Comic Books That Teach Mathematics

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Abstract

During the 2008–2009 academic year, the author embarked on an extremely non-standard curriculum path: developing comic books with embedded mathematics appropriate for 3rd through 6th grade students. With the help of an education professor to measure impact, an elementary-school principal, and talented undergraduate illustrators, this project came to fruition and the comics were implemented in elementary classrooms at Cumberland Trace Elementary in the Warren County School System in Bowling Green, Kentucky. This manuscript gives the history of this idea, the difficulties of developing the content of the comics and getting them illustrated, and the implementation plan in the school.

1 Introduction

In September 2008, I attended an Idea Kentucky meeting (www.ideakentucky.com) where the organizers had hired a professional cartoonist, Keith Bendis (keithbendis.com), to take notes of the meeting. He had three large pieces of white paper taped to the wall of the room, and a table full of markers. Throughout the meeting, he was taking in the salient points being made and then illustrating these points with small, humorous scenes capturing the essence of the conversation (Figure 1). When finished, I remember thinking that even people that did not care about the meeting would still be interested in the notes that he had crafted, and an idea was born. What if you could present mathematics in such a way that even people who did not care much about it would still be interested in the way it was presented, and take away the salient points?

Thus was born the idea of comic books that would teach mathematics. As a university mathematics teacher, I would develop the stories, embedding mathematics appropriate for the 3rd through 6th grade level, according to the National Council of Teachers of Mathematics (NCTM) standards. I contacted two graphic design/art professors that I knew at my university, Matt Tullis and Jeff Jensen, for help in identifying some students that could illustrate the comics. Determined to show that this approach had promise, I enlisted the help of an education professor at my university, Dr. Janet Tassell, to help measure the impact of the comics on the students who used them. I was lucky to find a elementary school principal, Dr. Mary Evans, who was supportive of the idea, and who agreed to involve her third grade through sixth grade teachers and students at Cumberland Trace Elementary in the project. And finally, I was able to wrangle $4,000 loose from my provost to cover printing costs. ***Operation Comics*** was in business.

In the interest of full disclosure, I must mention that this is not a completely original idea. Larry Gonick uses cartoons in his instructional books (see [2] as an example), Colin Adams has a comic book about knot theory [1], and mathematics (arithmetic, really) was a frequent antagonist in the *Calvin and Hobbes* comic

Figure 1: Cartoonist at the Idea Kentucky Think Tank.

strips by Bill Watterson, to name a few related works. Still, none of these works or any others I found were simultaneously plot-driven and instructional.

2 The Basic Premise of the Story Line

My basic idea for the story line in the comic was that we would have a superhero-type, ***Wonderguy***, who is super-strong, but not necessarily super-smart, and that two elementary school students, ***Claire*** and ***Dillon***, that he befriends will be the real heroes of the story. Having a superhero character helps disguise the fact that these are not standard comic books, and makes them look very much like a standard comic. Having the students be the real heroes gives the students positive role-models – one for each sex – who are good at mathematics, and a character through which they can "live vicariously".

Mathematics is not the driver of the main story line or even the individual stories in each episode of the comic. Rather, the stories are developed to stand on their own in terms of literary value. However, at some point during each of the stories, our heroes are able to "save the day" by knowing and applying mathematics. Developing stories for the different episodes where the use of mathematics is both plausible and necessary has been difficult, and has required some careful character development and planning. Having a character who can pick up a car eliminates situations where brute force removes the need for brains. And many situations are such that someone *could* use mathematics to resolve them, but they would not *have* to do so. I have had to be careful to develop situations where the use of brute force is irrelevant or even detrimental to the resolution of the situation.

The following is a description of the main characters that recur in each of the episodes, and some of the plot points I have added to make the addition of the mathematics content both plausible and entertaining. The line art in Figures 2, 3, 4, and 5 is the work of Anne Erskine, with the author taking partial credit for the drawing of Wonderguy in Figure 2.

*This work was made possible by a Provost's Initiatives in Excellence grant from the Western Kentucky University's Office of the Provost, PIE #O-09-039.

Figure 2: Cover to the first edition of Operation Comics.

Wonderguy. Wonderguy is the supposed "lead" character of each of the stories, which will be centered around his adventures in crime-fighting. Wonderguy is incredibly strong, but his brains do not match his brawn, a fact that is not part of his public perception. He is an immensely popular public figure, even perhaps a bit of a celebrity. His origins are left purposefully vague, although it is clear from the way that he carries himself that he has always had his super-powers.

Claire and Dillon. The real heroes of each story are the students, Claire and Dillon. Claire is an African-American student who is wise beyond her years, and not as star-struck with Wonderguy as Dillon is. Dillon looks studious and not too athletic. Both are on the school's academic team, and Principal Willoughby considers them the "best math students in the school".

Principal Willoughby. Miss Willoughby (she currently has no first name) is the principal at Best Elementary

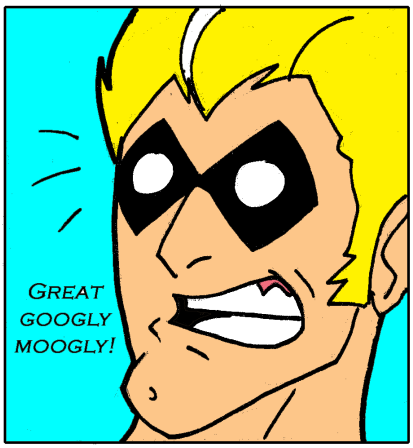


Figure 3: Our "hero", Wonderguy.

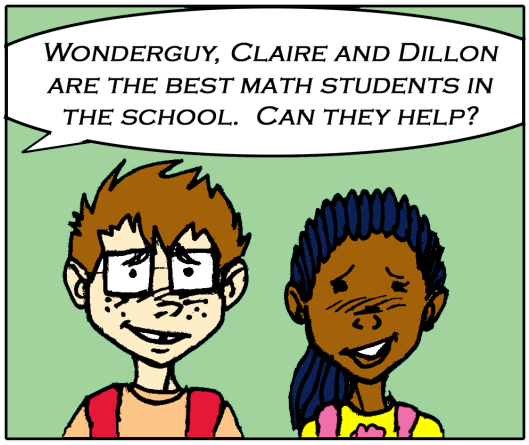


Figure 4: The real heroes, Dillon (left) and Claire (right).

School, where Claire and Dillon are students. She acts as an enabler in the story line. She first introduces Claire and Dillon to Wonderguy when he needs mathematical assistance, and will provide them excused time out of class to help Wonderguy when he needs it. She has some connection to Wonderguy that is not immediately clear, but hints of how they know each other appear in the different episodes.

3 Sample Episode: Captain Confusion's Revenge

In Episode 1, we meet the diabolical Captain Confusion, who apparently was a student at Best Elementary School as a child. He had also been on the academic team at that time, and suffered an event that caused him embarrassment during a match. Extremely arrogant and condescending to those he perceives as not as smart as him, even as a child, he sees his chance to discredit Wonderguy, whom he abhors, and get back at the school that had treated him unfairly.

Captain Confusion, who is now an inventor, encloses the entire school, including the visiting Wonderguy, in an indestructible bubble of his own design. He threatens to expose everyone in the school to a lethal dose of confusion gas, also invented by him, if Wonderguy can not solve three elementary-level math problems in five minutes without giving any incorrect answers. His assessment of Wonderguy's mathematical abilities are not far from the truth, so Principal Willoughby decides to put Claire and Dillon "into the game" to help

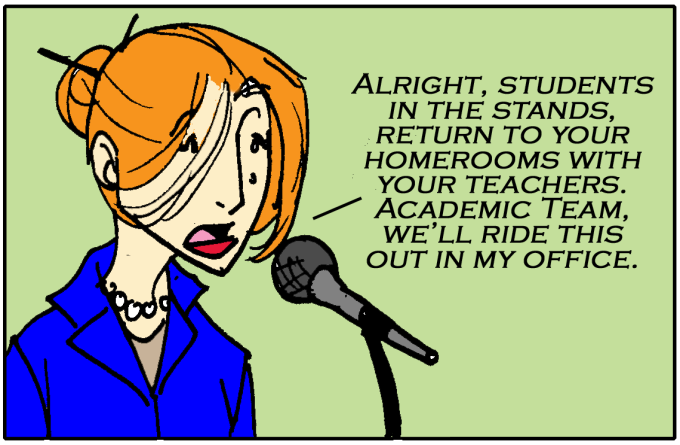


Figure 5: Miss Willoughby, the principal of Best Elementary School.

the muscle-bound hero.

The three problems and the content that they illustrate are given below, along with sections of the script of the episode. All three problems address both the standard for problem solving and the standard for reasoning and proof, for all grade levels, as provided by the NCTM [3]. Additional standards addressed are given with each problem.

Number Sense and Divisibility Theorems. The first problem can be solved by trial-and-error, but given the fact that time is ticking away rapidly, the better path is a reliance on divisibility theorems. The stated problem is

"Insert a digit in the blank so that __4268 is divisible by 9."

The dialog that follows the introduction of the problem is given below.

Wonderguy: I have already ruled out 1. (Showing messy work on a sheet of paper.) I'll rework it for 2 and 3. You do 4, 5, and 6, and you do 7, 8, and 9. We've got to hurry!
Claire and Dillon: 7! The answer is 7!
Wonderguy: We can't guess, guys! Any wrong answer, and were in trouble.
Claire: We're not guessing! To be divisible by 9, the sum of the digits has to be a multiple of 9!
Dillon: (Showing his work on paper.) Think about the 3-digit number "abc", where the "a", "b", and "c" are the hundreds, tens, and ones digits, in that order. That means that

$$\text{“}abc\text{”} = (a \times 100) + (b \times 10) + (c \times 1).$$

Then pull one of each thing out of each place:

$$(a \times 99 + a) + (b \times 9 + b) + c.$$

Claire: So, put all of your singles together:

$$(a \times 99) + (b \times 9) + (a + b + c).$$

The first two parts are divisible by 9, so if the last part, the sum of the digits, is divisible by 9, then the whole thing has to be divisible by 9! $4+2+6+8 = 20$, so to get the next larger number that is divisible by 9, you have to add a 7.

Wonderguy: Great googly-moogly! Alright, here goes nothing! (Types in 7 and hits enter.)

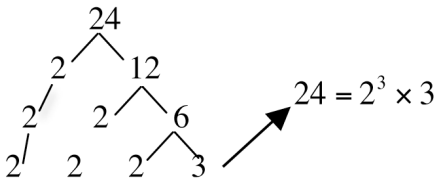
This problem addresses the NCTM standard for numbers and operations for grades 3–5, which says that "in grades 3–5, all students should understand the place-value structure of the base-ten number system and be able to represent and compare whole numbers and decimals", "recognize equivalent representations for the same number and generate them by decomposing and composing numbers", and "describe classes of numbers according to characteristics such as the nature of their factors" [3].

Least Common Multiple The second problem has a similar bend, in that it can be solved by listing all factors of each number and comparing lists until a common number is found on each list, but there is a more efficient path to the correct solution using the prime factorizations of the numbers. The stated problem is

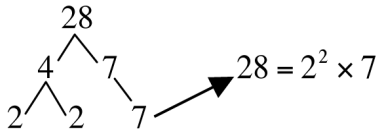
"What is the smallest number divisible by both 24 and 28?"

The dialog that follows the introduction of the problem is given below.

Wonderguy: Okay, I have a plan for this one. Brainy-Dude, you start writing out multiples of 24, and IQ-Girl, you start writing out multiples of 28. I'll watch both of you and wait for the same number to appear on both lists!
Claire: That would work, but given the shortage of time, can I suggest that we use the prime factorizations?
Wonderguy: (A very confused look on his face.) Er . . . , that could work . . . How exactly would that work?
Dillon: Break each number into its prime factors. 24 is 2 times 12, or 2 times 2 times 6, or 2 times 2 times 2 times 3. We write it like this.



Claire: And 28 is 4 times 7, and 4 is 2 squared. You keep going until all of the factors are prime numbers.



Dillon: Now, in order for our number to be a multiple of both, we have to have enough of each prime so that both of these numbers will divide into it, so we need at least 3 factors of 2, one of 3, and one of 7.
Claire: But to make it the least multiple of both, thats all of those factors that you want. So, the answer is

$$2^3 \times 3 \times 7 = 8 \times 3 \times 7.$$

Wonderguy: Okay, that's 24×7. (Starts working the multiplication problem on paper.)

$$\begin{array}{r} 24 \\ \times 7 \\ \hline \end{array}$$

Claire: Wait! It's quicker in your head: 8 times 7 is 56.
Dillon: Then 50 times 3 is 150, and 6 times 3 is 18, so . . .

Wonderguy: The sum is 168! Yeah, baby, . . . (entering the answer into the computer.)

This problem addresses the NCTM standard for numbers and operations for grades 3–5, which says that "in grades 3–5, all students should develop fluency with basic number combinations for multiplication and division and use these combinations to mentally compute related problems, such as 30×50" and "select appropriate methods and tools for computing with whole numbers from among mental computation, estimation, calculators, and paper and pencil according to the context and nature of the computation and use the selected method or tools". It also addresses the standard for numbers and operations for grades 6–8, which says that "in grades 6–8, all students should use factors, multiples, prime factorization, and relatively prime numbers to solve problems" [3].

Common difference. The last problem is an inverse problem, in that we are given a "black box" that outputs a number for each one that they enter, and they have to deduce what the formula is. The dialog that follows the introduction of the problem is given below.

Wonderguy: Holy moley, that could be anything!!
Claire: Wait. Remember that he said that only math taught at this school would be needed.
Dillon: Try a few numbers for x, and see what y is. And I recommend that you try some consecutive whole numbers, to help us see the pattern of the answers.
Wonderguy: Okay, when I give it "1", it gives me a "5". (Claire and Dillon are keeping track of the results on a piece of paper.) A "2" gives me a "7". A "3" gives me a "9". A "4" gives me an "11". This is going to take forever!
Claire: No, no! I see it! I see the pattern!
Dillon: Me, too! Each time we increase x by 1, the y is increased by 2. That means the formula has a "$2x$" in it.
Wonderguy: But its not "$2x$". Two times four is eight, not eleven.
Claire: Right, but if you notice, all of the values are three more than "$2x$". Check by putting a 0 in for x.
Wonderguy: Hey, you're right! Its a three! So the formula is . . . (Hesitates, looking at the kids.)
Claire and Dillon: (Together.) $2x+3$!!

This problem addresses the NCTM standard for algebra for grades 3–5, which says that "in grades 3–5, all students should describe, extend, and make generalizations about geometric and numeric patterns", "represent the idea of a variable as an unknown quantity using a letter or a symbol", "model problem situations with objects and use representations such as graphs, tables, and equations to draw conclusions", and "investigate how a change in one variable relates to a change in a second variable". It also addresses the standard for data analysis and probability for grades 3–5, which says that "in grades 3–5, all students should collect data using observations, surveys, and experiments" and "propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions or predictions". It also addresses the algebra standard for grades 6–8, which says that "in grades 6–8, all students should represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules" and "use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships" [3].

4 Usage and Measuring Impact

While I am comfortable developing mathematics curricula for elementary school students and teachers, elementary pedagogy and assessment are not something I feel qualified to address. Acknowledging my limitations, I have turned complete control of the classroom implementation of the comic books over to Dr.

Evans and her staff of teachers. Likewise, I have given Dr. Tassell complete control over the assessment of the effectiveness of the comics with the students.

Implementation in the classroom. At the time of this submission, the comics have not yet been introduced to the classrooms. My understanding of the implementation plan is that they will be introduced in a "fun and playful" context, perhaps as a part of center time or as a reward for good behavior or achievement. They will not be presented as a textbook – the whole idea is that the students see this as a comic first, that just happens to have some math ideas in it. I have been asked by Dr. Evans and members of her staff to develop some accompanying worksheets for students and teacher's guides to give an in-depth discussion on the mathematical content of the comics and how it relates to NCTM standards, which I will gladly develop. It has also been suggested that we let the students invent their own stories involving Wonderguy, Claire, and Dillon, and submit them to me for future comics, which I also believe is a marvelous idea. The back cover of each comic will solicit these types of ideas from the reader, and provide my contact information.

I am sure that actual classroom usage will suggest changes to improve the implementation plan. Again, I feel that giving my experts in elementary education control over this aspect of the project is crucial to its success.

Effectiveness of the Comics in the Classroom. While I or any other observer might think that this idea is innovative, "cool", etc., if it does not achieve the goals that we have set forth, then we need to either

- revise our product and/or its implementation, or
- let the project run its course and try something else.

We have Human Subjects Board approval for Dr. Tassell to have the students in the 3rd through 6th grade classes at Cumberland Trace Elementary take surveys, measuring their initial attitudes toward mathematics. Students will take a post-project survey at the end of the school year. We will also be collecting assessments from the teachers using comics to gauge their opinions about how well the comics were received by students and whether it helped and motivated their learning of mathematics. If these results are positive, then we may pursue funding to continue producing comic books on a larger scale.

5 Conclusion

Regardless of the outcome, I can truly say that this has been one of the most enjoyable grant projects I have ever undertaken. At present, that enjoyment comes from the artistic process of writing the stories, and then drawing out the scenes, and then turning them into the finished color comic books. The pride that I felt with the first completed comic is comparable to the pride I felt with my first accepted paper in a peer-reviewed journal. I hope to feel that same pride when the results from using the comics in the classrooms is known.

References

[1] C. Adams, *Why Knot? An Introduction to the Mathematical Theory of Knots*, Key College, 2004.

[2] L. Gonick and A. Huffman, *A Cartoon Guide to Physics*, Collins, 1992.

[3] "Principles and Standards for School Mathematics," National Council of Teachers of Mathematics, http://standards.nctm.org/document/chapter5/index.htm.

[4] B. Watterson, *The Complete Calvin & Hobbes*, Andrew McMeel Publishing, 2005.