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Beyond the Binary: Leaning on Materials-to-Queer-with in the "Doing of Mathematics"

Nickolina Yankova, University of Southern California, yankova@usc.edu
Kylie Peppler, University of California, Irvine, kpeppler@uci.edu

Abstract: Grounded in queer theory and constructionism and drawing on methods in design-based research, this study traces the design and implementation of a queering of mathematics, situated in the context of an interdisciplinary undergraduate course. This study evaluates the ways in which binary oppositions were ruptured in the course, subverting normative practices through an engagement with materials-to-queer-with and uncovering new ways of engaging in the "doing of mathematics."

Introduction

Queer pedagogies in educational contexts promise to disrupt inequitable learning practices by subverting norms and envisioning possibilities. Spaces that would perhaps benefit the most from a queer approach in the design of learning environments are the ones supposedly devoid of bias due to their perceived neutrality, such as mathematics. Steeped in socio-political context, STEM spaces, and by extension, mathematics, perpetuate systems of oppression that privilege who is white, cis, male, and straight (e.g., Leyva et al., 2022, Voigt, 2022). Following Dubbs' call for a queer turn in mathematics education research (2016) "to develop and engage with queer curriculum and queer pedagogy" more prominently (p.6), there is greater need to attend to the ways in which queer pedagogies can be undertaken in mathematics contexts toward more equitable and just ends.

Though there have been efforts to queer aspects of mathematics (e.g., Sumara & Davis, 1999; Pennell & Fede, 2017; Yeh & Rubel, 2020), what has garnered little to no attention have been the dominant tools and materials in mathematics education. Building on previous work which derived design goals for a queering of mathematics (Yankova, 2024), this study traces the design and implementation of such a queering with new tools and materials toward disrupting mathematics spaces as gendered, fixed, neutral, and reinforcing a binary. Situated in the context of an undergraduate interdisciplinary course at the intersection of robotics, mathematics, and weaving, this study asks: *How do we design a queering of mathematics that ruptures the binary with new tools and materials?*

Background

Queer theory and constructionism acted as a dual theoretical lens, underpinning a disruption of the binary. As a learning theory, constructionism (Papert, 1980) interrogates learning through making, positing that it is in the production and sharing of personally meaningful artifacts that learners learn best. Experimentation, failure, and a tangible engagement with objects-to-think-with characterize constructionist learning environments, where queer theory adds a more critical component, envisioning ways to disrupt what is normative toward the transformation of current oppressive practices. Challenging the binary is a central aspect to queer theory, which at its roots speaks of heteronormative structures that are to be subverted (e.g., Butler, 1999; Warner, 1993). With constructionism's focus on the materiality of learning and queer theory's notion of identity as socially constructed, invoking notions of gender performativity (e.g., Butler, 1999), engaging non-traditional materials in the doing of mathematics (i.e., through weaving) has the potential to overturn social norms around performing masculinity, further dismantling binary divides.

Though often presumed to be domestic, women's work, craft (e.g., knitting, crocheting, weaving) and the production of artifacts have shown to be inherently mathematical (e.g., Peppler et al., 2022; Thompson, 2020). Through the years, crafting as a practice has been recognized, albeit reluctantly at times, for the type of mathematics that is "frozen", or embedded, within the produced cultural artifacts (Harris, 1987). Weaving specifically, and associated tools, at their roots share many ties with computing and mathematics across areas. Historically, it was women weavers who first handwove an early form of computer storage, yet their work is often left in the shadows (Rosner et al., 2018). The mathematical nature of weaving, on the other hand, goes beyond simple practices like arithmetic to engage a more pluralistic mathematics (Thompson, 2020) across contexts and even advanced areas such as linear algebra (e.g., Hoskins, 1982; Rasmussen, 2007), number theory, combinatorics, and group theory (e.g., Grünbaum & Shephard, 1980; Knoll et al., 2015). Notably, experienced weavers tacitly engage in such complex mathematics practices without necessarily recognizing them as such, or at the very least, ascribing a name within school mathematics to these practices.

Methods

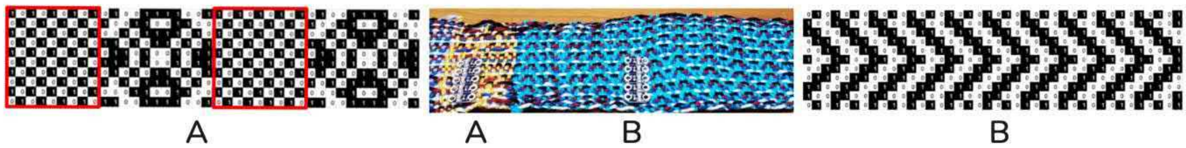
Grounded in design-based research (e.g., Brown, 1992; Collins, 1992), this study reflects on the design and implementation of a queering of mathematics in the context of a 10-week, elective undergraduate class in Southern California, bridging mathematics, weaving, and robotics. Following Sandoval (2014), a conjecture map helped organize design decisions for the course, scaffolding an evaluation of the overarching hypothesis (i.e., "Use of non-traditional materials and tools will "queer" normative math practices toward equity.") Working in 6 groups of 3-4, students constructed their own robotic loom, learned about math in the weaving context, and designed and wove their own textiles in a classroom space, set up and functioning as a makerspace. Drawing on data from groups' final projects as a culmination of queered practices in the course, this study evaluates if this initial foray into a course-long queering of mathematics met its intended design goal, that is, contribute to more equitable learning opportunities.

Findings

Students' engagement with materials-to-queer-with scaffolded a deeper understanding of math across contexts and as a space that can rupture long-held binary oppositions (e.g., right way vs. wrong way, simple vs. complex; theory-driven vs. applied, etc.) Disrupting the binary with new tools and materials was realized in embracing a multiplicity of approaches in the "doing mathematics" and the possibility of failure. Through the iterative design process, inherently embedded with mathematical principles and considerations, students learned about an entanglement of mathematical and cloth properties, and how to overcome perceived failures. A simplistic notation of weaving patterns presents them as an array of 0s and 1s, denoting the two possible types of interlacements: vertical thread going over horizontal, denoted with a 1, or vice versa, denoted with a 0. By embracing the representation of weaving patterns with 0s and 1s, which holds the ties to mathematical thinking and reasoning, we can first-hand observe that though simple at first glance, there are layers of complexity bound to disrupt what is seemingly a perceived binary.

One way in which *beyond the binary* was materially realized was through groups' design iterations and color selections. Groups found it necessary to make design adjustments based on how the material responded to the pattern, iterating on their designs over time and challenging notions of failure. In their second design iteration after their first unraveled, one group ended up interweaving sections of plain weave in their design, adding a more solid woven structure (see Figure 1, in red). In particular, plain weave alternates 0s and 1s to ensure a more tightly packed cloth. Reflecting on their design, students said, "This design we tried to learn from our mistakes of the first weaving draft and give some more structure, by integrating the plain weave." However, the group soon realized that the flower pattern in yellow did not stand out as clearly as intended in the black and white binary representation (see Figure 1A). Settling for a simpler, herringbone pattern the group selected a bright blue color, which, in combination with the colorful warp threads, created a clearly defined pattern (see Figure 1B). Though in crafting the design, groups were prompted to make seemingly binary, or discrete choices, selecting 0s and 1s, complexity was added in producing the artifact. The interplay of the binary representation and color choices infused a level of complexity, in large part due to the continuity of color, and paved a path beyond the binary.

Figure 1
Two Design Iterations, Exploring Pattern and Color, as Overlaying the Binary



Discussion and implications

This study aimed to contribute initial forays into the design of a queering of mathematics. Conventional mathematics spaces paint a divide between right and wrong, and other adjacent oppositions, often eliminating notions of complexity and reinforcing a binary. Yet embracing a multiplicity of approaches and failure as an encouraged outcome and a productive part of the learning process promises to unsettle present inequities. Additionally, engaging in the design and production of textiles further supported opportunities to bring personal preferences, engage in the doing of mathematics in new ways, and question what it means to perform masculinity in math spaces. The design and weaving portion of the class challenged fixed participant structures, methods, and content, typical for the mathematics classroom, redefining what counts as math learning. A subsequent design iteration would benefit from honing in more strongly on the nuanced connections between mathematics and weaving.

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