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## Math Stories: Learning and Doing Mathematics through Fiction Writing

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# Math Stories: Learning and Doing Mathematics through Fiction Writing

## **Cover Page Footnote**

A special thanks to an editor, Gizem Karaali, for her suggestions regarding our manuscript.

# Math Stories: Learning and Doing Mathematics through Fiction Writing

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## Synopsis

In this paper, we advocate the writing of mathematical fiction (*i*) as an aid for students in learning mathematics, and (*ii*) to engage students in doing mathematics.

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**Fred the professor:** I have taught game theory and mathematical economics at a liberal arts university for over 10 years now. Starting a few years ago, I require all students in my Game Theory class to write a paper using the tools of game theory. I place no restrictions on what topics students can write about. I only require three things. First, game theory is applicable to the situations that they want to study and write about. Second, they have fun with the assignment. Third, they tell me a good story.

That last requirement I only meant in a figurative sense. I do not want students to think that their papers have to conform to a certain structure that is often expected in their other courses. I do not expect them to infuse their papers with academic jargon and prose. Even though game theory is applied math, I do not even require the papers to have equations in them. I want to see, given a blank canvas, what they can do with the knowledge they have gained in my class. As I often tell students who ask me to elaborate on what I am looking for, I want them to “entertain me.”

I have seen some truly outstanding, interesting, and, yes, entertaining papers from my students. Many students choose to write about strategy choices in sports: when is the best time to steal a base in baseball, whether to run or pass in football, which side of your opponent to serve to in tennis, and so on. Some students have chosen to study the games that are played for fun (and sometimes for money). For example, betting in Final Jeopardy, the optimal way to play Mankala (or a simplified version of it), and certain situations that arise in poker. And others have written papers on real-world political or socio-economic interactions: what is the optimal way to bid in auctions, the Cuban missile crisis, collusion and the OPEC oil cartel, and others. A few students have, motivated by their own experiences in other courses, examined theoretically the effects of various grade curving schemes on students' incentives to study for tests. One student wrote his paper on how our university could utilize a lottery system to sell football game tickets to students. This paper was published in *Mathematics Magazine* after I generalized his model and proved a theorem or two about it [1].

And then this past semester, my student Janna actually wrote a story for her game theory paper.

**Janna the student:** I am in my final year of my undergraduate education and by now I have written more papers than I can count. So, when I got this assignment I first approached it like every other paper. After a sufficient period of grumbling, I just gritted my teeth and got to work. I know nothing about baseball or gambling, and originally I struggled to come up with a solid topic. Then, I got a wonderful call from my mother. "Did you get your flu shot? Because everybody needs to get their flu shot," she scolded. I was proud to beat my nagging mother to the punch and report that this year I had actually been proactive. More importantly, however, I realized that there might be more to this story. Did everyone really need to be vaccinated? Slowly, my game theory wheels started turning.

For this assignment we were required to turn in project proposals. No problem. I turned mine in and did not give it a second thought till Dr. Chen returned each proposal with his comments. Everyone else's paper had a few scribbled sentences either approving it or offering suggestions. Mine came back with an essay attached. It just so happens Dr. Chen actually does economics research on epidemiology, which clearly made me the most unlucky student in the class. My professor was already an expert on my

topic. He had been thinking about these ideas for years, and I felt like I was going to struggle to keep up. But since it was now too late to change my topic, I simply charged ahead (with renewed grumblings, of course).

I started out being frustrated and bored. Desperately, I tried to come up with terribly complex game structures but just ended up grasping for straws. Something needed to change. I am not a mathematical economics student; in fact, sometimes I still have to count on my fingers. So I just stopped pretending. It was obvious to me that I was not going to be writing some groundbreaking mathematical paper. Maybe this is just some blatant brown-nosing (I still need Dr. Chen to pass me in one more class in order to graduate), but my professor is a fairly intelligent man and chances were I was not going to outsmart him in his own area of expertise. Instead, I decided I could tell him a story he already knew in a way that he had never seen.

**Fred the professor:** I am telling you, I had never seen anything like it!

**Janna the student:** Somewhere between harassing Dr. Chen on multiple occasions to be sure he really wanted to be entertained, this story got a life of its own. I got increasingly bold. Not only that, I got increasingly interested and involved in the subject. It was the first and only time that I have seriously enjoyed writing a ten-page paper.

**Fred the professor:** I had no idea she was going to write a freaking *children's book*—complete with original artwork—for her paper! Oops, can I say ‘freaking’ here?

I couldn't stop smiling the first time I read her story. In fact, even now, it's hard not to smile when I read it. In a nutshell, Janna's story is about this guy, Gilbert, who is deciding whether to get a flu shot or not, and the reader gets to listen in on his thoughts as he makes use of game theory principles to arrive at a decision. Janna, why did you choose the name Gilbert?

**Janna the student:** Honestly, many of my protagonist's thoughts and actions mirror my own experiences. As embarrassing as this is, I actually played Dungeons & Dragons growing up. Luckily, I ended up with a stronger set of social skills than my character has, but there is still a part of me that relates to most nerdy, socially awkward kids. I felt like Gilbert was an excellent choice to reflect that type of person. Also, the name Fred was already out for obvious reasons.

**Fred the professor:** Hmm, I see...I think. Anyways, the beauty of Janna's story is that it illustrates how game theory can be used to analyze people's decisions to get flu shots, and it also explains clearly in easy-to-understand terms some of the basic principles of game theory. Her story would provide a great simple introduction to game theory for someone who knows nothing about the topic.<sup>1</sup>

I immediately fell in love with the story and the concept of what Janna did—writing fiction for her game theory paper assignment. As soon as I finished reading it in my office, I grabbed the paper and went around my department showing my colleagues, the department administrative assistant, and anyone who happened to be in my building at that time what she did. And then I said to myself, “Self, writing stories with something mathy in them might actually be an excellent way to learn math and to do math!”

Now, many people have talked and written about how reading mathematical fiction can aid students in the learning of math, see for instance [2]. And for those interested in reading mathematical fiction, there is actually a website devoted to such works (<http://kasmana.people.cofc.edu/MATHFICT/>). But what I am thinking about is to have the students write mathematical fiction as a way to learn math. There are several benefits to this approach, which (for convenience) I will call the *math stories* approach.

For many students, learning and doing math in school equals doing only problem sets. More advanced or motivated students may end up writing research papers. The math stories approach is more egalitarian because students of any level in terms of math background can write stories in which math plays some role. In fact, in writing their stories, students may end up wanting to learn new topics in math if they are integral to the plot. For example, someone writing a spy story involving secret codes might find it useful to learn more about number theory and cryptography.

This approach allows students to tap into different forms of creativity at the same time. Writing a piece of mathematical fiction gives students the opportunity to create and innovate in terms of mathematical, artistic, and literary expressions. Heck, for the film buffs or those who are musically inclined, why not let them create mathematical fiction through film, song, or sound?

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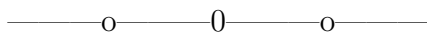
<sup>1</sup>EDITOR'S NOTE: For the complete story, see the attached Article Supplement.

The math stories approach lends itself to interdisciplinary instruction. Not too long ago, a math professor and a dance professor at my university collaborated to teach about the geometry of dancing [3]. I can see something similar for teaching math fiction writing, some kind of collaborative effort between math professors and English professors, for instance. Such interdisciplinary collaboration may be a great way to introduce math-averse literature students to the elegance of math; at the same time, such courses may open the eyes of literature-averse math students to the rich world of fiction, poetry, and storytelling.

Because of the fictional setting, i.e., the worlds that students create in their math stories need not be constrained by all the laws of nature that we know of, students have a ‘medium’ to experiment with new ideas. Perhaps there is a student out there who wants to imagine a world in which one and one do not add up to two, or a world in which things can simultaneously be discrete and continuous. I don’t know what that means; I am just saying. Math fiction would be perfect for these types of intellectual explorations. Maybe we will see some truly innovative and useful ideas come out of all this.

Who knows, maybe some of these math stories will turn into bestselling books, award-winning plays, or Hollywood blockbuster movies. Some of them might turn out to be particularly suited for teaching certain math concepts to young children. Hey, Janna, think your story can be turned into a George Clooney movie?

**Janna the student:** I think it could make an excellent George Clooney movie. . . .



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