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Writing in Mathematics: An Alternative Form of Communication for Academically Low-Achieving Students

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Abstract. *Classroom communication figures prominently in current math reform efforts. In this study, we analyze how one teacher used writing to support communication in a seventh-grade, low-track mathematics class. For one school year, we studied four low-achieving students in the class. Students wrote in journals on a weekly basis. Using classroom observations and interviews with the teacher, we developed profiles of the four students, capturing their participation in class discussions. The profiles highlighted an important similarity among the four students: marginal participation in both small-group and whole-class discussions. However, our analysis of the students' journals identified multiple instances where the students were able to explain their mathematical reasoning, revealing their conceptual understanding, ability to explain, and skill at representing a problem. In this respect, journals potentially facilitate another important form of classroom communication. The promise of writing is that it offers an alternative to the visions of classroom communication that are strictly oral in nature.*

Proficiency in mathematics is a worthy goal for all students. Unfortunately, this concept proves to be elusive for many (Rand Mathematics Study Panel, 2003). As defined by the National Research Council (Kilpatrick, Swafford, & Findell, 2001), mathematical proficiency includes five interrelated strands: (1) conceptual understanding; (2) procedural fluency; (3) strategic competence, the ability to formulate and represent problems; (4) adaptive reasoning, the capacity for logical thought, explanation, and justification; and (5) productive disposition, the belief that mathematics makes sense and is useful. International studies have found that mathematics instruction in the United States emphasizes procedural fluency, the quick and automatic execution of algorithms, with less instructional time allotted for activities such as problem solving (one aspect of strategic competence) and verification (one aspect of adaptive reasoning; Gonzales et al., 2000; TIMSS Video Mathematics Research Group, 2003). Thus, many students develop a vision of mathematics as a collection of arbitrary rules that make little sense (Kilpatrick et al., 2001).

To develop all five strands of mathematical proficiency, students need to communicate their mathematical thinking, thereby engaging in a process of active construction of knowledge (Ball, 1993; Cobb, Wood, Yackel, & McNeal, 1992; Lampert, 1990; Lampert & Blunk, 1998; National Council of Teachers of Mathematics [NCTM], 2000; O'Connor & Michaels, 1996). Class discussions, it is argued, need to be based on mathematical reasoning and evidence "in order for students to develop the ability to formulate problems, to explore, conjecture, and reason logically, to evaluate whether something makes sense" (NCTM, 1991, p. 34). In these discourse-oriented classrooms, students express their mathematical ideas, explain their solution strategies, and question the comments of others (Chazan & Ball, 1999; Williams & Baxter, 1996). Through participation

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in these conversations, students work to make sense of mathematics, which increases their self-efficacy and leads to a productive disposition. Thus, communication is critical to the development of mathematical proficiency.

Problems arise, however, when students do not or cannot describe their mathematical reasoning in a coherent manner. Ball (1993) alludes to this issue when discussing dilemmas of mathematics instruction, noting that at times, it is difficult to discern "what some students know or believe—either because they cannot put into words what they are thinking or because *I* cannot track what they are saying" (p. 387).

Classroom-based studies have identified problems that arise when teachers incorporate new discourse practices into their mathematics instruction (Baxter, Woodward, Voorhies, & Wong, 2002b). The results of several studies indicate that academically low-achieving students remain passive in small groups (Baxter, Woodward, & Olson, 2001; King, 1982; Mulyran, 1995). In addition, ability or status differences in the discussion group can lead to unproductive interactions that do little to develop students' mathematical thinking (Battistisch, Solomon, & Delucchi, 1993; Good, Mulryan, & McCalsin, 1992).

The challenge, then, is to include all students in mathematically meaningful communication. Written assignments that encourage students to justify and explain a problem solution have the potential to support and extend oral conversations. The relatively rapid pace of oral discussions is lessened when writing is used as a means to question, test, and clarify thinking (McMillen, 1986). Connolly (1989) claims that writing develops thought processes useful in doing mathematics: abilities to define, classify, or summarize; methods of close, reactive reading; metacognition, an awareness of one's own thinking and learning; and an awareness of attitudes toward mistakes and errors. King (1982) reported that when students are stuck on a problem and write out their thought processes, they see their errors and often solve the problem. Writing also allows pictorial representations that may benefit students who struggle to find the correct language to express their mathematical ideas.

Writing takes different forms in mathematics classes, ranging from more formal assessments, where carefully edited papers that present a logical argument are the goal (Morgan, 1998), to less-structured, impromptu journal writing that provides students with opportunities to explain their thinking about mathematical ideas (Shield & Galbraith, 1998). Our present analysis focuses on the latter form, which is also known as *writing to learn* (Connolly, 1989). This form of writing may entail informal written expressions such as notes, brief explanations, drawings, or diagrams. Proponents of writing to learn have identified many potential benefits when students write as a regular part of mathematics instruction. For example, when students write about a problem, they must clarify their thoughts about how they will approach the problem (Kenyon, 1989). A recent meta-analysis of the effects of writing to learn on academic achievement showed small positive effects (Bangert-Drowns, Hurley, & Wilkinson, 2004). The researchers identified factors, such as treatment length, which enhance the impact of writing and are consistent with the design of the current study.

PURPOSE OF THE STUDY

The purpose of our study was to examine what writing reveals about low-achieving students' mathematical proficiency. Although procedural fluency has traditionally been the primary focus of mathematics instruction in the United States, our research examines other strands of mathematical proficiency. The questions that guided our work were:

1. What does writing reveal about the students' conceptual understanding?
2. What does writing reveal about the students' strategic competence?
3. What does writing reveal about the students' adaptive reasoning?

These questions address an undocumented area of research that may shed light on the responses of low-achieving students to discourse-oriented mathematics instruction. Consequently, the study contains detailed profiles of students as exemplars of the types of students often found in remedial middle school math classes in the United States. We adopted a descriptive, case study approach (Merriam, 1998) in which the school setting, individual students, and daily instruction provide the context for finding meaning in the teaching and learning under study.

METHOD

The present analysis is part of a series of studies involving low-achieving students in reform mathematics classrooms at the intermediate grade levels. To address our research questions, we needed to look closely at the responses of particular students to specific writing assignments; thus, data sources and analysis followed a qualitative research approach (Patton, 1985). By using data from classroom observations, students' journals, and interviews with the teacher, we were able to develop a rich picture of classroom communication.

In our work with middle school students, we have studied both writing about opinions and feelings, what Shield and Galbraith (1998) call journal writing, *and* expository writing in what we call math journals (Baxter, Woodward, Olson, & Robyns, 2002a). Expository writing is intended to describe and explain (cf. Davison & Pearce, 1988). Students write in most mathematics classes, but typically they write numerical answers to problems or symbols to show the computational steps they used to arrive at a particular answer. In the present study, our focus was on communication. In particular, we examined what is revealed about students' mathematical proficiency when they are encouraged to write about their mathematical ideas and reasoning.

Context

Setting

We studied a seventh-grade general math class in a middle school located in the Pacific Northwest. The school had three levels for seventh-grade mathematics: prealgebra, general math 7a, and general math 7b. The primary difference between the 7a and 7b classes was in pacing. The 7a classes typically completed more topics than the 7b classes. We studied a 7b general math class with a high proportion of students who qualified for additional academic assistance. This class met daily for 42 minutes (one typical class period). Our data collection covered the period from early September until the middle of June.

Participants

The target classroom included 28 students. There was some turnover during the school year (about 14 percent), but the majority of the students participated for the entire school year. One third of the students in the class qualified for special education services. Students who qualified for special education scored at least two years below grade level on the Comprehensive Test of Basic Skills (CTBS). Four students had been identified for special education services with IEP goals in mathematics, and an additional five students in the class had IEP goals for reading.

For the present analysis we selected four of the special education students, all of whom scored in the lowest third of the class on the mathematics subtest of the CTBS. Two of the target students, Danny[1] and Ursula, had IEP goals for math. The teacher noted that Danny was at least two years below grade level in math, while Ursula was two years below grade level. A third target student, Frieda, had IEP goals for math until the present year, when it was decided that she had progressed to one year below grade level. The resource room teacher determined that Frieda no longer needed special help in math, although she continued to have goals in reading. The fourth target student, Sam, had IEP goals for both reading and writing. Although Sam did not have IEP goals in math, the teacher noted that he had many "holes" in his mathematical understanding and skills, and was working one year below grade level.

The teacher, Ms. Carter, had taught middle school mathematics and language arts for 15 years. Five years before our study, she had been awarded a one-year paid leave to examine gender issues in mathematics.

Daily Instruction

Ms. Carter was committed to engaging all students in challenging mathematics. She included opportunities for students to talk about mathematical ideas in every class period. Most days students discussed problems and their correct and incorrect solution strategies, focusing on process and seeking alternative solutions rather than following one standard algorithm. Once a month Ms. Carter provided a mathematical project in which the students worked in small groups to research an open-ended problem and develop solutions. The projects provided opportunities for students to "do mathematics" and develop procedures connected to concepts (Stein, Grover, & Henningsen, 1996). The structure of many lessons followed a similar pattern: (1) review homework, (2) introduce task, (3) allow time for small groups to work on task, (4) facilitate discussion of students' small group work, and (5) assign homework.

Use of Journals

Ms. Carter used writing about thinking in her mathematics instruction at least once a week. She developed writing activities that would (1) relate to the mathematical topics being studied in class, (2) improve students' awareness of their own thought processes (Marwine, 1989; Powell & Lopez, 1989), and (3) facilitate students' "personal ownership" of knowledge (Connolly, 1989; Countryman, 1992). She viewed writing as an integral part of classroom discourse. Writing provided opportunities for students to gather their thoughts before, during, or after a class discussion.

At the beginning of the school year, Ms. Carter's goal was to engage the students in the writing process. Based on suggestions from the National Writing Project (2003), Ms. Carter developed open-ended prompts that elicited students' opinions or feelings (e.g., Do you think that calculators should be used in math class? How do you feel about tests in math?). In October, Ms. Carter shifted from writing about feelings and opinions to writing about their mathematical thinking. During this phase, students wrote about long-studied topics, such as rational numbers and multiplication (e.g., Why is 0.3 greater than 0.003? Explain to a fifth grader how to place the decimal in a multiplication problem.). Ms. Carter felt that this step would enable students to develop confidence in their ability to write about more complex mathematical topics. Ms. Carter encouraged students to use words, pictures, and symbols to describe their mathematical thinking. As the students became more adept at writing about mathematical topics, she asked them to justify their explanations. By January, the writing prompts addressed the topics being covered in class, emphasizing new concepts and justification (e.g., Do 0.45 and 0.450 equal the same fraction? Prove (show) your answer.).

Ms. Carter varied when she assigned writing. Early in the year, she often began the lesson with a writing prompt. After allowing three to five minutes for silent work, she then invited students to share their writing. The next day she would begin the lesson by commenting on the students' written work in general, making suggestions to the entire class. Ms. Carter also provided brief, individual comments to the students in their journals. As the students became more comfortable with writing, Ms. Carter included writing prior to a discussion, as an opportunity for students to collect their thoughts and questions. On two occasions she stopped in the middle of a class discussion when many students appeared confused and asked them to write about their thoughts on the topic. Ms. Carter also directed students to write in their journals at the end of the class period, when she wanted to assess how students understood a particular concept.

Data Sources

To develop our descriptive case studies, we drew upon three sources of data: classroom observations, interviews with the teacher, and students' math journals. Classroom observations and interviews with the teacher provided a context for our analyses of the students' journals.

Classroom Observations

We observed classroom activities two to three times a week over the course of the year. Two observers visited the classroom on separate days or together. Both observers compiled detailed field notes. Observers noted interactions among target students and other students, the mathematical focus of the lesson, target students' participation during small and large group discussions, as well as interactions between Ms. Carter and each of the target students.

As motivation is a critical factor for students' success, our analysis of the observational data examined the mathematical proficiency strand of productive disposition. We developed profiles of the four target students, focusing specifically on how they functioned in the classroom discourse, and in particular, examining the relationship between individual students and specific writing assignments. To create the profiles, we used memos (Miles & Huberman, 1984) and thematic analyses (Glaser & Strauss, 1967). Miles and Huberman (1984) recommend memos to summarize field notes prior to the conclusion of a study, because ongoing memos can be a useful way to frame and reframe the focus of inquiry as a study evolves. The thematic analyses build on ideas identified in the memos (Glaser & Strauss, 1967). A thematic analysis might describe an intriguing pattern, illustrated with examples from classroom observations or interview transcripts.

Interviews with the Teacher

We interviewed the teacher in two ways: semi-structured interviews and more informal conversations before and after classroom observations. The semi-structured interviews were conducted at the beginning and end of the study. The first interview focused on the teacher's background, teaching experience, goals in using writing to teach mathematics, and knowledge of individual students. The final interview highlighted the teacher's thoughts on the impact of the writing on individual students. Each of these interviews lasted from an hour to an hour and a half. The more informal conversations were relatively brief, lasting from five to ten minutes. These conversations were practical, focusing on the plan for the day's lesson and any unusual circumstances relating to the school schedule or individual students.

Student Journals

Students wrote in their math journals at least once a week. From October through April, each student wrote an average of 30 journal entries. Both Ms. Carter and the researchers read the journals.

We analyzed students' journals using a coding system based on the work of Shepard (1993) in which levels of mathematical writing (Britton, Burgess, Martin, McLeod, & Rosen, 1975) reflect students' conceptual learning (Shuell, 1990; see Figure 1).

At Level 1, *recording*, students copy notes from the book or take dictation from the teacher. The student's task is to transcribe information as directed by the teacher. When *summarizing*, Level 2, students describe concrete experiences in their own words. The student provides an "eyewitness" account with no connections to other contexts or concepts. For example, a student at Level 2 might describe the steps taken to solve a particular problem.

Both Levels 1 and 2 correspond to Shuell's *initial* phase of conceptual development in which students focus on isolated facts, definitions, and procedures. Students who are recording (Level 1) might simply copy a definition without making sense of the information. In contrast, students who are able to write at Level 2 have begun to filter concepts through their own experience, a precursor for more abstract reasoning (Shepard, 1993).

Shepard (1993) noted that the transition between the initial phase and *intermediate* phase is critical, as students must work with information in increasingly abstract forms. In the intermediate phase the learner begins to see relationships among facts, thus building a more meaningful internal understanding. In this phase learning becomes increasingly abstract. To successfully make the transition, students need to apply and clarify concepts to build relationships among pieces of knowledge. In Level 3, *generalizing,* students identify general

Conceptual Codes

- **Recording (Level 1)**: Student transcribes information. Student copies from board or quotes what teacher says. Knowledge handed over from teacher to student.
- **Summarizing (Level 2)**: Student states memory of concrete experience in her/his own words with no inferences. Student repeats steps to solve a problem, with no attempt to explain what is happening mathematically.
- **Generalizing (Level 3)**: Student identifies generalization, but organization and relationships not perceived. Student attempts to use relevant mathematical ideas and representations to clarify the solution to a problem.
- **Relating (Level 4)**: Student notes relationships between generalizations, organized logically or hierarchically. Student moves back and forth between mathematical ideas, asks questions, poses possible alternative solutions. Posits connections among concepts.
- **Don't know**: Student writes "I don't know" repeatedly.

Affective Codes

- **Affective response**: Student writes about feelings, but does not try to engage teacher in dialogue.
- **Affective dialogue**: Student speaks directly to teacher about feelings and thoughts related to mathematics.

FIGURE 1 Coding categories for students' journals.

patterns, but they do not see relationships among the general patterns. At Level 3 students are able to recognize, explain, and apply mathematical concepts in contexts similar to those typically found in the classroom. Students' writing at Level 4, *relating*, includes generalizations as well as relationships between them.

Two important caveats accompany writing when used as a means to study students' mathematical thinking. First, a student's written response provides only a partial glimpse of a student's thinking. A student who writes at Level 2 may be capable of the more abstract thinking of the intermediate phase, for example. Students' written responses offer one version of their thinking. A second caution is that a writing prompt that is intended to elicit a response from a student at a particular level may not succeed. Again, for a variety of reasons students may respond in a way that shows only a small portion of their thinking.

We designed the coding categories to analyze three strands of mathematical proficiency: conceptual understanding, strategic competence, and adaptive reasoning. Journal entries at the recording level offer no evidence of any of these three strands of mathematical proficiency. Writing coded at the summarizing level reveals aspects of students' conceptual understanding and problem representation (strategic competence), but provides no insights into students' adaptive reasoning. In contrast, journal entries coded at the generalizing level include explanations and justifications, aspects of adaptive reasoning. The fourth level, relating, reveals evidence of all three of these strands of mathematical proficiency.

In addition, to study how the students' writing revealed their feelings toward mathematics, we used two codes: affective response and affective dialogue. Affective responses occurred when students wrote about their feelings, primarily reporting opinions. The affective dialogue code denoted responses in which students wrote directly to the teacher, often asking for help or advice. In addition, we included a "Don't know" code (see Figure 1).

To gauge the accuracy of the students' work, we calculated the percent correct of scorable entries attempted by each student. Journal entries were unscorable if the journal prompts focused on opinions or simply required students to copy a definition.

The two observers coded the journal entries of four nontarget students. Through discussions the observers refined the coding system and further resolved all discrepancies. One observer then coded all of the journal entries for all of the students in the class. One year after initially coding all of the students' journals, the same observer recoded the target students' journals. The code-recode reliability was 93 percent, well above the acceptable level of 80 percent suggested by Miles and Huberman (1984). We next identified patterns over time, as well as differences among the students. Thus, the coding revealed common trends as well as exceptional cases that focused our analysis of the students' writing.

To examine the writing of the target students in relationship to that of their peers, we randomly selected four students who scored in the top third of the class on the mathematics subtest of the CTBS. These four students are referred to as the comparison group. Analyses of their journal writing provided a contrast to the journal entries of our four target students. This comparison enabled a fine-grained analysis of key aspects of mathematical proficiency.

RESULTS

We present our results in three sections: a description of two lessons to illustrate how the teacher incorporated writing into the math class, profiles of the four target students, and our analysis of their journal writing. We developed the profiles to provide a context for the journal entries, a wider sense of the students and their level of engagement in the mathematics instruction. Our analysis of the students' journals focused on the conceptual level and affective dimensions of the students' writing.

Writing in Ms. Carter's Math Class

To illustrate how Ms. Carter incorporated writing into her math lessons, we describe two lessons that illustrate how the character of Ms. Carter's teaching evolved over the year. We developed these vignettes from observational notes after a thematic analysis of classroom interactions. We selected these lessons as representative of the way Ms. Carter used writing to support class discussion. In the first lesson, the writing prompts focused on students' opinions, while in the second lesson the writing prompts addressed mathematical content. These lessons also show how Ms. Carter interacted with students and the classroom climate she created.

Lesson 1

After reviewing the homework, Ms. Carter asked the students to take out their journals. She smiled and waited while students found journals and pencils. Ms. Carter nodded in approval, thanking the students for being so prompt and then explained the writing topic for the day. She spoke earnestly, making eye contact with individual students,

> A huge question in teaching math is, "Should kids be able to use calculators?" Parents ask me this at Open House. I want you to tell me what you think. And tell me why you think that. It's OK to write that sometimes you should and sometimes you shouldn't. (Obs. 10/9)

Ms. Carter spoke persuasively, capturing the students' attention. She urged the students to write for three minutes without stopping. All 23 students set to work when she asked them to begin. After about one minute, Danny, one of the target students, stopped writing and just sat there. Ms. Carter quietly walked over to Danny and told him to recopy what he had already written. He began to write as Ms. Carter moved on.

After three minutes, Ms. Carter asked students to share their writing. Twelve hands went up. Ms. Carter looked around the room, leaning toward the students to communicate her eagerness and reminding them to listen carefully as each student spoke. She called on students one by one, listening and nodding as each student spoke.

> "To check answers."
> "If an adult doesn't know the answer then it's OK to use calculators."
> "If it's easy, use a calculator, but not with new stuff."
> "You have to show your work, then self check with the calculator."
> "When you have a long, complicated problem, use the calculator when you don't have time."
> "It's not necessary to use a calculator. It doesn't help your knowledge."

Ms. Carter nodded and thanked each student after speaking. The entire class was quiet and appeared to be listening to the comments.

This episode illustrates how Ms. Carter introduced the students to journal writing and used the writing to prepare students to speak to the entire class. When planning the lesson, Ms. Carter commented that she selected the prompt because she thought that it would engage many of the students, reasoning that everyone could form an opinion about the use of calculators. At this early point in the school year, most students addressed their comments to her rather than peers, but the important first step was getting the students to speak in front of their peers. None of the target students spoke during this portion of the class.

Lesson 2

By winter term, Ms. Carter offered prompts that focused on mathematical concepts and processes. For example, in March, Ms. Carter introduced the concept of ratios, using colored chips to represent number of cookies per person. She then asked the students to write comparisons using different quantities. After the students were successful at describing situations such as four cookies to one person, she asked the students to write to the following prompt: "Be a peer tutor and write how you would explain what a ratio is to a new student in class." Students then shared their efforts in small groups. Ms. Carter then asked the students to revise their explanations, using ideas from the other students in their group. The majority of the students were engaged in the writing and discussion. The target students wrote, but they offered few suggestions during the small group conversations.

General Lesson Characteristics

In summary, Ms. Carter created a classroom climate that supported students' efforts to do math. She encouraged students to participate in class, by pausing after asking a question. In subsequent lessons she encouraged students to respond to each other's questions. During small group work, she walked quietly among the students answering questions and offering encouragement. She would then invite students to share interesting solution strategies during the whole class debrief. She did not allow students to criticize or ridicule those who spoke in class. The few times this happened, students were immediately sent to the hall, and Ms. Carter would talk with them after class. In addition, Ms. Carter worked with students before school and after school twice a week. She had well-established and efficient routines for the class. Every week she provided each student with detailed feedback regarding progress in the class, confidentially noting completed assignments and any test scores. Her directions were clear and quickly understood by the students.

Profiles of Target Students

Sam

The pattern that emerged from our observations of Sam was unusual, as Sam was both hardworking and easily distracted. When he sat with one of his friends, trouble usually resulted. He liked to be physical and tended to get in good-natured shoving and pushing matches with other boys. Ms. Carter frequently warned Sam and asked him to settle down. He, Danny, and Kevin (another student receiving special education services) often passed notes to each other.

A closer examination of Sam's participation in class revealed another side. In spite of many distractions, he was trying to be successful in math. Numerous observations described him impatiently holding his hand up for help and waiting for the teacher or aide to come to his assistance. A mid-January check revealed that he had turned in all 12 of the classroom assignments. The following example illustrates his perseverance in spite of frustration and distractions. In this class, Sam and Nick have been sitting next to each other and have already gotten into trouble once for talking. The teacher gives them a choice of staying or leaving the class. Both say they will stay. A short time later, however, Sam is talking to Danny and the teacher makes him move his work to a small table in the front corner of the room. These are the notes involving Sam from this point on:

> OBS #31, 4/2: Sam is still trying to get the teacher's attention, but she tells him to wait a minute, to skip the one he's having trouble with and go on, she'll get back to him. To this he replies, "I can't skip them all!" The teacher moves to the other side of the room to help two students. Sam remains sitting, turned sideways so he can see the room. He's making noises. The teacher returns to help him. A few minutes later, he returns to sitting with his chair leaned back on two legs and turned so he can watch the class. He gets the teacher's attention again and asks if he's done #5 correctly. . . . The teacher is again over helping Sam, saying, "Can you reduce it?". . . Sam is still fidgeting.

Ms. Carter reported that Sam came to her two or three times a week after class to get additional assistance. The special education teacher reported that he was the only student receiving special education services who was successful in a regular math classroom. She explained his success as twofold: he received support at home for his success, and he enjoyed and sought the extra adult attention he received from the math teacher after class.

Frieda

Our observations of Frieda revealed that she was socially preoccupied, yet wanted to do well in the class. She struggled to translate this desire into action. Frieda invested a good deal of her time and energy in her friends. She was not disruptive in class, but she was often more interested in social interactions than in math, necessitating the teacher to remind her to get back on task. At the beginning of the year, Frieda appeared to be trying to keep up in math, and teacher approval appeared to be important to her. She stayed after class one day to tell the teacher how happy she and her mother were with one of her grades (16 out of a possible 16).

At other times, Frieda experienced frustration while trying to do well on assignments. For example, the students were supposed to be working in class one day on problems from their textbook having to do with rounding decimal numbers. Both Ms. Carter and Marty, the classroom volunteer, were providing individual assistance while the students worked:

OBS #11, 11/5: Marty is sitting next to Frieda, who appears to be crying. Marty is saying, "Do you remember rounding, we went through it last year?" The girl is still crying, and Marty says, "Let's start with whole numbers."... Uma [another student] gets up and returns with a tissue for Frieda . . . Marty reassures Frieda, "I think we're going to go through this again." Uma gets up and brings the whole box of tissues over to Frieda.

By mid-January, Frieda was struggling to keep up, and had turned in 7 out of a possible 12 homework assignments. The following example demonstrates that Frieda was aware of her struggles:

OBS #30, 3/31: The teacher asks the students to stand up if they know what a denominator is. Three students immediately jump to their feet. Eventually, others join them, including Frieda . . . the teacher writes, "bottom part of the fraction" under "common denominator." Then she writes two fractions on the board, 6/7 and 7/8. She asks the class, "Who thinks 6/7 is larger?" No one stands. Then she asks, "Who thinks 7/8 is larger?" Again, no one stands. The teacher asks, "Who doesn't have a clue?" Frieda is the only one to raise her hand.

Toward the end of the school year, Frieda appeared distracted by social matters and less interested in math. She spent class time writing notes and drawing in her notebook. She sometimes did not do the warm-up at the beginning of the class and appeared to be daydreaming. When asked about Frieda's apparently diminishing interest in math, Ms. Carter commented that she had noticed this as well and had learned from other teachers that it was a common pattern with Frieda.

Ursula

Ursula was a quiet girl who attracted little notice during class. She was physically more developed than most of the girls in her class and sometimes dressed much older than her years. Ursula rarely drew attention to herself: she was quiet and polite in class. If she was off-task, she sat quietly, not talking to others. Because of this, Ursula often did not appear in the observations except as a bystander.

It was difficult to tell from the observations how Ursula was doing in math. She never volunteered answers, but if called on she often seemed to get the answer right. Sometimes, though, when called on she was not prepared, using the excuse of not having her book, a pencil, or paper with her. In January, Ms. Carter did a 6-week check of assignments turned in. Ursula had only turned in six assignments out of a possible 12.

Danny

Our observations of Danny revealed a consistent pattern of inattention to math during class. Danny was always in motion. During the early part of the year, he was noticeably fidgety and distracted during class. He seemed more immature than other students, often making exploding noises and other sound effects when he was supposed to be working. One of the assignments he posted on the bulletin board stood apart from the rest of the class for its childlike scribbles.

Danny had developed a variety of strategies to conceal his lack of engagement with the mathematical activities in class. For example, he hid notes or comic books on his lap while his textbook or resource-room packet was on top of his desk, so that he could go easily from off-task behavior to appearing to be on task. He also used trips to the pencil sharpener when the class was doing individual work or writing in journals.

Often Danny would open his resource-room packet on his desk. This packet was an assignment from the special education teacher. The understanding was that some of the special education students would participate in the regular class until they were unable to do the work, at which point they were to bring out the packet and work on math fundamentals. Danny did not actually work on his packet, but if the teacher walked by and asked how he was doing, he would say, "OK," and appear to work until she had passed. His lack of self-confidence in math was evident when the teacher called on him. For example, during one lesson the teacher called on him for an answer to a homework problem. Danny replied, "This is probably wrong" (Obs. #6, 10/17).

A seating change in October resulted in Danny's sitting in the front of the room, nearer the teacher. For several weeks, he appeared more engaged in the class, was called on and occasionally gave a correct answer. At one point he was even up-to-date on homework assignments. This seating arrangement lasted only a month. When he was moved further from the teacher, his engagement with the class seemed to suffer. In mid-January he had turned in only 2 out of a possible 12 homework assignments.

Student Profile Summary

All four students struggled in mathematics. Ms. Carter reported that Ursula, Frieda, and Sam had large "holes" in their mathematical understanding that interfered with their efforts to understand seventh-grade mathematics. The profiles highlight an important similarity among the four students: the sense of disenfranchisement, or being "turned off to math." Unlike the majority of the students in upper track classes who come to class with completed homework, these students do not (Baxter & Olson, 2000). The profiles also reveal the differences among these students, their somewhat startling range of abilities and problems. The "low kids" are by no means a homogeneous group. These students rarely volunteered to talk during class discussions, and when Ms. Carter called on them, they offered one- or two-word responses.

Writing and Communication in Mathematics

We analyzed the students' journals to determine what writing revealed about the target students' conceptual understanding, strategic competence, adaptive reasoning, and productive disposition. Our analysis of the students' journal entries revealed important aspects of the students' mathematical proficiency that our observations did not capture. We present these results in three sections: (1) analysis of target students' mathematical reasoning, (2) insights into the affective role of writing, and (3) contrast of target students' and comparison students' journal writing.

Analysis of Target Students' Mathematical Reasoning

The target students' journals in many cases offered a view of their involvement in mathematics lessons that was very different from that afforded by the classroom observations. Our observations had suggested that the four target students rarely volunteered in class and tended to be distracted by social concerns. For example, Frieda was often engaged in dramatic exchanges before, during, or after class that involved note passing and whispered support from friends. Ursula, on the other hand, did not appear in our observational field notes very often. She was present, but seldom spoke. Sam was most likely to have an answer when called upon by the teacher, but he too was often silent. And Danny was easily distracted, never volunteering a comment during class discussions. From our observations, it appeared that all four target students were passive participants in class.

In contrast, our analysis of the students' journals suggested that three of the target students, Frieda, Ursula, and Sam, tried to explain their mathematical reasoning and feelings in their journals. In over half of each of these students' journal entries, they were describing the steps they had used to solve a problem (i.e., Level 2, summarizing) or using mathematical concepts to clarify the solution to a problem (i.e., Level 3, generalizing; see Table 1). Danny, who was the exception, wrote, "I don't know," over and over again in his journal, for a total of 42 percent of his responses. All of the prompts were read to the students as well as written on the overhead projector, so low reading ability alone does not account for Danny's behavior. Of the four target students, Danny had the lowest performance. Only 30 percent of his scorable journal entries were correct, while the other three students scored above 70 percent. Sam scored the highest with 80 percent correct, while Frieda and Ursula scored 75 percent and 71 percent, respectively. Danny was the only student in the class who had a packet of math problems prepared by the special education teacher to use as a "back up" when the regular math class became too difficult for him.

Sam's writing was the most accomplished of the four target students. Almost half of his responses (46 percent) were descriptions of the steps he used to solve a problem, Level 2 (see Table 1). For example, in December the teacher asked the students to respond to the following prompt.

TABLE 1
Frequency of Specific Content Codes for the Target Students' Journal Entries

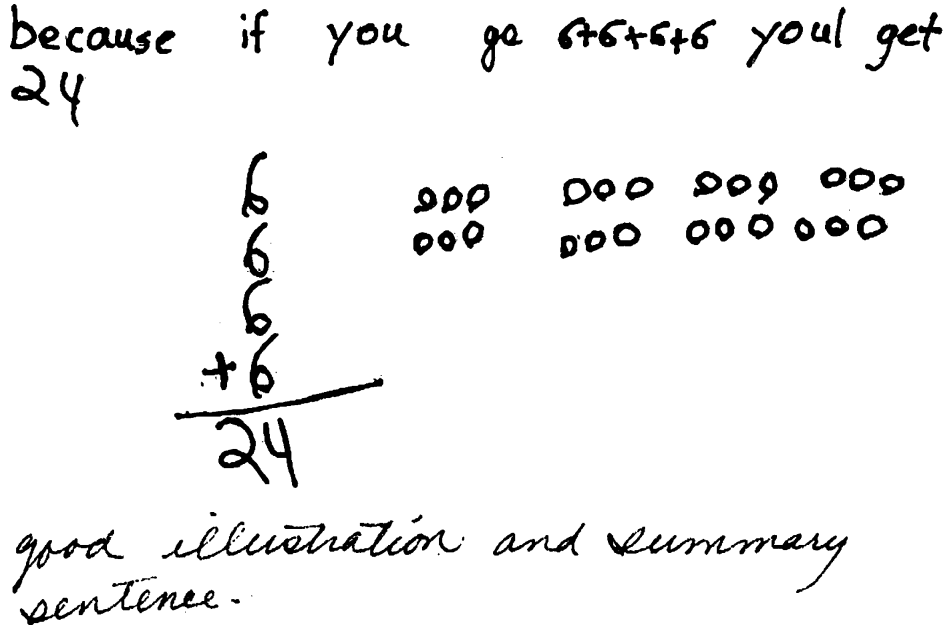
Students	Sam	Frieda	Ursula	Danny
Number of journal entries	33	28	38	29
Codes				
Don't know	0	0	2%	42%
Level 1: Recording	18%	36%	24%	45%
Level 2: Summarizing	46%	36%	37%	3%
Level 3: Generalizing	24%	3%	13%	0
Affective response	12%	11%	13%	10%
Affective dialogue	0	14%	11%	0

> Prompt: *Describe a time when estimation was helpful to you.*
>
> Sam: I made an estimation to buy a candy bar. The candy bar costed (sic) 99 cents. I rounded it to $1.00. Then I buy (sic) the candy for $1.00 and I got 1 cent back.

Sam's written response was remarkable in that we never observed him offer more than a one- or two-word comment during class discussions. In his journal, however, he wrote about a familiar situation, the purchase of candy, and how he used rounding to estimate the amount of money needed to buy the candy. He clearly described the situation as well as his mathematical reasoning.

Sam also attempted to explain his reasoning using mathematical concepts (Level 3) in 24 percent of his journal entries. Again, this was in sharp contrast to his infrequent contributions during class discussions. Sam's journal entries were simple and brief, but he did show both adaptive reasoning and strategic competence. For example, when asked to "Prove (show) that 24 is divisible by 6" Sam offered three different representations: words, algebraic symbols, and a drawing (see Figure 2). All three representations emphasized his main point, which was that equal groups of 6 make up 24. His writing suggests that he saw a close connection between combining groups and division. His explanation, one aspect of adaptive reasoning, moved beyond a simple statement of steps completed to reach the solution, as he was linking the concept of repeated addition to division. His strategic competence was demonstrated in his choice of representations that consistently supported his explanation.

Like Sam, Frieda rarely offered more than a one-word answer in class. Although she was less confident than Sam in her writing, she was able to express her approach to solving problems. Of Frieda's 28 journal entries, 36 percent were efforts to describe how she would solve a problem (Level 2; see Table 1). For example, in the following journal entry Frieda showed uncertainty about her response to a prompt on division.



Prompt: Prove (show) that 24 is divisible by 6.

FIGURE 2 Sam's written response during divisibility unit.

Prompt:	*What goes on in your mind when I ask you to put 16/32 in simplest form?*
Frieda:	Well, I really don't know how to do this but I'll try it anyway. 16/32 I think of 1/2 because 16 is half of 32.

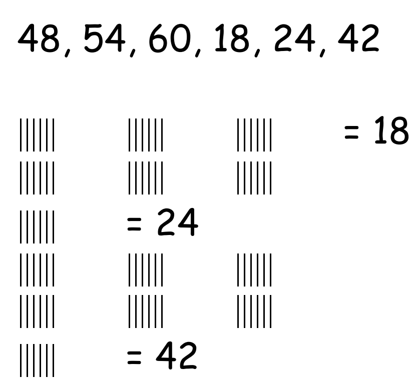
Frieda displayed her conceptual understanding of rational numbers, as she correctly noted the relationship between 16 and 32 when written as a fraction. In her journal she was able to express her hesitance and then describe her thinking without holding herself up to public scrutiny by her peers.

Frieda rarely linked mathematical concepts to her problem solutions, as only 3 percent of her journal entries were coded Level 3 (see Table 1). Her writing focused on the steps she followed to reach a specific answer, which suggests that she was working with concrete actions or objects, rather than abstract ideas. However, writing afforded Frieda the opportunity to use tools that supported her mathematical thinking. For example, during a unit on divisibility patterns, the teacher asked students to generate a list of two-digit numbers that were divisible by 6 and explain how they knew each number was divisible by 6. Frieda listed six numbers and then used tally marks to show that each was the sum of groups of six tally marks (see Figure 3). Using no words, Frieda was able to convey both her answer and support for her answer. Even though Frieda was firmly grounded in the concrete, she showed adaptive reasoning and strategic competence in her ability to represent and explain the problem.

As with Sam and Frieda, Ursula's participation in class contrasted with her writing. Her mathematical reasoning was never revealed during class discussions, but it emerged in her journal writing. She described her solution strategy (Level 2) in 37 percent of her responses (see Table 1). Ursula wrote clearly and correctly about her understanding of "range" in the following example.

Prompt:	*Copy the set of data: 7 3 8 14 2 10 5 What is the range of the data? In one or more sentences explain what range means.*
Ursula:	A range is when you take two numbers and subtract them. The numbers you subtract should be the biggest and the smallest number in a set of data.

Ursula simply listed the steps needed to determine the range. Similar to Frieda, Ursula did not often link her



Prompt: Write a set of two digit numbers that you think is divisible by 6. Explain how you know that each number is divisible by 6.

FIGURE 3 Frieda's written response during the divisibility patterns unit.

000000 - 6
000000 - 12
000000 - 18
000000 - 24

Teacher's reply written in journal:

This could be a summary sentence:
I could divide 24 into 4 groups of 6 with nothing left over.

Prompt: Prove (show) that 24 is divisible by 6.

FIGURE 4 Ursula's written response during divisibility patterns unit.

explanations to mathematical concepts. Only 13 percent of her responses were coded at Level 3 (see Table 1). Ursula wrote most often about specific events or objects. She also relied on drawings to convey her explanations. For example, when asked to explain how she knew that "24 is divisible by 6," she drew four rows of six circles (see Figure 4). Ursula's rows of separate circles suggests that she was adding groups of 6 rather than starting with a group of 24 and dividing it into groups of six. The implication is that she was aware of the connection between division and repeated addition, even if she was unable to capture it in words. Although her explanations were limited by concrete terms, she was attempting to go beyond the standard division algorithm.

Danny evidenced more consistency between his writing and his classroom participation. He displayed very little mathematical reasoning in either situation (see Table 1). Although his most common response was "I don't know," even his attempts at explanations were terse and difficult to follow. When responding to the previous prompt regarding divisibility patterns, Danny wrote, "I don't know" once and then drew two groups of objects (see Figure 5). Some of the objects were ellipses and some were 6's. It is not clear whether he was intending to draw groups of objects or to use symbols to represent the problem.

Insights into the Affective Role of Writing

The students' writing, especially the girls', suggested that the journals created additional connections to the teacher. All of the students wrote affective responses at the beginning of the year, when the writing prompts centered on students' feelings and opinions about mathematics. As the year proceeded and the writing prompts focused on mathematical concepts, most of the students wrote summaries (Level 2) or recordings (Level 1); however, Frieda and Ursula continued to write affective responses. We then examined the affective responses of these students.

The four target students as well as their peers had limited access to their teacher. As is typical in middle schools in the United States, the teacher saw from 130 to 160 students each day. Four-minute passing periods made it very difficult for students to talk with the teacher before or after class. Two of the four target students used their journals to communicate directly with their teacher. From October through March, Frieda wrote to Ms. Carter about her concerns or frustrations: 25 percent of her responses were coded either affective response or affective dialog. In over half of these responses Frieda addressed Ms. Carter by name, asking for a reply.

Prompt: Why is 0.3 greater than 0.003? Show visually and verbally.

Mrs. Carter I really don't know what you are talking about on this. Also I really need help with the things we are doing right now in class so if we can set up a time to talk about what and how to do it. I really like this class and I don't want to get an F in it. I like having A's.

Ursula also directed comments to Ms. Carter, using more indirect wording, but still looking for approval and a personal connection (24 percent of her journal entries were coded affective response or affective dialogue). She concluded one explanation of how to solve a problem with "so there's an example to show you how to do it and I hope you can follow (sic)." Ursula wrote to a real person, as if she was expecting a response. Half of her responses coded as affective were affective dialogue. It is interesting to note that the two girls both used their writing to develop a more personal connection with their teacher.

In contrast, both of the boys used a more impersonal voice when writing in their journals. Sam and Danny wrote in the first-person voice, but their audience

I don't know.

060060) 000000)

Prompt: Prove (show) that 24 is divisible by 6.

FIGURE 5 Danny's written response during divisibility patterns unit.

seemed to be a more distant other, as in the example cited earlier:

Prompt:	*Describe a time when estimation was helpful to you.*
Danny:	I don't know any thing (sic) about this statement. So I really don't know.

Danny's response is focused on the statement. He did not ask for help or any kind of response from the teacher. He simply declared that he did not understand.

Sam and Danny wrote about their feelings only at the beginning of the year, when the writing prompts were designed to engage students in writing (e.g., How do you like taking tests in math?). Of Sam and Danny's total journal entries, 12 percent and 10 percent, respectively, were coded as affective responses. Neither Sam nor Danny wrote directly to the teacher or asked for a reply; thus, none of their journal entries were coded as affective dialogue.

Contrast of Target Students' and Comparison Students' Journal Writing

Our analysis of the students' journals was based on the frequency of occurrences of the coding categories described earlier. The analysis revealed different patterns between the target students and the comparison group (see Figure 6). Both groups wrote similar numbers of affective responses and recording entries in their journals. However, the target students wrote "I don't know" six times more often than the comparison students, averaging 3.25 and 0.5 such responses, respectively. The most striking difference between the target and comparison groups appeared in the generalizing category: the comparison group wrote an average of five times the number of journal entries in which they used mathematical ideas to develop a solution (i.e., 18) as the target group of students (i.e., 3.5). These patterns suggest that the weekly writing activities were not used in the same way by all students.

DISCUSSION

Research in mathematics education offers many images of students who are eager to share their mathematical thinking (Ball, 1993; Lampert, 1990). These young students strive to explain their solution strategies and question each other's statements. This is true, too, of most of the students in the classroom we studied. In contrast, the target students we studied rarely shared their mathematical thinking. Our findings suggest that writing provided an alternative strategy for three of the four target students to communicate their mathematical thinking. Also, in the case of the two girls, writing offered an additional connection to the teacher.

Findings on Promoting Communication

Our results suggest that students who did not actively participate in mathematics discussions did respond when asked to write about mathematical ideas. Equally important, the results also raise concerns about mathematics education for low-achieving students. For example, Ursula presents a case of a student who is on the periphery of math instruction. Her behavior was consistent with our previous findings regarding the participation of at-risk students in math classrooms (Baxter et al., 2001): She never spoke during class discussions, and she followed the lead of a more able student during pair work. What we find encouraging is that Ursula

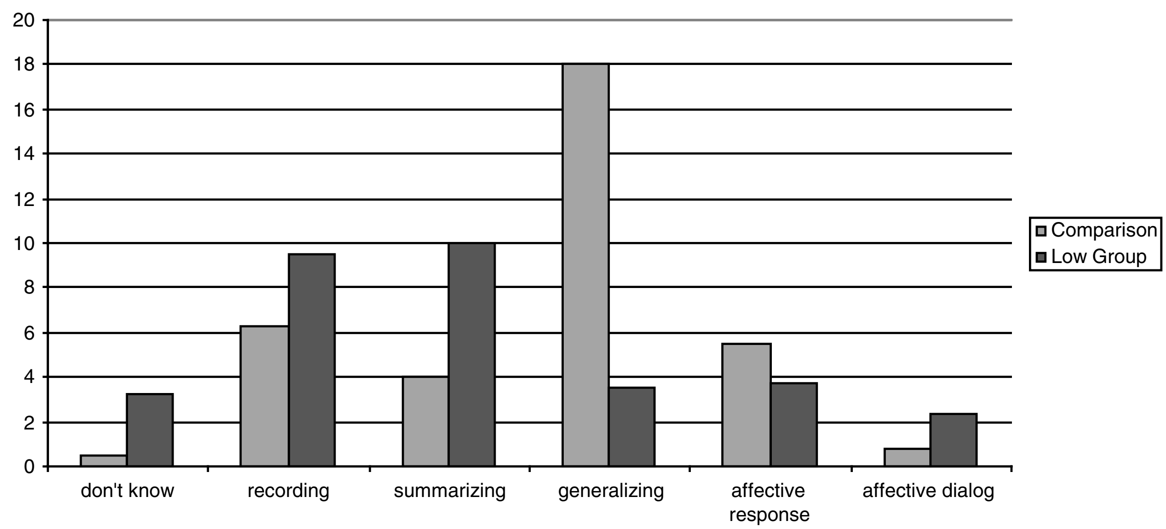


FIGURE 6 Contrast of target students' and comparison students' journal writing.

was able to express her mathematical thoughts in her journal. Through writing, Ursula shifted from a passive listener to a more active role. While the ultimate impact of writing on Ursula's conceptual understanding of mathematics is impossible to predict, her journal offers a means for the teacher to develop and examine Ursula's mathematical thinking.

Writing also allowed Sam more ways to communicate. Through his journal writing, he used drawings, symbols, and words to explain his mathematical thinking. Thus, his strategic competence was revealed in his journal entries. In contrast, his oral communication in math class was limited to one- or two-word responses to direct questions from the teacher. Sam's frequent use of drawings did not guarantee understanding; however, drawings and symbols enabled Sam to show what he did know about mathematical concepts.

Sam illustrates the importance of representations in mathematics instruction. The use of multiple representations is a common recommendation in the contemporary literature on mathematics instruction (Ball, 1993; Hiebert & Carpenter, 1992; Lampert, 1990; Silver, 1986). The way in which an idea is represented affects how it is understood, as different representations often illuminate different aspects of a complex concept or relationship (Gentner & Gentner, 1983; Janvier, 1987). In mathematics, both conventional and unconventional representations influence conceptual understanding. Idiosyncratic representations help individual students make sense of mathematical ideas, while more conventional representations facilitate the communication of mathematical thinking to others (NCTM, 2000). The ability to move from one representation to another leads to deep understanding of concepts (Ma, 2000).

Frieda's journal entries raise questions about another potential function of journal writing: the role of affect and emotion in mathematics instruction. Her writings illustrate the need of some students to connect with the teacher on a personal level. She wrote directly to the teacher, using her name and asking for help. She expressed her lack of confidence, but then tried to answer a mathematical question, actually showing a good grasp of estimation. Research suggests that mathematics is a difficult subject in which motivational factors are especially important for learning (Stipek et al., 1998). Schiefele, Krapp, and Winteler (1992), in their meta-analysis, found that, compared to other subjects, there is a strong relationship between interest and achievement in mathematics.

The reform movement's focus on helping students make sense of mathematics requires careful attention to both intellectual and affective factors. Mathematical proficiency includes a *productive disposition* or belief that one can learn and do mathematics (Kilpatrick et al., 2001). McLeod (1992), in a review of the research on affect in mathematics education, concluded that the relationship between the affective domain and mathematics learning and teaching needs to be better understood. One of the few studies that links affect and cognition focused on the affective characteristics of problem-solving instruction in the junior high classrooms of six expert teachers (Grouws & Cramer, 1989). The expert teachers in those classrooms worked hard to build a good relationship with students and to be friendly rather than formal, which resulted in improved performance.

Without connections to a teacher, which journal writing can facilitate, there is cause for concern about Frieda's future progress in school. Wehlage, Rutter, Smith, Lesko, and Fernandez (1989) found that students who do not feel an attachment to school personnel are more likely to have poorer attendance and to drop out than are students who feel that they are part of a caring school climate. In addition, when teachers and students create positive psychosocial relationships, academic achievement appears to improve (Rutter, Maughan, Mortimore, Oustson, & Smith, 1979).

In light of these promising features of writing, Danny presents an important cautionary case. It is not clear which factors contributed to his lack of response to the writing prompts. His skills in both mathematics and writing were at least two years below grade level. In addition, his off-task behavior suggested a poor attitude toward school and learning in general. The extra help that Danny was intended to receive from the resource teacher actually seemed to interfere with his learning. The resource-room packet of computational problems was designed to keep Danny occupied when the regular mathematics instruction became too difficult for him. In reality, the packet created an ambiguous situation, in which Danny was accountable to neither the resource-room teacher nor the general mathematics class teacher. He pretended to work on the packet in the regular class and thus was not responsible for the regular assignments. There was little time for the two teachers to communicate, so the resource room teacher rarely received information about Danny's daily involvement in the regular mathematics lessons. It is ironic that the student most in need of additional help was lost in the organization and time pressures of the middle school.

Formal and Informal Mathematics Communication

In addition to providing insights into students' understanding of mathematics, our work also contributes to the growing literature about the value of writing as a communication tool for low-achieving students. Meier and Rishel (1998) use writing extensively in their college-level math courses. They found that "when students write about math; they are placing the subject in a context which makes sense to them" (p. 90). They argue that students need to learn to communicate their ideas well, to make their comments precise. However, other mathematicians disagree, claiming that students must begin with rigorous proofs that require a formal logic to then understand mathematics and develop rigorous thinking (Gries & Schneider, 1995). From this perspective, writing about mathematics could be seen as counterproductive in that it causes students to stray from the precision of formal mathematics.

The debate over the importance of mathematically precise language is especially salient in special education, where instruction has emphasized basic computations and right answers. Researchers in the late 1980s and early 1990s first documented the focus in special education classrooms on computational proficiency and limited problem solving (e.g., one-step problems where students look for key words to solve the problem). On far too many occasions, students with learning disabilities spent a disproportionate amount of time involved in low-level practice built around extensive amounts of independent seatwork (Allington & McGill-Franzen, 1989; Parmar & Cawley, 1991). This was even found to be true of computer-based math activities (Becker & Sterling, 1987; Rieth, Bahr, Polsgrove, Okolo, & Eckert, 1987; Woodward & Rieth, 1997). The continued and predominant focus on computations and limited problem solving is apparent in research (or summaries of research) as well as reflection papers on practice (Bottge & Hasselbring, 1993; Cawley, Parmar, Yan, & Miller, 1998; Gersten & Woodward, 1995; Hasselbring, Bottge, & Goin, 1992; Maccini & Hughes, 1997; Mastropieri, Scruggs, & Shiah, 1991; Parmar & Cawley, 1997; Woodward & Baxter, 2001; Woodward, Baxter, & Scheel, 1997).

In these skill-driven instructional settings, mathematical communication is reduced to a very small set of words and symbols. Students are required to report answers or steps to reach answers. In contrast, researchers have found that students' conceptual understanding and problem-solving skills improve when they are encouraged to make sense of mathematics by writing about and discussing their mathematical thinking (Putnam, 2003).

In conclusion, the most productive relationship between the precise, formal language of mathematics and the messy, colloquial language used by students of mathematics is unclear. International studies, such as the Third International Mathematics Science Study, have documented the repetitive nature of mathematics instruction in the United States, especially at the middle school level. Perhaps this redundancy is necessary, as U.S. students have such a fragile grasp of mathematical ideas and processes. The advocates of writing in mathematics claim that students develop a more coherent and robust understanding of mathematical ideas by expressing their thinking in writing, even if that writing is less precise than formal mathematical expressions. Studies of the effect of writing in mathematics on students' abilities to retain mathematical skills and concepts are needed to test this claim.

Perhaps the greatest promise of writing in mathematics is that it will forge connections with students who typically drift or run rapidly away from mathematics. Writing offers a means for students to relate mathematical ideas to their own lives. As Meier and Rishel (1998) explain:

> Each field has its narrative, which contains its history, its culture, its assumptions, its people, and its life. Mathematics is no different. Each mathematician constructs his or her own life in mathematics, and each student—and we are all students at some level—needs to find him or herself within this narrative. Writing and speaking mathematics are central to learning and doing mathematics (p. 96).

Thus, rather than viewing the language of mathematics as completely distinct from the language of other disciplines, writing can be seen as providing an opportunity for more students to engage in making sense of mathematics.

Implications For Practice

Our study of journal writing raised both concerns and benefits for instructional practice. For example, after reading the students' responses to the first few prompts, the teacher was surprised by the students' ability to communicate their feelings and opinions. Students who had never spoken in class expressed strong feelings in their journals about using calculators in class. Unfortunately, the teacher quickly noted that it took a considerable amount of time to read and respond to students' writing. We then developed strategies for her to respond more quickly and efficiently to the journals (see Baxter et al., 2002a), but the journals clearly added to the teacher's daily workload.

The additional time needed to read the journals was offset by important benefits. The teacher noted that the journals allowed her to encourage a student for effort or for an original approach in a private communication channel. This was a delicate area for the teacher, as she felt that some students in her class feared peer ridicule if she were to compliment them in front of the whole class. The teacher also stated that she was impressed with what she was learning about her students from their writing. Their responses to a prompt about how they felt about math tests revealed a range of responses from "I like taking tests" (from a student who rarely passed tests) to "Tests make me sick."

When students grew frustrated during writing, she directed the volunteer aide to work individually with particular students, such as Ursula and Danny. She wanted the students to experience some success in communicating their ideas, hoping that this success would transfer to class discussions.

After two months of reading the students' journals, the teacher realized an unanticipated benefit from the students' writing. As the students wrote about familiar mathematical ideas, she was able to read students' responses and develop a more complete picture of what the students did and did not understand. The teacher noted that the journals gave her more than a simple wrong answer. She gained insights into the students' mathematical proficiency. For example, from reading the students' answers to the prompt requiring them to explain division to a fifth grader, she was able to see how her students made sense of division. For some of the more capable students, division was a systematic partitioning of sets of objects, while for others it was either rote memorization of steps or limited strategies, like repeated addition. The teacher began to use examples of the students' writing to justify decisions to develop lessons in particular ways during weekly planning sessions with the researchers.

When the students showed some skill in writing about familiar math topics, the teacher shifted to prompts that addressed new topics that they did not necessarily understand. Here again, student writing enabled her to do a richer type of planning, as she reviewed a day's lesson and planned the next. She also used the students' journal writing to direct the volunteer aide, suggesting particular problems and strategies based on difficulties that students showed in their writing.

Many of the comments that the teacher made at the end of the study indicated that writing presented far more information for instruction than she had anticipated. The journals also were a way for her to encourage students privately. Thus, the journals provided her with a picture of what students were thinking, facilitated a different type of planning, and offered a vehicle for students to communicate privately, an important alternative to oral communication.

NOTE

1. All students and the teacher have been given pseudonyms.

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