USING JOURNALS AS A WINDOW ON STUDENTS' THINKING IN MATHEMATICS

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Students and teachers learn about mathematics and about each other as they use dialogue journal writing.

"Creating occasions to write regularly is a powerful strategy for learning subject matter" (Vacca & Vacca, 1989, p. 260). First, writing clarifies thinking and promotes student learning. Theorists and researchers such as Britton (1970), Halliday (1975), Polanyi (1969), and Vygotsky (1962), have long argued for such use of language in an exploratory or heuristic way so that students may make greater sense of their own learning. Second, writing is a way students reveal their thinking/reasoning to their teachers and demonstrate what they know and do not know. Thus, students and teachers both discover and clarify meaning (Vacca & Vacca, 1989). Yet, all too often, writing plays a less than significant role in the mathematics classroom.

In this article we describe the use of one form of writing—dialogue journal writing—in intermediate grade mathematics classrooms as a way to gain insights into students' thinking. Through students' written language use, we wanted them to share with us the meanings they attributed to decimal symbols, but they also shared their thinking on many other aspects of learning mathematics.

Through the journals, we as teachers began to understand better what was happening in the classroom by "listening" and observing in a more focused way. As a result of this watching and listening, teachers and students became a community of learners. Just as Santa (1988) suggested, we could fine tune our craft by analyzing the performance of the students more closely, observing and reflecting on the teaching; thus we could make informed instructional decisions on the basis of the observations. The information gained, especially the insights on students' conceptual and procedural knowledge, was useful in making some immediate instructional decisions. As teachers, we were empowered by this information.

What Are Dialogue Journals?

Journals or logs, according to Vacca and Vacca (1989), are versatile writing-to-learn activities available to students and teachers. They add a dimension to personal learning in the subject areas. Tierney, Readence, and Dishner (1985) state that dialogue journals are distinguished from other forms of journal writing because of the importance given to communication between the student and the teacher.

A dialogue journal, then, is a written conversation, or a talk on paper, between a student and a teacher (Atwell, 1984; Calkins, 1983; Graves, 1983). Staton (1980) emphasizes that dialogue journals are intended to provide all students with an opportunity to share privately in writing their reactions, questions, and concerns about school experiences with the teacher, without any threat of reprisal or evaluation. Dialogue journals require thinking, but they do not demand a finished product in writing. Used as a writing-to-learn activity in the mathematics classroom, journals extend students' language and literacy across the curriculum.

We encouraged two types of writing in the mathematics journal: prompted writing, where students responded to questions posed by the teacher, and free writing (or open-ended writing) to encourage the discovery of ideas more independently. In an effort to gain insights into students' understanding of mathematics, students were encouraged by the teachers' prompts or questions to include specific kinds of in-

formation in their entries about their understanding of decimals. For example, students were asked to respond to such questions as: What do you think decimals are? Which is larger, 0.5 or 0.42, and why? However, on other aspects of the curriculum, open-ended entries were encouraged (allowing students to write on anything of interest or concern to them in mathematics); thus the entries provided us with information on their thinking in aspects other than decimal understanding.

How Did We Use Journals?

For 1 year, the 180 boys and girls (7 classes) in 4th, 5th, and 6th grade wrote entries in their mathematics journals. The school attended by the students was located in a large western Canadian city and designated as a fine arts upper elementary "magnet" school (Grades 4–6) with an underlying concept/philosophy of integration of subjects across the curriculum with the fine arts. All teachers worked with the fine arts teachers as a unit to develop all subject areas in the regular curriculum through the medium of fine arts. No fine arts background or exceptional fine arts abilities were required as prerequisites of students who attended the school. The students who chose to attend were of varying abilities and came from all areas of the city.

One of the driving forces for the students' writing appeared to be their keen interest in the teacher's response and the need to maintain that communicative bond.

The students were allowed 10–15 minutes to write in their journals during mathematics class. The

Table 1
Learning Objectives in Mathematics

GRADE	4	5	6
NUMERATION	• identifies and names place value of digits 0.01 • reads and writes and orders decimals to 0.01 • regroups tenths and hundredths	• identifies and names place value of digits 0.001 • reads, writes and orders decimals to 0.001 • regroups tenths, hundredths and thousandths • rounds numbers to tenths and hundredths • expresses tenths, hundredths and thousandths as fractions and decimals	• identifies and names place value of digits 0.0001 • reads, writes and orders decimals to 0.0001 • writes decimal numerals using expanded notation • rounds numbers to 0.0001 • expresses halves, quarters, and fifths as fractions and decimals • expresses fractions and decimals as percents and vice versa
OPERATIONS	• adds and subtracts decimals to hundredths	• adds, subtracts, and multiplies decimals to thousandths • multiplies and divides decimals by 10, 100, 1000 • divides decimals by one digit whole numbers	• adds and subtracts decimals • estimates sums and difference • multiplies decimals using 1, 2, 3 digit multipliers • divides decimals using 1, 2, 3 digit whole number divisors • divides decimals using 1 decimal place divisors

(Compiled from *Elementary Mathematics Curriculum Guide*, Edmonton, Alberta: Alberta Education, 1982)

teacher read the journals and returned them by the next week. Approximately 25 journals were handed in daily.

Journal writing was originally initiated to provide us with some insights into children's thinking in mathematics. No motivational techniques seemed necessary to get the students to write. They appeared to enjoy the writing and viewed it (as did we) as part and parcel of the instructional procedures and assignment expectations in mathematics. One of the driving forces for the students' writing appeared to be their keen interest in the teacher's response and the need to maintain that communicative bond. Often the journal entries were spontaneous. Billy, for example, once rushed toward the teacher saying, "I have something to tell you! I have something to tell you!"; but he headed right past her to the shelves where the journals were kept, grabbed his journal, sat down, and began writing. Students also *expected* the teacher's response the very next day after turning in their journals. Each day the teacher spent from 30 minutes to 1 hour responding to the entries.

The curriculum guide for mathematics in our province stipulates several objectives in terms of numeration and operations at the fourth-, fifth-, and sixth-grade levels. These are presented in Table 1. We bore these guidelines in mind as we prompted the students' writing.

Here's What the Students Told Us

Through the structured responses we were informed of students' decimal understanding. The open-ended entries were windows to students' thoughts about their personal feelings and emotions, their difficulties and problems, and their discoveries and insights. We made five key observations based on what students told us. The observations enabled us to draw some conclusions which influenced our instructional decisions.

1. Intermediate grade-level students have bits and pieces of conceptual knowledge but, generally speaking, acquire better understanding of the decimal system by the sixth grade. A number of misconceptions about decimals are evident at all these levels.

For example, one entry we asked students to make was in response to these questions:

> What do you think decimals are? How are decimals like fractions? How are they different from fractions?

Samples of students' responses are as follows:

a. I think it is a round sircel that is at the end of a sentence. (Grade 4)

b. Decimals are another form of period, but a more profeshinal way of putting it. (Grade 4)

c. I think decimals are little dotts that can mean so much. I really don't no what decimals are. I think they are like fractions because they both make shapes. I think decimals and fractions are not alike because a decimal is small and a fraction can be any size. (Grade 5)

d. A decimal is a fraction. We use decimals to show part of a number. Decimals are like fractions except the lines separate the numbers and the dots separate the decimals. (Grade 5)

e. I think decimals have something to do with a half of a whole number. We use decimals for money, for fractions, and to separate the tenths, hundredths, etc. (Grade 6)

We learned from such entries that intermediate students had some conceptual knowledge but, in general, acquired a more in-depth understanding of the decimal system by sixth grade. Most Grade 4 students were not able to answer the questions adequately and simply stated, "I don't know," or said that decimals were confusing to them. This confusion showed when they tried to explain the difference or similarity between fractions and decimals. Then it was evident that they seemed to have no secure base on which to support meaning, as is exemplified in (a) and (b) above. That is, despite fractions and decimals having been explored as an extension of whole numbers, students lacked a basic understanding of both and thus could not link new knowledge to old. It appeared as if students needed more exploratory learning situations using both fractions and decimals before completing pencil-and-paper tasks. Although responses from the Grade 5 and 6 students indicated that these students understood more about decimal numbers than did fourth-grade students, misunderstandings were common. Responses such as (e) above more fully showed the conceptions/misconceptions that students had of decimal numbers. Thus, getting a glimpse of students' thinking helped us to gain insights into their conceptions and misconceptions and enabled the teacher to explore other approaches to teaching.

We asked fifth-and sixth-grade students to make additional journal entries to explore further their con-

ceptual understandings and procedural links of decimals. A typical question given to students to investigate their thinking was:

(1) 0.5 (2) 0.42
Which is larger? Why? Are they the same? Why?

Some sample journal entries follow:

a. 0.5 is larger because the .5 is in the tenths place and 0.42 has a 4 in the tenths place. The 2 doesn't matter. So the 0.5 is larger than the 0.42 because there's a 5 in the tenths place. (Grade 5)

b. I think 0.42 is larger than 0.5. Because 42 is a higher numeral than 5. (Grade 5)

c. 0.5 is larger than 0.42 because when you round them, with 0.42 you get 4; with 0.5 you get 5. Five is larger than 4. (Grade 6)

d. I think 0.5 is larger than 0.42 because 0.5 is closer to a whole number then 0.42. 0.42 is farther from a whole number because its choped up into more and more numbers so it gets farther and farther from a whole number which makes it smaller. (Grade 6)

Through the description of their reasoning, the students confirmed that they were not linking any previous understanding of whole numbers to the new concept of decimal numbers. Our observation based on journal responses seems to concur with the observation made by Wearne and Hiebert (1984) that, in spite of the logical extension of positional place value and the clarity of the stated relationship between decimal numbers, many students did not make the necessary connections between the previously studied domain (whole numbers) and decimal numbers.

2. In our lessons, students could assess what they viewed as strengths and weaknesses that they believed affected their learning.

Examples of student journal entries which support this observation include:

a. What would really help me is if you could just go a little slower.

b. Sometimes I get board because I get tired and confused when you talk for the hole forty five minuits. I would rather work on pages because I can have time to think but when you talk and ask questions I don't even have time to think because people have already told the answer.

c. I'm having problems understanding. You are teaching me too much stuff and I'm getting confused.

d. You teach so that I understand. At my old school they never repeated anything.

We learned that students wanted to be heard, as they related comments about what might help them learn better. We learned that their requests must be considered and must result in an instructional change or, at the very least, an explanation of why an instructional modification was not possible.

> *"I feel more confident in math. I'm not afraid to give a wrong answer now. . . . It feels like your a friend trying to teach—not a teacher trying to be freindly. Thanks!"*

3. Students had sufficient awareness of themselves as learners to indicate what worked or did not work for them.

Students wrote in their journals as follows:

a. On the test I found question 6 a bit confusing but what I think is before you do a test you know all the answers but while your doing it your mind can't think as before but after you can. So if I could do another test I would because I think I'd like to get at least a B or a C.

b. I feel it is fine but why do you have to write it (decimals) out in blocks when it saves time in numbers.

c. I think I learn alot when I'm sitting up front. Sometimes I start to get how to do it, the base ten system, but then people ask different things. I get really, really confused. I try to understand what they're asking but it's hard when I'm trying to understand place value and whole numbers, too.

We learned about the insights students gained into their own learning processes. Mumme and Sheperd (1990) write that "when we ask students to talk or write about their thinking, we are telling them that we value what they have to say. . . . By pre-

senting what they think is important, students exercise greater power and control over their learning, that is, they become empowered" (p. 19).

4. Personal feelings and emotions were readily explored and expressed as trusting and personal relationships were built in the journal communication. The lines of communication were seen "to be open," and at times the journal served as a therapeutic tool.

Some typical entries which support this observation are listed below.

a. I'm a bit scared after what happened in mathematics to-day. Please help me, I am scared.

b. I am trying to listen but my hand is always tempting me to do something. Sometimes I can't stop myself and then I get caught. I'm going to try harder and hope I can have more self-control.

c. Sometimes I like Math but most times I find it very difficult, and when I get home I feel like throwing my math books in the garbage. But sometimes when I learn something I feel overjoyed and very proud of myself.

d. I want you to know I have quite a temper, if I have much trobel in anything.

e. I feel more confident in math. I'm not afraid to give a wrong answer now. The math room is nice to walk into. It feels like your a friend trying to teach—not a teacher trying to be freindly. Thanks!

No real attempt was made to "teach" mathematical concepts through the journal responses, but an effort was made to inform students whose answers were off-track that their misconceptions or concerns had been noted and would be attended to. . . .

As teachers, we learned a great deal about our students when we listened to their feelings and emotions. We learned that affective concerns are as important in the teaching/learning process as are cognitive concerns.

5. Students shared their difficulties and problems with decimal learning because the journal was not seen as an evaluative tool.

The following examples support this insight into students' thinking:

a. I think I could use a little work in decimal reading. It's not the number so much as deciding whether a tenth, hundreth or thousandth is the first place value.

b. I am priety sure I understand about whole numbers, but decimals, I'm a bit confused about them. I understand about place-value. I don't understand about the base-ten system.

c. Today I understood about decimals but some of the words you said were confusing, but then when you talked about it, I understood it.

d. Can you help me with rounding 10's and 1000's? Can you also help me in writing expanded, standerd and written form? Decimals I understand now better than I did before.

Students chronicled their frustrations and their confusions as they reflected on their learning in mathematics. They saw the journal as a place to take risks, to make mistakes, to sort out and to be open about problems they had in understanding mathematics. They also became aware of what they knew and what they did not know. As a result, they could then begin to exercise some control over their own learning. Thus, writing in the journal empowered them in still another way. At the same time, they informed us of their difficulties in their development as mathematical thinkers.

6. Students shared their discoveries and their insights in the journal entries.

The following journal entries support this observation:

a. I used to think math and decimals wouldn't help me at all, but the other day I had to use it for science. In French we read for equations. Even in music. I was amazed how much we use math.

b. Over the years, I've learnt the basics of math. I've learned everything is mathematical. Pretty soon I will be getting an appliance in my mouth. It is a mathematical structure.

c. I have a question for you and if you can answer it, tell me when you write back, OK? Where is mathematics on paper and what kinds of mathematics are on paper? I know the answer and I'll tell you what it is next time.

We learned that, while students looked forward to responses to their journal entries at any time, they were particularly interested in responses to journal entries on insights made entirely on their own. So while they chronicled their mastery of new concepts, their personal satisfaction and accomplishments, and their pleasure of doing mathematics, students also "chronicle(d) their breakthroughs. . ." (Thompson, 1990, p. 90).

What Was the Nature of the Teacher Response?

Teacher's responses to the journal entries were regular and sincere but not judgmental or evaluative. They consisted of comments, questions, notes of encouragement, and/or assurance. They showed that the teacher was "listening" and cared. No real attempt was made to "teach" mathematical concepts through the journal responses, but an effort was made to inform students whose answers were off-track that their misconceptions or concerns had been noted and would be attended to in large or small group instruction or through some peer tutoring. However, if a succinct explanation could be offered, it was. Generally speaking, the intent of the response was to "assure, teach, reteach, suggest, nudge and question" (Thompson, 1990, p. 92) and to share one's own thoughts and experiences with students in as positive a way as possible (Tierney, Readence, & Dishner, 1985).

In essence, the journal was the private interview or the hotline between a student and teacher.

For example, teacher responses included:

a. Thank you for telling me what to help you with. I will make sure you have a partner each class to go over these ideas.

b. Are you telling me you are having trouble? As for your temper, that does not seem like a mature way of solving any problems. Maybe talking it over with someone would be a good idea.

c. The base ten system is a very good example—but can you explain this a little more, using the base ten system and the idea of place value?

d. Sally, 0.5 is the same as 0.50. So 0.50 is larger than 0.42.

e. I really do care. And when you say you feel wanted and welcome, THANK YOU—because everyone should feel wanted and welcome. Keep working every night at home and paying attention in class, and I am sure you will do better than ever before in math.

f. Remember the number in the tenths place always determines which decimal number is larger!

Conclusions

We found that the journal entries provided a window on students' thinking processes, a way to look in on students' thinking. We could "get into students' heads" without holding private interviews. In essence, the journal was the private interview or the hotline between a student and teacher. It was also a realistic way to listen to all the students individually. We began to really listen to what students did or did not understand, and we began to adjust our instructional approaches accordingly. Information gleaned from the journal entries allowed guidance and instruction on a more individualized level. It allowed us the opportunity to reflect on the teaching/learning process and to better meet the instructional needs of each of the students. For many students who were nontalkers, talking on paper also proved to be easier than talking directly to the teacher. The journals, as a writing-to-learn activity, also let students discover things about themselves—to reflect on their own learning. Just as importantly, the journals allowed the teacher and students to share in a one-to-one communication.

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