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Queering the Math Curriculum: Pre-flections on nonbinary thinking in mathematics

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Abstract

This essay discusses a plan for a course I'm in the process of developing, tentatively titled Nonbinary Thinking in Mathematics.

> Logic is a prismatic glass that has the power to eliminate detail and particularity…Gazing into the prismatic glass can give us a candid glimpse of the master subject whose lineaments are usually lost in the flux of particularity, but the glass can also show us other more attractive forms and patterns of mutuality. For feminists and others to abandon selective engagement with logic would be to mount a very incomplete challenge to hierarchical thinking and oppressive forms of rationality.
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> Val Plumwood, "The politics of reason: towards a feminist logic" (1993)

Introduction

A common impression among mathematics educators is that students perceive mathematics as an oppressive form of rationality.[1] This perception is not baseless. After all, the use of tools from mathematics to measure and compare people to

[1]This is not something that has received ample attention in the mathematics education literature. When studying student beliefs, the focus is on more operational beliefs—such as "how do students understand the meaning of word problems?"—not to mention the difficulty in mea-

sort them into a hierarchy is so ubiquitous in modern society as to seem inevitable. Of course your educational achievement is measured by test scores and GPAs, and of course you need to maximize these numbers to ensure a favorable place in the hierarchy. How else would you run a school system? Even setting aside such applications and focusing on the purely mathematical, this perception is reinforced within mathematics classrooms. Math is taught to be a set of rules handed down by a nameless authority, and success is measured by how well a student can conform to and apply these rules.

Is it possible to queer the mathematics curriculum? In defining queer theory, Annamarie Jagose writes "queer describes those gestures or analytical models which dramatise incoherencies in the allegedly stable relations between chromosomal sex, gender, and sexual desire" [Jag96, p. 1]. These are not the subject matter of mathematics, so taken narrowly the answer would be no. But the term has been used more broadly. As Eve Sedgwick, one of the founders of queer theory put it, "a lot of the most exciting recent work around 'queer' spins the term outward among dimensions that can't be subsumed under gender and sexuality at all: the ways that race, ethnicity, postcolonial nationality criss-cross with these *and other* identity-constituting, identity-fracturing discourses, for example…Thereby, the gravity (I mean the *gravitas*, the meaning, but also the *center* of gravity) of the term 'queer' itself deepens and shifts" [Sed94, p. 8]. It is in this broader, one might say metaphorical sense, of the word that I ask the question. Can we break down boundaries and rigid binaries in the mathematics curriculum, opening up space for new potentialities?

Surely this is possible, for mathematics is already queer. "The essence of

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suring the prevalance of abstract beliefs about the role of mathematics in society. Nonetheless, something can be gleaned. This is seen readily in the research on math anxiety, a psychosomatic condition where people face adverse physiological or cognitive responses to mathematics, especially in educational and assessment contexts. (See [SCGSP19] for an overview on math anxiety.) Learning mathematics is so oppressive for some students that it is traumatizing.

This perception among students can also be noticed by taking account of how students describe their experiences with mathematics. For example, one essay about student beliefs about undefined operations [TT02, pp. 338–339] contains this quote from an interview with a high school student: "It is not allowed to divide by zero. In mathematics we have rules , and we operate according to them. These rules often do not seem reasonable. For instance, it is illogical that minus times minus is plus. When studying mathematics, we have to obey the rules and to work with them. There is no point at all in looking for explanations. One just has to accept them." This student perceived mathematics as a collection of illogical rules which one must nevertheless put oneself under the authority of. A different study about student beliefs [GM16, Chapter 4] reported that the middle school students who participated in the study had a positive view of mathematics but this was due it being a source of future job prospects. As the authors put it in the summary, "mathematics was seen as important because it is a *gatekeeper* to 'good jobs' " and "once you obtained the employment it was not noted as being important". The impact of mathematics being seen as a gatekeeper is especially apparent at the collegiate level where core math classes like calculus are both key prerequisites for many science and engineering degrees and are often among the classes with the lowest pass rates.

See also [Kol14] for a Foucauldian analysis which draws much the same conclusions about mathematics education being an oppressive system of rationality, but using higher-powered theoretical tools than what is available to the average mathematics student.

mathematics lies in its freedom", as said the mathematician Georg Cantor. Much work in mathematics can be described as asking "what if I made up new rules for how math works?"—from "what if I could take a square root of a negative number?" to "what if I made up new axioms for mathematics?" Students only get a taste of this freedom if they go to graduate school or take upper-division classes.[2] There are sound pedagogical reasons for this delay. The increased freedom is tied to increased abstraction; the student struggling with the algebra of numbers is not yet prepared for the less concrete algebra of vector spaces, or $\mathbb{Z}$-modules, or …

Nonetheless, I contend students with only knowledge of high school mathematics are adequately prepared to explore this freedom in mathematics. Compare to the core ethos of the early college program; much like many students are ready for college before the traditional age, with judicious choice of subject students are able to grapple with the boundary-breaking ethos of 'advanced' mathematics earlier in their education.

My choice of topic is logic, for threefold reason. For one, that is my specialization and so the area I know best. For two, there has been ample critical study of logic by feminists, giving a philosophical basis for this queering of the subject. For three, logic is about reasoning, and so is more concrete for students than topology or abstract algebra or …

Indeed, popular perception has it that logic is the science of correct reasoning and it subjects us to the authority of universal laws of thought which have been constant at least as far back as Aristotle. In contrast to this perception, here is Plumwood again:

> But it is the enormous diversity of modern logic, perhaps its most striking feature in comparison with the logic of the past, which does most to refute Nye's claims about the totalitarian politics inherent in logic and its inevitably normative and 'silencing' role.[3] *If there is not one Logic, but in fact many different logics*, if logics can be constructed which can tolerate even contradiction itself, logic can itself have no silencing role and no unitary authority over language. [Plu93, p. 440] (emphasis mine)

The goal then is to give students an introduction to different logics, and to thereby see them not as authorities over thought but rather tools we may choose between for different purposes. I sketch now a proposal for a course suitable for first-year college students.[4]

[2] This is not to say the freedom is absolute. Mathematics is a social practice, and whether you want tenure or merely others to read your work, you need to convince others your new rules are useful or at least interesting.

[3] Plumwood is responding to Andrea Nye's 1990 monograph *Words of Power* in which she advocates the complete rejection of logic.

[4] I hope in a future paper to report back on the failures and successes of this class after teaching it.

A proposal for a class to contribute to the queering of the mathematics curriculum

The tentative title of the course is Nonbinary Thinking in Mathematics.[5] Structurally, it is similar to many survey logic classes offered by philosophy or mathematics departments. However, the focus is different. One, rather than going in depth on a single logic (classical predicate logic being the most common choice), the point is to look at a variety of logics. Two, formal deductive systems are downplayed, in favor of encouraging students to think about applications of these different systems. Fitting with the theme of the class, the main choice of application is to thinking about gender and sexuality.

Class content

The plan is to have four units for the class, focusing on different propositional logics.

1. **Binary logic.** In this unit students will learn about boolean logic. The main purpose is to have a basis of comparison for later non-binary logics[6] we will study. But we will also touch on how by looking at multiple variables, from the two truth values of true and false can be extracted much more complicated and nuanced concepts, such as seen in boolean logic's use in circuits for computers.

2. **Fuzzy logic.** What if there were more shades of truth than just true or false? In this unit students will see their first non-binary logic, in which there is a continuum of truth values.

3. **Intuitionistic logic.** What if true and false weren't opposites? In the earlier logics students saw, false meant "not true" and "not false" meant true. Now we look at a logic where "not false" needn't mean true.

4. **Paraconsistent logic.** What if something could be both true and false? Previous logics treated true and false as exclusive categories. Now we look at a logic which allows statements to be simultaneously both true and false.

Planned readings for the students include Val Plumwood"s "The politics of reason", for a feminist critique of classical logic, and Robin Dembroff's "What is sexual orientation?", for an example of the discrete versus continuous issue

[5] One of the main reasons I'm developing this course is the Bard Queer Leadership Project at Bard College at Simon's Rock, where I teach. Students in this program have to take a number of classes that relate to queer leadership. At time of writing, they have options in the humanities—such as a queer theory or an LGBTQ cinema class—but none are offered from the Division of Science, Mathematics, and Computing. This class is my contribution to the program, to help create a space for students who are interested in both queer leadership and the STEM disciplines.

[6] For the specialist: this is synonymous with what we would usually say as non-classical logics. But I adopt nonstandard terminology so as to meet my students where they are.

that distinguishes boolean logic from fuzzy logic. For a textbook I'm considering using "What if? An open introduction to non-classical logics" as a reference for the technical material.[7]

Class structure and assessment

While this class is placed under the mathematics heading, it includes interdisciplinary elements. It's not just about studying mathematical systems, but also putting them in the larger context of the philosophical motivations behind them and how they might be applied, especially to understand sexuality and gender. To accommodate this the structure of the class will look different from the typical mathematics class. A portion of the time will be spent on common features of the mathematics classroom: students learning about formal systems and working exercises to develop and test their understanding. Other parts will look more like a philosophy class: students reading a piece of writing and then discussing it as a group.

A goal of the class is for students to write a term paper where they apply the mathematical ideas we look at to study something outside of mathematics: here is a domain that doesn't fit into a rigid binary classification, can we apply these logical tools to understand this domain? I imagine the traditional topics of queer theory will be common choices. But I think it best to let students choose their own topics, and I'm open to subjects outside queer theory.

Because this will be a major component of the class, I want to scaffold the writing project across the semester, and not just make it one big assignment. Early on in the semester we will do small writing assignments as practice. This will build toward students choosing a topic and producing a draft. They will give each other feedback on the drafts, as well as get it from me, and then revise to a final version they submit at the end of the semester.

A successful student should leave the class understanding the diversity of logics and able to choose between them for formal tools to study human experiences that don't neatly fit into a binary. My grading schema is an attempt to include all of the pieces of this. The tentative plan is to divide assessment between technical exercises, participation in readings and class discussion, small writing exercises, and the term paper.

My main target audience is students interested in both queer theory and scientific/mathematical disciplines. I anticipate many enrollees will already have already taken several technical classes. A secondary audience is students who don't think mathematics is for them, based on poor experiences in the core mathematics curriculum. I hope to be able to show them that the tools of mathematics can be useful for understanding their world and aren't just there to discipline them and make them suffer. To make the class accessible to those students, I won't put any prerequisites on the course. As said above, I contend students are

[7] This text is a product of the Open Logic Project (`https://openlogicproject.org`), an open source, collaborative project to produce teaching content for logic which can be remixed into books for different courses.

able to grapple with these ideas without having already studied a lot of advanced mathematics. But the exact schedule of topics is flexible based on the specific students. If, for example, a semester ends up entirely with students with a strong math background, then we can dig deeper into some of the technical topics I would skip over with a broader audience.

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