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Conceptu Mathema Using Narra

To support mathematical investigations, use this framework to guide students in constructing art-based and technology-based literature.

Narratives are a wonderful way to allow students to personalize mathematics. In the context of this article, we define narratives as short stories, written by students, that contain a mathematical word problem centered on the students' lives and interests. These narratives can be supported with art, such as drawings or photographs. When students conceptualize mathematics through these narratives, they are able to connect the relevance of mathematics to their everyday lives.

It is important to recognize that separating language arts and mathematics into their own individual curriculum slots may not be beneficial for students. Absent a word context and a meaningful setting, mathematical thinking can be unnatural (Moyer 2000). Through story creation,

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Terri L. Kurz and
Barbara Bartholomew

mathematical scenarios and numeracy applications are contextualized.

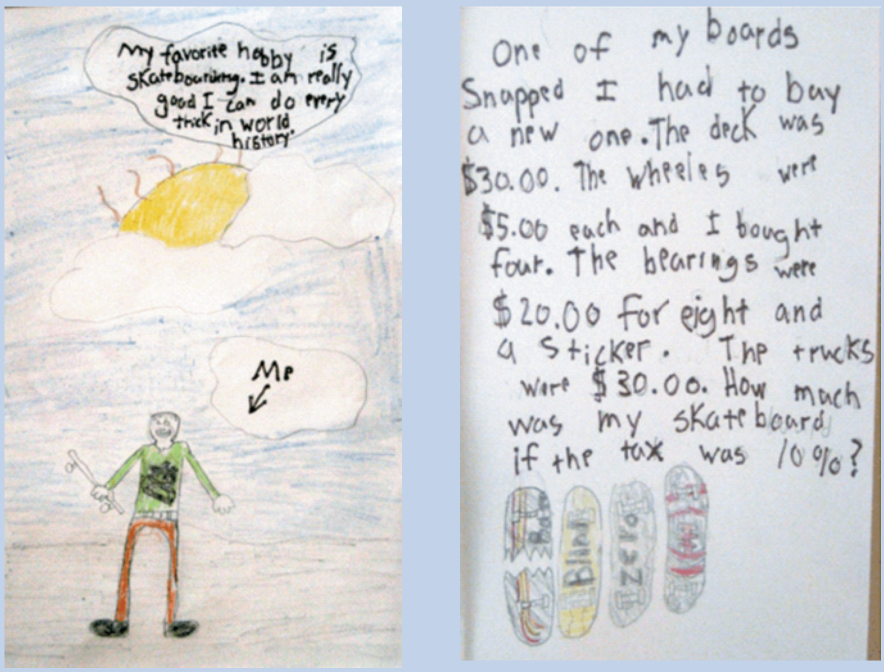
Contextualizing mathematics is an important element in student engagement. Nicol and Crespo (2005) found that when mathematical tasks contained content familiar to students' lives, the students were much more curious, engaged, and attuned to the tasks' mathematical relevance. As students create story scenes to illuminate newly acquired knowledge, integrated learning occurs (Bereiter and Scardamalia 1987). Furthermore, integrating language arts and math is a pedagogically useful way to help students learn mathematical material (Wilcox and Monroe 2011).

This article describes a framework using student-authored narratives to help students build stronger connections to the application of mathematics. The framework allows middle school students to use their creativity while applying and reinforcing mathematical material. The lesson is appropriate for all levels of middle school learners, including students with special needs and English language learners. Students will create narratives at their own ability levels, making the lesson appropriate for learners with a variety of needs (Hitchcock et al. 2002).

CONNECTING TO STANDARDS

Providing middle school students with the opportunity to write their own narratives directly relates to *Principles and Standards for School Mathematics* (NCTM 2000), as well as the Common Core State Standards for Mathematics (CCSSM) (CCSSI 2010). The NCTM Problem Solving Standard

Fig. 1 A portion of a narrative using art and titled Ollie the Skateboarder demonstrates the mathematics included by a fifth grader.



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states that students should solve problems that arise in mathematics and other contexts, with an emphasis on students' interests. The Connections Standard addresses the need for students to recognize and apply mathematics in contexts outside mathematics. Allowing students to write narratives provides the opportunity to address these various Standards.

CCSSM specifies that students will make sense of a problem by explaining it to themselves and to others, find entry points during the solution process, employ adaptive reasoning while comprehending meaningful applications, and demonstrate the ability to contextualize. One CCSSM goal is that all students will "read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments" (CCSSI 2010, p. 7). Further, CCSSM encourages the flow of curriculum between and across subjects so that students may more fully comprehend the connectivity of knowledge.

GUIDING THE STUDENTS TOWARD A CONTEXT

The lesson should begin with a whole-class discussion regarding mathematics in familiar settings. The following prompts can be used:

- Describe an incident in your life when mathematics was used.
- When have you used mathematics outside the classroom?
- Describe some ways that you have seen your parents or older siblings use mathematics.
- Describe some professions that use mathematics regularly. How is the mathematics used?
- Where do you encounter mathematics that makes sense and has meaning?

The prompts keep the topic broad and open for the students' imagination. Teachers may opt to use commercial literature to guide students' narratives. We have noted, however, that when commercial literature is used, students' ideas and creativity are often restricted to closely match the sample. Students frequently choose a similar theme and structure for their narratives. Depending on the teacher's goals, commercial literature may be a viable option. Using the students' responses to the questions as a forum for problem solving and extending the lessons, however, can result in more robust mathematical investigations and more personalized themes.

Middle school students will likely have a well-developed sense of story schemata, otherwise known as story grammar. Most students are aware that stories rotate around a problem or other goal-directed problem-solving episode. Students who may not have this knowledge will need to learn about simple story elements before beginning this activity (Mandler and Johnson 1977; Stein and Trabasso 1981; Schank 1995).

CREATING A FRAMEWORK FOR THE NARRATIVES

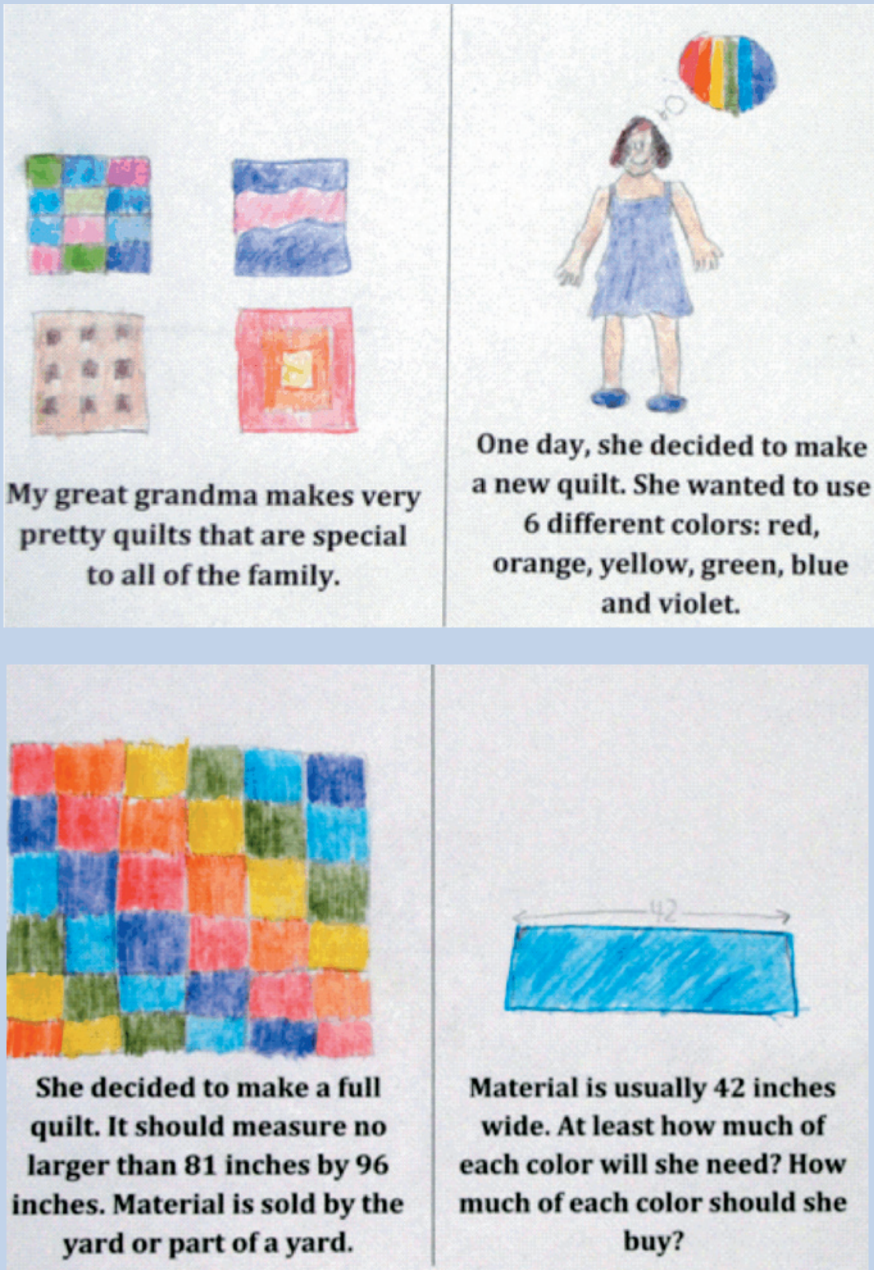
When creating the narratives, students can be asked to follow several general requirements and include various elements, which can include the following:

1. A title page
2. Four to eight pages of text (depending on students' ability), with writing on each page
3. A consistent theme
4. Art on each page (either drawings or photographs)
5. A final page that contains a solvable mathematical dilemma without an answer written in the text

A storyboard template can guide students. The template has an area for text and an area to describe (or draw in rough-draft form) the accompanying illustration. If more text is needed, the teacher can provide a sheet of lined paper for the drafts instead. The art portion of the lesson (whether drawings or photographs) should not be minimized in importance because students enjoy including art. Their fondness for art becomes especially evident when they are sharing the narratives.

Excerpts from narratives by a fifth grader and seventh grader, respectively, are shown in **figures 1** and **2**. Student themes are personal and demonstrate a practical application of mathematics. A pair of seventh graders developed the technology-supported narrative using PowerPoint®, the text of which is displayed in **figure 3**. The theme is student-centered; creating stilts by flipping over crutches is not often seen in a mathematical context. The text of another technology-created narrative, relating to the student's cat, is shown in **figure 4.**

Fig. 2 A Quilting with Grandma narrative was produced by a seventh grader. This excerpt provides some of the math included.



ADDRESSING POTENTIAL CONCERNS

To reduce grammatical and structural errors, ask the students to submit draft storyboards and text. The teacher should be proactive in evaluating the rough drafts. He or she may wish to make the task a peer-editing exercise as well. Critiquing the evolving texts is a time-consuming aspect of this lesson, but it is critical because students will make mistakes. These mistakes should be tackled early.

Several important points must be addressed when evaluating rough drafts.

- *Is there a theme? Did the student develop a narrative that makes sense in relation to the theme, or are word problems simply listed?* It is important to emphasize theme and plot as the students construct their rough drafts. Students sometimes misunderstand the instructions and just list word problems on each page.
- *Is the mathematics logical? Are the numbers reasonable within the context?* For example, a new shirt would not cost $0.25 or a standard car would not go 100 miles per hour on the freeway, but in certain comical or fantasy situations, these attributes may be appropriate.
- *Is the mathematical dilemma solvable using the data in the text?* Text elements must exist to help the reader answer the dilemma embedded in the narrative. Sometimes students omit critical information.
- *Can the author explain and answer the dilemma?* It is essential that students be able to solve and explain their own question because they are the experts. Students need to present the solution to the teacher before the final draft is created to be sure they can solve the dilemma.

Fig. 3 Taking Steps on Stilts, involving technology, was a narrative produced by a pair of seventh graders.

Closet Scavenging. Today, I decided to play with my stilts. I like to walk on my crutches upside-down.

A Question. I was wondering if I would take fewer steps on my stilts in track.

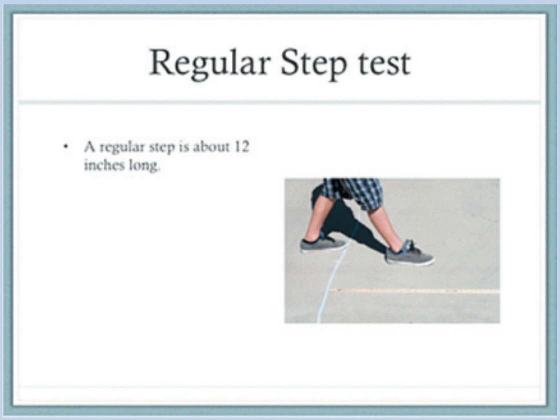
Measuring the Steps. I went outside to test the length of each step. I grabbed the tools I needed: my stilts, my yardstick, and some chalk.

Regular Step Test. A regular step is about 12 inches long.

Stilt Step Test. A stilt step is about 27 inches long.

The Math Question. How many steps would it take to go 100 yards? How many steps would it take to go 100 yards using stilt steps?

(a) The text of the narrative



(b) The Regular Step Test frame

A final consideration regards gifted students. Sometimes it may be necessary to encourage deeper, more challenging mathematics. For example, in **figure 4** the student challenges the reader to use a pie chart to display the ways in which the cat spent the day. The student originally had listed a simple number of hours (20) that the cat slept. This student was encouraged to make the narrative more mathematically challenging. Elapsed time, fractions, and decimals were integrated into the text with teacher encouragement.

The technology-supported narratives may take longer to construct because students may need to share equipment, especially digital cameras. If students develop a clear plan for photograph usage while constructing their rough drafts, they can use time more effectively when taking the necessary photographs. Students can also be given the option of photographing, or otherwise accessing media, at school or at home depending on the technology that is available outside class. Supplies or props should be prepared in advance. Using a cell phone camera to take, use, and download photographs may be an acceptable way to alleviate technology supply problems.

Another issue with the technology involves the accuracy of the photographs. For example, the draft version of the narrative in **figure 3a** had inaccuracies. The student put his foot too far behind the chalk line in the picture first provided. The corrected photograph is shown in **figure 3b**. The student measured his step at 12 inches, but the image showed a much smaller step because his foot was improperly placed. Although it is very difficult to catch all these errors, it is important to look for them when providing feedback on early drafts. In this instance, the student took multiple photographs and found a more accurate image. Encouraging students to take multiple photographs (perhaps three per subject) can help alleviate potential problems.

COORDINATING WITH OTHER TEACHERS

At the middle-grades level, students often take subject-specific courses. If this is the case, the narrative project could be a team effort: The language arts teacher could guide the language portion while the math teacher guides the mathematics section. This cross-curricular endeavor could help teachers unify their curriculum. If the students share an art teacher, he or she could then guide art content. In contrast, the math teacher might be the only instructor directing this lesson if coordination is not possible. The benefits of integrating language and mathematics can still be achieved, albeit with a little more effort by the math teacher.

SHARING THE MATH IN THE NARRATIVES

After the narratives are written, the teacher should provide an opportunity to investigate them with the entire class. Teachers can make copies of the projects and share them with the class or project them on a large screen for a class discussion. If students used

PowerPoint, projecting the narratives to the class would be simple.

The student author, in the role of presenter, automatically becomes the expert and assumes the role of teacher by answering questions and guiding fellow students (along with the actual classroom teacher) in solving the dilemma. Through rehearsing and retelling, the math lesson becomes processed into comprehensible components. In so doing, learning and mastery of subject matter are reinforced (Gambrell, Pfeiffer, and Wilson 1985). Students often enjoy this aspect of the lesson.

Students may not be able to emphasize the most fruitful mathematics in their narratives. Enrichment opportunities to explore deeper mathematical investigations may be needed. In one narrative, the author used the term *average;* the more appropriate mathematical term is *arithmetic mean*. The teacher can help the students discover the application of mathematical terms, such as arithmetic mean and average, within the student's narrative context while examining the ideas of mode and median. The teacher can address how average is sometimes used interchangeably with arithmetic mean in everyday contexts but, in reality, there are several types of averages.

The classroom teacher's role is to enrich the mathematical goals using the students' themes. Referencing the narrative in **figure 3**, several prompts can be given to guide students to a deeper mathematical analysis:

- Write an equation showing how many steps will yield a certain number of inches when taking regular steps. How would you define the variables? How would the table of values appear? Explain.
- Write an equation showing how many steps will yield a certain number of stilt steps. How would you define the variables? How would the table of values appear? Explain.
- Make a table of values showing the distance when taking a regular step in one column versus the distance taken in a stilt step in the other column. How would the variables be defined? Can you write an equation illustrating that relationship? Approximate the proportional relationship of the two steps, and describe how that proportion relates to the equation.
- How do the equations you wrote relate to the physical movement? Describe how the equation, table of values, and physical movement all connect to one another.
- How would you account for the differences in length of the child's shoes and the length of the stilts? How would this influence your equations and tables of values?

The content of the narratives can also be expanded. Technology could be used to produce illustrations or digital movies. Work could be laminated and bound. Media can be uploaded to the web or played at parent events. This project can be a simple exercise taking several days, or it can be a detailed collaborative project occurring over weeks or months.

Fig 4. A narrative titled My Life as a Cat, also incorporating technology, was explored by an eighth grader.

My Life as a Cat. I am a cat named Storm Cloud. I spend my days lounging around and socializing. One day, I decided to record how I spent 24 hours in a day.

Sleeping Is My Chore. I really like to sleep. I sleep so much that almost my entire day is wasted on catnapping. When I wake up, it is already night. I spent 5/6 of the day sleeping.

My Doggie Friend. Here is one of my doggie relatives. I spent 1.1 hours looking at him. We like to have staring contests. He is a good doggie; he never chases me.

Man, I Am Hungry! The bird looks mighty tasty. I sit and wonder what flavor he is. Does he taste like chicken or turkey? He looks good. He smiles at me because I can't eat him. I look at the bird from 1:35 p.m. to 2:20 p.m.

The Warm Fire. The fire feels good on my fur. It warms me to the bone. I like to sit here and think. I spend 1 1/4 hours in front of the fireplace thinking "I wonder if other cats are fixed like I am?"

I Wonder … I spend the remainder of the day eating and drinking. So, that was my day. Can you make a pie chart to show the breakdown of how my hours were spent? Remember, pie charts show percentages.

ASSESSING THE WORK

To assess this project, we recommend a rubric (see **fig. 5**) that focuses on several different areas. The rubric is designed for both the art and technology narratives and can be used for all middle-school-grade levels.

When referencing the examples given, the teacher should consider different forms of solutions. The math problems posed in **figures 1** and **4** have one mathematical answer. However, other narratives will have multiple solutions, depending on how the students approach the problem. **Figure 3**'s narrative will have different solutions, depending on whether

Fig. 5 A rubric such as this one can be used to assess the narratives.

	Does Not Meet Expectations	Approaches Expectations	Meets Expectations
Mathematical Components	Mathematics had errors and/or final question was missing.	Mathematics was relevant and interesting, but there were some minor errors.	Mathematics was relevant, interesting, and accurate.
Narrative Components	Narrative did not have a personal, focused component that was relevant to the student.	Narrative was interesting and personal, but needed more supportive details.	Narrative was interesting, personal, focused, and detailed.
Art Components	Art was missing on some pages.	Art was acceptable, but lacked details needed to support the text.	Art was neat, organized, and relevant; art enhanced the text.
Theme Consistency	The theme was inconsistent throughout the narrative.	The theme was consistent throughout most of the narrative.	The theme was consistent throughout all of the narrative.
Role as Expert	Student did not circulate and/or was off task most of the time.	Student helped students, but did not circulate enough; expert was sometimes off task.	Student circulated throughout the classroom and guided all students when needed.
Neatness and Grammar	Student had many grammatical errors and/or the text was unreadable in parts.	Student had some grammatical errors and/or the text could be neater and easier to read.	Student had few grammatical errors and the text was neat and readable.

Teacher comments:

students round their answers. With **figure 2**'s narrative, students may calculate the quantity of fabric needed exactly. But this is not normally done when quilting because mistakes are made in cutting and the fabric may not be the precise length or width. Extra fabric is always purchased, so solutions will vary with that narrative. The key is to make sure that students can justify their solutions.

PRODUCING POSITIVE STUDENT EXPERIENCES

When at-risk middle school students investigated math in this format, their confidence appeared to improve. They enjoyed being the star of the narrative and becoming an expert in mathematics. They circulated around the class, answering questions and guiding students in a way that is not usually possible with traditional class assignments. Because the lesson is in a personal, familiar context, students felt much more comfortable guiding others.

Using this narrative context, students are able to share some of their cultural experiences or family traditions with other students in a meaningful manner. For example, one Latina student used a family recipe for making tamales as the basis of her story. Her question asked students to double the recipe and determine the quantity needed for each ingredient.

MAKING MATHEMATICS PERSONAL

It is important for teachers to provide opportunities for learning mathematics beyond textbook lessons (Moyer 2000). The framework provided here can support teachers in their endeavors to move beyond canned learning. As shown in the student exemplars, mathematics becomes very personal when students write their own narratives. In allowing students to provide a context for mathematics, they are able to glean relevance from knowledge by applying it to novel contexts (Franz and Pope 2005). The work becomes interesting and exciting for students as they find themselves being not only mathematicians and storytellers but also peer teachers. Most important, however, is that in the process of students watching, doing, creating, retelling, and explaining what they know, visible evidence is produced so that the teacher can assess student understanding.

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Terri L. Kurz, terri.kurz@asu.edu, teaches mathematics and education courses at Arizona State University, Polytechnic in Mesa. She enjoys using technology and tools to support student learning. **Barbara Bartholomew**, bbartholomew@csub.edu, is an associate professor of Reading, Literacy and English in The School of Arts and Humanities at California State University, Bakersfield.

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