The many colors of algebra: The impact of equity focused teaching upon student learning and engagement

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A B S T R A C T

The number of students who leave U.S. schools mathematically underprepared has prompted widespread concern. Low achieving students, many of whom have been turned off mathematics, are often placed in low tracks and given remedial, skills-oriented work. This study examines a different approach wherein heterogeneous groups of students were given responsibility and agency and asked to engage in a range of mathematical practices collaboratively. The teaching intervention, which was introduced in the first paper, took place as part of a summer class on algebra, and it gave students the opportunity to participate with mathematics in changed ways. This paper will report evidence that the vast majority responded with increased engagement, achievement, and enjoyment. The students chose collaboration and agency as critical to their improved relationships with mathematics.

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1. Introduction

The number of students in the United States who dislike or fear mathematics and leave school mathematically underprepared has prompted widespread concern (Boaler, 2015; Glenn, 2000). Many students – even those who are successful – develop negative ideas about math and see the subject as something that is ultimately uninteresting and quite separate from their lives (Boaler & Greeno, 2000; Madison & Hart, 1990; Seymour & Hewitt, 1997). Additionally, mathematics has a wider “gap” across socio-economic and racial lines than any other academic subject (RAND, 2002; Secada, Fennema, & Adajian, 1995; Tate, 1997). Persistent failure and disinterest in mathematics is of particular concern given the growing importance of mathematical reasoning and ‘quantitative literacy’ (Boaler, 2013b; Steen, 1997) to people’s lives and work, and an increasing knowledge of the ways that unsuccessful mathematics experiences can impact students well beyond the classroom (Boaler, 2005; Moses & Cobb, 2001; Thompson, 1995).

Despite the development of mathematics education as a growing field of research in the last few decades, and the identification of features of learning environments that bring about mathematical interest and high achievement, traditional teaching of mathematics endures (Hilbert & Stigler, 2000; Rosen, 2001). Indeed there is a large body of research in mathematics education that shows the ways students can learn mathematics most effectively, with evidence of increased engagement and achievement success, that is not taken up in classrooms. There are many reasons for the gap between what we know works and what is used in classrooms, one of them being the inaccessibility of research knowledge that is largely
contained in journals teachers do not read. New technologies giving teachers access to research knowledge are helping to cross the research-practice divide, especially when they translate research knowledge into useable resources and ideas for teaching (see, for example, www.youcubed.org). Positive characteristics of mathematics classrooms include reasoning about applied problems, discussing mathematical ideas, and actively engaging in mathematical learning (e.g., Boaler, 2002a; Boaler & Staples, 2008; Kieran, 1994; Malloy, 2009). As Gutstein (2003) demonstrates, for example, inviting students to consider mathematically complex ideas with real-world implications fundamentally changes students’ orientations towards mathematics. In North America, such features of mathematical learning environments are rare and classroom environments more typically involve a teacher presenting examples while students are expected to sit quietly, watch, and listen, before practicing similar problems (Boaler, 2015; Hilbert & Stigler, 2000). A critical feature of active mathematical engagement that has gained recognition in recent years is the opportunity for student agency (Boaler, 2002b; Gutstein, 2003) – when students get the opportunity to express their own ideas and combine their own thinking with standard mathematics. Students who use their own ideas alongside and connected through standard mathematical methods engage in what Pickering has referred to as a ‘dance of agency’ (Pickering, 1995). Studies have shown that active engagement with mathematics increases student interest (Boaler & Greene, 2000; Engle & Conant, 2002; Martin, 2009) as well as high achievement and persistence in the discipline (Boaler & Staples, 2008). Such classrooms also offer students opportunities to engage with authentic mathematical work, rather than simply rehearse procedures that they may never need or use again.

While some classrooms in the United States offer students opportunities to solve complex problems and to act with agency in using and adapting mathematical methods (e.g., Ball, 1993; Lampert, 2001; Maher & Martino, 1996), such classrooms are rare and often such learning opportunities are restricted to high-level courses. When teachers inherit a class of students who have been identified as low achievers or “strugglers,” they often assume that procedural, low-level remediation is most appropriate (Anyon, 1980, 1981; Haberman, 1991). In this article, we consider a teaching approach that took the opposite approach. As we set out in the first paper, a diverse, heterogeneous group of students, many of whom had persistently failed mathematics classes, were invited to solve complex mathematical problems, act with agency, and reason about mathematics through peer collaborations. Our goal in this paper is to increase understandings of the ways such environments may impact students’ engagement and understanding of mathematics.

Engle and Conant (2002) describe four features of ‘disciplinary engagement’ in these ways:

1. Problematize content – providing students the opportunity to question, be curious, and conduct their own inquiries;
2. Enable student authority – encouraging students to take an active role in defining, addressing and resolving problems;
3. Hold students accountable to others and to disciplinary norms – encouraging students to listen to each other and to seek reasons for explanations that are accountable to the norms of the discipline;
4. Provide relevant resources – giving students access to resources such as time and materials, which enable the first three features (p. 406).

The four features Engle and Conant describe were central to the teaching intervention and associated research presented here. Like Engle and Conant (2002) our goal in this paper is not to promote a particular teaching intervention but rather to contribute to increased understandings of the different ways “productive disciplinary engagement may be fostered” (p. 401). Amidst concerns about the number of U.S. students failing algebra, and the move to introduce algebra to younger, mathematically underprepared students, we present a case of transformative student engagement that might otherwise be difficult to locate in the current educational climate.

In examining the intervention designed we ask: How might a five-week teaching intervention that focuses on collaboration and agency, promote student achievement and engagement in mathematics? We were motivated by the belief that by focusing on the development of mathematical ‘practices’ (Common Core State Standards Initiative (CCSS), 2010; RAND, 2002) through challenging collaborative tasks, disaffected students in mathematics could be re-engaged.

2. Theoretical framework

In mathematics education research, two theoretical developments of recent years have converged to powerfully highlight the need for studying student engagement through mathematical activity. Situated theories of learning moved researchers of mathematics education from the constructivist paradigm in which they had been immersed for many years (Zevenbergen, 1996) to a new paradigm that focused on the ways students engaged in mathematics classrooms, the practices in which they took part, and the forms of participation offered to them (Lave, 1988; Lave & Wenger, 1991). Lerman (2000) described the shift from a study of cognitive pathways to the ways students work in classrooms as a ‘social turn,’ and it came, in part, from the realization that students’ mathematical capabilities in different real world situations drew partly from their cognitive development but also from the practices in which they had engaged in classrooms. Boaler (2002a), for example, found that when students engaged in a range of problem solving practices such as choosing, adapting and applying known and invented methods, they were better prepared to solve complex real world problems than those who had been taught the same mathematical content but without engaging in problem solving practices. Researchers of recent years have come to realize that studying mathematics learning involves observing and exploring the ways students engage in mathematics classrooms.
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