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The Situatedness of Mathematics in Motherhood and Academia

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Abstract

The authors, a mathematician and a political scientist, examine mathematics, motherhood, and academia, and argue that feminist epistemology is necessary to explain the intersection. Relying on the principles of feminist epistemology laid out by philosophers Naomi Scheman and Marianne Janack, the authors consider how work, the concept of time, arts and crafts, teaching, and decision-making all reveal the situatedness of knowing and using mathematics.

Keywords: *mathematics, motherhood, political science, feminist epistemology, objectivity*

Introduction

Mathematics and motherhood, or really, mathematics, motherhood, and feminism, have revealed to us the ways in which mathematics is relational and situated. It was as if mathematical concepts changed a bit once we, as knowers, were also situated specifically as mothers. Mathematical formulas or comparisons which might have supplied an answer in the past do not necessarily or easily answer the pressing and loaded questions that come with

motherhood / parenthood / professorhood. This shouldn't be a shock to anyone familiar with the tenets of feminist epistemology—namely, that there will be an emphasis on the salience of gender, that gender will be used as an analytic category, that knowers are particular and concrete, not abstract and generalizable, and that when knowers are constituted as mothers / parents, our understanding of terms like "objectivity" and "rationality" change [15]. But each of these tenets has been driven home for us in a way that our formal education in feminist epistemology was unable to achieve until we were actually living it. We see the qualities of numbers and other mathematical constructs seemingly change once contextualized at work and as mothers. Part of this may be driven by life-cycle effects of reaching age milestones rather than life-style "choices" of becoming mothers; we will never clearly know which it is, as we experience both at the same time. But the following are our considerations of how motherhood has altered what we do as academics and mentors, and how we understand and use mathematics as mothers.

Our experiences as women, professors, and mothers have brought us to an understanding that our situations play an important role in our epistemic agency. "The task of feminist epistemology is to uncover how patriarchy has permeated both our concept of knowledge and the concrete content of bodies of knowledge, even that claiming to be emancipatory" [8, page 236]. In drawing out the principles of feminist epistemology, philosopher Naomi Scheman [19] identifies four tenets that we have found useful as a theoretical framework for understanding the interplay of mathematics and motherhood. The tenets are (1) a non-individualistic conception of knowledge; (2) attention to diversity; (3) a critique of objectivity as a goal of scientific knowledge; and (4) rethinking epistemic norms. In the following we discuss instances when each of these tenets has been revealed to us.

Work

Both: While motherhood may have revealed the deeply gendered nature of work in academia to us, mathematics helps us to pin it down for scrutiny. This is a phenomenon which could be an age effect, or it could be motherhood, but for many women in academia, after they give birth is when they begin to perceive a glass ceiling. We can use math to paint a picture of it: Women have been receiving just over 50% of doctoral degrees since 2004—

over a decade [17, Table 318.10]. Yet in 2009, only 28% of full professors were women [6]. Looking upstream, in 2006, only 23% of all college presidents were women, and as for female presidents of doctorate granting institutions, that figure was only 13.8% [6]. The gaps have indeed shrunk over time, but incredibly slowly.

To suggest that there is a dearth of women on college campuses is not quite right. Women are there; they are just overrepresented on the bottom rungs of the professional ladder. Women are overrepresented in the precarious part-time adjunct status—55.5% in 2009 [6]. And for full-time faculty, women are 30% more likely than men to be in non-tenure eligible positions [6].

And they make less money, too. Over all faculty ranks and types, women's average salary was only 82% of men's in 2010-2011 [6]. Female full professors earned 12% less than their male peers [6]. There is no rank at which the average pay is the same between men or women, or in which women are favored.

On campuses, women in academia observe apparent preferences for male leadership of committees and colleges, departments, and divisions. Emotional labor expected of women brings unique challenges to the doors of female faculty—reports of sexual assaults from students, for instance. Micro-aggressions, even from friendly colleagues and students, stretch to reach the places where downright aggression, hostility, and harassment may not touch.

The feminist epistemological tenet of "attention to diversity" tells us that one of the possible benefits of the #metoo movement may be none other than systematic data collection, which will allow these issues to be quantified on college campuses as well; as `Google` documents get circulated via Facebook groups, researchers get inspired with new study designs, etc. Of course, systematic data collection was one of the intentions of the amendments to the 1990 Clery Act which Congress legislated with the 2013 reauthorization of the Violence Against Women Act: now in addition to tracking the violent crime of rape, schools receiving federal funds must also report statistics regarding domestic violence, dating violence, and stalking [2]. It's important to note, however, that in 2015, 89% of colleges reported zero rapes on campus [2]. As an industry, we are not currently in a position to truly quantify the breadth and depth of gendered experience for women on college campuses, but the understanding that such knowledge gaps actually do exist is the first step.

Time

Both: Before motherhood, it was easier to conceive of time as a simple linear concept, never compressed or lengthened. But then that changed.

Political Scientist: In the movie *Vertigo*, Alfred Hitchcock pioneered a famous camera shot (the "Hitchcock zoom" or "dolly zoom") to give the viewer the sensation of vertigo—the backward tracking, forward zoom shot which distorts the picture in two directions at once, making the scene in focus both closer and farther away at the same time. Similarly, it is often said that one is mothering / parenting so intensely in the first years that "the days are long, but the years are short." Watching human development makes one keenly aware of growth and change, not all of which seems desirable, particularly when you realize it's happening to you and your elders as well. The thought of mortality has become a constant companion, perhaps because of the intense care and responsibility one has as a parent, but maybe also because as academic moms, we tend to have our children later than other women, so parenting may come hand in hand with middle age. But regardless, time accelerates with little children around. Or, more accurately, the relative nature of it becomes more apparent, as you alternatingly count the minutes until bedtime and worry about the decline of your own parents and body. The aspect of declining time to spend with one's parents, or siblings, or childhood friends, is succinctly and starkly laid out visually by Tim Urban [22]: "It turns out that when I graduated from high school, I had already used up 93% of my in-person parent time. I'm now enjoying the last 5% of that time. We're in the tail end." Couple that with the intense nature of a day spent caring for the needs of children, about which Jon Stewart once noted "do you know how long a weekend is? With children??" [21] Exhortations to "be in the moment" and "make memories" with one's children, alongside the familiar call to publish or perish, and try to climb the ladder of professional advancement, demonstrates how relative a concept like time, which used to seem so linear, really is.

Mathematician: Our students tend to think of time in terms of time management and this limits them to a linear perception of time. Time management is a great skill, and quantifying time is useful. Just adding the hours spent in class and homework drives home for students the fact that 15 credit hours requires 45 hours of work each week, and so being a student is a full-time job.

However, observing my children's development has inspired me to encourage my students to think of their learning as happening over time. Learning, like time, can feel as if it expands and compresses; sometimes you spend a week on related rates without being able to complete a problem and then in one short session you can solve all of them. Students need to be reminded that the short session wouldn't have happened without the week of struggle. As well-illustrated by the recent book and film *Hidden Figures* [20], achievements rely on a lot of work that isn't always acknowledged.

Motherhood has challenged us to rethink the epistemic norm of experiencing time's passage, and exposed the ways in which time is not linear. A quantitative approach to time may be necessary but it is not sufficient. When viewed linearly and objectively, time is a valuable and scarce resource and we must prioritize competing interests of family and work. When viewed through the lens of motherhood, time is cyclic and subjective—not every second spent is equal in its significance. This applies to our daily lives with children, as described above, but also to the life course [24] of academic mothers who may not follow the traditional, linear pipeline. A non-linear and fluid life course may be a better framework for women whose professional timeline may include different moments of stepping back and stepping forward. If "[m]aternal thought identifies priorities, attitudes, and virtues, [and] conceives of achievement" [18, pages 359-360], this provides an additional dimension to understanding growth and change over time.

Arts and Crafts

Both: Mathematics has long been associated with the arts. Mathematical concepts like perspective can be used to construct designs and artistic creations can be used to display mathematical concepts. See, for instance, da Vinci's painting *The Last Supper* [14] or Daina Taimiða's crocheted hyperbolic plane [13]. The arts that tend to get practiced by mothers offer opportunities for thinking about mathematics and teaching, and the epistemic understanding of the historical record.

Mathematician: Mathematical projects often replace craft projects in my house, but the most popular projects combine math and art. Since I frequently teach courses for pre-service secondary mathematics teachers, I have a variety of manipulatives and activities I can borrow from my lessons to use

with my children. We have explored tangrams, Moebius strips, paper protractors, snowflakes, and figurate numbers. The questions my children ask and the things they explore during the activities often give me interesting questions to ask my college students. For instance, when you fold a circle in half and then in half again, why have you found the center of the circle?

Political Scientist: For me, doing craft projects that aren't explicitly about mathematics, I still find myself contemplating math a lot. Depending on the medium, different mathematical concepts will seem relevant. Most of the projects I make these days are on behalf of my children. We converted an old bookcase into a dollhouse for our four- and six-year-old children, and found that the calculations needed are really the same as those needed if one was refurbishing a human-sized house. We also found that the materials can be that much harder to manipulate at the 1:12 scale. We miscalculated the finished height of the stairs and so had to patch and recut the window openings, and we didn't appropriately subtract for the thickness of the chair rail we installed on the wall as the stairs went past it. And as all knitters will recognize, turning the heel on a Christmas stocking or a sock involves very complex geometrical thinking about planes which go from two to three-dimensional (depending on the method used). As the person who is not the mathematician here, the situated thinking about my craft projects for my kids deepened my contemplation of planes with thickness and planes that curve. Political scientists use mathematics all the time, but not generally geometry. It took parenting to make geometry relevant to me again.

When I was in college, I took a sculpture class, which was based on methods used in the building trades—carpentry, plaster on expanded metal lath, welding, and concrete. In form it was very masculine, and I remember being assigned to "design an artifact," and reflecting at the time on the association between men and technology because the materials prehistoric men used for tasks like hunting or cutting were durable and therefore more likely to be found later by archaeologists [16]. Woven mats and baskets—fabrics of any kind—have always been less durable than stones, but if more textiles had stood the test of time, maybe more technological innovations would be associated with the crafting of women for their daily tasks and pleasures. I wonder how many geometric concepts were long understood by women working with textiles but then erased because the evidence given by a particular seam in some garment or sling degraded over time.

The development of "gender archaeology" in the 1980s started with an examination of the epistemology of that field, and critiqued the notion that all of human history could be understood by the partial extant record of human activity found in stone tools and the like. Attention to diversity in that field would require more understanding of the gendered nature of technology and materials used in artifacts. Crafting something for my children's use or for their joy makes me contemplate the mathematics and engineering underlying construction of any item, and I wonder about the discoveries and knowledge of a long line of mothers working with textiles or similar materials.

Teaching

Both: Carol Gilligan has written that gender "stereotypes suggest a splitting of love and work that relegates the expressive capacities requisite for the former to women while the instrumental abilities necessary for the latter reside in the masculine domain. Yet, looked at from a different perspective, these stereotypes reflect a conception of adulthood that is itself out of balance, favoring the separateness of the individual self over its connection to others and leaning more toward an autonomous life of work than toward the interdependency of love and care" [10, page 2]. For both of us, motherhood has helped us more consciously integrate love and care into our work life. In particular motherhood has expanded the way the mathematician acts as a role model and mentor to students. For the political scientist, motherhood has led her to teach quantitative literacy in ways particularly relevant to female students.

Mathematician: Serving as a role model and mentor to students is a role I embraced upon becoming an assistant professor at a teaching-focused university. I knew I wanted to be visible to my students as a mathematician and a woman and a feminist, and I envisioned mentoring female mathematics majors. In my pre-motherhood years this modeling and mentoring occurred in the usual ways of working with students—encouraging, advising, and providing opportunities to attend conferences or work on a project. When I became a mother, I consciously embedded motherhood into my role modeling. First, I deliberately make my motherhood visible to students. It is not the primary part of my identity that my students see, but it is visible. It is visible in the photographs on my office wall and the stories I tell about the funny conversations I have with my children. (This semester I shared that

my children want to convert our basement into an aquarium and my calculus class of engineering majors volunteered to help.) I also make my motherhood visible when students ask about work-family balance. These students (mostly seniors and mostly women) are picturing their lives after college and often explicitly wonder if they will have children and if they should stay at home or stay in the workplace. I think it is important for students of any gender to hear a variety of stories about how families arrange their lives, and I am willing to share mine.

Since becoming a mother I have also chosen to lean in to the trope of the motherly teacher. Much has been written about what students expect and how they see their male and female professors [4]. As a younger faculty member nervous about maintaining authority with my students (and respect from my colleagues) I was reserved in the classroom, often wore suits, and rarely shared details about my non-work life. I needed to discourage students from seeing me as a friend. As I aged I became more confident in my authority, but my age also meant that students no longer tended to see me as a friend, and I felt free to wear jeans or share a story about my weekend. When I became a mother, I realized that making that part of my identity visible also meant that I could take advantage of my maternal authority. By choosing the role of the motherly teacher I can, as a student told me, be "hard but get away with it because you are nice". It is important to note that this maternal role is often thrust upon female professors [12], but I have consciously embraced it.

Feminist epistemology conceives of knowing as not ideally "exercised in solitude ... rather ... knowing and coming to know are social and interactive" [19, page 192]. I have always presented to my students as a mathematician and a feminist, but not until I included "mother" as part of my identity did I situate myself as a woman. Motherhood meant embracing my identity as a woman just as fully as my identity as a person. Motherhood made me conscious that my attempt at a non-gendered work-self was actually conforming to a male script about my work-self. Thus, keeping my role of mother visible is not only beneficial to students, but necessary to situating myself epistemically.

Political Scientist: Being a mathematically-inclined mama and a feminist has put a fine point on the unique challenges facing many women in the workplace. Having a quantitative sense of the compounding nature of pay

discrepancies is not just an interesting fact, but a motivator to seek/create justice, and not just for oneself, but for fellow travelers. Feminism and motherhood have made that more acute.

As I look at my students, particularly the female ones, I think about the challenges women, including and especially mothers, face economically in the workplace and the marketplace. This caused myself, my co-author, and other women's and gender studies professors to direct the programing resources of our women's and gender studies program at our university to teach our students how to negotiate their salaries, because we do share a non-individualistic conception of knowledge and its power. We are not at all under the delusion that negotiation alone will close the gender-wage gap, or that the gender-wage gap is the only inequity women at work face, but we do want to give whatever tools we can to our students to help them be aware of and minimize the gap they encounter in the future.

As it turned out, a nationally license-able program already existed to do that. Now under the auspices of the American Association of University Women, the AAUW Start Smart program can be brought to any campus or community organization with the purchase of a license and a person willing to undergo some training to become a facilitator [1]. In this workshop, we teach our students about what the pay gap is, how it grows, and what it robs them of over the course of a lifetime. Then, the students learn how to research salary data for a particular job in the city they select, draft a monthly budget, and practice conversational techniques and strategies to conduct their own salary negotiations. It is part lesson, part pep talk, part bonding experience. Bringing this to our own campus has enriched our experience not simply as our students' professors, but as their fellow female travelers. As they enter the world of full-time work (which for most of our students will be new), we induct them into the sisterhood of women at work to which we already belong. Those of us who have been in the professional world longer share our tales of missteps and also our successes, and why advocating for one's own fair pay is so important. The starkness of the data graphically presented and knowing it represents real life challenges or opportunities—like paying off student loans, buying a house or car, starting a business, helping one's parents, educating one's children—brings small incremental but growing discrepancies to life, and motivates one to address the inequality.

Additionally, as a political scientist who wants students to be math literate because it puts the scope of public policy issues into sharp relief, I use math repeatedly to illustrate the necessity and/or impact of public policies. Because I teach about policies regarding reproductive rights (and poverty, and sexual assault, etc.) in the United States, it is important for a number of reasons for me to contextualize these issues for students. I want them to understand the policies under consideration have real world impacts, including on them. For those reasons, I have found it incredibly instructive to teach my students about the relative reliability of birth control.

College students comprise a large contingent of birth control users in the United States, but that doesn't mean they fully understand the risks (or benefits) of their use. So, one day each semester in my Women and Public Policy class, we turn our attention to the failure rates of birth control. We use the FDA's birth control guide which reports failure rates of methods with "typical use." For example, we see that of 100 women using birth control pills to prevent pregnancy each year, about 9 will get pregnant. We then talk about accumulated risk, and we learn that 100 women using birth control pills for 10 years will result in around 61 unintended pregnancies in that group of women. Over 30 years—a woman's likely reproductive lifespan—that's more like 94 unintended pregnancies in that group of 100 women. When we do this exercise, and the students get quiet and very serious, I can tell many are calculating their own risk of an unintended pregnancy. Then, we move from the personal to the political, by scaling the number of unintended pregnancies to the entire U.S. population. According to the 2010 U.S. Census [23], there were approximately 62 million females in the U.S. between the ages of 15-44 (roughly the reproductive lifespan). In any given year, if every single female in that group were relying on birth control pills to prevent pregnancy while sexually active, almost 6 million unintended pregnancies would result. And thus we see that reliance on prominent birth control methods alone will not be enough to prevent us from having to reckon with the problem of unintended and unwanted pregnancies societally.

To me, this is a critique of objectivity as a goal of scientific knowledge—my goal is for them to contemplate what this means for them subjectively. It is, after all, their lives on the line.

Decision-making

Both: For women who want to be mothers, one of the times you will both appreciate your quantitative training and see its limitation is when you are asked to make gigantic decisions on the basis of projected risks and values.

Mathematician: With my third child, I was a candidate for a vaginal delivery after Caesarean (VBAC). My doctor presented me with a form to sign, indicating that I was aware of the risks of VBAC, including the risk of uterine rupture and brain damage or death to the baby. I asked for statistics, thinking they could make the decision for me, and I was told that the risk of uterine rupture is about 1% of women who have VBAC and the risk of cesarean is "usual risk of surgery" [3]. To my quantitatively inclined mind this raised several questions. If a uterine rupture occurs, then what is the chance the baby will die? What is the risk to the baby during a typical vaginal delivery? What is the usual risk of surgery referred to for a cesarean? The numbers that could help me decide were not available, and I was confronted with the limitations of quantifying risk.

Political Scientist: For me, it was interesting to hear different women's perspectives about amniocentesis, in particular. The experience of a miscarriage before the birth of my first child, coupled with having had a mother who was a special educator, meant that I personally had a much greater fear of miscarriage induced during the procedure than I did of having a child with a chromosomal anomaly that might not be detected until late in the pregnancy or at birth without an amnio. Given that my genetic screen indicated that for me the odds were ten times higher that an amnio would produce a miscarriage (which is still quite rare), it was easy to know what my preferences were in this regard. For others, the concern about being outlived by a child with a lifelong need for caregiving weighs more heavily.

In both situations, genetic screening and childbirth, each of us turned to our quantitative training but were confronted by its limitations. Knowing the probabilities helps, but one still has to decide for themselves how to compare the weight of two different possible outcomes. Recognizing the weight of childbearing decisions explains why my obstetrician said to me about whether or not to have a scheduled c-section with my second child, "you can do all the research you want, but you should go with your gut."

In the above discussion, we see again a reflection of Scheman's third tenet "rethinking objectivity". Feminist epistemology questions objectivity as a goal of knowledge, primarily in that objectivity "denies that contextual values should have any epistemic power" [4, page 150]. The intersection of motherhood and mathematics in our situations (genetic screening and childbirth) makes visible the limitations of objectivity and the value of subjectivity.

Mathematician: Our experience in managing uncertainty as mothers is helpful when mentoring students. Often a student facing uncertainty feels that uncertainty spill over into all parts of their life. As a mentor, we can help a student analyze their situation, quantify what is quantifiable, and identify priorities so they can decide for themselves how to compare the weight of different outcomes. Of course, motherhood is not necessary to help a student manage uncertainty, but motherhood has provided an additional perspective on uncertainty and decision-making.

I recently had a conversation with my child about risk and uncertainty in decision-making, and felt as if the topic had come full-circle. The child asked why he had to get a flu shot even though not all his friends get one, and his friend A "doesn't get one because the shot makes people sick." In response, I talked about making decisions and about the science of vaccines. We discussed the "10% effective" headline found in many articles about the flu vaccine this year [5]. First, we placed four pieces of paper the table to represent the four strains of flu represented by the current vaccine. In three of the strains the vaccine is approximately 50% effective, so he shaded half of three of the papers. The fourth strain is predicted to be 10% effective so he shaded one-tenth of the fourth paper. Then he lined up stuffed animals on the papers and knocked over all the ones standing on the unshaded portion of paper. He decided that, even given the lack of certainty, it was worth getting the shot because more animals were knocked over than not.

During this conversation with my son, I was conscious of the epistemic norms on which I rely—I *know* the effectiveness of a vaccine because I *believe* the relevant data and analysis from the CDC. However, I also *believe* in the value of a critical examination of epistemic norms. I acknowledge that my confidence in vaccines stems from "ways social and political, having to do with relationships of trust and dependency" [19, page 189], including my education, my personal experience with vaccines, and my access to health care.

Thus, I guided the conversation with my son in a way that made sense to me as a mathematician, as a mother, and as a feminist aware of the epistemic norms underlying the issue.

Conclusion

Motherhood has revealed to us things about working, teaching, parenting, feminism, and math which we never would have deeply understood otherwise. We perceive ourselves as part of a class faced with disproportionate challenges at work (and elsewhere). We understand better how time can be such a relative concept. We are more cognizant of our jobs as role models, both to our children and to our students. We recognize the limitations of numbers and probabilities alone when faced with the seemingly enormous decisions that come with parenting, and that good scientific data and personal experience are both necessary to make good decisions. Our situatedness as mothers and users and sharers of mathematics has made us understand that we are, in fact, particular and concrete, and not simply abstract knowers of concepts, and that we can use our situated understanding of mathematics and motherhood in powerful ways.

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