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Telling Women's Stories: A Resource for College Mathematics Instructors

Cover Page Footnote

I would like to thank the reviewer for helpful recommendations that improved the quality of this paper.

Telling Women's Stories: A Resource For College Mathematics Instructors

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Abstract

Stereotypes about mathematicians that conflict with “traditionally feminine” identities are widely held by people from middle-school-age onwards, and can influence their participation in mathematics and related fields. Simply being exposed to women in mathematics is not enough to change students’ perceptions of mathematicians, and may even decrease girls’ interest in mathematics. This paper proposes a storytelling strategy to help change students’ perceptions of mathematicians. It includes several activities for intentionally incorporating women’s stories into the post-secondary classroom and a list of resources for finding existing powerful stories. The diverse stories of women mathematicians, including details of their personal lives and the barriers to success they faced, can relieve potential discord between students’ identities and those they see participating in mathematics.

1. Introduction & Purpose

Even if our students never take another mathematics course, they will continue to participate in mathematics. They may, for example, be scientists who select projects or tools based on their comfort with mathematics, teachers who talk about mathematics with their students, or parents who do math homework with their children. One of our responsibilities as educators is to help improve the way that all of our students interact with mathematics. This includes ensuring that they see mathematics as a domain where women can excel.

Unfortunately, research suggests that experiences in undergraduate mathematics classes often widens, rather than narrows, the gender gap in STEM. For example, Ellis, Fosdick, and Rasmussen found that women were over 1.5 times more likely to leave the calculus sequence than men, independent of grades and course performance [10]. For those who continue in mathematics, the dramatic drop in the percentage of women in math after the undergraduate level led Lacampagne and others to write: “something is happening in undergraduate mathematics to lead interested women out of mathematics” [18, page 241].

What can we, as tertiary mathematics educators, do to improve the formal and informal participation of women in mathematics? This paper focuses on one specific strategy informed by my own reflective teaching practice: intentionally using the stories of women mathematicians. Sections 2 and 3 provide background and justification for this approach. Sections 4 and 5 address how to identify powerful stories of women mathematicians and how to incorporate them into undergraduate classes, providing an annotated bibliography of sources for stories and describing a number of concrete and actionable strategies for implementation.

2. Perceptions of Mathematicians, Stereotypes, and Women

When asked to picture those occupying a certain career, a dominant image often comes to mind. One way of capturing an individual’s internal images of mathematicians is to ask them to draw a picture of one. By middle school, children draw pictures of socially inept, overwrought, genius, and overwhelmingly male mathematicians [22].

While these themes are also familiar from popular media, we might imagine that post-secondary students and adults recognize that these are simply stereotypes and not consistent with reality. However, even people who are embedded in the mathematics community appear to hold these images. Analyzing interviews with 3rd and 4th year female undergraduate students majoring in math or math education, Piatek-Jimenez identified three dominant traits in the students’ images of mathematicians [24]. They were (1) socially inept, (2) exceptionally intelligent, and (3) obsessed with mathematics. Each of these traits conflicts more with a traditional female gender identity than a traditional male gender identity [24].

For example, a belief that mathematicians need to be obsessed with mathematics conflicts with a desire to balance work and family; undergraduate women tend to be more family-oriented than their male peers [17]. Therefore, the images that we hold of mathematicians can "cause dissonance with the traditional female gender identity" [24, page 643].

Stereotypes about mathematicians that conflict with a woman's identities can negatively influence the way that she participates with or in mathematics through at least two mechanisms. First, she may perform worse in mathematics due to the *stereotype threat* effect, in which her ability to do mathematics effectively is damaged by the pressure of wanting to contradict the stereotype [19]. Second, women may not feel as though they belong in a mathematical community if they do not 'fit' the stereotypes that they see [15].

In summary, the dominant images of those who do or participate in mathematics interacts with an individual's identity, which in turn can influence their participation in mathematics. This creates a cycle, where we see far fewer women participating in mathematics and the dominant images of mathematicians are reinforced.

3. Using Role Models to Change Stereotypes

One potential way of breaking the cycle described in Section 2 is to introduce students to female mathematicians that do not conform to their stereotypes [15]. Research suggests, however, that simply introducing students to female STEM role models does not always have a positive effect.

For example, Betz and Sekaquaptewa found that, middle school girls were demotivated to continue in STEM when they were exposed to women physicists who exhibited more "traditionally feminine" characteristics than those who were more gender-neutral [3]. Another study of grade 9 girls who visited female scientists working for industry found that the girls' perception of their own capability to do science *decreased* after participating in the program [1]. The authors hypothesize that scientists who counter stereotypes may be seen as exceptions to the rule or viewed as 'unbelievable' or 'too good', far beyond where students see themselves. On the other hand, brief exposure to a woman in computer science who embodied stereotypical appearance and in-

terests decreased undergraduate women's interest in computer science, both immediately and two weeks later [5]. One may conclude that isolated exposure to both stereotypical and non-stereotypical role models can negatively influence girls' and women's interest in male-dominated fields.

In their study on the impact of female science professors on upper-year graduations, Young *et al.* argue that role models are effective in changing stereotypes and attitudes towards STEM only when girls and women view them as *positive* role models: "meaningful contact matters more than mere contact" [31, page 289]. However, such meaningful contact may not happen naturally in every mathematics department. While we can advocate for diversity within faculty and teaching assistant positions, individual faculty members ultimately have little control over the mathematical role models that students encounter and the relationships that develop.

One way to expose students to female mathematician role models is to tell their stories. Storytelling is used in math education to deepen understanding of both content and context. Burton, for example, describes how storytelling helped young children to learn listen, and remember in math class by supporting sense-making, mathematical meaning, and students' agency [4]. Several educators use their students' own mathematical autobiographies. In my own teaching, these autobiographies not only helped me better understand my students but allowed students to reflect on and learn from their own unique stories. Walker extends this idea by advocating that we dig deep into our own stories and those of our students to teach broader lessons about mathematics, including the experiences of girls and women in the discipline [30].

One reason that storytelling is so effective is that it provides the opportunities for 'imagined contact' between the reader, listener, or viewer and the subject, whether that subject is a contemporary or historical figure. Imagined contact has been shown to decrease stereotyping for the purposes of promoting tolerance and more positive intergroup relations [9]. Here, I propose that imagined contact through stories may also be used to reduce stereotypes. Further, the intentional integration of *powerful* stories may mitigate potentially negative side effects of some of the negative effects of role models identified above.

4. Finding and Identifying Powerful Stories

One of the difficulties that faculty face when introducing stories of women mathematicians is a lack of resources; stories of male mathematicians seem to be far more readily available. While it is true that there are *more* biographies of male mathematicians available, I find that, on average, accounts of female mathematicians are more powerful than those of their male counterparts, particularly when looked at through a storytelling lens.

Below I propose four characteristics of powerful stories, each accompanied with an example story that exemplifies this characteristic. Appendix A presents additional sources of stories about female mathematicians accessible to undergraduate students and provides information to help faculty members choose among them.

While this article focuses on stories delivered through writing and interviews, other media have been used to effectively tell stories. For example, in [28] Schaffer describes the impact of the stories of women mathematicians taught through dance.

4.1. Powerful stories include context.

Powerful stories help the reader to understand and imagine the surroundings and experiences of the subject. The story of Norma G. Hernandez in *Women in Mathematics: Celebrating the Centennial of the MAA* [2] begins with a rich description of her birthplace of El Paso; the description of how her hometown shaped Norma's life helps readers to feel as though they are part of the narrative.

4.2. Powerful stories describe a pathway.

Powerful stories don't just include the 'greatest hits' of a subject's life in the way that an awards citation or website profile might. In *Women in Mathematics; The Addition of Difference* [16], Joan Birman recounts her disappointment with and difficulty understanding college mathematics, careers in the electronics and aircraft industries, completing her mathematics PhD at age 41, and ultimately a successful career as a Barnard College professor. Through stories like these, students see that a winding pathway towards a career in mathematics can build on both mathematical successes and failures.

4.3. Powerful stories include the personal.

The stereotypes of mathematicians as being obsessed with their work and being social misfits can be counteracted by learning about their personal lives. In her autobiographical essay in *Complexities: Women in Mathematics* [8], Carolyn S. Gordon discusses how her personal life was enriched by her professional life (e.g. she met her husband when they joined the faculty at Washington State University at the same time) and how her professional life was enriched by her personal life (e.g. she collaborated with her husband, and her daughter contributes to her teaching).

4.4. Stories are more powerful when they are told together.

Exposure to a variety of stories helps to overcome stereotypes: students see that there is not just one way of being a mathematician. The breadth of coverage is where several of the online sources excel; many, such as the *Biographies of Women Mathematicians Database* hosted by Agnes Scott College [26], contain excellent references that can be used as a jumping-off point to learn more about the stories. The book *Pioneering Women of American Mathematics: Pre-1940s PhDs* [14] profiles every American woman to receive a PhD in mathematics before 1940, and notes that 14% of all US math PhDs during this time period were awarded to women.

5. Activities for Incorporating Stories of Women Mathematicians

A second challenge that faculty face when introducing stories of women is not knowing *how* to do it; common concerns include the fear of taking away from content coverage time or being seen as just including the story of a ‘token’ woman. Short descriptions of some possible activities are given below. Section 5.1 includes stories that can be implemented quickly during class, without any prior student preparation, Section 5.2 includes in-class activities that use students’ experiences reading stories outside of class, and Section 5.3 includes more in-depth projects. This builds on the work of Teri Perl, who has authored four books of classroom activities based on the lives of women in mathematics, most recently *Women and Numbers: Lives of Women Mathematicians* [23].

5.1. In-Class Activities: Seeing Stories

5.1.1. Prior Knowledge Inventory

One way to motivate women's stories is to simply ask students to list all of the mathematicians that they know. In my classes, most students can name several male mathematicians, but usually not more than one female mathematician (me!), and this motivates the need to balance their knowledge.

5.1.2. Internet Scavenger Hunt

Internet scavenger hunts are a fun way to expose students to the names of mathematicians and kick off more in-depth story reading. Here are some examples of short activity prompts:

- Find a woman on @evelynjlamb's list of *Mathy Ladies* on Twitter (available at <https://twitter.com/evelynjlamb/lists/mathy-ladies/>) who has something in common with you.
- Search the mathematics arXiv (available at <https://arxiv.org/archive/math>) for a recent paper (or one relevant to the course topic) containing a differential equation that has a woman as one of the authors. What else can you find out about this mathematician?
- Find a woman who earned a degree in mathematics from our institution. What did she do after graduation?

5.1.3. Virtual Conversation with a Mathematician

You can arrange for a mathematician to join your class virtually through a video call. Depending on the desired level of student involvement and preparation, you could ask students to ask questions, moderate the discussion, and even find and make arrangements for the visit. This activity is particularly effective if the mathematician's work is also connected to the content that your students are studying in the class.

5.2. In-Class Activities Requiring Preparation: Responding to Stories

5.2.1. Response to a Critical Issue

To help guide students as they read the story of a mathematician, ask them to imagine how the mathematician would respond to a question like the following: “should the Fields medal be restricted to mathematicians under 40?”, “what is the most important factor in ensuring success in mathematics?”, or “what advice would you give to a first year student who just failed their first calculus exam?” Start the next day’s discussion asking students how they think the mathematician that they studied would respond, and why they think that way. In a larger class, students can discuss in small groups and then you can call on a few groups to share their most interesting responses.

5.2.2. Mock Panel Discussions

A panel discussion is a moderated discussion between selected speakers on a specific topic, in front of an audience. Inviting students to plan and stage mock panel discussions with themselves playing the role of mathematicians gives them the opportunity to get to know a mathematician’s story in detail and share a variety of stories with the audience. Students in my classes have planned mock panel discussions on topics such as ‘balancing mathematics and family’, ‘collaboration in mathematics’, and ‘encouraging students to fall in love with mathematics’.

5.2.3. Poster Exhibition

Individuals or small groups can prepare posters profiling a mathematician, of varying degrees of formality depending on the time you would like to dedicate to the activity. It can be as simple as a gallery of marker-on-paper sketches prepared in class and hung around the classroom or as formal as an advertised event open to the public with polished, professional-quality posters and food. Virtual counterparts to this activity are also possible.

5.3. Out-of-Class Assignments: Creating Stories

5.3.1. Textbook Vignettes

Mathematics textbooks often include brief vignettes of mathematicians whose work is related to the text, but they tend to be dominated by men. Challenge your students to equalize the gender balance by writing vignettes of women that could be included in your own textbooks.

5.3.2. Recorded Interviews

Students can document stories of mathematicians by producing their own audio or video interviews. Consider asking students to interview upper-year mathematics majors or their high school teachers about their pathways to mathematics. Pedwell and Rowland have produced a detailed guide for producing high-quality recorded interviews of scientists using phones; it is available online [25].

5.3.3. AWM Essay Contest

The Association for Women in Mathematics holds an annual essay contest for Grade 6 through undergraduate students. Essays must be based on interviews with a woman currently working in a mathematical career. Consider having students write for and submit essays for this contest. Details can be found at <https://sites.google.com/site/awmmath/programs/essay-contest>.

5.4. Other Activities

There are many other activities for incorporating women's stories that are not detailed above. Other possibilities include: editing or writing Wikipedia articles [29]; creating a children's book about a mathematician (see, for example, the children's books written and illustrated by students in a class by Pitzer College professor Jemma Lorenat at <http://www.jemmalorenat.com/teaching>); creating a dance, music, or visual arts piece (see, for example, [28]); making a coffee table book of mathematicians (modelled after [7]); and reviewing a book or other piece about women mathematicians.

6. Conclusion

... [T]hose stories gave me faith and courage that despite the challenges that these women faced, most of them were able to overcome them and become successful in the end. Hence, I know I would persevere as well, as long as I am passionate about math and can find a strong [group] to be part of throughout the process.

- Former student, 3 years after studying the stories of women mathematicians in a first-year seminar

Even small efforts to thoughtfully share the diverse experiences of women mathematicians can have great impact on our students because they can provide alternative models and pathways for success in mathematics. This is important for all of our students, no matter how they may engage with mathematics after our classes. With intentionality our teaching can transform lives.

A. Sources for stories of women mathematicians

- *Women in Mathematics: The Addition of Difference* [16] by Claudia Henrion. Print book containing stories based on interviews with individual mathematicians interspersed in between essays on topics about being a woman in mathematics. Stories of nine mathematicians living in the late 20th century between 12 and 25 pages long. Strengths include Context, Pathway, and Personal themes. Stories organized around essays on myths of mathematics that interact with gender to prevent women from pursuing mathematics.
- *Complexities: Women in Mathematics* [8] edited by Bettye Anne Case and Anne M. Leggett. Print book containing stories in a variety of formats, from particular incidents to full biographical / autobiographical sketches. Stories of over 80 19th century through contemporary mathematicians, each between 2 and 10 pages long. Book excels in the variety of stories presented; individual stories vary in regards to other criteria for powerful stories. Anthology combines writings from the AWM Newsletters with contemporary stories; also includes separate chapters on context and commentary about women in math

- *Pioneering Women in American Mathematics: The Pre-1940 PhD's* [14] by Judy Green and Jeanne LaDuke. Print book containing stories of all 228 women mathematicians to earn a mathematics PhD in the United States prior to the 1940s. Each profile is between 1 and 5 pages long. Stories excel in Variety, Pathway, and Personal criteria. Extensive supplementary material available online.
- *Notable Women in Mathematics: A Biographical Dictionary* [20] edited by Charlene Morrow and Teri Perl. Print book containing stories of individual mathematicians, many of which are based on interviews. Includes 59 stories, each between 4 and 6 pages long. Focus is on 20th century mathematician. Excels in Context, Pathway, Personal, and Variety criteria.
- *Women of Mathematics: A Bibliographic Sourcebook* [6] edited by Louise S. Grinstein and Paul J. Campbell. Print book containing profiles organized into biography, work, and bibliography sections. Includes 43 stories each between 4 and 10 pages long. Profiles mathematicians from ancient times through publication (1987). Book excels in the variety of stories presented; individual stories vary in regards to other criteria for powerful stories. Women outside of the USA are included; comprehensive bibliographies are also provided.
- *Women in Mathematics: Celebrating the Centennial of the MAA* [2] edited by Janet Beery, Sarah Greenwald, Jacqueline Jensen-Vallin, and Maura Mast. Print book consisting of profiles of individuals, and groups of women, each between 10 and 30 pages long. 5 individuals and 10 groups are profiled, working from the 19th century to contemporary times. Excels in Context, Pathway, and Personal criteria.
- *Biographies of Women Mathematicians Database* [27] by Lawrence Riddle and Agnes Scott College. Online database of profiles of women mathematicians, written between 1995 and the present. Stories of 194 women mathematicians from every time period, between 300 and 1500 words. Database excels in the variety of stories presented; individual stories vary in regards to other criteria for powerful stories. Includes links to other resources and websites.

- *Association for Women in Mathematics Essay Contest Archives* [13]. Online database of winning entries from the AWM's Essay Contest for middle school through college students. Six to twelve essays have been posted each year since 2001, based on interviews with mathematicians. Stories profile contemporary mathematicians. Excels with regards to the Context, Pathway, Personal, and Variety criteria.
- *Mathematically Gifted & Black* [21] from the Network of Minorities in the Mathematical Sciences. Online database of profiles of contemporary black American mathematicians from 2017 to present. Each year 28 profiles are posted, about half are women. Stories are between 250 and 1000 words long. Database excels in the variety of stories presented; individual stories vary in regards to other criteria for powerful stories. Stories are autobiographical, biographical, or based on interviews.
- *Science Lives* [12] from the Simons foundation. Video interviews with scientists and mathematicians, including 4 women mathematicians. Each interview contains over an hour of interview footage of significant mathematicians; profiles posted between 2012 and 2016. Excels in Context, Pathway, and Personal criteria. Interviews are well-chaptered along themes.
- *Six Questions With...* [11] from the Isaac Newton Institute for Mathematical Sciences. Online database of transcripts of interviews with 19 contemporary women mathematicians, each between 250 and 500 words long. All stories excel in Personal criteria; they vary in regards to other criteria.

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