designed for accelerating fluency and practice. The rate at which special education students become fluent can be affected by classroom practices, which involve a careful assessment of entry-level skills and focused, repeated practice on target facts (Carnine et al., 1990; Stein et al., 1997; Woodward & Carnine, 1993). Automaticity allows students to readily retrieve requisite information to understand and complete advanced applications (Ashcraft, 1985; Cooper & Sweller, 1987; Hasselbring, Goin, & Bransford, 1988).

For this criterion, we examined the mathematics programs and tallied the number of practice examples representative of the target skill in the lesson. Typically, practice examples in all four programs were presented following the teaching examples in a lesson and were found in sections entitled "Practice," "Checking for Understanding," "Try it Out," or "Making the Connection." In addition to these specific practice activities, most programs provide additional practice that are optional and may be used to supplement the lesson. These were listed in the programs as "Extension," "Enrichment," "Challenges," "Extra Practice," "Skills Maintenance," or "Skills Review." Because supplemental practice activities are optional, they were not counted. We recorded a score of 0 if the lesson did not include practice. A score of 1 was awarded if practice was present but inadequate (less than 10 problems), whereas a score of 2 required that practice was sufficient (greater than 10 problems). It must be noted that the above numbers are arbitrary and not guided by any known standard, but were deemed to be sufficient for an individual lesson so that teachers can make the decision to provide more or less practice as needed for individual students.

Criterion 8: Appropriate review. To enhance retention of a new skill, provisions must be made to systematically and judiciously reviewing the taught skill (Gagne et al., 1988). Reviews that are spread out or distributed over time (spaced) are seen to be more effective than reviews that occur close together in time (Dempster, 1991). Spaced review involves reviewing the skill at reasonable intervals. The new problem type (e.g., subtraction of whole numbers) can be integrated into later lessons and serve as component skills for more complex skills (e.g., story problems). Once students master a particular skill, the teacher should gradually decrease the amount of review of the target skill (Stein et al., 1997). However, Stein et al. noted that the problem type should never totally disappear, but should be systematically reviewed. Review entails ongoing, additional practice needed to reach the required level of automaticity (Carnine et al., 1994; Dempster, 1991; Moore & Carnine, 1989; Swing & Peterson, 1988).

For this criterion, we tallied the number of review problems in lessons following the initial teaching. In addition, the frequency of review lessons was computed. Review of the target skill was examined in subsequent lessons entitled "Chapter Review," "Cumulative Review," "Practice," "Review and Maintenance," "Mixed Review," and "Mixed Application." We then recorded a score of 0 if the program did not include review. A score of 1 was awarded if the review included sufficient problems (greater than 20) but was inadequate (i.e., not distributed over time), whereas a score of 2 required that review was sufficient and adequate (distributed over time). Given that subtraction is addressed early in all fourth-grade programs, we deemed that the number of review problems (greater than 20) and frequency of review (greater than 10 lessons) should be high for a rate of at least 2 review problems per lesson.

Criterion 9: Effective feedback. A critical aspect of instruction for students with LD is providing immediate and instructive feedback (Stein et al., 1997; Werts, Wolery, Holcombe, & Gast, 1995). Research shows that correcting errors by providing effective feedback enhances the performance of both students with LD and without LD (Collins, Carnine, & Gersten, 1987; Kline, Schumaker, & Deshler, 1991; Stefanich & Rokusek, 1992; Van Houten, 1993; Werts, Wolery, Venn, Demblowski, & Doren, 1996). According to Baine (1982), "if errors are not quickly corrected, learners' experiencing difficulties may repeatedly practice an incorrect response. Once an error occurs, the probability increases that an error will recur, particularly if the response is unknown" (p. 27). To correct student errors, the teacher should first determine the cause of the error (Silbert, Carnine, & Stein, 1990). Errors could result from inattentiveness or lack of knowledge. Stein et al. (1997) pointed out that the correction procedures for errors caused by inattentiveness must focus on increasing motivation. On the other hand, correction procedures for errors resulting from a lack of knowledge depend on the nature of the task and generally follow a model, lead, test format.

For this criterion, we examined the lesson for feedback procedures and awarded a score of 0 if the lesson did not include feedback for correcting potential student errors. A score of 1 was noted if the feedback presented was not instructive, whereas a score of 2 indicated the presence of instructive or elaborated feedback that specified the necessary steps, rules, or prompts to help students correctly answer the problem.

Interrater Agreement

Two researchers independently coded the categories. Interrater agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. The mean percentage of agreement across categories was 96.8% (range = 71.4%–100%).

RESULTS

A summary of findings from the analysis of the target skill in the seven mathematics textbooks is presented in Table 1.

Criterion 1: Clarity of objective. All programs indicated subtraction as the general lesson objective. With the exception of Scott Foresman (Bolster et al., 1994), the remaining six programs also specified subtracting across zeros as the target skill. Scott Foresman (Bolster et al., 1994) noted subtracting numbers with up to four digits in the lesson objective. In contrast, Harcourt Brace Jovanovich (Burton et al., 1994) included a clear and complete objective that read as follows: "To subtract across zeros with regrouping; to subtract money amount" (p. 58). Also, this program explicitly stated the relevance of the task as follows: "Knowing how to subtract across zeros will help you figure the correct change when you buy something." None of the other programs noted the purpose for learning the skill. Four programs—Harcourt Brace Jovanovich (Burton et al., 1994), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman (Bolster et al., 1994), and Silver Burdett & Ginn (Champagne et al., 1994)—also specified regrouping in the objective. Although Addison-Wesley (Eicholz et al., 1995), Scott Foresman–Addison-Wesley (Charles et al., 1998), and Silver Burdett Ginn (Fennell et al., 1998) did not explicitly state regrouping in the lesson objective, they addressed the target skill in the lesson. In summary, only three programs—Harcourt Brace Jovanovich (Burton et al., 1994), Macmillan/McGraw-Hill

TABLE 1
Design of Instruction Criteria

	Basal Mathematics Programs							
Instructional Criteria	*AW*	*HBJ*	*MM*	*SF*	*SFAD*	*SB*[a]	*SB*[b]	*% Fully Met Criterion*
1. Clarity of objective	1	2	2	1	1	2	1	42.9
2. Additional concepts and skills taught	2	2	2	2	2	2	2	100
3. Prerequisite skills taught	2	2	2	2	2	2	2	100
4. Explicit teaching explanation	1	0	2	0	2	2	1	42.9
5. Efficient use of instructional time	2	0	2	0	2	2	2	71.4
6. Appropriate teaching examples	2	1	1	0	2	0	0	28.6
7. Adequate practice	2	1	2	2	2	2	2	85.7
8. Appropriate review	2	1	2	1	2	2	2	71.4
9. Effective feedback	0	1	2	1	2	0	0	28.6
Total percentage fully met criterion	66.7%	33.3%	88.9%	33.3%	88.9%	77.8%	55.6%	63.5

Note. AW = Addison-Wesley (Eicholz et al., 1995); HBJ = Harcourt Brace Jovanovich (Burton et al., 1994); MM = Macmillan/McGraw-Hill (Jackson et al., 1994); SF = Scott Foresman (Bolster et al., 1994); SFAD = Scott Foresman–Addison Wesley (Charles et al., 1998).
[a]Silver Burdett & Ginn (Champagne et al., 1994). [b]Silver Burdett Ginn (Fennell et al., 1998).

(Jackson et al., 1994), and Silver Burdett & Ginn (Champagne et al., 1994)—satisfied the criterion, whereas the remaining four programs partially met the criterion.

Criterion 2: Additional concepts and skills taught. None of the programs specified any additional skills in the target lesson objective. As such, all programs satisfied this criterion.

Criterion 3: Prerequisite skills taught. Prerequisite skills (place value, basic subtraction facts, and renaming) for the target skill were taught in previous lessons across all programs. Again, all programs met this criterion.

Criterion 4: Explicit teaching explanations. Three programs—Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), and Silver Burdett & Ginn (Champagne et al., 1994)—satisfied the criterion of including explicit explanations. For example, Macmillan/McGraw-Hill (Jackson et al., 1994) used modeling, questioning, and manipulatives to teach subtraction across zeros. Instruction in Scott Foresman–Addison-Wesley (Charles et al., 1998) included worked-out examples in the explanation portion of the lesson that the teacher had to model and discuss with students the subtraction steps. Instruction emphasized subtracting the ones or regrouping, if necessary, followed by subtracting the tens or regrouping, subtracting the hundreds or regrouping, and subtracting the thousands. The lesson in Silver Burdett & Ginn (Champagne et al., 1994) involved manipulative activities (e.g., base-ten blocks) with teacher modeling and clear explanations to demonstrate the connections between the manipulative activity and the subtraction algorithm.

In contrast, Harcourt Brace Jovanovich (Burton et al., 1994) and Scott Foresman (Bolster et al., 1994) did not incorporate any explanations and received a score of 0. These programs relied on a self-discovery approach with manipulatives (i.e., play money, place-value materials) to solve subtraction problems. For example, although Harcourt Brace Jovanovich (Burton et al., 1994) required students to answer questions (e.g., "How are dollars, dimes, pennies related to hundreds, tens, ones on the place-value mat?") within the context of cooperative groups, the connections between the symbols and manipulations were not made explicit. In Scott Foresman (Bolster et al., 1994), instructions required students to independently read, discuss, and solve subtraction problems using place-value materials. The remaining two programs, Addison-Wesley (Eicholz et al., 1995) and Silver Burdett Ginn (Fennell et al., 1998), received a score of 1, because they required teacher questioning only with no explanations of concepts and procedures.

Criterion 5: Efficient use of instructional time. Five programs—Addison-Wesley (Eicholz et al., 1995), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman–Addison-Wesley (Charles et al. 1998), Silver Burdett & Ginn (Champagne et al., 1994), and Silver Burdett Ginn (Fennell et al., 1998)—met this criterion. For example, Scott Foresman–Addison-Wesley (Charles et al., 1998) employed teacher modeling and questioning procedures only, whereas Macmillan/McGraw-Hill (1994) and Silver Burdett & Ginn (1994) included teacher modeling and manipulatives. In contrast, Addison-Wesley (Eicholz et al., 1995) and Silver Burdett Ginn (Fennell et al., 1998) used facilitative questioning techniques only. Instruction in the remaining two programs—Harcourt Brace Jovanovich (Burton et al., 1994) and Scott Foresman (Bolster et al., 1994)—was not efficient. Specifically, Harcourt Brace Jovanovich (Burton et al., 1994) required students to build understanding of the skill primarily through cooperative learning using manipulatives and a group discovery approach. Students had to independently work four examples using play money and place-value charts. In Scott Foresman (Bolster et al., 1994), students had to independently work on their own using place-value materials.

Criterion 6: Sufficient and appropriate teaching examples. The mean number of teaching examples across programs was 3.1 (range = 1–5). Addison-Wesley (Eichloz et al., 1995), Harcourt Brace Jovanovich (Burton et al., 1994), MacMillan/McGraw-Hill (Jackson et al., 1994), and Scott Foresman–Addison-Wesley (Charles et al., 1998) included a sufficient number of examples (5, 4, 3, and 5, respectively). However, only Addison-Wesley (Eicholz et al., 1995) and Scott Foresman–Addison-Wesley (Charles et al., 1998) met the criterion of including appropriate teaching examples, because, in addition to sufficient examples, they provided a range of examples that were explicit and they avoided teaching misrules. Problem types included in Scott Foresman–Addison-Wesley (Charles et al., 1998) and Addison-Wesley (Eicholz et al., 1995) were varied and included subtraction across zeros problems involving 3 digits by 2 digits (503 – 68), 3 digits by 3 digits (504 – 187), 4 digits by 3 digits (2,001 – 148), and 4 digits by 4 digits (7,003 – 2,568). In contrast, Harcourt Brace Jovanovich (Burton et al., 1994) and MacMillan/McGraw-Hill (Jackson et al., 1994) received a score of 1 because they did not include a range of problems. For example, Harcourt Brace Jovanovich (Burton et al., 1994) included only subtraction problems that involved money in the amount of less than $10, whereas MacMillan/McGraw-Hill (Jackson et al., 1994) included only two different problem types (e.g., 704 – 380; $9 – $3.47). The remaining three programs—Scott Foresman (Bolster et al., 1994), Silver Burdett & Ginn (Champagne et al., 1994), and Silver Burdett Ginn (Fennell et al., 1998)—did not satisfy the criterion of appropriate examples.

Criterion 7: Adequate practice. The mean number of practice examples was 18. With the exception of Harcourt Brace Jovanovich (Burton et al., 1994), which included only six practice problems, all programs met this criterion of adequate practice. Most programs such as Addison-Wesley (Eicholz et al., 1995), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), and Silver Burdett & Ginn (Champagne et al., 1994; Fennell et al., 1998) included a relatively large number of 22, 23, 20, 19, and 25 practice examples, respectively, in the target lesson. In contrast, the number of practice problems in Scott Foresman (Bolster et al., 1994) was 11.

Criterion 8: Appropriate review. The mean number of review examples was 54.6 and ranged from 27 to 84. Silver Burdett Ginn (Fennell et al., 1998) had the most, with 84 review problems, followed by Macmillan/McGraw-Hill (Jackson et al., 1994), with 80. Addison-Wesley (Eicholz et al., 1995), Harcourt Brace Jovanovich (Burton et al., 1994), Scott Foresman (Bolster et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), and Silver Burdett & Ginn (Champagne et al., 1994) included 42, 41, 27, 55, and 53 examples, respectively. The frequency of review lessons in Addison-Wesley (Eicholz et al., 1995), Harcourt Brace Jovanovich (Burton et al., 1994), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman (Bolster et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), and Silver Burdett Ginn (Champagne et al., 1994; Fennell et al., 1998) was 15, 6, 16, 7, 15, 14, and 33, respectively, indicating a rate of 2.8, 6.8, 5, 3.9, 3.7, 3.8, and 2.5 problems per lesson, respectively. Five of the seven programs—Addison Wesley (Thornton et al., 1995), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), Silver Burdett & Ginn (Champagne et al. 1994), and Silver Burdett Ginn (Fennell et al., 1998)—met the criterion by including review that was sufficient to promote fluency and distributed over time to maintain the learned skill. These programs provided ongoing spaced review of the target skill in numerous subsequent lessons and systematically integrated the target skill with other skills.

Criterion 9: Effective feedback. Harcourt Brace Jovanovich (Burton et al., 1994), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman (Bolster et al., 1994), and Scott Foresman–Addison-Wesley (Charles et al., 1998) specified both student errors and correction procedures. However, only Macmillan/McGraw-Hill and Scott Foresman–Addison-Wesley (Charles et al., 1998) included appropriate remediation of errors and met the criterion of effective feedback. For example, Macmillan/McGraw-Hill (Jackson et al., 1994) identified the following error that students are likely to make: "Some students may sometimes only partially regroup when subtracting across zeros." The error alert was followed by instructive feedback that required students to "cross out the digit in the places where they are regrouping to remind them that these digits must be reduced by 1. Students should perform these reductions before adding to other places" (p. 111). Scott Foresman–Addison-Wesley noted that "students may have difficulty regrouping thousands into tens, or renaming the answer as thousands" (Charles et al., 1998, p. 115). Although the program provided instructive feedback, it was less explicit than that in Macmillan/McGraw-Hill (Jackson et al., 1994). Error intervention indicated that "students might benefit from learning to regroup one place at a time, rather than across all the zeros at once" (p.115).

Harcourt Brace Jovanovich (Burton et al., 1994) noted potential errors (i.e., "Some students may bring down the digits in the number being subtracted when subtracting across zeros," p. 59) and specified correcting by having students model with play money. However, this program did not provide any teacher explanation in the instructional portion of the lesson. As such, the feedback was deemed to be inappropriate, because it is unlikely that the feedback would remediate student errors if they did not initially learn the skill using play money. Similarly, Scott Foresman (Bolster et al., 1994) provided information about possible student errors and noted having students use place-value charts and grid paper or reintroducing place-value models, if necessary. As such, these two programs only partially met this criterion. In contrast, Addison-Wesley (Eicholz et al., 1995), Scott Foresman (Bolster et al., 1994), and Silver Burdett Ginn (Champagne et al., 1994; Fennell et al., 1998) did not specify any feedback procedures and therefore did not meet the criterion.

DISCUSSION

Across programs, Addison-Wesley (Eicholz et al., 1995), Harcourt Brace Jovanovich (Burton et al., 1994), Macmillan/McGraw-Hill (Jackson et al., 1994), Scott Foresman (Bolster et al., 1994), Scott Foresman–Addison-Wesley (Charles et al., 1998), and Silver Burdett Ginn (Champagne et al., 1994; Fennell et al., 1998) adhered to 66.7%, 33.3%, 88.9%, 33.3%, 88.9%, 77.8%, and 55.6%, respectively, of the nine design criteria. Results of the analysis indicated that across the 1994 through 1995 mathematics series, only Macmillan/McGraw-Hill (Jackson et al., 1994) and Silver Burdett & Ginn (Champagne et al., 1994) satisfied most (eight and seven, respectively) criteria. However, both programs failed to meet the criterion of "appropriate teaching examples," which is an important consideration in selecting materials. Including sufficient examples and selecting examples that preclude misrules and foster conceptual understanding and generalization is critical. In addition, Silver Burdett & Ginn (Champagne et al., 1994) failed to meet the criterion for effective feedback. In contrast, Scott Foresman–Addison-Wesley (Charles et al., 1998), the most recent edition, was effective in satisfying eight out of the nine criteria. This program incorporated the most effective features of its two earlier programs—Addison-Wesley (Eicholz et al., 1995) and Scott Foresman (Bolster et al., 1994)—and added information (e.g., effective feedback) to improve its overall quality. This finding is encouraging because previous reviews have indicated that basal mathematics textbooks inadequately address the issue of pedagogy and research findings (Carnine et al., 1997; Jitendra et al., 1996). In contrast, the 1998 Silver Burdett Ginn program was less effective than its 1994 edition in adhering to the nine criteria. For example, the 1998 edition included less explicit explanations than its earlier edition in addition to the lack of clarity of its lesson objective.

The analysis indicated that only two of the nine criteria (clarity of objective, number of additional concepts, and preskills taught) were fully met by all programs. The study also identified four instructional design features across all programs that need to be considered as teachers attempt to modify instruction for diverse learners. These design features were those that less than 50% of the programs adequately met (see Table 1), which included (a) clarity of objective, (b) explicit teaching explanations, (c) sufficient and appropriate teaching examples, and (d) effective feedback. In addition, although most programs evaluated provided a sufficient number of practice examples, they were part of the independent practice portion of the lesson. The programs presented relatively few opportunities for guided practice (scaffolding) prior to having students solve problems independently. For students with LD, failure to adhere to the various criteria can lead to an ineffectual conceptual base that can adversely affect later learning of more complex concepts and procedures and lead to what Stanovich (1986) and Walberg and Tsai (1983) described as the Matthew effect. Children rich in their conceptual knowledge base get richer, and those poor in knowledge fall even farther behind and are unprepared to meet the challenges of inclusive classrooms.

Results of this study indicate the need to judiciously select textbooks that adhere to the nine criteria. An important implication of this analysis is that teachers should attend to important design principles and modify or supplement instruction in basal mathematics textbooks to meet individual student needs. As teachers design instruction for students with disabilities, they must begin by specifying learning objectives that provide a direction for instruction and for evaluating student performance (Ornstein & Levine, 1993; Stein et al., 1997). Furthermore, teachers must carefully select sufficient and varied examples and emphasize instruction that provides the learner with explicit problem solving skills (Gersten & Baker, 1998). Instruction must also focus on the application of acquired knowledge to solve new problems. One determinant of expert or skilled performance is practice and review. According to Yekovich, Thompson, and Walker (1991), "practice is not simply time spent learning facts, but rather includes time spent using the learned facts in both routine and new ways" (p. 206). Instruction should involve strategic integration of skills. Although practice is necessary, instructive feedback is necessary for promoting skilled error-free performance. As such, teachers must work toward developing learning environments in which adequate time is devoted to unambiguous explanations and strategic application of newly learned skills.

The results from this study should be viewed as part of a growing set of research results on curriculum analysis. At the same time, several limitations of this study must be addressed. First, our sample included only four mathematics basal programs, and we did not review other programs. Second, we evaluated only one lesson in each program and further limited our review to subtraction involving regrouping across zeros. As such, this analysis cannot be construed as an evaluation of lessons throughout the text, but rather a demonstration of one approach to curriculum evaluation. Third, we did not examine supplemental materials recommended in the programs. Fourth, we did not examine other aspects of these texts such as readability and illustrations.

The encouraging findings related to the two most recent basal mathematics programs—Macmillan/McGraw-Hill (Jackson et al., 1994) and Scott Foresman–Addison-Wesley (Charles et al., 1998)—indicate that publishers need to continue to carefully attend to effective principles of instruction as programs are designed. Until then, the onus of evaluating textbooks and modifying instruction remains with the classroom teacher to ensure that all students have the opportunity and support needed to reach the NCTM standards. Modifications may be as simple as clarifying objectives and providing instructive feedback or involve more challenging practices, such as selecting appropriate examples, explicitly teaching for understanding, or providing appropriate practice and review.

In summary, it seems clear that many students with LD are going to need some type of modifications in instructional design of materials and teaching methods along with systems of support to adequately address their mathematics deficits in the general education classrooms. If these students are to succeed, it is incumbent on teachers to take a proactive approach by judiciously selecting materials and using effective teaching practices (e.g., clear explanations, adequate practice and review) to enhance mathematics achievement. Although we discussed the importance of a well-designed public curriculum (commercially prepared teaching materials) in this article, curriculum entails much more than this limited definition and description (Gehrke, Knapp, & Sirotnik, 1992). The concept of the enacted or implemented curriculum (i.e., what happens in the classroom) plays an even greater role on student achievement. According to Hafner (1993), "the implemented curriculum refers to how the teacher presents the curriculum, what subject matter is taught, the teacher's belief systems and intentions, together with the context in which instruction occurs" (p. 72). Eventually, the focus on the implemented curriculum may be deemed more important in understanding classroom processes (e.g., the interaction between teacher, student, and materials) than the intended or public curriculum (Ball & Cohen, 1996). That is, the underlying curriculum theory is one that assumes a child-centered ideology to reflect contemporary learning theories that acknowledge teachers' understanding of the content and creativity in guiding students' thinking.

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