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Doing things: Organizing for agency in mathematical learning

Tesha Sengupta-Irving

University of California – Irvine, 3200 Education, Irvine, CA 92697-5500, United States

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ABSTRACT

In the United States, school mathematics generally fails to help students see themselves as capable of impacting their world – a perspective Freire argues defines human agency. This analysis draws from a five-week Algebra intervention for middle school students ($n = 46$) designed to promote agency through collaborative mathematical activity. Typically, students identified as underperforming (as most in this intervention were), teachers revert to procedural, low-level instruction. In contrast, this intervention was designed around tasks of high cognitive demand that required visual or symbolic representation of algebraic concepts. Qualitative coding of student interviews ($n = 46$) confirm the design principles of authority, agency and collaboration were positively impactful for students. In particular, interviews evidence a changing perspective from math as boring to the possibility of math as comingling intellectual challenge and personal enjoyment. These results are traced to the design principles and in particular, the focus on organizing for agency.

> What is required is that every individual shall have opportunities to employ his own powers in activities that have meaning. Mind, individual method, originality . . . signify the quality of purposive or directed action.
>
> John Dewey, 1916/1944, p. 203

John Dewey (1916/1944) believed in learning through meaningful activity so much so that he argued quantifying and comparing students' abilities was "irrelevant" to the work of teachers. As the quote above suggests, teaching should provide students a chance to discover and pursue meaningful learning opportunities that reveal their ingenuity and individuality. However, comparative international studies of 8th grade students show that those who average among the highest in mathematical achievement average among the lowest in their interest in math (Mullis et al., 2000). In the U.S., but for few exceptions (e.g., Gutstein, 2012; Silva, Moses, Rivers, & Johnson, 1990), school mathematics generally fails to help students see themselves as capable of making and remaking their world, which, from a Freirean (1994) perspective, *defines* human agency. As educators and child development researchers argue, the failings of traditional schooling become most visible in adolescence: at precisely the time when students want to express their agency, adults at school exert increased control over their behaviors (Eccles, Lord, & Midgley, 1991; Moje, 2002; Rogers, Morrell, & Enyedy, 2007). Creating opportunities for adolescents to express agency through meaningful mathematical activity is therefore worthy of greater consideration in current debates about the purposes and nature of mathematics education in schools.

This analysis is based on a five-week middle school mathematics intervention in the western United States, designed for ethnically and racially diverse youth ($n = 94$) with a range of prior mathematics achievement. This article describes how learning opportunities were organized for student agency; then, drawing on student interviews, examines students' perceptions of agency in learning mathematics during the summer program.

E-mail address: t.s.irving@uci.edu

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1. Conceptualizing agency and productive mathematical engagement

Gresalfi, Martin, Hand, and Greeno (2009) suggest agency is *not* something someone "has" or "lacks" as one might say, for example, of motivation. The authors argue that the simplest acts of complying or resisting – taking out your pencil to copy an example problem, or not – are expressions of agency in a learning environment. As such, agency is available to everyone, from the most reserved to the most flamboyant of students. Pickering (1995), sociologist and historian of science, describes agency as the antithesis of passivity in his writing *The Mangle of Practice: Time, Agency, and Science*. As Wagner (2007) points out, Pickering equates agency in the pursuit of high-level mathematics with purposeful action. "One can start from the idea that the world is filled not . . . with facts and observations, but with *agency*. The world, I want to say, is continually *doing things*, things that bear upon us not as observation statements . . . but as forces upon material beings" (Pickering, 1995, p. 6, his emphasis). By living in the world, by interacting with others, by responding to forces of nature, humans see and express agency in daily existence. In U.S. mathematics classrooms, however, human agency is displaced by passivity, as students sit quietly, watching, and listening, before practicing similar problems (Hiebert & Stigler, 2000; Rosen, 2001). This leads many students to disengage (Boaler, 2002; Boaler & Staples, 2008). In Boaler's numerous studies of students learning mathematics in contrasting teaching environments, she found that even students who are successful through passive engagement frequently plan to stop taking math courses at the earliest opportunity (Boaler, 2002, 2006, 2009).

In Pickering's conception of agency in mathematics, he describes the "dance of agency" (1995, p. 116), as involving two partners: human agency and agency of the discipline. Human agency refers to people creating initial ideas or extending established ones. Agency of the discipline refers to standard procedures of mathematical proof or widely agreed-upon methods of verification, for example. The interaction between human ingenuity and standards of the discipline is a dance that Pickering argues has been central to conceptual advances in mathematics, historically. Classrooms where students engage in a dance of agency while working on complex mathematical tasks are shown to encourage student interest (Boaler & Greeno, 2000; Martin, 2000), achievement, and persistence in the discipline (Boaler & Staples, 2008).

Frequently, when teachers work with students identified as underperforming (and lower-income), they remove the possibility of active learning and revert instead to primarily procedural, low-level remediation, with the belief that students simply need more practice of rules (Anyon, 1980, 1981; Haberman, 1991). The features of a positive learning environment – whoever the learner – include opportunities to reason about problems, discuss mathematical ideas, and debate solution pathways (Kieran, 1994; Malloy, 2009; NCTM, 2014; Stein, Engle, Smith, & Hughes, 2008). Students should be engaged in developing their own strategies, exploring outcomes, developing reasoned understandings, and formulating identities as capable mathematics learners (Boaler, 2015; Fasheh, 1982; Kilpatrick, Swafford, & Findell, 2001; Langer-Osuna, 2007; Schoenfeld, 2007). Engle and Conant (2002) offer four principles for designing learning environments that, as the authors call it, support productive disciplinary engagement. These principles also articulate a vision of learning environments where expressions of agency are concomitant with expressions of disciplinary interest, engagement, and achievement.

Engle and Conant's four principles for designing robust learning environments include: (1) *Problematizing*, where students are encouraged to take on intellectual problems; (2) *Authority*, where students are given authority to address those problems; (3) *Accountability*, where students are held accountable to others and to disciplinary norms; and (4) *Resources*, which refers to students having sufficient materials for inquiry (2002, pp. 400–401). The first principle, expecting students to problematize, is the opposite of passivity and therefore a necessity in learning environments organized for students "doing things".

Engle & Conant's second principle is authority. Gresalfi and Cobb (2006) define authority, using Engle & Conant, as the "degree to which students are given opportunities to be involved in decision-making . . . have a say in establishing priorities in task completion, method, or pace of learning" (p. 51). In short, they posit authority as being about "who's in charge" of making mathematical contributions. They recognize the limits of either teacher or text being positioned as the sole mathematical authority (Amit & Fried, 2005). Authority is intimately related to agency: students play an active part in defining, addressing, and resolving problems because they have the authority as authors and producers (not simply consumers) of knowledge (Lampert, 1990; Lehrer, Carpenter, Schauble, & Putz, 2000; Magnusson & Palincsar, 1995).

Engle and Conant's (2002) third principle is accountability as when a teacher asks a student if the solution she or he has devised is most efficient in its use of variables. Gresalfi and Cobb (2006) also refer to this sort of exchange, where the student and teacher jointly determine the mathematical legitimacy of methods, as "distribution of authority" within the learning environment. This exchange can also occur among students (e.g., Godfrey & O'Connor, 1995; Oyler, 1996). This idea of holding students' thinking accountable to the subject matter is critical in advancing mathematical learning

Engle and Conant's fourth and final principle is resources, which essentially refers to providing students the material support for pursuing their choice of mathematical activity. Limiting freedom within the physical space (e.g., students sit at desks) or the variety of mathematical tools to represent thinking (e.g., pencil and paper only) can impede expressions of agency. As Fiori and Selling (this issue) illustrate, the physical layout and resources available within the learning environment significantly shape how students define and pursue interesting mathematical work.

In sum, drawing together notions of active learning and what prior research demonstrates as the principles of productive disciplinary engagement, redesigning learning environments to facilitate expressions of agency ("doing things") becomes possible and practicable.