Got Books? A Story of Creative Mathematics Children's Book Writing

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Got Books? A Story of Creative Mathematics Children's Book Writing

Cover Page Footnote

We would like to express our gratitude for the Teaching and Learning Grant from Worcester State University that paid for the common reading books for our students and the refreshments for our joint event.

Got Books? A Story of Creative Mathematics Writing

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Synopsis

In this report, we describe a joint project between a mathematics content course and literacy methods course for pre-service elementary teachers that resulted in our students writing children's mathematically themed books. Our report focuses first on the creative process of combining mathematical knowledge and ideas for teaching with the craft of writing for children, and second on the creative connection between mathematics and literacy education at the elementary school level.

Keywords: Pre-service elementary teachers, mathematics education, common project, children's books

1. Context

Most content-area methods classes in the elementary education curriculum are taught separately, and hence pre-service teachers may not see potentially fruitful connections among different subjects, particularly those between literacy and mathematics. We, a mathematics and literacy educator, used a common mathematics-themed children's books project. Our intent was to interrupt this separation for pre-service teachers who were enrolled in two different courses: a mathematics content class (MA 130: Numbers and Operations for Teachers) and a literacy education methods class (ED 261: Foundations of Literacy). The Foundations of Literacy class is the introductory class in a two-part series on Literacy that all pre-service elementary teachers take. The Number and Operations course is the first one

in a three-course mathematics content courses designed specifically for pre-service elementary teachers that most students complete in the first two years of their college studies. We only shared two students across the two courses, but we linked our courses through common readings and a common final project.

This creative final project undertaken by both classes replaced the usual final project in each class. In MA 130, the typical final project was writing a complete lesson plan for the elementary classroom that focuses on the natural numbers, integers, or the rational numbers and their operations. In ED 261, that final project was a lesson plan related to a children's book or a paper that connects classroom observations to course material.

Children's books are, by their nature, creatively conceived and presented, and reading children's mathematics books with our students represented a chance to stress the connections between creativity in the genre of children's literature and in presenting mathematical concepts, as well as between literacy and mathematics education. Children's authors with expertise in mathematics have written a variety of children's fiction around distinct mathematical ideas, as evidenced by a long list of children's books the literacy students compiled from library searches. Well-known examples of mathematics educators who have focused on writing children's books with a mathematics theme include Marilyn Burns and Greg Tang. Many educators have used these books successfully in their classes [2, 8], as a way to tell engaging stories to young minds and improve understanding and recall in mathematics students.

Our four common reading books were: *How Much Is a Million?* by David M. Schwartz [5], *The Grapes of Math* by Greg Tang [7], *The Greedy Triangle* by Marilyn Burns [1], and *The Great Graph Contest* by Laureen Leedy [4]. These books offer the double benefit of being real children's literature and being a mathematics content teaching tool across diverse topics in the elementary mathematics curriculum. As we discuss in more detail later in this paper, both groups of students got hands-on practice with literacy across the curriculum, through analysis and creative writing about the common readings first, other math-themed books next, and then finally through creating their own books. Some of the titles of the books written by our students were: *Colorful Butterflies Using Fractions*, *The Hungry Hexagon*, *Little Mathletes*, *The Great Picnic Fix*, *Adding and Subtracting at the Zoo with Mary Lou*, and *Mathematical Huskies*. Two of these books are included as appendices in this article.

2. Definition of Creative Mathematics

Current views maintain that frames of mind that promote creativity can be encouraged and taught [6]. This holds great promise not only for young students, but also for pre-service elementary teachers, who are exposed to integrated instruction in Mathematics Education and Literacy Education. Based on this conceptualization, we felt buoyed about our ability to influence elementary education students with our intervention.

Having the freedom to try things at an experimental school called Nueva, in 1970, Laycock sought out ways to teach mathematical ideas that would encourage and make use of creativity. From her reflections on this experience she defines creativity this way:

“It is the ability to analyze a given problem in many ways, observe patterns, see likenesses and differences, and on the basis of what has worked in similar situations decide upon a method of attack in an unfamiliar situation. Materials for “figuring out” answers are available, and children are encouraged to select things that help them find an approach for themselves. They are not told how to solve problems.” (pg. 325)

As suggested by Laycock’s definition, creativity in mathematics is associated with going beyond what is “familiar,” or immediately known, to find a path or a solution. In her later work, Laycock used the term “divergent thinking,” to describe creative thinking. We believe our common project of creating mathematically-themed books allows pre-service teachers to forge their own path to understanding both mathematical ideas through a pedagogy lens, and how to incorporate them into the genre of children’s literature story-telling.

As mentioned by Laycock, the set up including materials, types of problems and scenarios, and plan for the lesson can all impact the fostering of creativity. A theme running throughout the literature is that mathematics problems should be real life problems—problems with reliability and relevance to children’s real lives [3]. The ability to see mathematics as a way to solve real problems contributes to the child’s motivation and stamina. Children’s mathematically themed literature is an effective example of how this could be done in practice. Exposing pre-service teachers to this idea through reading, analyzing, and finally writing children’s books is a powerful tool in awakening their creativity by thinking about and ultimately teaching mathematical concepts.

To recap this discussion of creativity in mathematics, one needs to be

concerned with the environment of learning, the conveyance of expectations, the real-worldness of the topic, and activities/tasks given to students. In this next section we will talk about how the interaction with mathematics-themed books aided students in their ability to be more creative and imagine themselves teaching creatively young children to be creative themselves when approaching mathematics.

3. Interacting with Mathematics-Themed Books

Pamela:

Students in the Foundations of Reading class were asked to answer these two questions about each of the mathematics-themed children's books:

1. What mathematics concept or concepts are being explored in this book?
2. What literary features do you notice that you might be able to incorporate into a lesson or reading of this book with students?

I wanted my students to see the breadth of the work they could do with one book. They could teach literary elements and mathematics elements, using students' involvement in the story to their advantage in two ways. I wanted my students to take time to explore both the math and literacy elements in a way that you don't always get to do if you read something quickly. I wanted them to take their time to focus on each math and literacy element, break each down, and think about how they could use the element to get students to problem solve or to teach students a math or literacy concept.

For this second question, I am including a summary of the literacy features of each of the books, which could be used as the basis for teaching instruction in the area of literacy.

- The Great Graph Contest
 - Text Structure: Comic book thought and speech bubbles.
 - Characters: Gonk, Beezy, Chester (friends).
 - Plot: Graph contest with winner.

- Readers are asked to participate to see who won the contest. Humor from little asides from characters.
- The Grapes of Math
 - Rhyming.
 - Poem-like visuals (for each riddle) and word play (for example, Win-doze).
 - Titles of each poem are big like a headline. There is reader involvement in solving each riddle.
- The Greedy Triangle
 - Story set up: there is a problem, main character, other characters and selected quotes from the main character.
 - Repetition with new elements introduced each time.
 - Specific words/vocabulary/good specific verbs such as supporting, slip, orchestra. Conflict and resolution.
- How Much Is a Million
 - Text Structure (Question and Answer/If...then) Mixture of real and imaginary.

In each of the children's books, the authors took a mathematical concept and presented it to children in a creative way. The authors exhibited all of the aspects of creativity previously mentioned, as they created a context that never existed before to showcase a particular mathematics concept. Several of the books included stories with characters, settings, central problems, and a resolution (*The Greedy Triangle* and *The Great Graph Contest*). These stories were original, and stories in general are associated with original thought; even if the story borrows elements from others, it will have its unique elements as well. The books focus on real-world situations and problems, like counting seeds in fruit or estimating how many goldfish make a million. Friends Gonk, Beezy and Chester use graphs to analyze the regular world around them like the surfaces of rocks, or designs on clothing. In *How Much is a Million?* children are asked to visualize how big a million and a billion are, and they are engaged in thinking about large numbers in a way they have not before, with stand-ins like stars, fish, and wizards. Like doing

mathematics itself, the books include both structure and room for creativity of both the author and the reader. For example, in *The Greedy Triangle*, Greg Tang presents his riddles about grouping as a counting strategy as riddles that rhyme, but what is written in his book has never been written before. These books reflect the interests and thinking of their young audiences. Marilyn Burns's triangle character longs to try on the characteristics of other polygons with more sides, much the way his preschool and kindergarten audience plays dress up. These books model and engage the reader in divergent thinking, problem-solving, flexibility, and fun.

These books act as a model for creative activity, and they can inspire more creative activity when pre-service teachers are asked to first analyze the books and then write their own books. The students become familiar with the creative aspects of the books' presentation of mathematical ideas and concepts, and this opens their eyes to the possibility of approaching mathematics instruction this way to begin with.

For those students who then wrote their own books, they had a chance to try their hand at being creative with the starting point of a mathematical concept. For those students who chose to analyze the literacy and math elements of existing books, the experience was more about observing how someone else was creative mathematically.? Uncovering the process and elements of the author's *literary conceit*—what the audience has to believe—and the math involved, gave students an opportunity to trace and inhabit the creative moves of the authors. A couple of the students in my course chose to create their own book, and all students (organized in small groups) in Maria's course wrote their own mathematical stories.

Maria:

The students in MA 130 Number and Operation for Teachers had to expand on the creative ideas in *How Much is a Million?* by choosing their own favorite parts of the story, selecting a reasonable measure for the quantity in question and showing the mathematical steps that produce the mentioned result. For example, the book claims that if you wanted to count from one to one million, it would take you about 23 days. My students made an estimate about how long it would take to count from 1 to 100, 101 to 999, 1000 to 9999, etc. and then added these times and converted them from seconds to minutes to hours to days.

After reading *The Grapes of Math*, my students created their own count-

ing puzzles using rhymes. This was the first time in the course when they became a writer of a children's puzzle, combining the mathematical ideas of counting by groups with a fun context and with rhyming appropriate for children. Some of the students stuck pretty closely to the text, changing only a word or two, but several ventured out into creating their own stories. Here is a small example of a puzzle from my class, "Tom and Mary are very smug, they are looking for ladybugs. Some are hiding under leaves, all have dots in twos or threes. How many do you see? Count them fast and get to me." This small creative writing exercise set the tone for the larger assignment of creating an entire children's book.

The project for *The Greedy Triangle* asked the students to retell the story from the viewpoint of the triangle. Pre-service teachers changed viewpoints in telling a story (and realized how this impacts a narrative) and thought about geometric concepts that were not part of the regular class material.

The final common book *The Great Graph Contest* again served the purpose of introducing students to a topic that is not a required part of the course content but it appears prominently in the elementary school mathematics curriculum-descriptive statistics. My students used the text as a starting point in coming up with children friendly data that can be organized graphically in more than one way. Correct mathematics, creativity and neatness-criteria introduced in the book, persisted into the final project for the course.

The final project included self-selection into a small group first, followed by proposing a mathematical theme. After providing feedback to my students, I asked them to keep a detailed meeting log and asked for additional check-ins such as letting me know the roles each took in the group (mathematics editor, language editor, illustrator and producer), as well as a short report on at least one children's book on a similar topic. The students from Pamela's course generated a long list of children's mathematics-themed books that my students used as a starting point to get more exposure to children mathematically themed literature. Finally, my students submitted a final draft a week before the joint meeting with the other class. I provided suggestions for improvement (mostly minor) and we were ready for the end-of-semester joint activity.

The rubric for assessing this creative project was as follows:

- Mathematical topic and its presentation 0-5 points, from underdeveloped or inappropriate to well-presented and suitable. Choose a topic

that is essential to the elementary mathematics curriculum. Develop your mathematical ideas fully so a child can learn about them from reading your book.

- Creativity and appearance of book 0-3 points, based on being both interesting (relevant) and beautiful (good choice of illustrations, color, setting). Take pride and make your book both pleasant to look at and intriguing to read.
- Writing 0-2 points, based on good writing for the audience, proofreading, and clarity. Write in a clear way, following the rules of grammar and punctuation.

The final joint meeting occurred at the end of the semester, over pizza. Students from both courses mixed in groups, and read to each other the books they created or the analysis of other children's books they had written. It was a memorable experience for all!

We recognize that based on access to resources some of the produced books might have looked more professional than others. Never did we use that as a requirement for the project or a part of its evaluation.

4. Student-Generated Books in Depth

We take turns discussing the two books written by our students as a result of our joint project and presented in the appendices of this article.

Maria:

Adding and Subtracting at the Zoo with Mary Lou is a delightful story for young children. The student-authors are future early childhood teachers. They focus on single digit addition and subtraction in the context of zoo animals who have different attributes. The audience for this book are children in Kindergarten and in first-grade, and the creativity of this charming book shines through the choice of context that kids love (a trip to the zoo, and exploring different animals) and the masterful combining of arithmetic with sorting by attributes.

Sam's Fractional Birthday Party is an illustrated account of a mom having to triple a cake recipe in time for her child's birthday party. The mathematical ideas in this book are more advanced and appropriate for upper

elementary school students. This is reflected in the language of the book and the use of pictures with actual measurements. This book focuses on multiplication of a whole number with a rational number represented as a mixed number. It provides beautiful models of the *repeated addition* concept of multiplication, with grouping of the extra parts. It tackles the concept of a unit through pictures which is a powerful tool to use with children.

Pamela:

Using the common children's book trope of a zoo visit, *Adding and Subtracting at the Zoo* is a good example of how students were creative within the confines of familiar structure. After all, a future teacher is aware of how children like books that are both a little familiar and a little different from other books. The most impressive thing about the book was the neat, professional, high-quality of the presentation of the book. It had a real hard cover and was bound. The pictures were expertly done in pleasing colors. The layout was professional and well-thought out as well. The students interpreted the assignment to mean they should come up with their own creation, and that creation should be painstakingly planned out and executed pleasingly for the reader.

The rhyme structure and counting of animals is common among early childhood books, but the particular feature of the animals mentioned and what the reader is asked to think about is unique. For example, Mary Lou, the main character sees "4 snakes slithering along. She also saw 4 lizards where they didn't belong." Talking about animals "where they don't belong" is a unique way to talk about animals as opposed to talking about their physical characteristics. The author uses the opportunity to create her own rhymes, many of which are unexpected. Another example of unique rhyming description of the animals to be counted was "There were 3 zebras eating grass/When 3 more arrived who were world-class. How many zebras did the zoo amass?" Another unique element this author added was the depiction of her zoo. The zoo is entered under a banner on the first page exited through a parallel banner at the end, creating a nice symmetry, and there is literally a twist, as we see the main characters' backs this time as they leave—a nice touch.

Sam's Fractional Birthday Party was more involved mathematically, and although the drawings are in black and white, and simpler, a comic book type character is created that is redrawn and redrawn in different situations—no

easy task. When faced with needing cake for 15 and having a recipe for 5, Sam's Mom decides to make a GIANT cake by tripling the recipe. She chose not to make three separate cakes. The thought balloons that show all of the increasing cups of ingredients are quite clearly drawn. There is no rhyming in this book, but there is a very cohesive storyline with characters and a problem and a resolution. The drawings are very original as is the storyline. Like the authors of *Adding and Subtracting at the Zoo*, this author took ideas that she may have seen elsewhere and put them together into her own unique story. In order to do this, she needed to think about mathematics and about how to present the material to the audience. She also needed to think about the best way to make her story understood.

5. Concluding Remarks

Pamela:

Using mathematics-themed books holds promise for increasing mathematics creativity for pre-service teachers. It enables instructors to provide models where authors are demonstrating how to be creative using mathematics. Interacting with these books shows students what is possible, and then when they make their own mathematics-themed books, they apply what they have learned, but with their own creative twist. All literature builds on familiar tropes and structures, but then authors need to generate something new that makes their book unique. Students have to consider how a particular character would talk about a mathematical concept for example, to keep with the feel of the world of the story. Our students got to see mathematics presented within real life scenarios in a creative way, and then they were able to do their own creative work turning mathematical concepts into stories.

Maria:

Creativity in pre-service mathematics education could encompass choosing engaging contexts for introducing concepts, involving learners in individual and collaborative inquiry, problem-solving centered on rich tasks involving multiple approaches, and creating one's own materials. Students are nudged to become more mathematically creative when they have to fit mathematical concepts into the context of the story genre. Business-as-usual thinking will not get the job done when mathematical concepts need to be

fit into a specific dramatic setting and communicated to an audience used to a particular format. More importantly, students need to think about elementary mathematics in creative ways that allow young children to readily understand the concepts. Our students experienced all these facets through this joint project. Here is a quotes from a course evaluation:

Writing my own children's mathematics book was truly exciting for me. I enjoyed creating this because I was able to use my own creativity and ideas, while also teaching mathematics at the same time.

And another:

I had a great experience writing my own children's book. It was fun to think in the minds of children to wonder what they might like to read. Putting illustrations together was also very fun! Making a book interesting and educational was a great experience!

Students loved coming to class, participated eagerly in all in-class activities and took solid responsibility for their learning. Their final exam and course grades were overall considerably better than other sections I have taught. Could this be attributed to the creative book project? It is very difficult to know with certainty since there are so many factors influencing student buy-in and success. It seems clear that the process of writing the books and sharing them with the other class created a sense of community through a common purpose and through the pure fun in reading together. It is Pamela's and my hope that other instructors choose to incorporate creative projects across courses. This process devises a more holistic integrated educational experience that has the potential to unleash not only connections among subjects but ultimately creative approaches to learning and teaching.

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A. Sam's Fractional Birthday Party

Sam's Fractional Birthday Party

By Brooke Tresker

Today is Sam's birthday! Her mother had been planning to throw her a surprise party after school. Everything was set; balloons were blown up, streamers hung, presents wrapped, and the table was set.

All that was left to do was make the birthday cake. Sam's mom pulled out her cookbook and flipped open to the page with her cake recipe. "Oh no!" she exclaimed when she read it over.

This recipe only made enough cake to feed 5 people. There were more people coming than that. In total Sam's mom was expecting to have 15 guests. "That's not going to be big enough," she said sadly to herself.

She didn't have time to look for another recipe and even if she did this was her special recipe that she knew Sam loved. She didn't have time to make three separate cakes either. After a few moments of thinking she came up with an idea.

"If I can't make 3 cakes I can make the cake 3 times bigger," she said aloud with a smile. Sam's mom went and gathered her ingredients and baking tools, finally ready to start. The first thing she needed to do was add $1\frac{1}{2}$ cups of sugar to a large bowl

"If I need 3 times as much sugar than that's 3 times $1\frac{1}{2}$," Sam's mom thought aloud. "3 times 1 is 3 and 3 times $\frac{1}{2}$ is $\frac{3}{2}$. That's $3\frac{3}{2}$." She then realized that $\frac{3}{2}$ could be broken down further into $1\frac{1}{2}$ so all together she needed $4\frac{1}{2}$ cups of sugar.

With that in mind she scooped out the right amount of sugar and poured it into the bowl. The next step was adding a $\frac{1}{2}$ cup of butter to the bowl.

"Hm..." she thought as she looked at the butter. " $\frac{1}{2}$ times 3 is $\frac{3}{2}$. So that means I need $1\frac{1}{2}$ cups of butter." Once she did the math Sam's mom measured the butter and put it in the bowl, stirring it in with the sugar.

"What comes next?" she asked herself as she looked at the recipe. "It says I need 2 eggs. Well that's easy," she said with a smile. "3 times 2 is 6 so I need 6 eggs." She grabbed the eggs she needed and mixed them into the batter.

Looking back to the recipe she needed to add $2\frac{1}{4}$ teaspoons of vanilla. "So I need to do $2\frac{1}{4}$ times 3. Well that's $6\frac{3}{4}$ teaspoons." Double checking her math Sam's mom added the vanilla to the mixture and moved on to the next step.

In another bowl Sam's mom needed to add $2 \frac{1}{3}$ of flour. "2 $\frac{1}{3}$, hm...." she hummed while thinking. "2 times 3 is 6 and 3 times $\frac{1}{3}$ is $\frac{3}{3}$. So I need $6 \frac{3}{3}$ cups of flour, which is 7 cups total."

Once the flour was all placed in the bowl she looked to see that she need $1 \frac{3}{4}$ teaspoons baking powder. Thinking out loud she said, "1 $\frac{3}{4}$ times 3 is equal to $3 \frac{9}{4}$. $9/4$ is too big. I can make it $2 \frac{1}{4}$. That means I need $5 \frac{1}{4}$ teaspoons of baking powder."

Putting the right amount of baking powder in the bowl she mixed together the two mixtures. Once they were well combined she looked to see there was only one step left, adding $1 \frac{2}{5}$ cups of milk.

" $1 \frac{2}{5}$ times 3 is $3 \frac{6}{5}$. So I need to get $4 \frac{1}{5}$ cups of milk." Pouring in the Sam's mom gave the batter one last stir before pouring it in a pan and putting it in the oven.

While the cake baked she put on the last few finishing touches to the house. Once the oven timer went off she went back to the kitchen and pulled out the cake, letting it cool before frosting it.

Putting in the candles she set the cake on the table. Soon after guests began arriving at the house, setting down more presents for Sam.

Not long after the guests had all arrived the sound of Sam's bus got louder and louder before stopping in front of the house. She came inside to the best surprise ever; her friends, her family, and a cake made with love.

It was the best birthday ever!

B. Adding and Subtracting at the Zoo

Adding and Subtracting at the Zoo
With Mary Lou

I wonder what's new at the zoo!
So many fun things to see and do!

Mary Lou

Saw a total of 9 monkeys at the zoo.

4 were swinging from a tree.

How many on the ground do you see?

Mary Lou saw 4 snakes slithering along.
She also saw 4 lizards where they didn't belong.
How many reptiles did she come upon?

2 turtles were basking in the sun.
4 swam over to join the fun.
How many are there when they are done.

As Mary Lou heard a loud roar,
She decided the lion exhibit was the next to explore.

"There are a total of 6 lions," Mary Lou exclaims!
She spots 3 with fluffy manes.
Can you figure out how many don't have manes,
Before it rains?

As they continued touring the zoo,
Mary Lou spotted black bears and counted them: 1, 2
But that was not the only bear,
There was another type with brown hair.
She noticed that there were: 1, 2, 3
How many total bears should there be?

Mary Lou spotted 2 hippos in the water.
"Look! There's another 4 on land," she told her daughter.
How many total hippos can you count,
To make sure you find the right amount?

4 giraffes were eating leaves,
When 2 left to nap, Mary Lou guarantees.
We need to figure out how many are left she believes.

There were 3 zebras eating grass,
When 3 more arrived who were world-class.
How many zebras did the zoo amass?