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Operation Comics: The Story Continues

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Operation Comics: The Story Continues

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Abstract

During the 2008-2009 academic year, the author K. wrote three issues of ***Operation Comics***, a comic book with embedded mathematics content appropriate for 4^{th} through 6^{th} grade students. Several printed comics were placed in Cumberland Trace Elementary in the Warren County School System in Bowling Green, Kentucky, US. The author Ta. was enlisted to measure the impact of the comics on the attitudes and motivation of the students using the comics. A preliminary report was given by K. at the 2009 Bridges Banff Conference, and the written report appeared in [5]. Since then, data has been collected on the initial cohort of students using the comics, and the project has been given new life with an infusion of money from an anonymous corporate donor and a new illustrator, author Tu. This manuscript will give an abbreviated summary of our initial findings, and will show how Tu. is addressing the presentation of mathematical content in her illustrations in three new comics. We will also outline the 2-1/2 year study we are beginning during the Spring 2011 semester, and how the project is spawning other outreach activities.

1 Introduction

Operation Comics is a comic book series that follows the adventures of a strong-man superhero Wonderguy, shown in Figure 1, and his friends at Best Elementary School, the principal Miss Willoughby and academic team members Claire and Dillon, both shown in Figure 1, as well. Wonderguy is a good-natured fellow, who constantly patrols the city helping people in trouble and stopping crimes as a special member of the city's police department. We learn in the series that he has been strong his whole life, with the result that he never focused on academics as a child, and now his strength has become his default solution to every heroic situation. His friendship with Claire and Dillon is forged in the first issue, when a villain tries to ruin his superhero career by demonstrating his lack of general mathematics knowledge, thus preventing Wonderguy from saving the students and faculty inside Best Elementary. Claire and Dillon come to his aide, encouraged by Miss Willoughby, who seems to have inside knowledge about Wonderguy. In each issue, Wonderguy is thrust into situations where being super-strong is just not enough, and Claire and Dillon eventually end up being the behind-the-scenes heroes of the story.

The comic book series and characters were created by the author K. in November 2008, as a means to present mathematical concepts to elementary school students in a way that they would enjoy and find motivating. K. has written the stories for all six issues, developed teacher supplements and worksheets for the first three comics, and has occasionally had to serve as illustrator. You can see some of his work from [6], and a demonstration of how math contents are woven into the stories, in Figures 2. The author Ta. has been with the project since its inception, studying the impact of the use of the comics in the classroom on the students in the 4^{th} through 6^{th} grade at Cumberland Trace Elementary in the Warren County School System in Bowling Green, Kentucky. The school's principal Dr. Mary Evans and math faculty Cathy Willoughby, Melissa Zimmer, and Emily Duryea have been wonderful partners in this project, and have helped us gain insight into the worth of the comics and how they are best used in the classroom. Tu. is the newest member to the team, illustrating comics #4, #5, and #6, and working with K. and Ta. on measuring the comics' impact as part of her Ogden Foundation Research Scholarship. For more on the origins of this project, see [5]. For other works involving math and comic illustrations, see [1, 4, 9].

Figure 1 : *Our hero, Wonderguy, with the mathematically-minded Claire and Dillon, the real heroes of the series. Illustration by Tressa Tullis.*

2 Initial Findings

Students using the comics in the Spring 2009 semester were given an extensive online pre- and post-survey, and teachers were asked to submit comments. The following questions guided the research for the comic book impact:

1. Do boys and girls (both genders) have pre-existing perceptions that are gender neutral?
2. Does the comic book treatment change pre-existing perceptions regarding gender in mathematics?
3. What are the pre-existing mathematics beliefs/attitudes?
4. What are the post math beliefs/attitudes?
5. What are the pre-existing attitudes about reading?
6. What are the post attitudes about reading?

Note that, because the comics amounted to such a small part of the student's mathematics curriculum and may not be the only time the students were exposed to the math content in the comics, we have not tried to draw conclusions on student learning from this survey.

The following is a brief summary of the types of questions asked on the student survey and the results noted after the post-survey. Students were asked to mark either "Strongly Agree", "Agree", "Not Sure", "Disagree", or "Strongly Disagree" on most questions (exceptions will be noted with the question). Note that in the following summary of the results, we have pooled together the responses of "Strongly Agree" and "Agree", as well as the responses of "Disagree" and "Strongly Disagree". The pre-survey was given early in the Spring 2009 semester, before the students had been exposed to the comics, and the post-survey was conducted near the end of the Spring 2009 semester. The survey was approved for use at Cumberland Trace Elementary by the WKU Human Subjects Review Board. A full analysis of the data collected will be available in a future manuscript by Ta. and K. Note that, in the surveys, the comics were referred to as the "Math Comic Book" for clarity's sake.

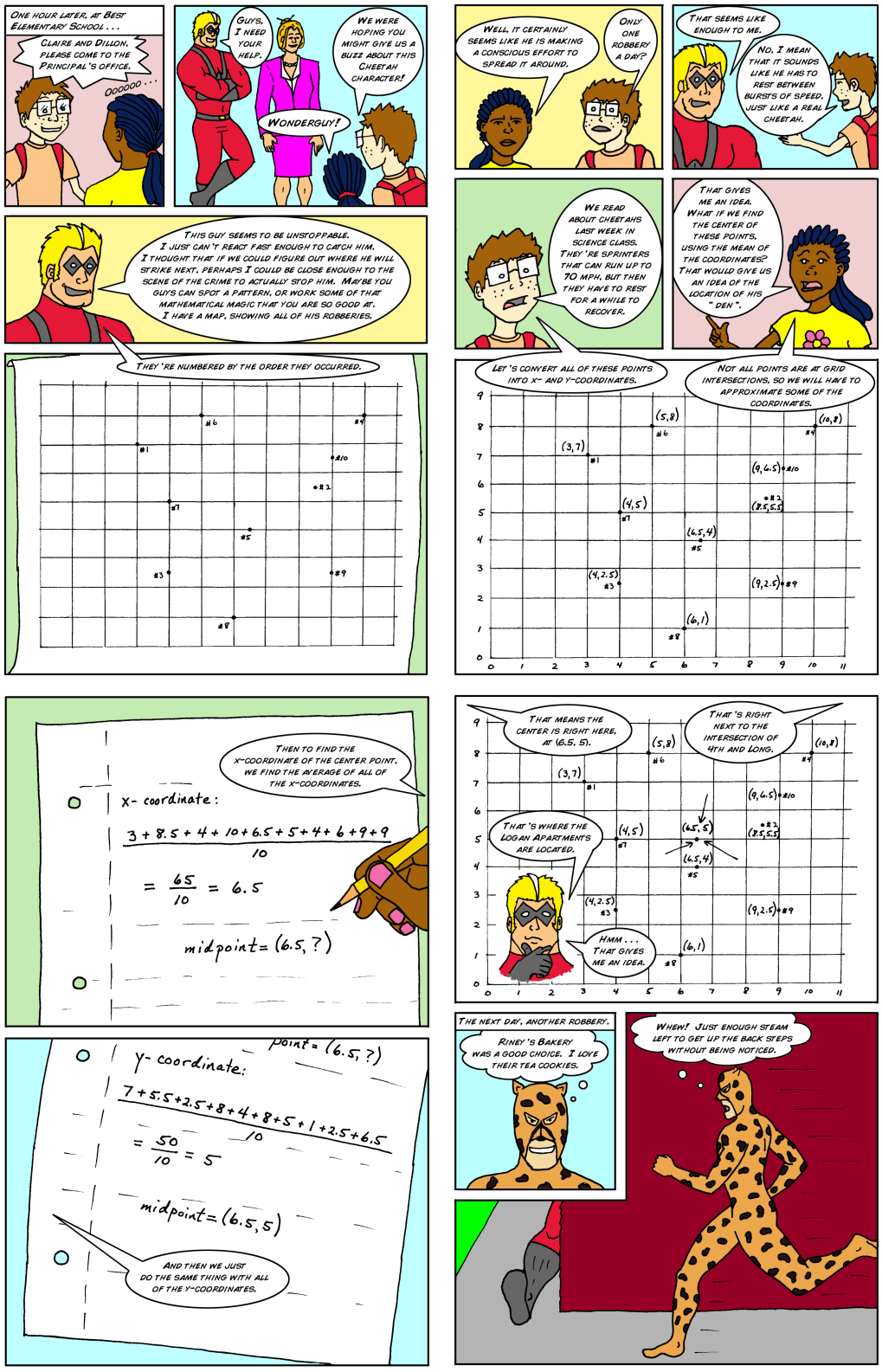

Figure 2 : *Four successive pages from* Operation Comics #3, *showing how Claire and Dillon use statistical methods to catch the Cheetah. Illustration by Bruce Kessler.*

Gender issues. The following statements were given for the students' reaction on both the pre- and post-survey.

- "Girls and boys who do well in math are both congratulated." The post survey shows an increase in those agreeing that both girls and boys are congratulated in math, from 81% on the pre-survey to 84.3% on the post-survey.
- "In a math class with both boys and girls, girls tend to speak up more than boys." The data show a decrease in the total population that agrees, at 33.8%, which is down from 43.1% on the pre-survey.
- "Boys like hard math problems more than girls." The post-survey data show that there was a 1.3% decrease in agreement that boys like hard problems more than girls. Those that disagreed also decreased from 43.6% to 41.9%.

Our conclusion for research questions 1 and 2 was that gender differences did occur from pre- to post-survey. The questions targeted looking at the math comic book treatment as a potential affect on the gender beliefs. In regards to more equal treatment perceived in the classroom by being congratulated, the students agreed more to this equality perception in the post survey an increase of 3.3%. From the question regarding who speaks up more in class, there was a large decrease of about 10% showing that boys and girls were being seen as possibly acting more the same in the classroom. Furthermore, there is a shift seen in how the perceptions of girls and boys liking hard math problems in that the percentage agreeing decreased when asked if boys like hard math problems more than girls. The hope of the treatment is that the gender gaps become smaller, as we see in the above results.

Pre-existing beliefs and attitudes about math, and then after using the comics. The first question "How good are you at math?" was given on both the pre- and post-survey. The remaining statements were given for the students' reaction on the post-survey.

- "How good are you at math?" On this question, students were asked to respond with either "Excellent", "Good", "Average", "Below Average", or "Weak". The data shows an increase from 83.1% on the pre-survey to the post-survey at 84.9% of students believing they are "good" or "excellent" in math. Those believing they were below average or weak decreased from 4.6% to 3.5%, with no one self-reporting as weak on the post-survey.
- "The Math Comic Book improved my attitude toward math." The data shows that 56.4% of the students believed that this helped their attitude toward math. Furthermore, only 21.5% disagreed that the comic book had impacted their attitude.
- "The Math Comic Book helped me appreciate how math can be fun and used in the real world." A majority of the students, 61.7%, agreed that the Math Comic Book helped them see math as fun and useful in the real world. The percentage of students disagreeing was at 16.3%.
- "The Math Comic Book did not affect how I felt about math." The data show that 40.3% agreed that the Comic Book did not affect their feelings toward math, but 48.8% disagreed allowing a possible inference that the Math Comic Book did affect their feelings.

The survey showed that the use of the comics did have a positive impact on the students' attitudes towards mathematics in general.

Attitudes about reading and art as a motivator for learning mathematics after using the comics. The following statements were given for the students' reaction on the post-survey.

- "The Math Comic Book was not interesting to me." The data showed that 22.5% agreed that the Math Comic Book was not interesting. However, 66.9% disagreed, so we can infer then that these students found the comic book interesting.

- "Reading about math in the Math Comic Books helped me learn math better." About half of the students, 52.9%, agreed that reading about math in the comic books assisted in their learning of math. Less than a third of the students, 22.7%, disagreed.
- "The art in the Math Comic Book was interesting and made me want to read more." The data showed that 64.5% of the students agreed that the art made them want to read more. A relatively small number, 17.5%, did not agree.

The survey showed that the stories and the illustrations did have a positive impact on the students' desire to learn mathematics.

Student satisfaction with the project. The following statements were given for the students' reaction on the post-survey.

- "I looked forward to each new Math Comic Book." A majority of the students, 66.2%, looked forward to the new math comic book during the semester. A minority of 16.9% disagreed.
- "I would like for the Math Comic Books to continue to be used in my classroom." The data showed that 72.1% of the students would like to have the project continue being used in the classroom. A relatively small 13.4% of students indicated that they would not.

The survey showed that a large majority of the students enjoyed using the comics and wanted to continue using them in their math classes.

Feedback from teachers using the comics. Teachers that had used the comics in their math classes were asked for their perceptions of how the students responded to the use of the comics in their classrooms. The following is a list of comments that were particularly telling.

- "The students were extremely excited to see comics and even wondered why we were using comics in math. The students like the characters."
- "The students were happy to welcome a change of pace in class. They laughed a bit at the superheroes, but were able to predict the role the various characters would have after scanning the first few pages. Most students eagerly volunteered to read a role each time we used the books."
- "I used the comic books in different ways. First as an introduction to prime factorization as we had talked about prime numbers but not prime factorization. Second, I used it as a review of variables as this was something we talked about at the beginning of the year."
- "First, I briefly reviewed the math content that the characters would encounter, starting with divisibility rules. Then, I assigned roles and the students read aloud. Once the math problem was presented, I had them close their books and try to solve the problem on their won. After we discussed the students' approaches and solutions, we opened the comic to see how Claire and Dillon solved the problem."
- "These materials were great graphic organizers for follow-up assessments. They are challenging, even for more advanced students. In some cases, the content may be too advanced for 3-4 graders to pick-up without a teacher devoting a large chunk of time to the concept."
- "I believe the mathematical situations in the book showed students how a deeper understanding of math allows you to solve problems faster. During the prime factorization/LCM problem, most students were ready to start listing the multiples of each number, but were attracted to Dillon and Claire's method when they saw how much faster their classmates who used it solved the problem."
- "Most of my students already appeared to like math. However, I believe the comics deepened their interest in math. I have many bright students that also enjoy art - this provided them a way."
- "Normally, students roll their eyes at students who volunteer to read in class and exchange berating looks if someone goes as far as to read with expression. When we used the comic books, reading aloud

and animatedly seemed to be deemed cool again. I cannot say how this impacted students abilities, though we did review vocab. like villain, but it did impact their attitude about reading aloud in class."

3 A New Lease on Life

After the first three comics were completed and survey data had been collected, the project seemed, sadly, to be over, except for the dissemination of the results in a education journal. K. had more ideas for stories, but all of our printing funds had been depleted. Also, the time that it had taken K. to illustrate the last two comics was enormous, and was prohibitive even if printing funds had been available. But early in 2010, two events occurred that breathed new life into the project.

An anonymous donation from a corporate donor. In January 2010, our university received an unsolicited donation from a corporation in support of the comic book project. The donor has asked to remain anonymous. The donation provided funds for printing an adequate number of three more issues of the comic for use at Cumberland Trace Elementary, and for paying an illustrator to draw the comics. The initial plan was to contact colleagues in WKU's art department for a recommendation of one of their students to serve as illustrator on the next three comics.

A "real" illustrator is found. In March 2010, in a conversation with WKU art professor Matt Tullis, we learned that his daughter Tu. was returning to WKU as a student after a brief stint at Harvard University. Tu. had previously taken math classes at WKU while still a high school student, and also had an extensive portfolio of drawings and paintings she had created previous to starting college. The two of us met late in the Spring 2010 semester, and the rest, as they say, is history. You can see examples of her work in Figure 1, and from [7] in Figure 3. The quality of her artwork, in comparison to K.'s illustrations from [6] in Figure 2, makes a dramatic and convincing case for how badly a talented illustrator was needed for the project. Tu. will have completed illustrating two more comics by August 2011.

4 The New Issues and the Educational Plan

The authors and their previously-mentioned team at Cumberland Trace Elementary met early in the Spring 2011 semester to discuss how to proceed with both the presentation of the new comics in the classroom, and how to structure Ta. and Tu.'s research study into the impact of the comics in the classroom that will last through Spring 2013. The decision was made to introduce the comics to the students by aligning the content in the comics to their current curriculum map instead of the order the comics were created. The following sums up the grade levels at which the comics are intended to be used in the classroom. Of course, once a comic has been introduced, it may be reused later in that grade or any following grade.

- Fourth grade
  - *Operation Comics #1: Captain Confusion's Revenge* This story sets up the storyline, and establishes the role of each of the characters. The math content included in this issue is the divisibility theorem for nine, the least common multiple of two numbers using prime factorizations, and using linear formulas to describe patterns.
  - *Operation Comics #3: Not Your Average Cat* This story pits Wonderguy against a biologist who has conducted his genetics research on himself, which has given him the ability to run at up to 71 mph. Assuming the name "The Cheetah", he commits a series a petty crimes to get the attention of potential sponsors of his research, showing how not even Wonderguy can stop him. The math content included in this issue is the arithmetic mean and the graphing of points on a coordinate axis.

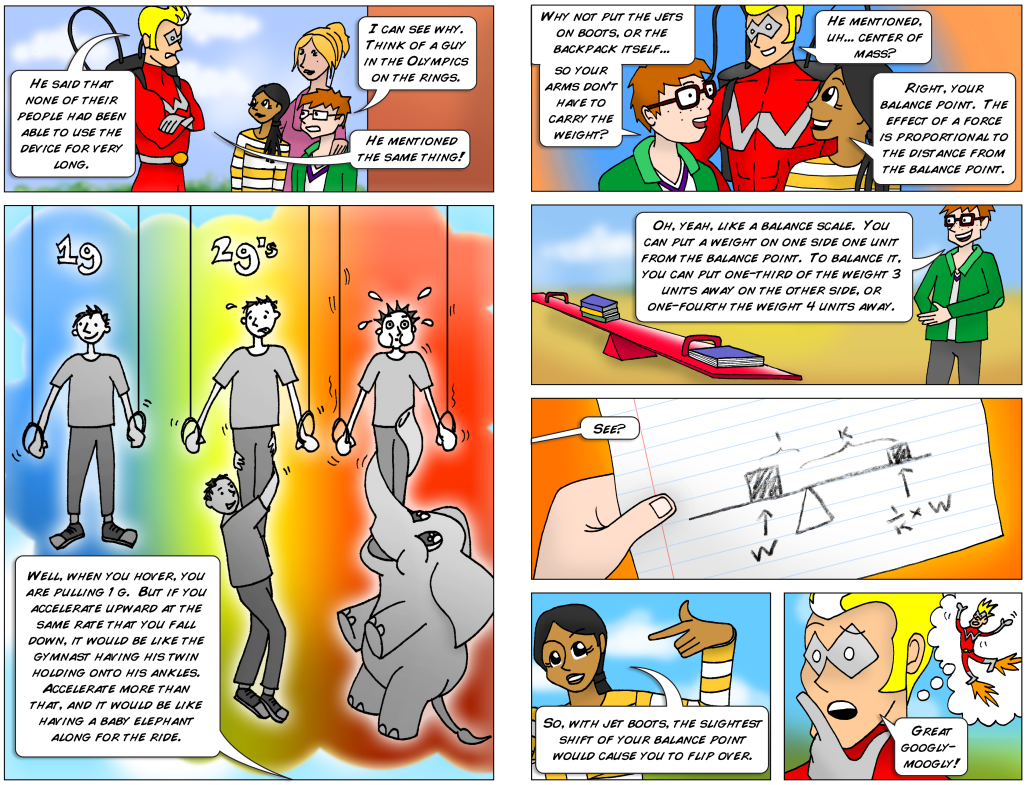

Figure 3 : *Sample pages from* Operation Comics #4*, where Claire and Dillon are explaining some of the math (and physics) involved with Wonderguy's new jet pack. Illustration by Tressa Tullis.*

- Fifth grade
  - *Operation Comics #2: The Shape of Things* This story pits Wonderguy against a disgruntled janitor who has been fired from the local government research facility, who accidentally gives himself the ability to change his shape. Under the guise of "The Shape Master", he tries to profit from his newfound powers. The math content included in this issue is the volume of cylinders, spheres, and rectangular prisms.
  - *Operation Comics #5: The Origin of Wonderguy* This story explains how Wonderguy came to exist, and how he foiled his first crime. The math content included in this issue is simple probability and the compound probability of independent events. (It also includes some science content, as Punnett squares are introduced.)
- Sixth grade
  - *Operation Comics #4: Wonderguy in the Sky!* This story pits Wonderguy against a circus trapeze artist Aerial, who decides to use her skills for crime. The math content included in this issue is the concept of proportionality and the solution to an equation with a squared term. (It also includes some science content, as Newton's Second Law, $F = ma$, is introduced, as well as the concept of center of gravity.)
  - *Operation Comics #6: The Return of Captain Confusion* This story pits Wonderguy against his archrival from *Operation Comics #1*, Captain Confusion, who has found a way to "confuse" Wonderguy's genes, tricking his dominant genes into acting like recessive genes, and vice versa. The math content in this issue is the arithmetic mean, adding positive and negative numbers, additive inverses, multiplying positive and negative numbers, and multiplying two negative numbers.

The teachers at Cumberland Trace Elementary will decide how to best integrate the comics into their units on these topics. Tu. will work with Ta. to construct instruments to measure the attitudes and understanding of the students after they have used the comics in their classroom. The project will culminate with a research paper as part of Tu.'s Ogden Research Scholarship and her Honors College thesis, and hopefully a joint manuscript on the research to be submitted for publication in a peer-reviewed educational journal.

5 Conclusion

Initial finding on this project are promising, and due to a little luck, we are able to add three more issues to the series for placement at Cumberland Trace Elementary, allowing a more detailed study of their impact in the classroom. The project has caught the attention of the general public. The project was the topic of a February 4, 2010 segment on Bowling Green, KY television station WBKO, called "View from the Hill" (see [2]), a WKYU-FM public radio news interview (see [8]), and a Bowling Green Daily News feature story (see [3]). The project will be the cover story for the summer edition of the WKU Spirit, a magazine produced by the WKU Alumni Association. Tu. will be providing the cover illustrations, and more artwork in the article. Tu. was been invited to be one of the featured women artists at *A Fine Arts Gala* at Cumberland Trace Elementary on March 3, 2011, sponsored by the Cumberland Trace PTA and the Kentucky Foundation for Women. Also, both K. and Tu. have been invited to participate in a Author/Illustrator Meet-and-Greet, a fairly regular event held at Cumberland Trace Elementary. We hope to gain some valuable feedback, at least from a creative aspect, on how the students are liking the comics, and gather any ideas that they have for future issues.

As for future issues, by August 2011, the funds currently being used for printing the comics will once again be exhausted, but we have plans to generate revenue through sales of the comics, while simultaneously growing the audience of potential readers. K. has reformatted the comics for download to the NOOK and NOOKcolor, and the readers for PC, Mac, and iPad, as e-books. The electronic versions are available through the Barnes & Noble's website `www.barnesandnoble.com`. The WKU Research Foundation has established a website for the sale of hard-copies of the comics, at `www.wku.edu/research/wkurf/operationcomics`. All proceeds from the sale of the comics will be reinvested into the project.

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