

Journaling in the Secondary Mathematics Classroom

An Introduction, Defense, and Resource

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Dave sits near the back of the class during Algebra every day. He is one of the loners--a student who rarely speaks a word to anyone and never participates in class discussion. He sits quietly with a faux air of attentiveness that keeps the teacher focused on her lesson and not on him. The truth is that Dave is lost; Dave has not understood any of the topics for many weeks. He was doing OK at the start of the term, finished and turned in most of the daily assignments, and even got a B on the first quiz. But things fell apart after a while, and he could not quite keep up with the pace. Instead of asking for help, he would "listen" to lecture and pretend to do his assignments, either only copying the problems from text to notebook or writing random numbers and symbols on his paper. Since handed-in daily work usually was not thoroughly checked by the teacher for accuracy, Dave was able to get away with this until his quizzes and test scores gave him away. At that point, however, it was too late--he was poised to fail the course, and failure would mean he would not graduate in May. Dave was transferred out of Algebra and into a half-semester computer class.

Could anything have been done to help Dave?

One solution could have been for the teacher to meticulously check all students' daily homework. This, however, can consume most or even all of a teacher's preparatory time, time better spent with lesson planning and extracurricular supervising. Another suggestion may have been to expand classroom discussion, encouraging Dave to verbally explain mathematical concepts or work problems on the board in front of the class. Considering Dave's quiet, withdrawn manner, this may

have caused him high stress, and, with teacher and peer assistance while working problems, his lack of knowledge potentially may not have been easily detected.

Another solution, one that many from traditional mathematics settings would consider unorthodox, is the loosely defined method of "journaling." Journaling, which usually involves writing of expository--or explanatory--nature, prompts students to describe math concepts in their own words and can allow students to express their feelings about mathematics and how they are learning the mathematics. Journaling can also be more open-ended, encouraging students to express mathematics in terms of poetry and even art. The written dialogue is one-to-one with the teacher, facilitating a closer relationship between instructor and learner. The practice of journal writing in the mathematics classroom is lauded among users and supported by national mathematics organizations but remains relatively unpopular nationwide due to uncertainty and misconception. By connecting the languages of mathematics and English, this tool gets to the core of students' comprehension and provides the teacher with assessment opportunities traditional tests and quizzes cannot hope to match.

The strong potential of writing in the mathematics classroom was not fully realized until the early 1980s as a result of the "Writing Across the Curriculum," or WAC, movement. Dr. David R. Russell, assistant professor of English at Iowa State University, discusses the history of this phenomenon in his essay, "American Origins of the Writing-across-the-Curriculum Movement." This plan to improve both student writing skills and education as a whole was formally recognized in the mid-1970s.

While initial stirrings were felt in the 1960s and early Seventies, 1974 brought two reports that jarred public and professional awareness of the status of writing in American schools. One report came from the officials of the National Assessment of Educational Progress (NAEP), a test administered every five years that had begun in 1969. In 1974, their second testing of American students, the results showed a decline in student writing skills from the previous testing. These results were considered inconclusive since more testing was needed to determine a significant pattern, so the NAEP officials called for "caution in making global statements about writing" (35).

Then came a *Newsweek* cover story on December 8, 1975, titled, "Why Johnny Can't Write." "Willy-nilly," author Sheils Merrill charged, "the U.S. educational system is spawning a generation of semi-literates" (Sheils 58). Academics hoisting the article and the NAEP report (despite its indecisiveness) as their battle standards began campaigning for reform in the way writing was taught and used.

Traditionally, writing has been used almost solely in the English classroom. Granted, some history teachers, for example, may ask for a term paper, but the brunt of the writing done by high school students is isolated in classes about writing and literature. This phenomenon was exacerbated in the post-World War II era by increases in technology; students could be more efficiently tested with fill-in-the-circle answer sheets that could be scored by machine (Bauer).

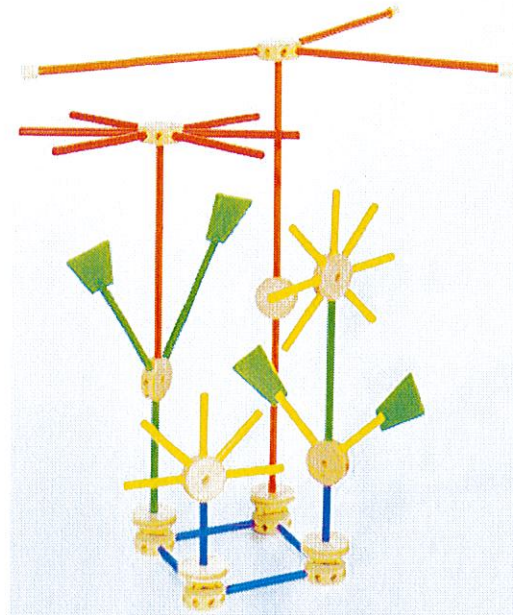
In 1977, Janet Emig, an education professor at Rutgers, wrote the essay "Writing as a Mode of Learning," a piece that integrated British research begun a

decade before with the educational psychology theories of psychologist Lev Vygotsky and other researchers. The essay addressed what would be the central themes of WAC: writing has "unique value for learning" not limited to the English classroom but in *all* disciplines, and that writing is a "central academic process" (qtd. in Russell 36).

The work of Lev Vygotsky, a prominent name in educational psychology, contributed strongly to the push for writing in all subjects. Vygotsky, a psychologist in post-World War I Russia, theorized that children learn by using speech as a tool. He observed that, when given a problem, children will naturally try to make sense of it by using speech, "often first verbalizing a situation to make sense of it and then internalizing their speech as part of self-regulated thought" (Langrehr and Palmer). In other words, to integrate new knowledge into memory, learners will talk to themselves about it and then think to themselves about it. Vygotsky believed that writing then forces the learner to "compact inner speech maximally so that it is fully understandable, thus necessitating the deliberate structuring of a web of meaning" (Pugalee 308). Before a person can communicate ideas in writing, he must have established a strong understanding for himself and then must consciously transform his thoughts into language that others will be able to understand.

The theories of Vygotsky also contributed to two areas of educational psychology: metacognition and constructivist learning. Metacognition can be thought of as simply "thinking about thinking." Thinking about how to approach a given problem and evaluating progress towards the solution would be considered metacognitive activities. Journaling allows the teacher to see the metacognitive

processes of students. Constructivist learning can be visualized by a set of Tinkertoys™. As we learn new ideas, the theory maintains, we build new knowledge upon knowledge that we already possess. Each new fact is a spoke added to one or more of the wooden hubs of our mind. The theory can be broken down into four methods of learning: knowledge is constructed *physically*, *symbolically*, *socially*, and *theoretically*. Knowledge is *physically*



Tinkertoys: "Flower Garden"
http://www.tinkertoy.com/default.asp?x=creations_junior

constructed by learners who learn actively. Copying lecture notes from the board is passive; independent writing forces the learner to answer questions and expand upon a subject. Knowledge is *symbolically* constructed when a learner makes his own representation of action, or communicates knowledge in his own words, while knowledge is *socially* constructed by a learner conveying her meaning-making to others. Knowledge is *theoretically* constructed by a learner explaining what she does not completely understand (Gagnon, Jr. and Collay), such as when the teacher asks an unsure student to "talk through" a problem or idea the student is having difficulty grasping. Writing touches each of these four learning areas, making it a powerful constructivist learning tool.

Due to this research about writing's benefits and its relevance to accepted educational psychology ideology, small WAC programs began springing up in

colleges and universities to inform educators. The idea soon spread nationwide. Classes and workshops promoted the idea of using writing in all classes even as national focus shifted in the early 1980s to other academic topics of concern such as the inclusion of culture and ethics (Russell 29-38). As the Eighties progressed, writing gained a stronger presence in the mathematics classroom, notably in the form of journaling.

Merriam-Webster Dictionary defines a *journal* as "a record of experiences, ideas, or reflections kept regularly for private use." A journal entry in the mathematics classroom is just that--a collection of a student's thoughts where the privacy is kept between the student and the teacher. Journal entries can be categorized for convenience purposes, but many can address more than one category. One type of journal entry would be a free-write, where students can write about anything they wish, as long as it connects to mathematics. Other types of entries begin with a *prompt*, a question or statement provided by the teacher.

Prompts can be categorized in many ways. One method groups them into three areas: affective/attitudinal, mathematical content, and process (Dougherty 557). An affective/additudinal prompt is more creative and personal in nature and can ask a student their feelings about the class or about mathematics in general. Two examples are for students to complete, "My best experience with math was when..." and, "When it comes to math, I find it difficult to...". A more creative prompt would be, "Design two mathematics bumper stickers." The second type of prompt, mathematical content, concerns writing that delves into mathematical terms and operations, asking

the student to discuss them in their own words. Students can be requested to describe a square root or to tell how fractions are used in their everyday lives. The third type, process, asks students to detail their problem solving techniques and classroom habits. Examples include, "What does it mean to solve an equation?" and "When I study for a test, I...". A list of one hundred categorized example prompts can be found in Appendix A.

To examine the numerous positive effects of journaling, specific journaling experiences from national publications will be detailed and commentary will accompany each. Each instance highlights one or more benefits to both student and teacher that journaling provides.

One of the primary purposes of journaling is to *observe the thought processes* of students. Arthur Powell, associate professor in the Academic Foundations Department at Rutgers University, quips that "a nonintrusive technology does not exist that allows us to view in real time the workings of our students' minds as they work on mathematics problems" (21). Such science-fiction technology is unnecessary, however, since the goal of seeing students' thinking can be met with the simple use of pencil and paper.

Powell employed journaling in an Algebra class when covering the topics of greatest common factor (GCF) and lowest common multiple (LCM). When asked to explain the GCF, one student wrote:

"I found that I could find the greatest common factor of two integers by first finding common factors of both integers and then by taking the largest common to both, e.g., (24,30) 1, 2, 3, 6 GCF = 6." (21)

This student correctly and efficiently explains the concept. He chooses two example numbers, 24 and 30, lists their common factors (the numbers that will divide both of them), and chooses the largest of these as the greatest common factor. His writing shows his thinking is clear, and by expressing this abstract topic in his own words, he has *internalized the process*.

A writer must organize information clearly in order for her prose to make sense to the reader. Not only are the thoughts solidified in the student's mind by writing, but they are also made tangible for the teacher to assess. "If students write clearly about mathematical concepts, then it is apparent that they understand them," notes educator Marvin L. Johnson. "Students who are required to write must do considerable thinking and organizing of their thoughts before they write, thus crystallizing in their minds the concepts studied" (117). Additionally, with writing, students themselves will realize whether they truly understand a concept. If a learner finds difficulty in writing an explanation, she may realize she does not have a strong enough understanding of the topic at hand. This brings a self-assessment element to journaling.

Another student entry concerned the LCM. This student wrote:

"The way one goes about finding the LCM of a group of integers is by looking at the prime factorization of the integers in the group, then picking out the common prime factorizations, thus giving one the LCM, e.g., $\text{LCM}(28, 36) = 2^2$, since $28 = 2^2 \times 7^1$ and $36 = 2^2 \times 3^2$. In this case, 2^2 is the LCM." (21)

This entry shows a misconception, but the student's thinking is not entirely wrong. Looking at his definition, the teacher saw that he has written about how to find the **GCF** instead of the LCM; he simply has confused the names of the two processes. In a test situation, this response would have meant a loss of points. But since the error was made in a journal, the teacher has the opportunity to respond appropriately to correct the simple misconception. The teacher can praise the student for knowing the method of how to find the GCF, stressing that *process is more important than product*.

"Too much emphasis on product and a corresponding lack of attention to process hinder learning," writes educator Anne Wescott Dodd. It is entirely possible for a student to get the right numerical answer for a math problem by guessing or by using a faulty method. If this is the case on a student's paper, the teacher has no chance to amend the incorrect thinking, even if the student attempts to show work (297-8). Teachers should not have a superficial, black-and-white sense of "right or wrong" but should instead focus on how students are approaching tasks and solving problems (NCTM 24). Students most likely will not have to solve story problems in their future occupations, but they will have to utilize problem-solving skills. Journaling

is an avenue allowing teachers to critique students' thinking and see how they are connecting mathematical ideas.

Journal prompts, even those with a less "personal" bent, can elicit some delightful results. Barbara Dougherty asked her Algebra students, "How would you describe a square root?"

"Dr. D--I could just look in the glossary. Hee! Hee! But . . . you'd probably notice it. And anyway, I guess I'm supposed to give my own opinion.

Describing a square root can be compared to describing the color green to a blind person. It's very hard. I'd say that the square root of a number is its square! It's the number that squared gives you that number. For instance, 25. The square root is 5. And the square of 5 is twenty-five. It's sort of like multiplication and division, like fact teams. $5^2 = 25$, $\sqrt{25} = 5$." (557)

This entry is a perfect example of how *students' personalities shine through*.

Since there are only so many minutes in the class day, few can be spent getting to know the students. Rare are those young people who will sacrifice peer social time in order to parley with a teacher. Through journaling, teachers have extra opportunity to know the students as individuals, not as entries in a gradebook. The above student answered the question posed to him and entertained both himself and his audience, the teacher. A test drilling numerical facts would not have allowed this expressive side to come forward. When journaling is done on a regular basis and the teacher consistently offers written comments in return, a bond of trust is forged, and

the students allow the teacher to get into their hearts as well as their heads (Ciochine and Polivka 318).

A second student in Dougherty's class answered a different way:

"Say there is a number **a**. The number **b** that, when multiplied by itself (squared), equals the first number **a**.

Ex,

$$\mathbf{b^2 = a}$$

↑

square root of **a**

OR

$$\mathbf{b = \sqrt{a}}$$

↑

↑ The radical sign shows that

|

b is the square root of **a**. (52)

This neat entry shows a learner able to *organize information*.

This student has taken the concept of square root and has clearly explained it in several different ways that are easy to follow and understand both for herself and for her teacher. Some students, when not entirely sure of a concept, will write correctly but chaotically, saying "as much as possible, with the objective of maximizing partial credit" (Keith 715). While the entry will still have merit, the teacher can respond appropriately to help the student "clarify, refine and consolidate" their ideas (Ciochine and Polivka 319). In this case, however, the writing is succinct and tidy, showing the command the student has over the subject matter.

Brian, a student of teacher John G. Ciochine, provides another creative response to a journal prompt more work intensive in nature. Students were to answer the question, "How far is it to the cafeteria?" Brian answered with a short essay:

How Far Is It to Lunch?

It's way too far. I have the last locker in the . . . hall. I believe I might have the longest walk. First thing I did was picture the 1st hall. Then I thought of the closest and easiest thing I could measure, my room. My room is about 9 yds long (pretty small). Then I visualized my room inside the hall. Then I moved it from end to end. I could fit about 6. So I believe it's about 54 yds., minus (because the problem starts at Mr. Ciocine doorway) about 27 yds. Then I have to turn the corner. I can fit about 2 bedrooms in there, which is another 18 yds. Now we have a total of 45 yds. Then the next hall I would say is about 4 bedrooms. So that's 36 yds. Now we've got 81 yds. Next, the staircase, that's about 3 bedrooms, another 27 yds. That gives us about 108 yds. The next hall looks like $3\frac{1}{2}$ rooms. Making about 41 yds. Now having 149 yds., we've got 2 halls left. I will combine the next two and say 4 bedrooms which is about 36 yds. So after all that I believe we've walked 185 yds. Which is way too far. (318)

To divine the distance to the lunchroom, Brian did not guess, and he did not reach for a tape measure. Instead, we see *the problem solving methods* he uses to reach his solution.

The act of problem solving is as unique to students as their personalities. If a class is asked to write about their problem-solving techniques, several approaches to

a single problem will appear in their journals. These methods can later be discussed as a class, reinforcing to students that there can be multiple correct ways to solve any specific problem. While Brian used his room as a measuring tool, other students may have used their heights or other measures. Respect for diversity of thought creates a comfortable atmosphere conducive to written and oral discussion of mathematics (Dougherty 558).

Also in the above example, the student uses estimation. Perhaps his estimation is not of the finest quality, since a nine yard room seems a bit large, but he is *actively learning* by bringing information from his own life into his problem solving. Writing allows students to work on a more personal level, "using their own language and real-world experiences" (Nahrgang and Petersen 461). Any method that helps students make those connections, be it by comparing factoring to taking apart a carburetor or describing an inverse as a "turn of a phrase" in English, should be encouraged, as this active importation helps students retain the mathematics and make it relevant to them.

The next two entries were made by a student named Seth.

"What I don't understand about sections 3-1 to 3-3:

Sections 3-1 to 3-3.

Not a joke.

What I do understand:

Standard Form: $Ax + By = C$

Pt. Slope: $y - y_1 = m(x - x_1)$

Slope Int.: $y = mx + b$

Formula for Slope: $\frac{y_2 - y_1}{x_2 - x_1}$

Okay, so I know these equations, but I have no earthly idea where and when to use them. That's my main problem. A little problem: graphing the things when I'm through. I don't think I've understood one thing in Algebra on the first go around yet. That's pretty scary. But is it because of A: a lack of concentration on my part, or B: a lack of cooperation by the Algebra gods? I think answer A." (Elliott 92)

Seth is indeed having some problems. He is confused, and he says he does not understand any of the sections. He does know some formulas, but he does not know how to use them. In his own words, "That's pretty scary." Seth probably is experiencing what is called math anxiety, or math phobia.

When a student has a negative learning experience in a mathematics class, especially in the middle school or early high school years, chances are likely the feeling will persist long after the class has ended. The feeling may last so long that the sufferer may not be able to remember a time where math was fun or accessible. Even the mention of math will invoke dread, confusion, and hopelessness, rendering the victim virtually unable to learn.

There is a cure for this crippling condition. Anne Wescott Dodd, a former English teacher, was a longtime sufferer from her public school days until well into adulthood. The cycle was broken when she visited a friend's statistics class, and, when listening to lecture, realized she could understand the lesson. Later, when she

struggled with difficult material on her own, she conjured the positive memory of her classroom experience to motivate herself, and this positive reinforcement kept her from giving up on the assignment. Another day, when she was attempting to access some computer data for an assignment, she had difficulties logging-in. She took a break and tried later but got the same errors, causing some frazzled nerves. Another day, a teaching assistant was there to help her, and the aide's gentle, supportive comments drove away the anxiety.

"When students are anxious," Dodd writes, "they need teachers who are patient and encouraging." Teachers need to be extremely careful with the language they use in the classroom. When confused, students often believe they are the only ones in the class that do not understand, so they do not ask questions in front of their peers. On one occasion, when Dodd asked a question in her statistics class, the professor jokingly said, "I feel like I'm back teaching seventh grade." If a similar comment were made in a middle school or high school classroom where peer acceptance is an overpowering force, the results of such an unintentionally demeaning comment could be disastrous on a student's psychological state and ability to learn. A small misconception may completely halt a student's learning if she fears asking for help to clarify her thinking (Dodd 296-7).

Journaling can assist in both of these areas. Teachers have more time to carefully respond to questions posed in journal entries, and they can purposely use supportive language in order to boost student confidence. The chance of writing a potentially hurtful comment becomes substantially lower. Since journaling is a private

communications channel, the student does not have to fear peer derision when he wishes to ask for assistance.

In Seth's next entry, we see a change in attitude.

"Time: 8:01.12. Place: HE2, North Stafford High School, Stafford, VA, USA

I have just had a wahoo!

I was subtracting the wrong things for slope--call me a dummyhead, but I did. . . .

What I was doing wrong: $(6, 8)$ $(9, 2000)$

If those were my numbers, I was taking the first and just arbitrarily calling them both x's and for the next set y's. It must have been a power trip or something." (Elliott 92-3)

Seth has discovered an error and is able to share his "wahoo" moment, or mathematical epiphany, with the teacher. The more positive tone of this entry can be felt; the journal discussion between student and teacher has *decreased math anxiety*. "The first goal of every teacher," Dodd believes, "should be to help students come to believe that they can learn" (298). The "can't" mindset fear of mathematics can instill in a learner is a formidable force, but not an indestructible one. A teacher's positive, personal comments have the potential to change this time-acquired attitude. Seth has progressed from being cursed by the algebra gods to discovering and correcting errors in his mathematics--from math phobic to math fan with the aid of pencil, paper, and a supportive teacher.

Another student in Seth's class produced a memorable entry in the days following an exam. Mike said, "This test is going to nearly-failed math test hell; excuse me, 'heck.'" Then this quiet student went on to express some frustrations:

"There was a test in Algebra Two
But not enough of my answers were true
So I asked my teacher, "Where did I go wrong?"
She said, "Look, you scrub, I haven't got long
So let me decide in the simplest way
How to explain why you ate it yesterday"
I said, "Let me be, I don't need no help"
She said, "Then be gone, thou idiot whelp!"
I'd lost my confidence in one single day
And continued to screw up in every possible way." (Elliott 93)

A teacher obviously would not speak to a student in the manner this poem describes. Nevertheless, the writing has served a significant purpose, for the teacher can see the high level of frustration and isolation the student feels.

This student failed a test, and although he does not give any details as to why this was the case, the journal does have the potential to be a medium for the discussion of external factors that affect performance. Students can use the journals to inform teachers about personal problems and other details they may be too shy to talk about in person (Stewart and Chance, 92; Dodd 298). If the teacher faithfully responds to journal entries in a positive manner, *strong one-to-one relationships*

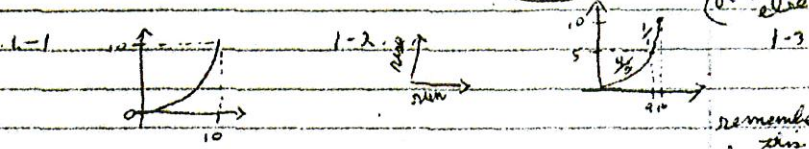
develop between the students and teacher. Students are reassured that their ideas, concerns, and individual needs matter (Powell 23).

The journal can then proceed to *build confidence and be a motivator* for students who have difficulties, be they personal or cognitive in nature. Here is an example of how one teacher responded to an AP Calculus student's entry:

13

How does a curve have a slope?

The best way I can explain my answer is to draw a couple of diagrams and also reflect on what you taught us about the slope of a line at a tangent. Note diagram 1-1 below. ^{Not all} no curves has a definite slope, ^{mean constant} (or something else?)



but you can find the average slope or an instantaneous slope. The average slope for the graph in 1-1 is $\frac{1}{1}$. I found that by finding the rise divided by the change (Δ) run [1-2]. Now I found $\frac{1}{1}$ to be the slope average slope assuming that the curve is near straight for the period I am finding the slope for. Now let us say that the curve has a different steepness towards the middle or up. Graph 1-3 illustrates my explanation. In this case I would find the slope for the period of (0,0) to (9,5) and the period (9,5) to (10,10). The slopes would be $\frac{5}{9}$ and $\frac{5}{1}$. Remember: graphs are not drawn to scale.

Now you can find the slope of any point on the curve by finding a line tangent to that point. The slope of the tangent line becomes the slope of the point on the curve.

Well done!

Well done, You show a good understanding of average slope, but I'm not sure about the instantaneous slope and its connection to the tangent line. Could you expand on that connection next time?

In the right margin of the paper, the teacher has marked the student's error in the use of a term. There is also a bit of humorous banter, as the student uses a word, "instantaneous," that must have made an impact in lecture. At the bottom, the phrase "well done" appears twice, the teacher making a point to use supporting language to reward the student for his efforts and build his confidence. The teacher also asks in a non-threatening tone for clarification of how slope relates to tangent lines, motivating the student to respond in the next entry.

Speech is ephemeral, existing for mere moments after spoken. Writing, however, is *a stable medium* that can be used for days to correct or reinforce concepts or for months when studying a student's overall progress (Powell 23). Speech has the benefit of facial expressions, hand gestures, and corroborating signals from the audience to help it along. Writing, however, is independent; returning to the theories of Lev Vygotsky, a student must be perfectly clear when transmitting information in writing.

The preceding examples have shown ten major benefits of journaling in the mathematics classroom.

1. The teacher can observe the students' thought processes.
2. The students internalize what they learn through writing.
3. Journaling emphasizes that process is more important than product.
4. Students' personalities shine through in their writing.
5. Journaling facilitates the organization of information.
6. Teachers can see the students' problem-solving methods.

7. Journaling emphasizes active learning.
8. Journaling can be a tool to decrease math anxiety.
9. Strong one-to-one relationships can develop between student and teacher.
10. Writing is a stable, physical assessment medium.

While each of these goals can be accomplished through other activities in the classroom, journaling is one of the only instructional tools that, when standing alone, can meet all ten.

While journal entries can be informal and spontaneous, the writing can also be more formal in nature. Terry Bagley and Catarina Gallenberger use the same format each time they ask their students to write a journal entry. This six-part template shown to the right addresses the topics learned on that day, combining expository work with personal reflection. These entries can be gathered together in a portfolio in order

Date _____
In your own words state today's goal or goals.
What was the special topic of the day?
These are the strategies we learned today:
What was your "AhA" [now, I understand!] today?
I'm still confused about:
Today in class I felt _____
because

Source: Bagley, Teresa and Catarina Gallenberger. "Assessing Students' Dispositions: Using Writing to Improve Students' Performance." *The Mathematics Teacher* 85.8 (1992): 660-3.

to view a student's progress; such a record is valuable for parent/teacher conferences. Some teachers would like the consistency of this prompt style, while others may find it too restricting.

Other journal ideas could be used over the course of several days. Cherlyn Kern writes about a descriptive paragraph miniproject she uses in her geometry class. The goal of this project is to help students master geometry definitions. She gives her

students one week to write these riddles, and the students share in small groups as well as with the entire class. The students become so involved in the project, admits Kern, a dictionary must be used when she grades them (362). Here is an example entry from Gabriel W.:

DESCRIPTIVE PARAGRAPH MINIPROJECT

To improve your mastery of vocabulary terms, you are to create and write your own descriptive paragraph about an object with which everyone should be familiar. You cannot identify your object, so your description must be sufficient to allow a reader to deduce the object. Include at least five geometrically descriptive terms, but you may use as many as you need to describe your object successfully. Be careful when using terms to describe two- or three-dimensional figures. Be brief!

On a second sheet of paper, write the name of the object, then list each descriptive term you used and its definition. The second sheet of paper is the answer key. Include your name, date, and class on both sheets of paper. Neatness, spelling, and correct grammar, along with creativity and originality, are included in your evaluation. This project will be due on or before _____. Five points will be added for projects turned in early. The grade is treated like a quiz.

Source: Kern, Cherlyn. "Descriptive-Paragraph Miniproject." *The Mathematics Teacher* 90.5 (1997): 362-3.

"A child receives a present which contains several items that are each made up of two solid shapes and consist of a colored waxy material. Each item is a solid truncated cone attached to one base of a solid cylinder with the second base being convex. The diameter of the base of the cone is less than the diameter of the base of the cylinder."

A second riddle is not solved as readily:

"[This figure is] a garish, parchment cone bedizenment, exhibited upon one's cranium with dualspheroid apertures opposite its vertex, consociated with a rubber strap and can be found at a convivial soiree." (352)

The answers along with more examples appear in Appendix B. The students delight in sharing their creations with one another, and most are practically unaware that they are learning powerful vocabulary along the way.

The inclusion of writing in the mathematics classroom is obviously not a renegade, isolated movement. On the contrary, the method has been promoted for decades across all academic subjects and is supported both nationally and locally by organizations that promote excellence in the teaching of mathematics. The National Council of Teachers of Mathematics (NCTM) has issued publications outlining how mathematics should be best taught. Their recommendations include using written communication as a means of assessment and increasing student comprehension.

The NCTM is an international, non-profit professional organization "committed to excellence in mathematics teaching and learning for all students" (NCTM ix). In 1989, they published three landmark documents addressing the teaching of mathematics. They began revising and updating these volumes in April of 1996, producing in 2000 the book/CD-ROM combination, *Principles and Standards for School Mathematics*. The document is a guidebook describing how the NCTM's vision of optimal learning and teaching can be attained. The text details that vision, proposes principles to guide teachers in classroom instruction, and sets standards for the mathematics content and processes that students should learn from kindergarten through grade twelve. Innumerable hours of research rests behind the proposals and claims contained in the text, where "much of the content . . . is based on the experiences and observations of . . . classroom teachers, teacher education researchers, and mathematicians" (NCTM xii).

There are six principles describing the features of high-quality mathematics education: equity, curriculum, teaching, learning, assessment, and technology.

Journaling has direct bearing on four of these principles.

- **Equity:** Excellence in mathematics education requires equity--high expectations and strong support for all students.

Journaling can be a great resource to provide support to the entire classroom.

Instead of responding to a potentially small number of students who are vocal in a classroom, journaling gets responses from all students so that teachers can respond to every individual.

- **Teaching:** Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.

As we have seen, journaling asks all students to express their thinking in prose. The closer relationship that journaling cultivates between student and teacher creates a positive atmosphere that motivates students to clarify and expand on their ideas.

- **Learning:** Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.

Journaling actively builds knowledge by allowing students to express mathematics in their own words and on their own terms.

- **Assessment:** Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.

The one-to-one contact journaling provides facilitates the exchange of many kinds of useful information. Students can each ask the specific questions they have, and teachers are able to give detailed feedback as well as individualized praise to keep them learning and motivated.

In introducing the Standards for mathematics in grades 9-12, the NCTM notes:

"Secondary school students need to develop increased abilities in justifying claims, proving conjectures, and using symbols in reasoning. They can be expected to learn to provide carefully reasoned arguments in support of their claims. They can practice making and interpreting oral and written claims so that they can communicate effectively while working with others and can convey the results of their work with clarity and power." (288)

It has been shown how writing helps students meet these expectations. New is the notion of practicing arguments. Journals are an excellent way for students to gain experience in explaining concepts and defending their positions. Once confidence is built, students will feel empowered to share in oral discussion with their peers.

Of the ten standards detailed in the text, one standard was specifically established to address the oral and written learning that occurs in the classroom. The Communication standard asserts that "communication is a fundamental element of mathematics learning" (348). Communication skills are essential in the workplace, so the development of these skills helps students both inside and outside of the classroom. The standard verifies the value written communication has for

assessment, since writing gives teachers insight into student misconceptions. The teacher's role in communication, they say, involves creating a classroom climate that is conducive to discourse. Student knowledge should become a starting point for instruction (348), and journaling is a device that makes this possible.

If so much support is given to journaling by national organizations and by teachers who use it, then why is it not more popular in schools? When a colleague suggested he use writing in his mathematics classroom, teacher John Ciochine responded, "I teach mathematics, not English" (316). Many mathematics teachers still believe that writing is a tool of the English classroom, despite the work of the Writing Across the Curriculum movement. But even when mathematics educators are convinced of the value of writing, there are still many issues that cause enough trepidation to keep teachers from trying journaling in their own classes.

One of the main issues is time. A teacher identified as Brenda comments, "I have enough trouble getting through the material as it is without incorporating something else into the lessons." Betsy predicts, "I see others using it. It seems to create a great deal of extra paper-grading time" (Quinn and Wilson 18-19). These concerns have merit, because journaling does have the potential to be a burden. If implemented the right way, however, journals do not have to add to the teacher's already substantial workload.

For many who use journaling, experience has shown daily writing becomes "laborious" for the students and is not necessary (Bagley and Gallenberger 661). Instead, writing every few days seems to work best. Teachers should take care to use

mathematical content prompts, those that ask students to describe terms and operations, at least three or four days after a concept has been introduced in order to give the students time to mentally explore that concept (Dougherty 557-8).

It is up to the teacher to decide when journaling should be done. Many choose to use it during the first few minutes of class, since "exemplary teachers do not waste class time" (Miller 354). As a teacher does administrative business like taking attendance, the students can be engaged in a prompt instead of chattering amongst themselves. Journaling helps students make the transition from their previous class and from the previous day's math class.

Other teachers prefer journaling be done at the end of class periods. As in Bagley and Gallenberger's prompt previously illustrated, an end-of-class writing session can ask students to summarize the day's lesson and ask any questions they have about the material. The last few minutes of class can be as neglected as the first, and journaling can keep the students thinking about mathematics instead of clustering by the door waiting for the bell.

Journal entries can even be written spontaneously in the middle of class. If a substantial amount of material is being covered on a certain day, the teacher can stop at the midpoint of the lesson and ask students to reflect on what they are learning. The teacher can walk about the room, reading student responses as they write (Elliott 92). Any recurring misconceptions can be clarified before moving on with new material.

Some teachers allow journaling to be done outside of the classroom on the students' own time. This method works well as long as the entries are collected the following day. If students are told to journal and the entries are all due on a certain date, some students will complete all their entries at the last minute, defeating the purpose of the journals (Bagley and Gallenberger 661). To prevent this outcome, many teachers require that separate journals be kept inside the classroom and do not normally allow them to be removed. This strategy or an overnight-assignment method will assure that students give proper thought to their entries.

Another idea that misleads teachers to think of journaling as a considerable time commitment concerns assessing the writing. To be most effective, informal journal entries should not be graded for spelling or grammar. To keep some reign on the language, however, complete sentences should be encouraged. This type of relaxed writing environment allows students to write without the fear of formal evaluation of their English or their mathematics skills (Nahrgang and Petersen 461). A teacher who corrects grammatical errors "tends to drive students into using a smaller vocabulary and taking fewer risks" (Keith 719). With journaling, the purpose is for students to explore what they know, not to mentally corral them with restrictions.

The time needed to read over and respond to the journal entries can be kept to a reasonable amount. According to L. Diane Miller, secondary teachers who use journaling say that twenty-five to thirty papers can be read in five to ten minutes since the entries do not require the critical eye that proofs and other computations

necessitate (354). Responding to these entries would take anywhere from thirty seconds to a few minutes each, depending on the content.

Teachers often do not know how to grade journal entries. When Cynthia L. Nahrgang began to use journals, she decided to grade each one and average the scores as part of the final grade. But she realized that this was not true to the spirit of journaling. Assigning grades, she was indirectly telling students how they should think and process information. She abandoned this method and decided to instead give extra credit points for the entries. A correct and thoughtful entry would earn two points towards the next major exam, a good effort would earn one point, and little effort would deserve no credit (463).

Nahrgang found that students valued the extra credit they earned, but just as important were the comments the teacher wrote on their papers. The inclusion of writing in the mathematics classroom itself does not "automatically generate effective teaching and learning" (Keith 717); the teacher must respond to the writing so the two-way communication can be utilized.

Before students' journals are assessed, the assessment method the teacher chooses must be explained to the class. Assessment rules must be clear, and students should be able to view examples of entries the teacher views as "good" and "bad" (Mayer and Hillman 432). Also, teachers must not set their expectations too high regarding the quality of writing they will receive. Students should know that the ideas contained in the entries are the essence of the exercise. Teachers should strongly consider modeling the process for their students, especially when writing

about problem-solving behavior. The students will be able to "see the teacher's process of thinking--in all its messiness," dispelling the myth that math teachers compute in a textbook-neat fashion (Ciochine and Polivka 320).

Considering my enthusiasm for the method of journaling, I thought the task of implementing this tool would come easy to me once I entered the classroom. But I found out otherwise as I began student teaching at Bemidji High School in the spring of 2001. I found that consciously making time for this unconventional method unmentioned by the textbook was difficult, but I managed to reap many benefits from the small amount of writing I was able to include.

One of my three classes was an accelerated geometry class of thirty-four students, a class that I taught for nine weeks. I only found time to use journaling twice in this class. My second attempt at journaling was assigned after distributing my second exam. This test came soon after the introduction of one of the most difficult topics in mathematics both to learn and to teach--proofs. I experienced my first real tastes of frustration and futility as I tried as many approaches as I could think of to lead my students through the challenging material, including some informal pre-writing called "plans." As the class began to work on the test, I readied some scratch paper for the students to use for a multi-part prompt I wrote on the board: "How do you feel about proofs? How do you feel about plans? How can I help you improve?" After the students finished their tests, they would bring them to me, and I would give them the scratch paper and point solemnly to the prompt on the board. While I

waited for all students to complete the exam, those who finished had at least one task to keep them occupied.

The response to this prompt was overwhelming! The students relished the chance to articulate their own frustrations, and, to my delight, many grudgingly admitted they needed rigor and constant practice to become better at proofs. My most shocking entry came from Buck, a student who signed his name to the entry despite the fact that I suggested names be left off to facilitate any and all comments. Buck was a vocal young man, often bellowing his frustrations and negativity during class until a look and a raised eyebrow from me would bring his decibel level down. Responding to how he felt about proofs, he noted, "I hate them, but I know I am getting better which is good." I had expected a rant, but instead I received affirmation that my teaching and personal support was helping him learn this difficult topic. Nick, a low-B student, also responded positively, stating, "I'm getting better!" Still others voiced their consternation, calling proofs a "waste of time," and asking, "What are proofs supposed to prove?" In general, though, the responses told me that the class was improving and their attitudes, while still a bit sour, were becoming more positive as they gained more experience.

Many wrote that plans, pre-writing about proofs focusing on the statements and not the reasons, were not as helpful to them as I had believed. "Plans are a little better . . . but they don't help me very much at all." "They make the problem a little clearer." From these responses, I subsequently focused less on plans during lecture.

The last part of the prompt asked how I could help make proofs easier for them. I did my best to have a proof of the day as well as several examples during class discussion, but the journals told me the students needed more. "I think all that will help me is going over them over and over..." One student suggested that we do more to "pick the proofs apart," one summarized the class needed "just plain practice," and another begged "don't give them to us."

One response prompted me to reflect upon what more I could do to aid them. "I think if we spend a couple days doing non-stop proofs of all different kinds maybe I can get a little better handle on it." As a result of this comment, I talked with my fellow teachers at Bemidji High School, and from their input I devised what was to be called the 2001 Proof-a-Thon. I worked for two days to compile a packet of all different kinds of proofs. I bought some balloons and streamers. From observing the students during worktime, I knew who would work well with whom, and I assigned teams of three or four, allowing them to pick team names such as "Size 13 Boots" and "The Denominators." On a Wednesday before a four-day weekend, a situation where students can become their squirreliest, I had the class happily engaged in group proof work for almost 80 minutes. The special event atmosphere and group collaboration definitely helped them learn.

This episode highlights another use of journals. Not only can teachers use writing to assess student development, but they can also use the entries to assess their own teaching methods. Student feedback alerted me to a need for a more intense approach to proofs, and, as a result, the entire class became more

comfortable with the material through the Proof-a-Thon. I also began to devote less time to "plans" since many students did not find them valuable. Because of their feedback, I was able to meet their needs and make better use of class time. I found their input to be invaluable, and I hope to continue and improve my use of journaling as I enter the education profession.

Since journaling seems to have such a positive effect on learning, statistical studies should numerically support the praise. Murad Jurdak and Rihab Abu Zein of the American University of Beirut attempted a study to prove the benefits of writing in the mathematics classroom. Their study, using students ages 11-13 (younger than secondary level), looked at the achievement variables of conceptual understanding, procedural knowledge, problem solving, mathematics school achievement, and mathematical communication. By studying two groups of students, one group who journaled and the other that did not, they determined that writing had a positive impact on conceptual understanding, procedural knowledge, and mathematical communication, but not on the other factors (412). The researchers had expected to find all of the studied variables to exhibit positive effects, especially on problem solving, so this result was puzzling. They attributed the result to the complex natures of both problem solving and journaling, since both of these topics can be approached in a myriad of ways (417). They also noted that the lack of a result showing mathematics achievement, or grades, improved because of journaling was due to tests not asking for the same type of information as the journals did (418).

Teacher Cynthia L. Nahrgang also attempted to find a data relationship between journaling and increased problem solving skill, but could find nothing strong. But analysis of the journals themselves "clearly indicates that students used their journals to think about solving problems associated with mathematical concepts" (465). Jurdak and Abu Zein also cited other studies done, the results of which sometimes contradict one another. A study performed in 1985 by Bell and Bell showed journaling had a positive effect on problem solving, where a study by Phillips showed no effects when journals were used in a trigonometry class.

While educators can see how journaling positively affects achievement, it appears difficult to produce concrete statistics proving this. The difficulties may rest in the nature of journaling itself. Journaling elicits unique responses from all students, and journaling is employed and assessed uniquely by every teacher. As Jurdak and Abu Zein noted, mathematics tests often do not ask for the same type of responses that journals do. Nahrgang suggested that her results not be considered as an absolute, since the data came from an "isolated setting" (465). But each mathematics classroom is in itself an isolated system, so journaling will produce different results. Despite the lack of empirical data, the dozens of nationally published testimonials show that journaling is effective, and organizations like the NCTM support the method. These facts should strongly indicate to any doubter the validity of journal use.

In published articles about journaling in the mathematics classroom, teachers who use the method unfailingly praise its effects and recommend their peers try it in

their own classrooms. One area of opinion that articles seem to neglect is how the students feel about journaling. Lynn Havens's students were upset when they learned they would have to write, but after a while they agreed that the experience was positive "both scholastically and personally" (554). Students appreciate the chance to be heard (Keith 717), and many students enjoy writing simply for the fact that it is "unusual" (Elliott 94). One student wrote, "I didn't think I understood . . . but after having to write about . . . [graphing] I'm pretty sure I do. I never thought I'd get it!" (Mayer and Hillman 429) "I like it and feel good about what I am learning" (Stewart and Chance 94).

This student entry is highly insightful, for she realizes benefits for herself as well as her teacher:

"Writing in journals is a privilege to be able to express your thoughts about the math work, the class, rules, and new ways to accomplish goals.

Writing in journals helps the teacher to understand you better. It also gives the teacher new ideas and new methods of teaching. Writing in the journals is a good way of communication between the class and the teacher. To me, writing benefits the students more [than the teacher]. The reason for this is, if the teacher never listened to your thoughts and something was going on you didn't like or want to do, then you would have to just accept it. But if she makes you write in journals, it means she does want to listen to you and you can work the problems out instead of just accepting it. If there is no real communication between students and the teacher, then it makes it harder to teach and learn." (Stewart and Chance 95)

Could journaling have helped Dave, the quiet student who eventually was transferred out of Algebra class? A journal could have helped the teacher identify the problems he was having early in the year. The one-to-one relationship created by journaling could have persuaded Dave to mention any personal problems that affected his performance. Journal writing may have kept Dave motivated. But the impersonal, textbook-blackboard atmosphere did not give Dave a reason to ask for help.

Journaling is not only a tool to build mathematical thinking, it is a support for the whole student on intellectual and emotional levels. The teacher becomes a sharer of information instead of a presenter, and the students become comfortable enough to offer suggestions on how the class can be improved for their benefit. Some teachers are hesitant to use writing since it interrupts traditional teaching methods. Although mathematics classrooms are becoming more dynamic, activity-driven places, many remain the traditional sort that Dave experienced, where a teacher lectures, problems are assigned, and student input is minimal. This model cannot stand, for communication has become a focal point of optimal mathematics instruction. Journaling in the mathematics classroom initiates that exploratory discourse, proving an inexpensive, inspirational tool that brings students to the center of the curriculum while connecting mathematics to their lives.

Appendix A: Journal Writing Prompts

Affective/Attitudinal Prompts

- Explain how you feel about mathematics now as compared to before you took this class.
- My best kept secret about math is...
- If math could be a colour (shape, sound), it would be...because...
- Write a letter to the newspaper editor explaining why more importance needs to be given to math education.
- My parents feel that math is...
- I want to become better at math so that I...
- People who are good at math...
- My best experience with math was when...
- My worst experience with math was when...
- When it comes to math, I find it difficult to...
- When I hear someone say math is fun, I...
- Draw a picture of a mathematician and describe what a mathematician does.
- Is journal writing helpful? Do you like writing in your journal?
- If I were better at math, I would...
- What kind of math figure are you? (Circle, square, triangle, parallelogram, etc.) Why did you choose that figure?
- Which trigonometric function are you? Why did you choose that function?
- Write a story, "If I Were a Centimetre Tall".
- Describe your feelings about showing your work on the board.
- What images come to mind when you think about (math teachers, tests, jobs involving mathematics, etc.)...
- Does mathematics or math class scare you in any way?
- Project yourself ten years into the future and describe your life as you imagine it at that time. Describe the role of math in your life at that time, and describe your math experiences in the years between now and then.
- My three personal goals for this term are...
- Describe how today's math class will affect your day.
- What is your favourite single digit positive number? List the reasons for your choice. Elaborate as much as possible on why it is your very favourite number.
- What did you like most about your previous math class. What did you like the least?
- I think I am a math student because...
- My math grade now is ...because...
- This is how I feel about Calculus (Algebra, Trigonometry, Fractions, etc.)
- Draw a cartoon of the 'Math Monster' and write what the 'Math Monster' is saying to you.
- One mathematics activity I really enjoy is...because...
- This is how I used math this week (outside of school)...

- Write a letter to a student who will be taking this class next year, giving some advice about this class.
- Design two mathematical bumper stickers, one funny, one serious.
- If you could meet any mathematician/scientist, who would it be and why?

Mathematical Content Prompts

- The difference between undefined slope and zero slope is...
- I think a function is... (I thought a function was...)
- How would you describe a square root?
- What patterns do you notice in ... (Fractions, Geometry, Trigonometry, Derivatives, etc.)
- How do you use fractions in your life?
- Write a poem about numerators and denominators.
- Make a list of objects or figures in the room which have symmetry. How can you tell?
- What is a reference angle. Why is it necessary?
- Write your own definition of a polynomial.
- Explain how the first derivative can indicate where a relative maximum or minimum occurs on a graph.
- Write all you know about (exponents, the Cartesian plane, vectors, standard deviations, etc.).
- How many squares are there on a chess board? Describe your strategy for solving this problem.
- Describe the mathematics seen in a photograph. (Photograph may need to be provided).
- Write and solve a word problem whose solution involves multiplying/dividing two or more fractions.
- Find a shortcut for adding the numbers between 1 and 100.
- Explain the Pythagorean Theorem. How could it be used to remember the distance formula?
- Describe practical uses for each of the conic sections.
- Compare and contrast the terms median, altitude, perpendicular bisector of a triangle.
- Explain everything you know about imaginary numbers.
- Write an explanation about the differences between area and perimeter.
- How many dimensions does a pencil have? Explain your answer.
- In geometry, what is a degree? What is a radian? Which do you prefer to use?
- How are the graphs of $y = 1/x^2$ and $y = x^2$ related? How could you predict the behaviour of the second from that of the first?
- What is the difference between combinations and permutations and by what clues do you distinguish problems involving one or the other?
- Explain the FOIL method.
- What are the differences between a circle and an ellipse?
- Compare and contrast the meanings of the terms 'parallel' and 'perpendicular'.

- Why can't you divide by zero?
- How can you find a number with thirteen factors?
- What is a prime number? Write all you can about prime numbers.
- How can you tell which is the larger of two fractions?
- What is scientific notation? Write all you can about it.
- How do you simplify a radical expression?
- What is an asymptote? Explain as much as you can.
- Distinguish between congruent and similar triangles. Write all you can about them.
- Why do we need proofs in mathematics?

Process Prompts

- The most important part of solving a problem is...
- What does it mean to solve an equation?
- Write instructions for a fifth grader to follow when (adding fractions, finding percentages, calculating averages, etc.)
- Write a lesson plan on how you would teach a specific math topic.
- Find something that you learned today that is similar to something you already knew. Write about these similarities.
- Do you use tables or diagrams when solving a problem? Why or why not?
- You know several ways to....(solve an equation, factor a quadratic, add fractions, etc.) Which method is your favourite? Why?
- Write a multiple choice question about and explain how each of the wrong answers could be logical.
- How important is being neat and organized to you in general, and when you are doing math?
- When I study for a test, I...
- Write a letter to your teacher explaining what you do understand about the topic, and what needs to be clarified.
- When I read a math textbook, and see a word I don't know, I...
- The key idea of the lesson today was...
- Describe the graph of...as if you were explaining it to a friend over the phone.
- When I see a word problem, the first thing I do is...Then I...
- Write a word problem using 'OF'. What does 'OF' mean as a math procedure?
- What are the benefits of journal writing for mathematics classes?
- How could journal writing be changed to be more effective?
- When you get a test back, do you make corrections or ask questions? Why or why not?
- How do I read my math textbook?
- Describe any computational procedure that you invented.
- How should we use class time to the best advantage?
- Write possible test questions for this unit.
- What is the most significant thing you learned today?

- What questions are still unanswered at the end of class today?
- Explain how you can improve your communication and cooperation in the mathematics classroom.
- Describe any discoveries you make about mathematics (patterns, relationships, procedures, etc.).
- Describe the process you undertook to solve this problem. (Problem needs to be provided.)
- Write WHO, WHAT, WHERE, WHEN, WHY, and HOW across the top of your page. Answer these questions based on today's class.
- Describe the steps you take to prove something in geometry.

Source: Mathematics Journals

<<http://www.ucs.mun.ca/~mathed/t/rc/jour/journal.htm#prompts>>

Appendix B: Descriptive Paragraph Miniproject

1. "A child receives a present which contains several items that are each made up of two solid shapes and consist of a colored waxy material. Each item is a solid truncated cone attached to one base of a solid cylinder with the second base being convex. The diameter of the base of the cone is less than the diameter of the base of the cylinder."

2. "[This figure is] a garish, parchment cone bedizenment, exhibited upon one's cranium with dualspheroid apertures opposite its vertex, consociated with a rubber strap and can be found at a convivial soiree."

3. To what do we owe our education in mathematics? (That is, besides our teachers!) Here is a clue...

It has a hexagonal body containing six rectangular faces. One extremity is a solid cylinder adjacent to a small excurvature. The other end is a solid cone with a slight endpoint and circumfluent to this is a longitudinal cylinder. What is it?

4. This figure is a rectangle containing at least 14 smaller rectangles, one of which contains 50 of the 10-sided geometric figures formed by the interior diagonals of a regular pentagon. In the same figure, 14 of the segments making all of those rectangles are parallel to each other, while 3 lines are perpendicular to those lines.

5. [This is] a spherically shaped object with symmetrically placed concave incurvities. It is a 3-D solid object. The concave incurvities help the object travel the farthest distance possible. It is used in a certain sport.

Answers:

1. Crayons
2. A party hat
3. A pencil
4. The U.S. flag
5. A golf ball

Appendix C: Teacher Survey and Results

The following survey was given to the mathematics teachers of Hibbing High School, Hibbing, MN; and Bemidji High School, Bemidji, MN. Due to the lack of responses-- only nine were returned to me, some incomplete--the results were not used in the body of this paper.

"Journaling" in the mathematics classroom is not explicitly defined; the activity can occur daily, weekly, or simply whenever the teacher deems it useful. Journal entries can be initiated with prompts, can be assigned for specific problems so that students can explain problem-solving methods, can be a free-write session, or can even consist of poetry or math-inspired art. This survey will let you share your experiences (or non-experience) with journaling.

1. Were you ever assigned any sort of journaling in your own elementary school, secondary school, or college *mathematics* classes? If so, what kind(s) and how often? Did you find the activity valuable (at the time, in retrospect, or both)?

No	7	Very Rarely	2
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2. As a college undergraduate, did any of your mathematics/education instructors mention or recommend journaling?

No	5	Yes	4
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3. From your experiences, how "popular" do you think journaling in the mathematics classroom is in northern Minnesota? **Not at all, not used very often, not popular, somewhat popular, not very, it's starting to become more popular, 10% or less, don't think anyone uses it, non-existent.**

4. Have you attended any seminars/workshops about journaling?
If so, when and where? What did you learn?

No	8	A workshop	1
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5. **The National Council of Teachers of Mathematics
Communication Standard for Grades 9–12**

Instructional programs from prekindergarten through grade 12 should enable all students to—

- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely.

How do you address and evaluate this standard in your classroom?

Group work, problem solving, homework; justify test answers; journaling, word problems, notes; vocabulary; look at "wrong" ways to do a problem; testing, group work; orally explain thinking; 2 no response.

6. Do you incorporate interdisciplinary units into your teaching, such as waste management with a science class, or mathematics history with a history class? **No 7 Limited 2**

A. Do you currently employ a form of journaling in your classroom?

If no, skip to letter B.

No 7 Yes 2

- a. What kind(s) [prompted, problem-oriented, free, etc.] and how often? **At the end of each chapter; freewriting after breaks and long weekends.**
- b. Is the activity in-class or outside of class? **Inside 2**
- c. If in-class, when during the class period is the journaling usually done? **After tests; beginning.**
- d. How is the journaling assessed? **Read through and respond; credit for doing it.**
- e. Is journaling a stand-alone activity or do you use it in place of other activities, such as quizzes? **Stand-alone; both--some is embedded in the tests.**
- f. How does journaling affect student performance and achievement? **Communication between student and teacher makes a big difference; gets them back on track after a long break.**
- g. How do your students feel about journaling? **If not too frequent, they like it; they hate it.**
Has it had a noticeable effect on "math anxiety?" **I believe so**
- h. Why do you personally like journaling? **Students share many things that they would not otherwise; get to know students better.**
- i. How have parents responded to journaling? **They think it's great; not sure.**
- j. Feel free to include sample journal entries/activities (with no names, please). **None included.**

B. If you do not practice journaling:

- a. Are there specific reasons (time constraints, unfamiliarity, ineffectiveness)? List your greatest concerns first. **Time 5 Unfamiliarity 1 Don't know how to be consistent 1**

- b. Are there other ways you employ writing in your mathematics class, such as requiring in-depth explanations for exam questions? **Reasoning for test problems 3 No 2 Other 2**
- c. How would you describe the level of your own writing/English skills? **Poor, average, good, good, good, I enjoy writing, very good.**
- d. Would you consider trying journaling in the future? Why or why not?
Yes; maybe, huge time issue!; yes, excellent way to make a student organize thoughts; yes but I probably won't; no, don't care for it; no, no room in the curriculum; no, another attempt at "modern" math, trend to get away from the real skills of math which are calculation, reasoning, and problem solving.

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