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# Research Report

## Book Review for the AMS: Math Girls - Miruka?

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## Book Review for the AMS: Math Girls – Miruka?

When we were asked to review *Math Girls*, translated from the Japanese novel, 数学ガール, we were unsure how to respond. A cursory glance at the cover of the book might lead naïve, prospective readers to assume it is a pro-math book to inspire young women to pursue a career in the mathematical sciences. A quick search on the internet retrieved a comic book series and some free, downloadable short stories. Was this an adaptation of a strange *manga* (Japanese comic book)? Our curiosity was further piqued on finding that many of our female colleagues received copies of the book as a gift from their husbands (who appear to be greater fans of the book than their wives), and so we decided to dive in.

We hope our review will answer some questions that came to mind before our readings. Will this tremendously popular Japanese book enjoy the same, success and appeal with the American (or English-speaking) readership? Or will that special something, that “*je ne sais quois*”, be lost in translation? Does it successfully bridge cultural differences (American-Japanese, male-female)? Can a male writer portray young females engaging in mathematical dialog in a positive, exciting and realistic light? Is the title appropriate? Or was it selected to be intentionally misleading? By the conclusion of the book, most of these questions seemed less relevant. The journey to the magical world of mathematics, the user-friendliness of the book, and its cheerful and playful prose make *Math Girls* a enjoyable read for persons with an inquisitive mind and mathematical inclination.

We do caution that *Math Girls* is not for everyone, particularly those who have little interest or affinity for mathematics. To help determine the suitability of the book as a gift, we provide a brief background sketch of the author, profile of the characters, and remarks on the mathematical presentation. We do not summarize the mathematical content as it is available in the Table on Contents<sup>1</sup>.

### Background.

Hiroshi Yuki was an established author of books on computer science until a series of vignettes serendipitously posted on his website became very popular. In response to requests from fans, he compiled the stories into a book, *Math Girls*. The overwhelming, positive response to the book was highly unusual given the main subject matter, i.e., mathematics. According to the publisher<sup>2</sup>, *Math Girls* is “currently in its eighteenth printing in Japan, and has been one of the top 5 general interest mathematics books on amazon.co.jp since its original release in 2007”.

A new *Math Girls* novel is being published almost annually, with each subsequent novel

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<sup>1</sup> The table of contents is available for browsing on-line at amazon.com<sup>TM</sup>: <http://www.amazon.com>

<sup>2</sup> Bento Books website: <http://bentobooks.com/2011/09/math-girls-publication-announcement/> Accessed 6 Dec 2011.

covering more advanced material. Major topics covered in the second volume are number theory, abstract algebra (groups, rings, and fields), methods of proof, Euler's identity, and Fermat's last theorem. The third volume introduces the Peano axioms, sets and logic, limits, trigonometry, and Gödel's incompleteness theorems, and the fourth, some topics from probability and mathematics in computer science, leading up to a discussion on randomized algorithms. Japanese comic books based on *Math Girls* have also been published, each featuring the imaginative talent of a different artist. The publisher hopes to release an English translation of *Math Girls manga* and the second novel in the series within the next 12 months. We review the first *Math Girls* book published in 2007.

### **Overview of the Plot and Profile of Characters:**

*Math Girls* can be viewed a collection of conversations between high school students on how to solve mathematics problems that require deep thought. Each chapter focuses on a historically significant problem, which (in some cases) can be solved via more than one approach. In addition to tutoring readers on how to solve math problems, the conversations between the students are on mentoring each other on how to think, approaches for tackling a new problem, and understanding difficulties associated with the learning process.

When the book opens, the protagonist (and narrator) is an awkward, male teenager who loves mathematics and has limited experience conversing with girls. He is simultaneously flattered, bewildered, and flummoxed when a young, confident female math whiz named *Miruka* lavishes attention on him in the form of mathematical puzzles and quizzes. In the naming of this character, the author has invoked a typical play on words by Japanese. Although the Japanese written characters differ, the pronunciations for name *Miruka* and the phrase, "*Will you take a look at this?!*" are identical.

Separately and equally unexpectedly, the protagonist is approached by an awkward younger girl named *Tetra*, who is interested in mathematics but suffers from a lack of confidence. Her introduction and the subsequent hint in the text, "*As in mono-, di-, tri-?*" direct us to the four elements from Ancient Greece: earth, air, fire and water. And as we read on, we find four main characters in the book, each embodying characteristics ancient Greeks associated with the elements. The name *Tetra* also references Empedocles's book, *Tetrasomia* or *Doctrine of the Four Elements*, in which the ancient Sicilian (Greek) philosopher, scientist and healer proposed, "*all matter is comprised of four 'roots' or elements of earth, air, fire and water ... the interaction of (which) is influenced by the relationship between the two great life energies of Love and Strife*"<sup>3</sup>. The two characters who complete the world of four elements are Mr. Muraki, the mathematics teacher, and Mrs. Mizutani, the librarian.

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<sup>3</sup>Marks T (1998) Elemental: The four elements – from Ancient Greek science and philosophy to poetry: <http://www.webwinds.com/thalassa/elemental.htm> Accessed 16 Dec 2011

The young and pure Tetra, who inspires the narrator in his math work, is the embodiment of *air*<sup>4</sup>. Miruka is the embodiment of *fire*, an element said to provide clarity and commonly associated with energy, assertiveness, and passion. Mrs. Mizutani is the embodiment of *water*, an element associated with binding and separation. Tetra and/or Miruka and the narrator often meet in the library, whose caretaker, Mrs. Mizutani disperses them at closing time. Mr. Kimura is the embodiment of *earth*, an element associated with seasons, crops and fertility. He assigns new math problems that serve as catalysts that drive meetings between the narrator and the Math Girls (Miruka and Tetra). A Japanese reader would immediately realize Mr. Muraki's association with *earth* from his name, which means *village tree*, and Mrs. Mizutani's association with *water* since her name means *valley of water*.

Three minor characters contribute to the boy-girl, girl-boy subplots. AyAy is a talented pianist who is the President of *Fortissimo*<sup>5</sup>, the school piano club. She is introduced to us when she gives a duet recital with Miruka. The Japanese word *ay* (more commonly spelled *ai*) has several different meanings depending on the Japanese character. It can mean *love*, *meet*, *companion* or *play pal* (when combined with the character for play) or the *indigo* (blue) color or dye<sup>6</sup>. A second minor character, Kaito<sup>7</sup>, a friend and classmate, provides a pair of tickets to a planetarium, which the narrator uses to take Tetra for what was intended to be a date (she falls asleep in the dark). In Japanese, *kaito* can have several meanings, depending on the characters used in written form. Two common spellings consist of two characters, the first being, *sea* (*ocean*) and the second, the *constellation Ursa Major*, or the character, *to soar* (*fly*). Several common words share the same pronunciation. Some nouns are: *answer* (*reply*, *response*), *answer* (*solution*, e.g., of a math problem), the *President*, *a small ferry*; or the verb *to dissolve* (e.g., a party); or the adjective: *thaw* or *defrost* (e.g., frozen foods); or *decompress* (a compressed or encoded file) in computer science. A third character, a flute appears in the background when the narrator and Tetra meet in the library. In ancient Greece, the music produced by flutes was associated with the voice of love<sup>8</sup>.

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<sup>4</sup>The Latin terms: spiritus, anima, animus; and Greek terms: psyche, aura, pneuma describe air as a universal power or pure substance, from which the English terms: aspire, inspire, perspire, spirit are derived.

<sup>5</sup>fortissimo (adj. and adv.) meaning very strong, loud (in printed musical notation)

<sup>6</sup>In the original, Japanese book, AyAy's was named EiEi (エイエイ). Its pronunciation would be puzzling for Americans and would lead some to recall lyrics from Old MacDonald's farm ([http://en.wikipedia.org/wiki/Old\\_McDonald\\_Had\\_a\\_Farm](http://en.wikipedia.org/wiki/Old_McDonald_Had_a_Farm)). In Japanese there are several characters that are pronounced *Ei*. For example, in Japanese, *eiei* is an onomatopoeic word thought to evoke the sound of *cheering* (rooting) for someone or something. Alternatively, it can be mean *English*, the *first letter of the alphabet A*, to *reflect* or *project* (and is the first character for the compound word used for *movie*), first character for nutrition, family of sea creatures that include the sting ray.

<sup>7</sup>The translator changed the name of this character from *Tsunomiya* (東宮) in the Japanese text due to its length and the difficulty in pronunciation for Western readers lacking familiarity with Japanese morphology. In addition, *Tsunomiya* would have been the only character to be addressed by his last name by other students, which would be very odd in the United States. *Tsunomiya* means Eastern residence of the Emperor, referring to Tokyo (東京), which means *Eastern Capital*.

<sup>8</sup>In Greek myths, the birth of the flute is attributed to Pan, a creature who is half human and half-goat, One day when Pan is scampering about in a forest, he encounters Syrinx and immediately falls in love. However, she panics from unwanted advances by the odd-looking creature, and flees to the water's edge. In response to Pan's plea for help, Zeus turns Syrinx into reed, and the heartbroken Pan cuts and bundles the reed to make panpipes. He uses the panpipes to "give voice to his pangs of love". Puscuiu C, White B, History of the Panflute: <http://pan-flute.com/history/> Accessed 22 Dec 2011.

Although the protagonist's girl-boy, mentor-protégé, and protégé-mentor relationships which involve platonic love and strife are contrived and puerile even by high school standards, they serve several purposes, the most obvious being to enliven the text and tie together what would otherwise be dreary and dry expository dialogs on mathematics. Another may be to inspire readers to look into the history of mathematics, particularly of ancient Greece<sup>9</sup>. Unfortunately, many hints, jokes and double entendres in the story that worked in Japanese are lost in translation, and would be difficult to replicate in English since the Japanese language (which uses three different types of characters) can be used to more subtly to poke fun. For example, Miruka could be translated as CeeCee or CC (similar to "JR", as in "Who shot JR?"), AyAy as Venus, and Mr. Muraki as Mr. Arbre. However, a second meaning that could be associated with Muraki = Mu + Aki = *never grow bored* cannot be adequately captured in translation.

For reasons we may only venture to guess, the name of the narrator remains a mystery through the entire book, perhaps suggesting that he can be any adolescent male. Omission of a name and clear identity helps readers travel to the mathematical world of the narrator and empathize with his challenges.

For readers who are uninterested in the historical context in which the mathematics was developed, the girl-boy subplots and the simplistic text replete with symbolism may become wearisome. If they accept *Math Girls* as a mathematics textbook in disguise and the girl-boy encounters as (sometimes trite and sometimes more successful) attempts to introduce approaches to thinking like a professional mathematician, the book will read swimmingly. We venture to guess that remarks by the author in the *Afterword* section probably go over better with the Japanese male readership than with females and Americans, due to cultural differences:

"This fascination one can have with mathematics is similar to the fascination a boy can have with a girl. You try to solve a difficult problem, but you can't seem to find an answer – you don't even know where to start. But there's something about it that draws you in and won't let go. You know that something wonderful waits, if you can only coax it into sharing its secrets. That's the kind of feeling I hope this book has brought to you." (p. 271)

### **Mathematics in Math Girls**

Mathematics is clearly the superstar of this novel, with beautiful derivations and proofs. Equally important are the one-on-one discussions that illustrate the need for patient and thoughtful nurturing of young people interested in mathematics. We found that people who did not major in mathematics found the math problems much more interesting than textbook style assignments they encountered in school. They also enjoyed the emphasis on thinking – and different ways of thinking – about a problem. Explanations on different approaches to solving a problem were "exciting", with each approach boasting its own, unique type of mathematical elegance and

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<sup>9</sup>Before the advent of prep schools and college entrance exams (see, e.g. p. 8, top) – the history of mathematics was taught alongside mathematics – origins of ideas, derivations of identities, proofs, ways of thinking, etc.

finesse or high practical value (e.g., speed in computation).

The first chapter eases us into the playful world of mathematics. The discussions center on the discovery of patterns in numerical sequences, and puzzles based on Fibonacci sequences, primes, and powers of integers. To solve for the  $n^{\text{th}}$  Fibonacci number, a computer science major accustomed to coding solutions would most likely code a recursive method for finding a solution for an input natural number  $n$ . The idea of and the process involved in deriving a closed-form formula seemed exciting and new to CS majors with whom we talked.

The final puzzle in Chapter 1 stumped the protagonist (as well as us). Upon hearing the answer, he is unembarrassed, unapologetic, and even a bit defiant:

“what I didn’t like about this problem was ... It relies on memorization. Math isn’t about dredging up half remembered formulas. It’s about making new discoveries. Sure there are some things that require rote memorization ... but math is not like that. With a math problem you have a set of rules. You have tools and materials... math is not about *memorizing*, it’s about *thinking*. Or at least that’s what it is to me.” (p. 7)

This is the first of a series of impromptu, philosophical discussions that magically pop-up in the midst of mathematical dialogs throughout the book. Questions, such as, “*If (a) sequence goes on forever, at what point can you figure out the rest?*” are answered in a delightfully casual, adolescent manner. “*There’s always a chance that the pattern will suddenly change somewhere beyond what you’ve seen ... But that’s the way the world works. You never know what’s going to come next. Predictions fail. Check this out ...* (followed by an abrupt change in topic)” (p. 9). These moments of thoughtful inquiry sprout and dissipate at a moment’s whim, typifying adolescent dialog. More often than not, they work.

The next several chapters happily zip along in a similar tone, with increasingly more sophisticated and interesting mathematical concepts and derivations (derivatives – continuous and discrete, Harmonic numbers, Taylor Series, the Basel Problem, partitions, ...). At the same time, the book helps readers understand the difficulties and hurdles associated with the human learning. Among the general populous, for some inexplicable and unjustified reason, mathematics has come to symbolize and embody the horrors of required schoolwork and the inability of earnest students to make headway. When the narrator falls into this mathematical rut, Miruka consoles him with wisdom that all math majors gratefully received at some point in their careers from their teachers:

“‘I couldn’t solve it,’ I said, ‘I got lost.’ ...  
‘You’re hardly the first mathematician to go down the wrong path. But you know what? If you don’t go looking, you’ll never know what you might have found. If you don’t try new things, you’ll never know what you’re capable of. We’re on a journey here. Sometimes we get tired, and sometimes we get lost. But that’s no reason to give up. ... If you get tired, rest. If you get lost, backtrack. That’s what the journey is all about.’ (p. 252)

*Math Girls* is not a novel. To dub it a “romance” or “love story” would be grossly

misleading. It is a math book that clearly reads like one written by an author who truly loves mathematics. Some viewed the intended message of the book to be about the awkwardness of teenagers, freedom of exploring interests outside of prescribed courses of study, and the delights of self-directed learning, as can be gleaned from conversations in which the narrator urges Tetra to play with math until she is satisfied with explanations, to see the beauty in elegant proofs and approaches, and not to focus on solving math problems as a means to some other ends (grades, a job, etc.).

Though not intentionally written for a male audience, our guess is that *Math Girls* will resonate more highly with males than females, due (in part) to the depth with which the male narrator is portrayed compared to the female characters<sup>10</sup>. However, we enjoyed the read and look forward to immersing ourselves in the magical world of mathematics in future volumes.

In closing, we note that only 5 years have passed since former Harvard President Lawrence H. Summers resigned before facing an all but certain vote of no confidence following several major and divisive actions, including a public speech in which he proposed that women might lack an intrinsic aptitude for math and science<sup>11</sup>. Last year Princeton celebrated the 50<sup>th</sup> anniversary of its first female degree candidate. The university organized an event, *She Roars*, “to celebrate and to reflect on the evolving role of women ... to mark the contributions that women have made ... as well as the challenges that still confront (them)”<sup>12</sup>. Challenges and myths still abound. Interestingly, *Math Girls* was first published in 2007 in Japan, a country considered more backward than the United States in gender equality attitudes and policies. It is refreshing to have a popular book with females actively participating in mathematical discussions and tackling historically significant math problems. We applaud the author for putting politics aside and focusing on the beauty of mathematics, the development of friendships through collaboration, highlighting the importance of thinking, and understanding and appreciating different perspectives in approaching problems (perhaps not just mathematical). Seen in this context, the book serves as a lively and fun public ambassador from the world of mathematics to the general public, and helps free readers from many unbecoming and baseless stereotypes.

**Addendum:** Curious readers may sample the first two chapters of *Math Girls* as free downloads from the publisher website<sup>13</sup>. Since the content of the book advances quickly in mathematical difficulty, we found them to be a bit unrepresentative of the book; More specifically, we found

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<sup>10</sup>The author is in good company as similar comments have been made regarding J.R.R. Tolkien's *Lord of the Rings Trilogy*.

<sup>11</sup>Finer A, Healy P D, Zernike K (2006) President of Harvard resigns, ending stormy 5-year tenure, NY Times online: <http://www.nytimes.com/2006/02/22/education/22harvard.html> Accessed 5 Dec 2011

<sup>12</sup>Ciatt C (2011) “She Roars” conference celebrates women at Princeton: <http://www.princeton.edu/main/news/archive/S30/34/23146/index.xml?section=topstories> Accessed 5 Dec 2011.

<sup>13</sup> MathGirls homepage, sample section: <http://bentobooks.com/wp-content/uploads/2011/10/Math-Girls-Sample.pdf> .

them to be among the least interesting. Readers who experience difficulty following the math in these samples are unlikely to enjoy the remainder of the text. Unfortunately, a large portion of the recommended supplementary readings were written in Japanese and have not been translated

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