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Promoting Strategic Learning by Eighth-Grade Students Struggling in Mathematics: A Report of Three Case Studies

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Abstract. This article presents three in-depth case studies focused on supporting students with learning challenges to learn math strategically. Participants were three eighth-grade students enrolled in a learning assistance classroom who were of at least average intelligence but who were performing significantly below grade level in mathematics. These case studies document the processes by which these students were supported to self-regulate their learning in mathematics more effectively. We begin by outlining important instructional foci in mathematics education for intermediate or secondary students with learning disabilities, along with what research indicates are effective instructional processes. In that context, we introduce the theoretical principles underlying the instructional model used here—Strategic Content Learning (SCL). Based on analyses of case study data, we describe how SCL instruction was structured to promote strategic learning. Throughout the discussion, intervention processes are described in sufficient detail to be of use to practitioners.

Teachers in learning assistance or resource settings are often required to support students struggling in mathematics. Although estimates vary, it has been suggested that between 5 percent and 10 percent of elementary students within the general population have trouble learning math (Kroesbergen & Van Luit, 2003), and that 5 percent and 8 percent of children have specific math disabilities (Fuchs & Fuchs, 2003; Geary, 2004). But while supporting mathematics learning is a pressing need, much debate has centered on how best to support struggling students. Critical questions include: on what should mathematics instruction focus for intermediate or secondary students with learning disabilities (LD)?; what instructional strategies might help in achieving important goals?; and how can instruction be effectively adapted to meet individual needs? To add to the growing body of research addressing these critical questions, this article reports on case studies designed to investigate how teachers in support settings could foster effective and strategic learning in mathematics by students with varying challenges.

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Foci for Effective Mathematics Instruction

In 1989 the National Council for Teachers of Mathematics (NCTM) issued standards that have served as a catalyst for educational reform in mathematics for the last 15 years (NCTM, 1989, 2000; Woodward & Montague, 2002). Although there has been controversy about the instructional implications for special education (Woodward & Montague, 2002), the standards do identify important instructional foci. For example, it is hard to disagree with the position that mathematics instruction should foster a deep understanding of mathematics as a field of study, rich conceptual knowledge about mathematics, and the ability to apply mathematical concepts adaptively and flexibly to solve complex problems (Carnine, 1997; Fuchs & Fuchs, 2003). Further, the majority of special educators would likely agree that students should be active learners who know how to derive meaning from math instruction strategically and efficiently.

Indeed, many instructional goals articulated in the recent literature on mathematics instruction for students with LD are consonant with the NCTM standards. For example, researchers have emphasized the importance of students' developing conceptual knowledge in mathematics if they are to become flexible and adaptive problem solvers (Brown, Campione, Reeve, Ferrara, & Palincsar, 1991; Carnine, 1997; Fuchs & Fuchs, 2003; Maccini & Hughes, 1997; Morocco, 2001). In addition, cautions have been raised about approaches to mathematics instruction that treat problem solving as applying predictable procedures (Fuchs & Fuchs, 2003; Resnick, 1988). Recommendations are to avoid teaching students how to employ step-by-step procedures for mathematical problem solving without attention to conceptual understandings, or how to classify problems based on operations required or key words without attention to underlying mathematical structures (Hutchinson, 1993). Unintended results of such traditional special education practices may be that students fail to understand the big ideas that underlie mathematics (Carnine, 1997), and come to misperceive mathematical problem solving as simply memorizing rules and procedures for solving stereotyped problems (Resnick, 1988).

Unfortunately, much research and practice in special education focuses more on instruction in basic skills or step-by-step procedures than on supporting students' understanding of mathematical concepts. For example, in a review of studies on math interventions for secondary students with LD, Maccini and Hughes (1997) found that most studies focused either on basic skills (primarily multiplication), or on problem solving and word stories. Further, the vast majority focused on the teaching of procedures (i.e., rules, facts, or step-by-step solutions) without attention to students' construction of conceptual knowledge.

Another instructional goal consistent with NCTM standards is to support students' knowledge about and use of domain-specific and metacognitive problem-solving strategies (Hutchinson, 1993; Maccini & Hughes, 1997; Montague, 1993, 1997a, 1997b). Domain-specific cognitive strategies are used to understand and solve a problem; metacognitive strategies are used to manage and monitor problem-solving activities (Butler, 1998c; Montague, 1997a). That students with LD benefit from strategies instruction in mathematics has been demonstrated in many studies (e.g., Hutchinson, 1993; Maccini & Hughes, 2000; Montague, 1997a, 1997b). For example, Montague (1997a) reviewed three studies she conducted on the problem-solving performance of middle- or high-school students with LD. Students were taught cognitive strategies focused on problem representation and problem solution that included: "Read (for understanding), Paraphrase (in your own words), Visualize (a picture or a diagram), Hypothesize (a plan to solve a problem), Estimate (predict the answer), Compute (do the arithmetic), and Check (make sure everything is right)" (p. 171). Three types of metacognitive strategies, self-instruction, self-questioning, and self-monitoring, were taught in tandem with each of the cognitive strategies. Across studies, Montague found gains in students' problem-solving performance associated with strategy instruction.

A good deal of research has focused on defining cognitive and metacognitive strategies underlying successful problem-solving performance (Hutchinson, 1993; Maccini & Hughes, 2000; Montague, 1997a, 1997b). However, less research has focused on teaching strategies for building conceptual knowledge in math. If students are to think like mathematicians (NCTM, 1989, 2000; Schoenfeld, 1988), and to benefit from mathematics instruction, they need to know *how to* mindfully abstract concepts, principles, and procedural knowledge from the various forms of instruction to which they are exposed.

A final instructional focus recommended in the special education literature is to support students' self-regulated learning (e.g., Butler, 1998a, 1998d; Harris & Graham, 1996). Models of self-regulated learning encompass students' knowledge about and use of cognitive and metacognitive strategies, but they situate strategy use within a recursive cycle of learning activities (Butler & Cartier, 2004; Butler & Winne, 1995; Corno, 1993, 1994; Zimmerman & Schunk, 2001). When presented with academic work, self-regulated learners start by interpreting task demands (e.g., by representing a problem to determine what it is asking, recognizing the need to learn a mathematical concept that can be applied to solve problems). Then, based on a clear understanding of task objectives, they select, adapt, or invent strategies for learning and/or problem solving, self-assess outcomes, and redirect learning if needed. Note that task interpretation and self-assessment are pivots around which cycles of self-regulation turn (Butler & Winne, 1995). For example, a student who interprets learning in mathematics as about memorizing formulas is likely to self-direct, self-assess, and adjust learning activities to best achieve that goal. Further, how students self-regulate performance is shaped by the knowledge, beliefs, and conceptions they bring to a task, such as self-perceptions of competence (Bandura, 1993; Borkowski, 1992; Butler & Cartier, 2004; Zimmerman & Schunk, 2001). The implications are that instruction should foster students' engagement in the cycle of self-regulated activities, so that they take responsibility for self-directing learning (e.g., Butler & Winne, 1995; Carnine, 1997), and that instruction should support students' construction of knowledge, conceptions, and beliefs that support effective self-regulation (Borkowski, 1992).

Instructional Processes for Effective Mathematics Instruction

Drawing on cognitive and constructivist leaning theories (Woodward & Montague, 2002), the NCTM describes students as active learners who construct understandings through discussion and reflection on learning and problem solving (NCTM, 1989, 2000). Pedagogical recommendations include engaging students in challenging activities, promoting active construction of mathematical understanding, facilitating discussions that probe for alternative ways of thinking, and employing assessment strategies that guide teaching and learning.

Much discussion has focused on how NCTM instructional guidelines should be adopted for use in special education (see Woodward & Montague, 2002). One challenge is that a mainstay of empirically validated instruction in special education is the direct teaching of concepts, skills, and/or strategies. Teachers and researchers therefore struggle to articulate methods to engage students in constructive learning without compromising the explicit, systematic support that is most often recommended (e.g., Carnine, 1997; Jones, Wilson, & Bhojwani, 1997). Unfortunately, in debates over the best mathematics instruction for students with special needs, constructivism is sometimes equated with "discovery learning," as if constructivist methods of teaching necessarily entail leaving students to figure out concepts, skills, or strategies by themselves (Butler, 1998b; Woodward & Montague, 2002). The result is often an unnecessary dichotomization between stereotyped versions of opposing perspectives (e.g., constructivist vs. behaviorist). Fortunately, research is emerging that integrates best practices in special education with a constructivist or socio-constructivist perspective (e.g., Butler, 1995, 1998b; Gersten & Chard, 1999; Harris & Pressley, 1991). In that spirit, one aim in the current article is to provide for teachers an elaborated description of how teachers in special education settings can support students' active and constructive learning from instruction in mathematics.

Concrete instructional principles have been suggested in the special education literature to promote students' active construction of conceptual and procedural knowledge. For example, one common recommendation is to engage students in constructive conversations (Morocco, 2001; Woodward, Monroe, & Baxter, 2001), dialogue (Englert, Berry, & Dunsmore, 1991; Wheatley, 1993), or interactive instruction (Ellis, 1993; Pressley et al., 1992; Woodward & Montague, 2002) as a means of spurring meaningful learning. Morocco (2001) suggests that constructive conversations "make thinking visible and encourage students to connect, compare, contrast, and negotiate different understandings" (p. 9). Within interactive conversations, teachers can enlist students in a shared enterprise of making sense of mathematical procedures and assist them in their interpretations of concepts (Dana & Davis, 1993; Wheatley, 1993). Students can also be supported to abstract understandings about concepts and principles, to try out and evaluate alternative solution strategies, and to engage in cycles of self-regulated learning.

A second recommendation emerging in the special education literature is to support students' mindful abstraction of concepts and principles during mathematics instruction (Butler, 1995; Wong, 1991). For example, following on Salomon and Perkins (1989), Fuchs and Fuchs (2003) argue that students' mindful construction of conceptual knowledge in mathematics translates to adaptive problem solving and transfer. They argue that "abstraction provides the bridge from one context to the other; metacognition is the conscious recognition and effortful application of that abstraction across contexts" (p. 308). Consistent with this perspective, research has demonstrated that when students actively reflect on learning to formulate and search for connections between problems, particularly in terms of underlying mathematical structure, they are more likely to solve problems successfully and to adapt solution strategies for novel or complex problems (e.g., Hutchinson, 1993). Similarly, research by Rittle-Johnson and colleagues (Rittle-Johnson & Alibali, 1999; Rittle-Johnson, Siegler, & Alibali, 2001) suggests that conceptual and procedural knowledge in mathematics are interdependent and develop in tandem, and that supporting students' mindful abstraction of concepts and principles while engaged in procedural learning may help in fostering conceptual knowledge construction.

A third instructional guideline from the special education literature is for teachers to use dynamic, curriculum-based, contextualized forms of assessment to guide intervention in mathematics (Carnine, 1997; Englert, Berry, & Dunsmore, 2001; Woodward & Montague, 2002). Common recommendations are to construct assessment so as to permit students to express personal understanding and uncover students' background skills and understandings (Carnine, 1997; Dana & Davis, 1993; Englert et al., 2001). Further, assessment should be broad enough to consider learning processes, not just products (Brown et al., 1991). For example, in a year-long case study focused on ways to improve problem solving for students with LD, Woodward et al. (2001) developed and tested an alternative form of assessment of mathematical problem solving that required students to solve complex problems, articulate how they derived their answers, and write about their mathematical understanding (in pictures). After intervention, the researchers were able to trace shifts not only in students' problem-solving performance, but also in their representation of problems and knowledge and use of problem-solving strategies.

Consistent with the literature review in this and the preceding sections, instructional goals in this research were to promote (1) self-regulated learning in mathematics, and within that framework, (2) construction of conceptual knowledge in mathematics in tandem with development of procedural skills; (3) co-construction of effective and efficient cognitive and metacognitive strategies for learning and problem solving; and (4) construction of knowledge and beliefs supportive of self-regulation (e.g., positive self-perceptions of competence). Instructional processes based on the above recommendations were used to engage students in interactive discussions during which (1) learning was socially mediated and meaning was negotiated, (2) students were supported to mindfully abstract concepts and principles from mathematics instruction, and

(3) support was calibrated to meet individual needs based on ongoing assessment of learning processes and outcomes.

Meeting Individual Needs Through SCL Instruction

Students who struggle in mathematics do so for varying reasons (Kroesbergen, Van Luit, & Naglieri, 2003). For example, Geary (2003) identified subtypes of math disabilities noting that, while some students experienced problems learning mathematical concepts or procedures, others' challenges were linked to reading disabilities or to visual–spatial processing problems (see also Fuchs & Fuchs, 2002). Some students have difficulty mastering and memorizing basic math facts and achieving fluency in computation. Many students with LD have trouble with problem representation (Montague, 1993, 1997a) and/or with knowledge or use of other kinds of problem-solving strategies (Woodward & Montague, 2002). For example, in Butler's (1999) research with postsecondary students with LD, students' self-reported strategies for learning math and/or math problem solving were vague or inefficient. Example are: "If I don't understand something I'll keep going over it till I do"; "[I] read, use rules, find a reasonable answer, cheat;" and "I look at it and try different methods, but if I can't do it straight off, if I don't recognize it . . . then I find it quite hard." Further, as described earlier, depending on the instruction to which they have been exposed, students may have constructed less-than-optimal perceptions about mathematics as a field of study or of what learning in math is about (Campione, Brown, & Connell, 1988; Resnick, 1988; Wheatley, 1993). Students with LD often perceive mathematics as requiring memorization and rote learning or application of algorithms (e.g., Butler, 1999).

Students with LD may also be at risk for low self-perceptions of competence (Butler, 1999; Jones et al., 1997), which can lead to less persistence in academic learning (Bandura, 1993; Schunk, 1994). Further, Montague (1997b) reviewed five studies and found that students with LD were at risk for less positive attitudes toward mathematics. She also found that, although students perceived problems as more difficult than did average-achieving or gifted peers, they did not adjust their problem-solving strategies accordingly. They spent the same amount of time solving the problems and used fewer problem-solving strategies.

Given the diversity in underlying problems associated with challenges in mathematics, what would be of considerable benefit to learning assistance or resource teachers is an instructional model that includes mechanisms for ongoing assessment and instruction responsive to individuals' needs. This article provides a description of one such instructional model, Strategic Content Learning (SCL; Butler, 1993, 1995, 1998a, 2002), and reports case studies on how SCL instructional principles were applied within a learning assistance setting to support three students struggling in mathematics for different underlying reasons.

Previous research has documented SCL efficacy in supporting self-regulated learning by postsecondary students with LD (e.g., Butler, 1993, 1995, 1998a, 1998d; Butler, Elaschuk, & Poole, 2000). In a series of studies, students selected tasks of importance in their academic studies (typically variants of reading, writing, or math tasks) and were provided with adjunct support to regular classroom instruction in either one-on-one or small-group settings. Positive gains associated with SCL intervention were found across studies in students' task performance, metacognitive knowledge about tasks and strategies, and self-perceptions of competence. Systematic analyses of case study data also suggested that students were actively involved in co-construction of personalized strategies responsive to their individual needs (Butler et al., 2000), and that they used new strategies flexibly and adaptively across contexts and tasks. To complement analyses focused on evaluating SCL efficacy, in-depth analyses of instructional processes were also conducted to examine *how* SCL worked. For example, using discourse analysis, we characterized student and teacher interactions that promoted successful performance (Kamann & Butler, 1996). We also analyzed *how* SCL allowed teachers to individualize instruction for students with different needs working on a common task (Butler et al., 2000).

Building from the success of the postsecondary studies, the present study extended SCL application into secondary schools. The three case studies described here were conducted within the context of a broader project focused on documenting teacher learning processes as they adapted SCL principles for use in their own grade 8 to grade 11 classrooms (see Butler, Novak Lauscher, Jarvis-Selinger, & Beckingham, 2004). As a study within a study, three case studies were conducted to describe the instructional processes used to support mathematics learning by three eighth-grade students in one teacher's learning assistance classroom.

SCL Instructional Principles and Guidelines

Table 1 contains an overview of four basic principles that undergird SCL, distilled from theory and prior research (Butler, 2002). This article describes how these SCL principles were adapted to support students in a learning assistance classroom, with the goal of helping them learn *how to learn* more independently from general classroom instruction.

A first central principle in SCL is that support for self-regulated learning should be integrated into instruction, rather than being treated as a separate curriculum. Within any academic activity, students can be supported to interpret a given task (e.g., to solve an authentic problem, to apply a math concept when solving different kinds of problems) and explicitly define task criteria. Instruction can then be structured so as to

TABLE 1
SCL Instructional Principles

Principle 1: Integrate support for self-regulation into instruction
- Engage students in the recursive cycle of cognitive activities central to self-regulation:
  - interpreting tasks and defining task criteria
  - identifying and articulating strategies
  - self-assessing outcomes
  - revising work and strategies as required
- Support students to construct knowledge and beliefs through cycles of self-regulation

Principle 2: Students as active interpreters (filters of information)
- Information (e.g., from classroom teachers, texts, videos) impacts learning only to the extent that students focus on, make sense of, and use that information
- Structure instruction so as to engage students in actively focusing on, interpreting, and using information
- Build into instruction ways of assessing how students are actually making sense of what they are learning
- Promote students' active interpretation of the information you provide

Principle 3: Learning in mathematics as guided (re)construction
- Teachers can orchestrate how students actively construct knowledge (ideally, in ways we wish them to go)
- Active reconstruction requires that students engage actively in making meaning
- Procedural facilitators, dialogue, cue sheets, strategic selection of examples, and other instructional strategies can help guide students' attention and knowledge construction
- Engage students in reconstructing knowledge that will support effective learning

Principle 4: Learning in pursuit of a goal
- Engage students in collaborative problem solving and guide learning in that context
- Frame tasks as a "goal" (make as meaningful as possible)
- Engage students in identifying goals, selecting, adapting, or even inventing strategies, self-assessing outcomes, and modifying approaches to working
- Act as a facilitator of students' problem solving
- Ask students to articulate what they are doing and learning, in their own words

assist students in reflectively and deliberately selecting, adapting, and implementing strategies to achieve task goals, self-assessing outcomes against task criteria, and revising learning approaches as needed. Further, it is by engaging learners in cycles of self-regulation that knowledge and beliefs can be reconstructed. For example, it is when students set goals, use effective strategies, and reflect on positive outcomes that they build positive self-perceptions of competence and control over learning (Borkowski, 1992). Similarly, it is when students attempt to self-direct learning of a mathematical concept that they construct, not only domain-specific knowledge about that concept, but also understandings about what learning in mathematics entails.

A second instructional principle in SCL is to recognize that students are "active interpreters" whose interpretations of information mediate what they learn. As described earlier, it is commonly recommended that instruction for struggling students be explicit and include direct explanation and modeling, followed by guided and independent practice (e.g., Ellis, 1993), However, no matter how explicitly presented, information (from teachers, texts, videos, worksheets, etc.) impacts learning only to the extent that students focus on, make sense of, and use that information. It follows that in special education settings it is not sufficient to re-present information already made available to students in a general classroom setting (e.g., in a lecture, a textbook, a worksheet), especially given that there is never sufficient time to re-teach a mathematics curriculum. Instead, teachers can promote independent, self-directed learning by assisting students to learn *how to* interpret and learn from available information resources.

A third instructional principle in SCL is to support students' *guided reconstruction* of important concepts and procedures. A constructivist metaphor for describing learning is valuable because of its emphasis on students' active role in creating meaning. And, if mathematics instruction poses to students authentic tasks, such as real-world or ill-structured problems with no one answer and multiple potential solution strategies (Resnick, 1988; Schoenfeld, 1988), then students are actually afforded opportunities to construct new insights that are not predetermined. That said, there are times in schools when teachers have the goal of assisting students to learn important concepts, skills, or strategies that are fundamental to a domain. It is in this context particularly that a constructivist metaphor has been criticized as requiring students to discover knowledge for themselves. But as noted earlier, in applications of constructivist theory, students are not typically abandoned to learn on their own, but are instead guided to construct knowledge through social mediation. Similarly, in SCL it is recommended that teachers structure activities, information resources, interactive discussions, and other instructional processes so as to guide students' active "reconstruction" of important concepts and procedures. For instance, teachers can guide students' interpretation of carefully selected examples to influence their mindful abstraction of a given mathematical concept.

A fourth instructional principle in SCL is to frame all academic work as an opportunity for collaborative problem solving in pursuit of a clearly defined goal, whether the "problem" is to learn and apply a new math concept or literally to learn how to solve a math problem. It is recommended that teachers start by working collaboratively with students to explicitly articulate task demands (i.e., the "problem" to be solved). Students can then be actively engaged in co-constructing strategies to achieve common task goals. In that context, students can attend to and make use of already provided or new information to the extent that is relevant and useful for solving the problem (e.g., learning a concept). Thus, in SCL, teachers act as facilitators of students' active problem solving (broadly defined) not just as providers of information.

Taking these four SCL principles together suggests that mathematics instruction for students with LD should promote students' self-directed learning and problem solving in pursuit of important curricular goals. Within that context, students should be supported to actively interpret information (e.g., from modeling, textbooks, videos, examples, cue sheets, etc.) so as to construct and/or "reconstruct" conceptual knowledge and procedural skills.

Two specific instructional guidelines also emerge from this combination of principles. The first is to engage students in interactive discussions as a means of constructing assessment–instruction cycles and of promoting active learning and problem solving. More specifically, in SCL teachers are encouraged to use "strategic questioning" to uncover students' current knowledge and beliefs and then guide students' effective self-regulation. Strategic questions are those that are used intentionally for assessment purposes and/or to mediate student learning. For example, strategic questions can be used to assess students' knowledge (e.g., "What does this concept mean?") and skills ("How would you solve this?"). Using strategic questioning throughout instruction also allows for continuous reassessment of students' shifting knowledge, beliefs, and skills.

Strategic questions are also extremely useful for mediating self-regulated learning. For example, open questions can be used to focus students' attention on important self-regulated processes, such as task interpretation (e.g., "What are you supposed to do here?"), strategy selection (e.g., "What do you think you could do to achieve this goal?"), self-assessment (e.g., "How well is that working?"), and strategy revision (e.g., "What might you do differently?"). More focused questions can be used to guide students' thinking and problem solving in very specific directions (e.g., "What is this part of the question asking?"; "I saw you draw a picture over here to better understand the problem. Do you think that would help you again here?"). Note that it is important to extend strategic questioning from cuing to fostering independence in self-regulation. For example, at the end of a successful learning experience, asking "What did we just do here that enabled you to learn and apply this concept?" pushes students to articulate emerging understandings about self-regulated learning processes. Further, as Englert et al. (2001) emphasize, engaging students in interactive discussions is enhanced by providing supportive artifacts or other materials. Thus, SCL teachers commonly select, highlight, or restructure materials to better reveal patterns, and then use strategic questioning to guide students' interpretation of those information resources.

A second specific instructional guideline that follows from SCL principles is to support students' co-construction of powerful cognitive and metacognitive strategies. In many interventions designed to support strategic learning (e.g., Ellis & Larkin, 1998; Schumaker & Deshler, 1992), instruction begins with teaching students a set of strategies that are taught directly to students. Instructional guidelines typically include explicit explanation of strategy steps, modeling, guided practice, and independent practice. SCL provides a different approach for assisting students to develop more strategic approaches to learning (Butler, 1995). To promote strategy construction, teachers and students build from very explicitly articulated learning objectives. Then, in the context of collaborative problem solving, teachers guide students to develop, adapt, or invent personalized strategies, building from what students already know while also responding to their individual needs. Students are asked to articulate strategies they observe leading to positive outcomes, and to keep track of and build strategies over time on cumulative "strategy sheets." This approach supports students to "reconstruct" effective learning processes, to see where strategies "come from," and to directly observe the relevance of strategies to achieving important objectives.

To pull these SCL principles and guidelines together, imagine a learning assistance teacher whose job it is to support students to be successful in mathematics. Following SCL principles, this teacher would guide students to self-regulate completion of actual classroom work. First, the teacher and students would jointly interpret the task (e.g., understanding a math concept in order to represent problems and solve them correctly). By explicitly co-defining the task with students, the teacher would establish a context for strategy development. The teacher and her students would collaboratively solve the "problem" of meeting task demands by co-constructing cognitive and metacognitive strategies. The teacher would mediate learning by asking strategic questions (general and/or focused) to assess students' knowledge and processing and push them to learn more strategically. Students would be cued to reflect on and abstract understandings from learning so as to shape their knowledge and beliefs. For example, focusing attention on common patterns across problems would support mindful abstraction of mathematical concepts; focusing attention on links between effortful strategy use and outcomes would promote construction of positive perceptions of self-competence; and focusing reflection on successful learning processes would foster construction of knowledge about strategies. In the end, students would be supported to learn how to self-regulate learning and use cognitive and metacognitive strategies so as to (re)construct conceptual and procedural knowledge.

CASE STUDIES ON SCL INSTRUCTIONAL PROCESSES

The broader project within which these case studies were situated was launched by inviting teachers within an urban school district to collaborate with researchers in adapting SCL for use at the secondary level. In total, over 2 years, 13 teachers from five schools volunteered to participate in the project. Twelve teachers worked within resource or learning assistance settings; one worked with students in a regular, inclusive classroom. Note that teachers in the first year of this project, from which these case studies were drawn, had just started working with researchers to co-construct strategies for implementing SCL principles. Thus, the purpose of this project was not to conduct a formal evaluation of SCL efficacy, as we had done at the postsecondary level (Butler, 1993, 1995, 1998a, 1998d, 2002). Instead, our purpose was to chronicle how SCL was used to foster self-regulated learning in mathematics by three eighth-grade students.

Three questions guided our case study inquiry, parallel to those posed at the outset of this article. First, *how* did SCL achieve important instructional goals, namely promoting students' conceptual knowledge, cognitive and metacognitive strategy use, and self-regulated learning? Second, within the context of actively using SCL, *how* was students' learning mediated? Finally, how was SCL used to respond to individual needs? We provide case-by-case descriptions to address each topic in turn, and close this section with a cross-case comparison that elaborates on key themes we found across students.

Design and Procedures

This article reports three case studies designed to examine how SCL instructional principles could be instantiated to support self-regulated learning in mathematics in the context of a learning assistance classroom (Merriam, 1998; Yin, 1994). Multiple data collection strategies were employed to identify individual needs and to document instructional processes in relation to student learning. First, background information on each student was collected through a review of Individualized Educational Plans (IEPs) and available psychoeducational assessments. Second, an 8-item Metacognitive Questionnaire (adapted from Butler, 1995; Graham & Harris, 1989; Wong, Wong, & Blenkinsop, 1989) was used at the beginning and end of the year to assess students': (1) conception of what learning in mathematics is about, (2) knowledge about their strengths and weaknesses in mathematics, (3) knowledge about strategies for learning math, and (4) approaches to self-assessment. Although in previous research scores were reliably calculated from the questionnaire using a detailed rubric (see Butler, 1998a), here students' written responses were entered into a case study database for qualitative interpretation.

Additional data for in-depth case studies were collected through researcher observations and field notes, teachers' daily descriptions of instructional interactions and student progress (on "teacher reflection forms"), videotapes of instructional sessions, student work samples (worksheets, quizzes, etc.), and copies of personalized strategies developed by students (on strategy sheets). These multiple sources of evidence converged to provide a complete picture of how SCL instructional activities were linked to students' development of self-regulation (Merriam, 1988; Yin, 1994).

Although not a formal evaluation of SCL efficacy, we did keep track of students' task performance on classroom math tests so that we could link students' learning to the intervention. Our collection of students' work samples provided data from between six and eight common curriculum-based quizzes/tests (6 for Kelly, 7 for Kimi, 8 for Denise). To provide a more reliable picture of progress, scores were combined across measures to create indicators of performance at "pretest" (two tests given in the early fall, with 68 possible points in total), "during the project" (four tests given between December and April, with 102 possible points in total), and "posttest" (two tests taken in May and June, with 112 possible points in total).

In our case study analyses, data were sequenced and rigorously interpreted to construct a descriptive account of SCL intervention in relation to student learning. We began by collating background information for the school and teacher with all data sources for each case study. Student information was assembled to ensure we had parallel data across all three students (e.g., IEP, questionnaires, strategy development records, teacher reflection forms). All data were labeled and organized into a "case study" binder. Original data were then converted into soft data files (Excel tables) so that personal narratives and cross-case observations could be constructed.

Next, two researchers carefully scrutinized all of the materials for a first student, and each independently constructed a narrative that described the process of intervention. Each researcher kept the three central research questions in mind to lend a common focus to the case. Further, whenever patterns were defined, the researchers searched for disconfirming evidence to test emerging conclusions. The researchers then compared their respective narratives for similarities and differences. This process ensured that all relevant details were accounted for in a systematic and unbiased way. The analysis also ensured that conclusions could be directly and reliably linked to catalogued evidence. Once the narrative was constructed for the first student, narratives for the two remaining students were co-constructed (with one researcher taking a lead role and the second providing an independent check). In the end, each case study narrative was constructed to "tell the story" of how SCL worked. Note that one of the researchers co-constructing narratives had been responsible for collecting the case study data. Her knowledge of the classroom, the teacher, and the individual students assisted in constructing rich, contextualized narratives. At the same time, the second researcher brought an outside perspective to data analysis that provided an important credibility check.

The final step in the analysis was to complete a cross-case comparison. The two researchers compared the three case study narratives to co-construct themes across students. To begin, both researchers independently reviewed case files and narratives to find themes and patterns. For example, where students' pretest strategies differed from posttest strategies, the researchers analyzed how the strategies changed (e.g., strategies moved from being general to more specific). Then the researchers came together to compare and co-construct final themes.

The School and Classroom Context

This research was conducted within a school district located in an urban community in western Canada. In this school district, secondary schools typically include students in grades 8 to 12. The three case study participants were all in grade 8, and received support for math and science learning in the same learning assistance classroom. In the district where this research was conducted, students were provided learning assistance if they were chronically underachieving academically, even if they had not received a formal disability diagnosis. However, all students receiving learning assistance were required to have annual IEPs. During this research, the three case study participants received learning assistance support from the same teacher for two to three 80-minute blocks per week. Generally, the teacher rotated among three to four students in the block, working one-to-one with students to help them in learning from classroom assignments.

During this first year of the project, teachers were experimenting with ways to adapt SCL principles in their classrooms. To support teachers, members of the research team visited classes, co-taught students, observed teachers trying SCL, and debriefed after sessions (see Butler et al., 2004). In this capacity, the principal investigator worked with the case study participants occasionally during the year. Thus, SCL implementation occurred with both the classroom teacher and with the principal researcher in the "instructor" role, and examples provided in this article include student interactions with both the researcher and the teacher (who shifted roles dynamically in co-teaching situations).

Case Study Participants: Kelly, Kimi, and Denise

The students selected for in-depth case study analysis were female and roughly 13 years old (see Table 2). One of these students had been formally diagnosed as having a "severe" language learning disability in addition to a math disability (Kelly). The other two students had chronically underachieved in school and had received learning assistance for many years. All were functioning below grade level in math and science.

We selected these participants for case study analysis for several reasons. First, these three students were in the same grade, worked on the same or similar tasks, and received support from the same teacher in the same class. However, although their performance was similarly "below grade level" in math and science, students' problems with mathematics were quite different (as will be described more specifically below). Therefore, contrasting SCL processes for these three students provided an optimal opportunity to investigate how SCL could be adapted to meet individual needs. Another reason for selecting these students was that they were typical of the kinds of students that teachers often encounter in learning assistance settings. Although only one had a formally diagnosed learning disability, all had received learning assistance support throughout their school careers. Finally, we selected these students because we had the opportunity to collect in-depth data (e.g., combinations of teacher reflections and videotapes of sessions) with which to complete case study analyses.

CASE STUDY FINDINGS

In this report we provide a detailed description of each case in turn, followed by a cross-case comparison. However, to avoid repetition, we focus on a different research question in each case summary. In Kimi's case we chronicle how students were supported to self-regulate learning. In Kelly's case we zero in on the quality of teacher–student interactions. Finally, Denise's case presents evidence as to how SCL addressed individual needs. Note that while our presentation of findings within each case study is particular to a given student, the themes we report within each were common across cases.

Kimi and SCL Instructional Processes

In this case study report, we focus attention on how a teacher applied SCL instructional principles to promote

TABLE 2
General Description of the Three Case-Study Participants

Participant	*Kelly* [a]	*Kimi*	*Denise*
Age	12-11	13-00	12-10
Grade	8	8	8
Diagnosis	Severe learning disability	Learning assistance through school years	General academic underachievement
Cognitive functioning (general)	Borderline to low average: verbal IQ 75-83; performance IQ 81-91	Below average	Average–Above average
Achievement	Math: 13th percentile Reading comprehension: 18th percentile	Below grade level in math and science	Below grade level in math and science

Note. Information summarized from students' psychoeducational assessments and/or Individualized Education Plans as contained in their school files.
[a]Measures used in Kelly's assessment were the Wechsler Intelligence Scale for Children-III as a measure of cognitive functioning (Wechler, 1991), and the Canada Quick Individual Educational Test (QUIET) as a measure of achievement (Wormeli & Carter, 1991).

Kimi's self-regulated learning, development of personalized strategies, and construction of conceptual and procedural knowledge. We focus in particular on how support to Kimi's strategy development was explicit and sequential.

Background Information

Kimi had never been tested for a learning disability; however, she had received learning assistance support throughout her school career. In her IEP, Kimi was described as a cooperative student who was willing to accept help and to be helpful and who had a "good attitude" toward school and learning. Kimi's major academic struggles were in the areas of math, reading comprehension, and written expression. She was reported to have difficulty with interpreting task demands and teacher expectations, understanding math concepts, articulating her knowledge, and completing assignments on time. She was also described as lacking self-confidence and needing frequent feedback and reassurance. Across two work samples collected in early fall, Kimi scored 40 percent (see Table 3).

On the pretest Metacognitive Questionnaire, Kimi's descriptions of math tasks and strategies were couched in very general terms. For example, when asked what "learning math is about" Kimi replied, "What we get out of math is a better education . . . If you don't have math you can't be an astronomer or scientist." Similarly, when asked what she needed to do to improve her performance, Kimi replied that she needed to "study more; do work when asked to do extra work." Kimi's responses suggested she knew of few independent strategies for learning in mathematics and relied heavily on others for support. For example, her strategy for solving math problems was to "read the questions through and ask for help." Despite her difficulties, Kimi self-assessed her math ability as above average "[because] I always ask for help when needed." In total, Kimi's responses suggested that she was a willing student who wanted to achieve in mathematics, but was not sure how to do so.

TABLE 3
Task Performance Data for the Three Case-Study Students Across the Year

Participant/ Time Period	*Percentage Correct Across the Assessment Periods*		
	Kelly [a]	*Kimi* [b]	*Denise*
Early Fall	40	24	40
During the project	56	62	51
May–June	60	62	23

[a]Data were missing for Kelly for two tests, one from early fall, one from during the project.

[b]Data were missing for Kimi during the project test.

SCL Intervention

Analyses of Kimi's case study narrative revealed that instructors (1) used strategic questioning to assess what Kimi already knew and structure support for her self-regulated learning, (2) created examples with Kimi to highlight patterns or links between ideas, (3) helped Kimi interpret instructional materials from her classroom, and (4) assisted Kimi to develop problem-solving strategies grounded in conceptual knowledge about math. In the case study description that follows, we present evidence supportive of these general observations.

Early in the year (on October 15), Kimi brought to her learning assistance classroom an assignment requiring her to apply conceptual knowledge about square roots to representing and solving different kinds of problems (e.g., $\sqrt{81} = ?$; "The square root of what number is 9?"; "Find a number whose square root is between 7 and 9"). An instructor observed that Kimi was struggling with the more complex problems. For example, when asked to find a number whose square root was between 7 and 9, Kimi initially identified a number between those two numbers (8), not a number whose square root fell between them (e.g., 64).

To begin, the instructor asked Kimi strategic questions to determine what she understood about square roots. Because Kimi had trouble putting her understanding into words, they worked together to generate concrete examples to represent her understanding. For example, the instructor asked Kimi for help in identifying the following relationships:

$$\sqrt{144} = 12 \quad 12 \times 12 = 144.$$

It was clear within this discussion that Kimi had a basic grasp of the meaning of a square and square root (she could link the two equations above and calculate the square root of a given number). However, she had difficulty working with the concepts fluently (going back and forth between numbers and their square roots) and applying the concepts to represent problems.

To support Kimi's fluency with the concepts and their application, the instructor worked with Kimi to extend the set of examples so as to highlight important relationships. For example, when working toward solving problems of the type, "Find a number whose square root is between 7 and 8", the instructor asked strategic questions to guide Kimi in writing out for herself the following list of examples:

$$\sqrt{49} = 7$$
$$\sqrt{56.25} = 7.5$$
$$\sqrt{64} = 8.$$

After generating these examples with Kimi, the instructor asked Kimi to try again to interpret a problem. She noted that this time Kimi read the question and interpreted it correctly. Building from this success, the instructor asked Kimi what she had just done that had helped her interpret the problem successfully. Kimi responded verbally that it helped to "write out the questions using pictures." Kimi went on to solve the problem correctly. Given Kimi's obvious pleasure, the instructor seized the moment to ask Kimi to reflect again on the strategies she was using that worked and that she could use again in the future. She asked Kimi to record her ideas on a math strategy sheet on which they would build strategies over time. In this session, Kimi wrote down two strategies for representing problems: "Writing down different answers to figure out the questions" and "looking carefully at the words 3 or 4 times."

Six days later (on October 21), Kimi was struggling to solve problems about mixed fractions (e.g., 21/2). Building from what Kimi had done successfully when working on square root problems, her instructor asked Kimi if she could draw her understanding of a problem in pictures. The instructor recorded that Kimi "drew out the question and came to an answer right away." Kimi then drew a picture for another problem that she solved independently. When the instructor asked Kimi to reflect on what strategy she was using this time that was enabling her to be so successful, Kimi elaborated her math strategy sheet by adding: "Use pictures to show fractions. The pictures help you figure out the answers." She later told the other instructor that she had "found a good strategy for fractions—drawing a picture" so that she now found the task "easy." The long-term efficacy of her strategy for fractions was demonstrated in February when she received 8/8 on a fractions quiz.

In these and other sessions, Kimi continued to elaborate her math strategies, ultimately building a combination of problem-specific and metacognitive strategy steps. For example, her first three strategy steps (above) were cognitive strategies for problem representation. Other strategy steps supported her active self-regulation of learning. For example, one cued her to consider examples in her textbook to learn problem-solving strategies ("use the instructions on the left side of the work page"). Another reminded her of the importance of self-checking ("Check through the work to see if you made mistakes"). Domain-specific strategies for solving math problems linked back to Kimi's understanding of relationships between numbers. For example, Kimi and an instructor developed a problem-specific strategy for solving problems involving multiplying fractions and whole numbers: "if you have a fraction like 1/3 and it is x by 24, you can divide 24 by 3 and you would get a number like 8." Similarly, in a subsequent session (March 3), one of Kimi's problem-specific strategies was "when solving algebra equations you can use the opposite sign. e.g., $N + 6 = 18$ $N = 18 - 6$." Note that Kimi's strategies were recorded in her own words and were not always expressed as an instructor might have chosen. However, both instructors ensured that Kimi knew what her own strategies meant and could apply them effectively in actual work. Further, Kimi was proud when her approaches to working were recorded in her own words on her strategy sheets.

Later in the year (March 6), Kimi applied her "picture" strategy when studying for science. On one occasion, Kimi's task was to learn the anatomy of the eye so that she could label a diagram correctly. Kimi's initial strategy for studying was to reread the labels on the diagram and try to memorize them. But when asked what strategies she had used in the past that had worked well, Kimi remembered that she understood math concepts better when she represented them in pictures. So Kimi decided to redraw the picture herself as a way of learning the material. She made a list of features at the top of the page and practiced labeling the drawing. Kimi and her instructor evaluated the success of her strategy the next day by seeing how much she could remember. Kimi smiled brightly as she was able to label all twelve parts of the eye independently. Based on that success, Kimi dictated the following step for addition to her strategy sheet: "If I'm studying a diagram I can draw the picture and write all the parts that have labels. Then I try to figure out where they go." Kimi explained to her instructor that she could use this approach to study any kind of diagram.

Over time, Kimi developed 14 new strategy steps (7 for math and 7 for science). Her personalized strategy sheets chronicled evidence of strategy development across: (1) time: strategies were developed and articulated over two academic terms; (2) subject: strategies were used to navigate both math and science tasks; and (3) tasks: strategies were developed for worksheets, exams, chapter quizzes, and homework. The strategies Kimi recorded clearly targeted her specific needs (see Table 4). Further, over time Kimi's strategies became more sophisticated and better connected to task demands. She was able to articulate her strategies in more detail and with considerably more facility. Finally, the strategies Kimi was developing and testing could be linked to better problem solving during instruction (as described above).

Kimi's average performance during the project (across three measures) improved from 40 percent at

TABLE 4
Examples of How Kimi's Strategy Steps Were Linked to Her Areas of Need

Kimi's Articulated Areas of Difficulty	*Kimi's Strategies*
• Understanding and thinking through math questions.	• Attend to details of the question to check understanding; Read several times • Illustrate thought process with pictures
• Articulating her understanding of math concepts (i.e., demonstrating her knowledge in words).	• Illustrate understanding of math concepts with pictures
• Understanding new vocabulary related to math (and science).	• Look up word in dictionary or glossary, define it, put it in my own words, and think of an example of that word/concept in my life so it becomes more meaningful.

pretest to 51 percent (see Table 3). This shift is notable for a student with longstanding academic difficulties, especially given that tests during the year became increasingly challenging (as new material was introduced). Note, however, that Kimi was the only one of the three case study students whose performance on classroom math tests declined at the end of the year (her May/June performance dropped to 23 percent). Thus, Kimi clearly needed additional, specific support on the end-of-the-year material. Nonetheless, assessments collected during learning assistance sessions (e.g., informal tests of her knowledge about the anatomy of the eye), and classroom work samples collected during the project (e.g., the fractions quiz) showed that improvements in Kimi's performance could be directly linked to the strategies she was developing.

Kelly and Student–Instructor Interactions

In our case study analyses, we scrutinized various sources of data to document how SCL actually worked. In Kelly's case study, we present evidence to describe more specifically how instructors mediated learning.

Background Information

Kelly was the only case study participant who had been diagnosed as having a severe learning disability. A review of her academic records evidenced a long history of academic and speech–language difficulties. A recent psychoeducational assessment reported that she had below-average cognitive ability. Primary areas of academic concern were in reading comprehension, verbal expression, and math computation and problem solving. Also of concern was the level of anxiety Kelly experienced in testing situations. At the same time, her assessment reported good visual–spatial abilities and relative strengths (in the average range) in expressive and receptive vocabulary. In her IEP, Kelly was described as a cooperative and helpful student who was skilled in art and music.

On the pretest Metacognitive Questionnaire, Kelly did not respond to a question asking her what learning in math is about. She reported that "I have lots of struggling in math" and rated her ability as "below average, probably because I hate math." She, like Kimi, could not provide focused descriptions of math strategies or what she could do to improve, although she recognized that "I need to improve on lots of things." Her strategies were simply to "try different methods for every different question." In the one work sample we collected for Kelly in the early fall, she scored 24 percent (see Table 3).

SCL Intervention

An analysis of the interaction patterns between the instructors and Kelly showed how the instructors guided Kelly's cognitive processing through the use of strategic questioning. The questions the instructors asked focused on cognitive and metacognitive processes, as in other strategy intervention models (e.g., Maccini & Hughes, 2000; Montague, 1997a, 1997b). Cognitive questions focused Kelly's attention on task-specific concepts or domain-specific skills. Metacognitive questions focused Kelly's attention on important self-regulated processes. For example, instructors used questions to cue task interpretation (e.g., "What are you supposed to do here?"), strategy development (e.g., "So, how can you solve that problem?"), self-assessment (e.g., "So, how do you know if that worked?"), and strategy revision (e.g., "What can you do differently so that we get the correct answer?").

To illustrate the strategic questioning observable in Kelly's case study, Table 5 presents an excerpt from a transcript of one session. In this session, Kelly was confronted with questions of the type "$3x = 15$." In this excerpt, you can see how an instructor asked questions to cue Kelly's problem representation, including "What do they want you to do?"; "Solve for what?"; "What are you trying to find out?"; and "What does this mean, in words?"

The excerpt in Table 5 also shows how Kelly's instructor used strategic questioning to diagnose what Kelly already knew about the math concepts involved in this kind of problem. Through questioning, the instructor learned that Kelly understood that she needed to solve for x and how to interpret "$3x$," but Kelly was confused about how to solve problems that required subtraction ($3 + x = 15$) instead of division ($3x = 15$). This understanding gave the instructor important information about what Kelly needed to learn, which she used to structure her subsequent support. Further, note how Kelly's instructor shifted her questions from more general to more specific to draw more information from Kelly. She provided Kelly with several opportunities to respond in light of her expressive language difficulties.

As the interaction continued, Kelly's instructor continued to diagnose the source of Kelly's difficulties by asking her to describe the difference between two types of problems (i.e., "$3 + x = 15$" and "$3x = 15$"). To do this, she wrote simple examples of each kind of problem in separate columns (i.e., setting up examples to highlight patterns, as in Kimi's case). When asked, Kelly was able to describe how the multiplication and addition problems differed (one with x times a number, one with x plus a number). This approach supported Kelly in observing what was common and what was different about the two types of problems.

By asking questions that cued self-regulation (e.g., "What are we trying to do here?"), Kelly's instructor had established a context in which she and Kelly could collaboratively construct strategies for solving math problems. With the two-column list of examples in front of them, the instructor suggested they work toward building a strategy for solving addition/subtraction problems first (e.g., "$4 + x = 8$"). When asked, Kelly could not verbally articulate a strategy that she used to solve such

TABLE 5
Using Strategic Questioning to Cue Self-Regulation and Metacognition

SCL Intervention Session[a]	*Annotation*
K: I don't know how to solve this.	Kelly asks for help (in very general terms).
I: Okay. So it says $3x = 15$. So they want . . . what do they want you to do?	The instructor asks a question to cue task interpretation (i.e., problem representation).
K: To solve?	Kelly shows she knows that she has to solve the problem.
I: Okay, solve for what?	The instructor asks a more specific question to diagnose what Kelly understands about the task.
K: Solve the problem?	Kelly elaborates on her first response (but still remains unspecific).
I: Um hmm, and what are you trying to find out?	The instructor asks another question while gaining insight that Kelly is struggling with what the equation involves.
K: What x equals?	Kelly shows that she understands the concept of solving for a variable.
I: Okay, so you're trying to find out what x equals. So at the end, we want to know what x equals, right?	The instructor validates Kelly's response and reframes her reply.
K: Would it be 12?	Kelly's response indicates that she may not understand what "$3x$" equals, that she is unsure of the difference between problems of the type "$3 + x = 15$" and "$3x = 15$," or that she just may not know which operation to use to solve the equation.
I: What does this mean, $3x = 15$ in words, like in a few words to the equation, what does this mean in words?	The instructor tries to assess the source of Kelly's misunderstanding by asking another question to assess Kelly's knowledge.
K: Umm, 3, times a number.	Kelly's response shows that she understands what $3x$ means.

[a]I = Instructor; K = Kelly.

problems. Instead, she started giving answers (e.g., "4"). Her success at answering rather simple questions suggested that she did have some understanding of the problems, but she needed a more robust strategy for questions not so easily done "in her head."

Table 6 presents another excerpt that shows how the instructor guided Kelly's construction of a strategy that could work on more difficult problems. At the beginning of this excerpt, the instructor asks Kelly to self-check her answer to one of the simple problems ("How would you check this? How do you know if that's right?"). We noticed here how asking strategic questions had multiple benefits simultaneously. First, the question allowed assessment of Kelly's background knowledge and skills. The instructor found that Kelly did have a strategy for working backward to check her work, and a reasonable understanding of how addition and subtraction are related and of how equations work. Second, asking Kelly to self-check cued her use of an important metacognitive strategy (Montague, 1997a). Third, the instructor created a framework for further discussion wherein Kelly could be engaged in testing whether her strategies were working.

To assist Kelly in developing a more robust strategy, the instructor presented a more difficult question ($x + 12 = 35$). Kelly quickly launched into solving the problem, but came up with the wrong answer (47). The instructor treated this mistake as an opportunity for Kelly to reflect on the success of her strategies. She again asked Kelly to self-check her work, and, when Kelly recognized her error, suggested that they needed to develop a strategy for solving more complex problems. So that she could build on what Kelly already knew, the instructor asked Kelly to think again about the strategy she used to solve the simpler problems successfully. Table 6 shows that Kelly described her strategy more fluently than she had previously. As a result, the instructor was finally able to uncover the strengths and limits of the strategy that Kelly already knew (counting up from the smaller number to the answer).

Notice several features of the instructor–student interaction in this excerpt: (1) The instructor spent a good deal of time establishing what Kelly already knew, and working toward developing strategies for one type of problem. Previous research suggests that investing the time in working through a few examples thoroughly pays off in greater independence in learning other concepts (Butler, 1998d; Woodward & Montague, 2002). (2) The instructor validated what Kelly did well, and encouraged Kelly to think of errors as opportunities to develop better strategies. (3) The instructor asked Kelly to self-check her work (Montague, 1997a), thereby promoting self-regulation. And (4) The instructor used language that framed their joint goal as developing and testing strategies, including: "So that's the strategy you're using there"; "So let's figure out when you can't do it in your head, what's your strategy for figuring these out?"; "But it didn't work, so we have to try and see how can we fix your strategy so it does work."

At the end of the excerpt in Table 6, the instructor challenged Kelly's "counting up" strategy by presenting a problem that she could not do in her head. Then, the instructor asked Kelly to rethink her approach to solving the simpler problems and to define a strategy that might work more generally. After considering the example problems, Kelly recognized that she could use subtraction (an example of guided reconstruction). The instructor asked Kelly to explain which numbers she would subtract to find the answer. Rather than expressing herself in words, Kelly showed the instructor

TABLE 6
Using Strategic Questioning to Co-Construct Strategies Building from Extant Knowledge and Skills

SCL Intervention Session [a]	*Annotation*
I: (To double check whether Kelly's answer was correct to the problem, "4 + $x = 8$"): How would you check this? How do you know if that's right?	The instructor asks questions to see what Kelly understands about this kind of equation after answering it right "in her head."
K: Um. Do 4 plus 4 um equals 8.	Kelly shows she knows to replace x with the answer to double check.
I: Perfect. So you know that if you put that number in there, you'd get 8.	The instructor validates and paraphrases Kelly's understanding, providing language for talking about Kelly's strategy.
K: Yah.	Kelly provides affirmation.
I: Excellent. So that's the strategy you're using there. Sometimes though they might be a little harder. Now you might not be able to do it in your head. Like what if I did one . . .	The instructor validates Kelly's strategy use and frames the discussion in terms of strategies. She pushes Kelly to think about how her strategy would work for a more difficult problem.
K: Okay (smiling).	Kelly expresses willingness to go on. She is engaged in collaboratively solving a new problem.
I: See if I can make one. $X + 12 = 35$. I dare you to do that one in your head (laughing).	The instructor poses a more difficult problem, so that Kelly can start to explicitly articulate her understanding and a general strategy for solving this kind of problem.
K: 47 (smiling)?	Kelly offers an answer.
I: Ah, now you have to figure it out. Good try, good try. So you thought it was 47, right?	Instructor validates Kelly's efforts and leads into guiding Kelly to self-assess her answer.
K: Yah.	
I: Okay. Try your strategy here though. So if you say $x = 47$, check it. (Kelly does). So that didn't work but you're on the right, you're on the right track. So let's figure out when you can't do it in your head, what's your strategy for figuring these out, sort of the mathematical way for figuring it out. Okay. What do you, what do you know, tell me what you understand about what you could do?	The instructor has Kelly self-assess her answer. She then uses Kelly's recognition that the answer is wrong as an opportunity for collaboratively developing strategies. She again tries to diagnose Kelly's understanding of the problem (to build on what she knows).
K: Subtract 8 – 4 and then that's how many um 4, 5, 6, 7, 8 and then you minus 4 equals 4.	Kelly explains her process when solving a simpler problem.
I: So that's for this one?	The instructor asks for clarification.
K: Yah.	Kelly clarifies.
I: So tell me what's your strategy? Describe your strategy for how you solved this.	The instructor asks Kelly to articulate her strategy.
K: I counted 4 up to 8 and the answer's 4.	Kelly describes a strategy that will only work when the numbers are small. But her strategy shows a basic understanding of how the numbers work.
I: So what did you do to the 8 to figure it out? Like, like okay so think you gotta describe a strategy you used here that you could use here.	The instructor encourages Kelly to figure out what she is doing that might apply when the numbers are larger.
K: I tried to do something to that one but it didn't work.	Kelly expresses her understanding of how her strategy for solving the questions with smaller numbers won't work when the numbers are larger. She recognizes that the strategy didn't work when she tried it previously.
I: But it didn't work, so we have to try and see how can we fix your strategy so it does work. So here if you were to write out for me how you approach this. We'll use this as an example and let's extend it to this one.	The instructor suggests that if they can define what worked for the smaller problems, they can define that as a strategy, which can then be applied more generally.

[a] I = Instructor; K = Kelly.

how she would solve each of the simple examples (e.g., "$8 - 4 = 4$").

At the start of the excerpt in Table 7, the instructor encouraged Kelly to try this new strategy with the more difficult problem introduced previously ("$x + 12 = 35$"). Kelly did so and self-checked her answer, recognized that she was correct, and smiled shyly. Next, the instructor posed a new problem ("$x + 18 = 100$"). Kelly also correctly solved the new problem using her emerging strategy. Once Kelly self-assessed that her strategy was working, the instructor encouraged Kelly to write her new strategy down on a math strategy sheet (supporting mindful abstraction based on experience). In the instruction that followed, the instructor used the same general process to help Kelly develop a strategy for solving the multiplication/division problems.

The excerpts presented here illustrate how, in the support provided to Kelly, discussions about strategies were interwoven with task-specific support (Brown et al., 1991; Palincsar & Brown, 1984). Kelly constructed knowledge about strategies that was grounded in concrete experience. But Kelly was not expected to make up strategies on her own; SCL is not discovery learning (Butler, 1995, 2002). The instructor diagnosed Kelly's understandings and built from her extant knowledge and skill, but instruction was not limited by the

TABLE 7
Using Strategic Questioning to Develop Domain-Specific Strategies

SCL Intervention Session [a]	*Annotation*
I: How about this one?	The instructor returns to the harder problem and asks Kelly to apply her strategy.
K: 35 – 12 . . . 23.	Kelly uses her strategy to get an answer.
I: So you think the answer's 23. You want to check that one?	The instructor asks Kelly to check her answer (to test her strategy).
K: Yah. 35.	Kelly checks her answer.
I: So is that right?	The instructor encourages Kelly to judge the result from her self-checking.
K: No. Oh, yah.	Kelly initially expects that a question is associated with her having been unsuccessful, but then recognizes that she did solve the problem correctly.
I: 35. Yah, it's right. So you used a strategy. Let's try one more. $X + 18 = 100$. Okay. Just follow your strategy. Okay, on this one, what was it?	The instructor validates Kelly's answer and links it to her strategy use. Then she introduces another problem. She asks Kelly to review how she used her strategy with simpler problems first.
K: 8 – 4, 7 – 5, 9 – 7, 35 − 12, 100 – 18 . . . 82.	Kelly verbalizes how she successfully used her strategy on the previous problems, extends her strategy to the current problem, and then solves it.
I: So you think x is 82, now are you sure that's right?	The instructor cues self-assessment.
K: 100.	Kelly verbalizes (in an incomplete way) her thought process when self-checking.
I: Okay. So what we have to figure out is whenever we have a strategy that has this or a problem with this kind of pattern, you kinda got a strategy that seems to be working.	The instructor validates Kelly's efforts while guiding her to think about the strategy she is using.
K: Yah.	Kelly agrees.
I: Tell me in your own words what your strategy is.	The instructor guides Kelly to articulate a generalized series of strategy steps that might work with this type of problem.
K: Subtract the answer to the number that you have?	Kelly begins to articulate her strategy (somewhat tentatively).
I: Okay. Let's kind of, it's kind of hard to describe somehow. So let's get to the, let's make sure we have the language. So you're saying you're gonna subtract what from what?	The instructor validates that describing one's strategy can be difficult (being sensitive to Kelly's challenges with verbal expression). Next, the instructor paraphrases Kelly's previously stated first step.
K: 100, the answer and it equals to the number that's on the equation.	Kelly further articulates her process.
I: So in your terms, what you're saying is you take this and you take that away . . .	The instructor rephrases Kelly's articulation.
K: Yah.	Kelly affirms.
I: . . .is what you're saying. Okay. Um, and if you wrote that on your strategy sheet, that would make sense to you? Is that, you would know then, for this kind of problem, you would know the, so you know that if you take away this from this, you'll get the answer.	The instructor asks Kelly to judge whether this strategy will work for her in similar future problems, and to evaluate how she has expressed her strategy. Kelly then writes down her ideas on her strategy sheet.

[a] I = Instructor; K = Kelly.

understandings Kelly brought to the learning context. Instead, the instructor built from Kelly's partial understandings while also guiding her to extend her knowledge. By framing support as collaborative problem solving, Kelly also was engaged in the process of interpreting tasks, developing strategies, self-checking, and knowledge reconstruction. An analysis of Kelly's affective reactions also showed how much more engaged she was in the learning process (in contrast to videos of previous lessons) and her obvious pleasure at her success. She was pleased that her classroom performance improved, from 24 percent on the fall test to an average of 62 percent during and at the end of the project (see Table 3).

Denise and Individualized Instruction

In this section, we focus on how SCL instruction was tailored to meet individual needs. Kimi, Kelly, and Denise all were achieving well below grade level in mathematics. However, a cross-case comparison showed that, while Kimi and Kelly struggled with math concepts and expressing their understandings in words, Denise was relatively strong in her conceptual understandings. Denise's lack of success in math could be linked to problems in her self-regulation of learning (e.g., interpreting tasks, working deliberately, rechecking her work), including her task organization and management skills.

Background Information

Like Kimi and Kelly, Denise was referred to learning assistance for support in math and science. A "Communications and Thinking Skills Assessment" conducted by a speech and language pathologist used a variety of formal but nonstandardized measures to test Denise's ability to organize and remember visual–spatial information; use classification to organize and remember words; represent and manipulate visual materials; analyze, label, and integrate information; and reason logically. The assessment concluded that Denise had "a good ability for learning," but that she made errors when she launched into work without analyzing tasks, worked too quickly, and neglected to recheck her work. The assessment also underlined Denise's difficulties with time and task management and recommended organizational strategies and instruction in "strategies for problem solving." In her IEP for the year, Denise was described as friendly and cooperative with an expressed interest in being helpful to others. Her academic difficulties were in math, especially math problem solving, organization, and time management. On the Metacognitive Questionnaire, Denise described math as hard "because sometimes I just don't understand." She rated her ability as below average "because I don't understand the questions." Across two work samples collected in early fall, Denise scored 40 percent (see Table 3).

SCL Intervention

As was the case with Kimi and Kelly, Denise's instructor used strategic questioning to identify her strengths and difficulties in math. Consistent with previous assessments, she observed that Denise's problems with task management and organization were significant barriers. Denise frequently forgot her notes, text, binder, or agenda; she often lost work she had completed; she rarely knew when a project was due. The instructor also observed that Denise worked quickly, without taking time to represent problems. On the other hand, given Denise's poor math achievement, the instructor was surprised to find that Denise picked up concepts quickly and had solid background knowledge in math.

As with Kimi, early in the term (October 15), Denise struggled with solving square root problems (e.g., to find the square root of 36, to find a number whose square root was 6, to find a number whose square root was between 5 and 7). Initially, Denise's difficulties appeared similar to Kimi's, in that she had trouble interpreting questions. Her initial strategy for each type of problem was to "do it in my head.'' As with Kimi, constructing a series of concrete examples assisted Denise in recognizing the underlying concept, and correspondingly, what the questions were asking. In fact, after looking at the different kinds of questions on square roots, Denise turned to her instructor, and described (with surprise) how all of the problems required understanding of the same concept and were just framed in different ways. Denise carried this insight forward into her subsequent learning.

Over time, Denise developed strategy steps for interpreting and representing math and science problems. Her strategy steps focused on understanding the vocabulary and underlying concepts (e.g., "writing down strategies and reading over the problem"; "I will read over the question again to see if it makes sense"). She also developed cognitive strategies for solving math problems (e.g., "I will work the problem out in stages instead of looking at the whole problem") and for learning from materials (e.g., "Look back to other problems to find the answer"; "if you don't understand the concept of the question or problem, you can look at the index in the back and flip through the pages in that chapter"). These strategy steps could be linked to the specific strengths and difficulties Denise brought to learning mathematics.

However, because Denise's lack of organization was also a barrier to her being successful, many of Denise's strategies focused on supporting her organization. For example, on November 15, Denise started an "organization" strategy sheet and included the following strategies: 'have different folders for each subject and organize them into categories" and "have a folder for homework and write the homework and put the homework in it." Later in the term, Denise added more strategies for keeping her binder organized, such as "put work in chronological order and put work in binder" and "put a page in the front to record homework." At the end of the year, in a final interview, Denise's instructor reflected that ". . . for Denise, it was mostly her organization that improved. With Denise, this is where the need was. And at the end, she definitely had more of an awareness of what worked for her and what didn't work. She didn't always use the strategies, but she certainly knew which ones were more useful to her." By spring, Denise was passing math quizzes (marks between 55 percent and 63 percent). Although not outstanding, these scores reflected a significant improvement (see Table 3).

In sum, the themes illustrated in Denise's case were that SCL (1) surfaced the root of her academic problems, in knowledge and processes (Woodward et al., 2001), revealing not only areas of needs but also unanticipated strengths, and (2) assisted Denise in developing personalized strategies tailored to her unique strengths and needs.

Cross-Case Comparison

Our approach to data analysis for this article was to begin by constructing case study narratives for each student separately prior to drawing conclusions across cases. Nonetheless, as noted earlier, the findings we described in our individual case study reports reflect patterns observed across cases. To supplement the above reports, in this section we highlight major cross-case findings to illuminate how SCL principles and associated instructional guidelines were followed to support mathematics learning by three eighth-grade students.

First, in each case study we found that support to students' self-regulated learning was integrated into mathematics instruction (SCL principle 1; see Table 1). All three students were supported to learn more effectively while completing classroom work. Further, we found that support to students' self-regulation and strategy construction was explicit and systematic. Instructors deliberately guided students' engagement in cycles of self-regulation as a means to complete assignments, supporting students to build from task interpretation to strategy development, self-assessment, and strategy revision. Kelly's extended excerpt provides an excellent example of how students' self-regulation and strategy development were explicitly supported in the context of actual classroom assignments.

Second, our case studies revealed that instructors were sensitive to how students were active interpreters of information (SCL principle 2). Instructors assessed students' extant interpretations about mathematical concepts (e.g., what Kelly understood about algebraic equations, what Kimi and Denise understood about square root problems) and learning processes (e.g., strategies Kelly knew for solving problems). Further, instructors deliberately cued students' active interpretation of information as a means of spurring knowledge construction. For example, instructors assisted students to actively interpret information in classroom textbooks or worksheets to learn how to learn from those materials (see the strategy steps with this focus developed by both Kimi and Denise). Instructors also consistently asked students to articulate emerging understandings, in their own words. In doing so, instructors supported students to abstract new conceptual knowledge about math while working through problems (Fuchs & Fuchs, 2003; Salomon & Perkins, 1989; Wong, 1991), and to reflect on and record new understandings about strategies on cumulative strategy sheets.

Third, instructors did appear to direct students' reconstruction of knowledge about mathematical concepts and approaches to learning (SCL principle 3). For example, in all three cases instructors supplemented classroom materials with examples to highlight patterns and support students' abstraction of important concepts or principles (Englert et al., 2001; Hutchinson, 1993). Similarly, they used strategic questioning to guide students' learning processes in ways previous research suggests is effective. Indeed, across time, students were guided to identify and employ a full slate of metacognitive and cognitive strategies when learning mathematics. We found that students' new strategies were similar in content and specificity to those taught in strategy interventions, such as drawing pictures to visualize problems (e.g., Maccini & Hughes, 2000; Montague, 1997a), suggesting that teachers effectively guided students in their "reconstruction" of effective learning strategies.

Fourth, we found that instructors framed learning as opportunities for collaborative problem solving between the instructor and the student (Campione et al., 1991). Kelly's extended excerpt again provides an excellent example here. In that interchange, the instructor and Kelly shared the common goal of learning how to solve algebra problems, and they worked together to develop strategies for achieving that goal. One surprising finding was that these struggling learners, who admittedly "hated" math, were positively engaged in active learning and collaborative problem solving through SCL instruction. Both Kelly and Kimi were visibly delighted with the progress they made as they learned how to learn more effectively. Kimi beamed when she successfully learned the anatomy of the eye; at one point Kelly grabbed a calculator so that she could self-check an answer. Research suggests that motivation is bolstered when students link positive outcomes with effortful strategy use (Borkowski, 1992). But we did not quite expect the positive affect that accompanied students' success, or the enthusiasm with which they participated in collaborative problem solving in a subject they found so difficult.

We also observed across cases how instructors followed the two instructional guidelines central to SCL instruction (i.e., using strategic questioning, fostering strategy development). First, completing in-depth analyses of student–instructor interactions led us to better understand how strategic questioning works. For example, it was informative in Kelly's case study how a single strategic question could have multiple beneficial outcomes (i.e., diagnosing Kelly's understanding, cueing self-checking, and setting the stage for judging the effectiveness of strategies). It became clear how using strategic questions is a powerful strategy for bridging ongoing assessment with intervention. Thus, while it is increasingly common to call for interactive discussions as a means for supporting active and strategic learning (Englert et al., 2001; Morocco, 2001; Woodward & Montague, 2002), this study was useful in documenting how interaction could be structured to foster self-regulation. Second, we were able to observe how instructors systematically promoted (re)construction of cognitive and metacognitive strategies, not through direct explanation about strategies, but rather by supporting learners to construct effective strategies to achieve task goals while self-regulating learning.

Finally, our case studies allowed us to examine how instruction following a common instructional framework could be applied to identify and address individual needs. We found that, although each of our case study students struggled with mathematics, each had unique problems that undermined their success. For example, Denise and Kimi similarly struggled with problem representation, but did so for differing reasons. SCL allowed for co-construction of strategies with individual students targeting their specific learning needs.

CONCLUSIONS

The purpose of the present research was not to conduct a formal evaluation of SCL efficacy for secondary students, something that will be pursued in future research. Instead, in the project described here, we embedded three case studies on student learning within a project focused on instructor professional development (Butler et al., 2004). We built from previous research that has associated positive outcomes with SCL intervention in postsecondary settings (Butler, 1993, 1995, 1998a, 1998b, 2002) to illustrate how the SCL instructional approach might promote self-regulated and strategic learning by three eighth-grade students.

Further, this article does not speak to how SCL principles might be adapted for use in classroom mathematics instruction (Woodward et al., 2001). We are sympathetic to calls for mathematics reform and for a shift in the mathematics curriculum (NCTM, 1989, 2000; Resnick, 1988; Schoenfeld, 1988). However, in this article we were more narrowly focused on SCL as a model for providing adjunct support in a learning assistance setting. We remained mute on the qualities of the classroom instruction to which students were exposed, and concentrated instead on helping them learn how to learn from the instruction that was provided.

A major contribution of the present article is the rich documentation of instructional processes underlying a promising theoretically grounded and empirically validated intervention model. Providing a rich description of instructional processes is critical for at least two reasons. First, in-depth case study reports assist in clarifying how and why interventions work (Merriam, 1998; Yin, 1994). As such, they support the development of an explanatory framework for describing instructional processes. In that respect, these case studies define instructional mechanisms in relation to student learning (Butler, 1998b, 2002). More specifically, they illustrate how students can be supported to construct concrete and specific strategies for use in academic work in the context of collaborative problem solving between instructors and students.

A second, crucial reason for writing in-depth case study reports is that the results are reported in such a way that they can be of immediate use to practitioners (Lincoln & Guba, 1985). To better communicate our findings and methods to instructors in schools, we have provided rich descriptions of instructional processes, including excerpts of transcripts from instructor–student interactions. Further, although only one of the three case study students had a documented learning disability, all three experienced problems with mathematics learning commonly observed in practice. Showing how instruction can be effectively individualized to meet students' needs is of paramount importance to teachers of students with LD.

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