Dare to Care: The Impacts of a Caring Pedagogy on Mathematical Making, Teaching, and Learning

Eileen Fernández, PhD
Montclair State University
fernandeze@montclair.edu

Jessica Davidson
Montclair State University
davidsonj5@montclair.edu

Erin Pomponio
Montclair State University
pomponioe1@montclair.edu

Abstract

Our study presents findings from a Maker project as it was enacted through a caring pedagogy in a course for preservice and practicing mathematics teachers. We focus on the cases of three individuals - outsiders to the traditionally exclusionary cultures and spaces of Making and mathematics - as we explore the questions: How does enacting a caring pedagogy during a Making-centered experience impact and broaden opportunities for meaningful mathematics learning? How does this challenge traditional notions of who can and cannot Make or do mathematics? We suggest a pedagogy of caring, sharing, and Making as one way to accept the educational responsibility of celebrating such marginalized and often excluded individuals, and centering them in meaningful mathematical learning within these spaces.

Objectives

Our study concerns a semester-long project from a mathematics education graduate course taken by practicing and prospective K-6 mathematics teachers (PMTs). The course project of Making, 3D printing, and sharing a manipulative for a child's mathematical learning sets the stage for our investigations. Making is defined as designing, building and innovating with tools to make an object that solves practical problems (Halverson & Sheridan, 2014). Typically recognized as a male, "adult, white, middle-class pursuit," Making culture can feel closed to entrants who do not fit these stereotypes (Barton, Tan & Greenberg, 2017, p. 5). The subject of mathematics also carries an exclusionary culture alternately characterized as a "gatekeeper" subject (Stinson, 2004); a "proxy for intelligence" (Gutiérrez, 2017; p. 18); and as powerful enough to "crush students' spirits" (Boaler, 2016; p. 17). While educators proffer multiple avenues of entry to mathematics' potential in students' lives, we focus on caring as a central element for benefitting those who are marginalized from mathematics' activities (see Bartell, 2011).

The current study concentrates on three participants who, in some way, were outsiders to the project context. The teacher educator (TE) and an author is a Cuban female with caring-centered pedagogies who identified as a novice and interloper to the Making culture. Her PMT student, David, was student teaching in a kindergarten class and brought a lived history with caring teachers to the course. Even though he is a white male, David did not feel like a "Maker," bringing anxiety over the project's technological aspects. And Vincent, another white male is also atypical within mathematical communities: as a child with Autism Spectrum Disorder, his bustling, energetic and physical ways of engaging and learning are not commonly "tolerated" in traditional mathematics classrooms where procedural knowledge and efficiency are privileged 2 (Lambert, 2015). By focusing on caring-centered relationships, we illustrate how together, the participants redefined values associated with Making, traditional mathematics, and what can get celebrated as learning.

Perspectives

Given Bartell's (2011) framework of caring and its benefits for mathematics' under-represented students, Noddings' (1995) question is crucial for TEs: "What kind of schools and teacher preparation are required, if themes of care are to be taught effectively" (p. 678)? In this paper, we present one approach based in a Making experience.

Our theoretical background is organized around the learning theories of constructivism (Piaget, 1970) and constructionism (Papert, 1993). Recognizing that knowledge is actively constructed by learners, both theories value struggle, surprise, and discovery in mathematical

learning. Constructionism adds that knowledge is constructed during the process of making a shareable object (Halverson & Sheridan, 2014), a trait we leverage in our framework. With much of the Maker literature focusing on interactions between the Maker and the tool (see Schön, 1992), the personal experiences of its user do not always appear central to this process. In our project, our PMTs were tasked with Making and sharing a mathematical manipulative for a specific child. For the majority of our PMTs, their child's experiences were as much an influence in the Making process as the software or the mathematics behind their tool.

Making and sharing can elicit both cognitive and affective concerns in caring and suggests a need for a framework that reflects these dual traits. Hackenberg (2010) terms a mathematical caring relation (MCR) as one that honors both the mathematical and affective parts of learning. She recognizes a teacher's sensitivity to a student's learning needs and ability to participate in the activity at hand as central to supporting meaningful MCR's. Hackenberg further illustrates how cognitive decentering can help a teacher to navigate an MCR by decentering "from his or her own perspectives...to help students realize and expand their ideas and worlds" (Hackenberg, 2010; p. 239).

In our project, we honor and utilize the mathematically open-ended nature in designing and Making a manipulative; the sometimes, uneasy navigation through emergent mathematical "unknowns"; the child's unique experiences and needs; and the tensions that are negotiated by carers (Noddings, 2012) in balancing these considerations. With this framing, we pose the following research questions: How does enacting a caring pedagogy during a Making-centered experience impact and broaden opportunities for meaningful mathematics learning? How does this challenge traditional notions of who can Make, who can participate in mathematics, and who cannot?

Methodology

The current study is part of a larger research project (blinded) which investigates PMTs' knowledge and how they see themselves in relation to Making, mathematics, and mathematics teaching. To capture such complex phenomena, we employ a qualitative approach to data collection, sampling, analysis and presentation (Patton, 2015). This particular implementation of the project proceeded in overlapping phases and generated video data from in-class design sessions and three interviews between each PMT and their child; conversations between PMTs and TE (journaled by the TE); and written assignments intended as deliberate reflection devices for the PMTs to wonder about their project considerations. Because these situations are neither manipulated nor controlled, this positions our work as naturalistic (Patton, 2015).

In exploring the larger question of how the PMTs see themselves, we were drawn to caring relationships that developed between project participants and utilized the methodological stance for purposeful sampling (Creswell, 2007). We opened our analysis to participants' verbal utterances and intonations, body language, actions and mutual positionings (Simmt, 2000) as revealing defining moments in MCRs. The possibility of intersecting caring theories with Making and the novelty of our data suggested a grounded theory approach (Glaser & Strauss, 1967) to analyzing and cross-referencing our sources. In presenting our data, we employ text and figures and encourage the reader to carefully study both as they read the results.

Results

In their first design session, David worked with peer PMT, Natalie, who took the lead on designing an already-existing manipulative with the project technology. The TE noticed a sense of relief in David who believed he and Natalie had found a (mathematically traditional) quick, "correct answer" to the task of Making the project manipulative.

Shortly after this design session, David submitted his first video interview with Vincent. Upon watching it, the TE was struck by David and Vincent's warm interactions and careful calibrations of each other's movements on the classroom floor. David's voice was comforting and supportive, and he observed quietly and patiently as Vincent experimented with Katie Cubes. Struck by their special exchanges, the TE purposefully invited David to her office to

propose the possibility of his working independently from Natalie to design a new manipulative centered on Vincent. The TE remembers feeling apprehensive about making this suggestion because it would bring David back to "square one" in the design process, recalling a reciprocal apprehension in David's response:

David: So, I have to design something by myself?

TE: No, you're not by yourself. I'll support you and we'll get through it together. Tell me about Vincent. What can we make for him?

The TE accepts responsibility for supporting David in caring for Vincent, and navigates the discomfort and tensions (Noddings, 2012) that accompany this pedagogical decision. David, in turn, opens to accepting responsibility for Vincent's care, sharing and utilizing Vincent's knowledge and love of diverse shapes to pose a new goal of designing regular polygons for Vincent to tessellate. In investigating this goal during the second interview, David realizes Vincent can already tessellate the floor with like and unlike shapes (see Fig. 1). This prompts David to change his design path away from tessellations, seeking out the TE after the interview to brainstorm. Still honoring Vincent's love for shapes, they settle on designing triangular, square, and hexagonal prisms with holes and correspondingly shaped inserts intended to create a one-to-one matching task (e.g., which of these shapes fit together?) (see Fig. 2). During a subsequent design session, David notices that multiple printed inserts do not fit into their intended holes. The TE takes advantage of this moment of struggle to support David through his technological anxieties, and recommends including the extra "mis-shapes" in the matching task (e.g., which of the multiple hexagonal inserts can fit into the hexagonal hole?). David reflects on this being a "teachable moment" as his "mis-shapes" can become usable for Vincent's learning.

In the final interview, Vincent begins as expected, attempting to match kindred inserts and holes. Eventually, he breaks with this and plays with the possibility that not every shape and insert must match to fill the holes (e.g., he drops hexagonal inserts into the square hole). These uninhibited moments of insight suggest a transition in Vincent's attention from categorizing shapes by number of sides, to whether each piece has a hole or not—a driving force in understanding topological equivalence. For example, the inserts, having zero holes, are topologically equivalent and the prisms with one hole are topologically equivalent. These

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explorations culminate when Vincent aligns the hexagonal and square prisms with unlike holes to peer through them (see Fig. 3). David responds by arranging the pieces between himself and Vincent so that they form a telescope (see Fig. 3)! Together, they lock eyes and exchange laughter and words of affirmation in an MCR where David decenters from the intended activity to literally see his child's point of view (Hackenberg, 2005).

Discussion

AERA's call challenges TEs to accept responsibility for teachers' actions within P12 schooling. One question that arose in considering this call was, "How do we accept responsibility when it feels like every choice generates struggle?" In mathematics classrooms, we are pressured to cover topics quickly at the expense of understanding, while recognizing that these approaches exclude so many students from what mathematics offers (Boaler, 2016). In teacher education classrooms, we are pressured to be responsive to research that supports meaningful learning when we know our teachers are going into school systems that are too overwhelmed to do likewise (see Shulman, 1983; Kennedy, 2005). Because of these pressures, enacting a caring pedagogy in schools may seem like a daunting task for teachers. Our project's focus on Making something for and with a specific student enables both a TE and PMT to leverage their caring-centered pedagogies, all of which became actionable for the PMT as a teacher education student and a kindergarten teacher.

Our study speaks to the inclusivity that caring brings to learning. Vincent, a member of the students with disabilities (SWD) community, approached and demonstrated learning with animated physical enthusiasm. In a typical mathematics classroom, he might be considered a

"disturbance" and subjected to repetitive, rote, and explicit instruction (Lambert, 2015). Instead, the TE and David's caring-centered pedagogies supported opportunities to embrace Vincent's inclination to learn with his body, and explore open-ended mathematical ideas together. The TE and David cared for and supported each other through technological apprehensions, even recognizing that design "mis-shapes" could become viable learning tools for Vincent, which helped to dissolve their feelings of exclusion from the Maker culture as their attention turned to care.

By inviting David to substitute a more open-ended investigation for his initial "easy" project solution, the TE set in motion a ripple effect that challenges traditional notions of mathematics learning in which authentic and sometimes uncomfortable discoveries are dismissed as divergent from intended tasks (Lampert, 1990). Instead, David embraced mistakes as an important part of his learning and celebrated Vincent's mathematical discoveries. In doing so, he defied the limited notions that SWDs should not participate in conceptual thinking and problem solving and welcomed the unexpected (but worthwhile) mathematical interpretations that open-ended investigations can bring.

Hackenberg's (2010) caring framework connects affective and content concerns in characterizing caring relations in mathematics. We explored Making and designing as a novel opportunity to facilitate these same connections "through the process of jointly negotiating the meaning of concepts and activity," allowing our teachers to "demonstrate care for individual students and for the subject matter itself" (Bartell, 2011, p. 54) in a way that embraces mathematical struggle, surprise and discovery. For future research, we wonder how Making experiences can be leveraged in teacher education settings to involve more diverse teacher and student audiences, and whether or not Making for and with someone can help to forefront caring pedagogical practices.

Figures

Fig. 1. Vincent demonstrates tessellation knowledge with pattern blocks

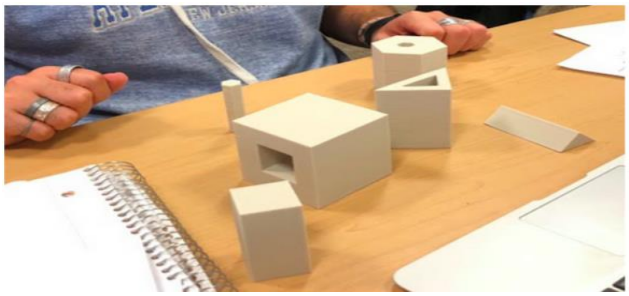

Fig. 2. First Iteration of David's Prisms with Holes

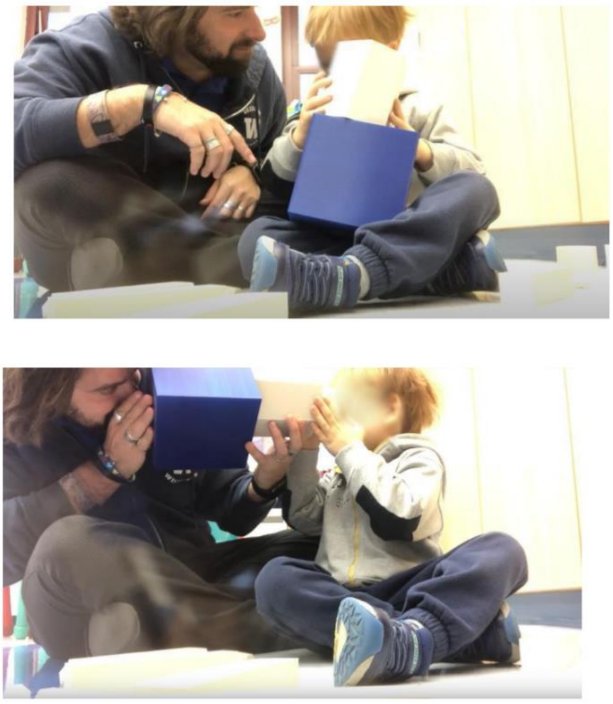

Fig. 3. Vincent Sees Similarities in Different-shaped Holes

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