Inquiry as an Access Point to Equity in the Classroom

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Although many policy documents include equity as part of mathematics education standards and principles, researchers continue to explore means by which equity might be supported. Teaching practices that include active learning have been proposed to address this issue (e.g., CBMS, 2016; NCTM, 2014). In this paper, we theoretically explore the ways in which active learning teaching practices that focus on teaching for inquiry (e.g., Inquiry-Based Learning (IBL) or Inquiry-Oriented Learning (IOL)) support equity in the classroom. Specifically, we claim that some characteristics of inquiry (Student Ownership, Knowledge Building, Peer-Involvement, Doing Mathematics, Student-Instructor Relationship, and Student Success) put forth by Cook, Murphy, and Fukawa-Connelly (2016) may align with the Four Dimensions of Equity (Access, Achievement, Identity, and Power) proposed by Gutiérrez (2009). Therefore, inquiry teaching may be a first step for a focus on equity without compromising the excellence (Gutiérrez, 2002) or material that is often prescribed in undergraduate mathematics courses.

Key words: Active Learning, Equity, Inquiry-based Learning, Inquiry-oriented Learning

Many policy documents and institutions both highlight the importance of equity and caution educators with possible consequences of not attending these issues in research and teaching. Most recently in their *Statement on Active Learning* (2016), the Conference Board of the Mathematical Sciences stated, "Pervasive problems caused by issues of equity and access, starting long before students begin post-secondary study, prevent or discourage many students from continuing in their study of mathematics and other STEM disciplines" (p. 3). More strikingly, Nasir, Shah, Gutiérrez, Seashore, Louie, and Baldinger (2011) reported that three decades after the release of *A Nation at Risk* (1983), which "cautioned that America's economic future depended on the mathematical and scientific literacy of all of its citizens" (p. 1), there are still "substantial disparities both in resources and in achievement" that are "organized along troublingly clear lines of race, ethnicity, and socioeconomic status" (p. 1).

Although many policy documents include equity as part of standards or principles of mathematics education, ways in which this goal can be achieved are not explicit. For example, at the K-12 level, the *Principles for School Mathematics* provided by the NCTM have included *Equity* since the early 1990's. The American Mathematical Association of Two-Year Colleges (2006) states, "All students should have equitable access to high-quality, challenging, effective mathematics instruction and support services" (p.10). Yet, as Gutiérrez (2007) indicates, "[m]ost members of the mathematics education research community would agree that equity is a valued goal, maybe even the reason behind their research. However, much less consensus arises when the question is raised: how do you think we should address equity?" (p. 2).

Teaching practices that include active learning have been proposed to address this issue (e.g., CBMS, 2016; NCTM, 2014). We explore the ways in which active learning teaching practices,

with a focus on teaching for inquiry (e.g., Inquiry-Based Learning (IBL) or Inquiry-Oriented Learning (IOL)), can provide a pathway to equity in the classroom without compromising the excellence (Gutiérrez, 2002) or material that is often prescribed in undergraduate mathematics courses. We claim that characteristics of inquiry align with the Four Dimensions of Equity proposed by Gutiérrez (2009). That is, we claim these four dimensions explicate how inquiry pedagogy promotes equity in mathematics courses. This particular framing helps us to identify how the inquiry instruction can promote a more equitable experience for all students within the context of the curriculum that is usually required in undergraduate mathematics courses.

Equity

In general, equity teaching promotes a mindset where all students are capable of learning mathematics (Bullock, 2012; Gutiérrez, 2002; Jett, 2012). Equity research seeks to surface teaching practices that enable these mindsets (Gutiérrez, 2002) among instructors and students alike (Oppland-Cordell & Martin, 2015). It is important that instructors bracket prejudices about student participation and achievement levels based on race, gender, social class, proficiency in the dominant language, or ethnicity (Gutiérrez, 2002). Similarly, judgments based on a student's prior performance, particularly if s/he has performed poorly in the past should not be seen as personal weakness, rather as a consequence of the complex social, economic, and cultural factors (Frankenstein, 1983) that affect individual experiences while learning mathematics.

Gutiérrez (2009) argued that teaching for equity includes four dimensions: *Access*, *Achievement*, *Identity* and *Power*. *Access* and *Identity* are considered precursors to *Achievement* and *Power*, respectively. *Access* addresses the resources that students have available to them to participate in mathematics such as "quality of teachers, adequate technology and supplies, classroom environment that invites participation, infrastructure for learning outside the classroom" (p.5), and the opportunities to draw upon their "cultural and linguistic resources" (p. 5). *Achievement*, on the other hand, is an outcome affected by students' opportunities to learn and can be measured by "participation in class, course taking patterns, standardized test scores, majoring in math, having a math-based career" (p. 5). Adiredja, Alexander and Andrews-Larson (2015) summarized this description by offering that learning outcomes can range from the "knowledge on specific content to students' ability to productively use mathematics to participate in society" (p. 64).

On a different axis, *Identity* attends to the "balance between self and the global society and ways students are racialized, gendered and classed" (Gutiérrez, 2009, p. 5) and to pay "attention to whose perspectives and practices are 'socially valorized'" (p. 5). The goal is to "strike a balance between opportunities to reflect on oneself and others as part of the mathematics learning experience" (p.5). *Power* can mean to empower students towards high academic achievement, but Gutiérrez explained it as students using their math knowledge to reach "personal goals of excellence such as helping their community to solve a local problem" (p. 6). Adiredja et al. (2015) added that learning focused on this dimension attends to "disrupting the existing power distribution and dynamics in a society based on race, gender, and social class" (p. 64). To achieve this, students can be involved in decision-making on "what counts as productive mathematical knowledge" (Adiredja et al., 2015, p. 64), pacing of content (Laursen, Hassi, Kogan, and Hunter, 2011), and starting points for curriculum (Frankenstein, 1983). This type of learning requires a social transformation as measured by whose voice can be heard in the classroom and "opportunities to use math as an analytics tool to critique society" (Gutiérrez, 2009, p. 6).

Gutiérrez (2009) situated these four dimensions more broadly, namely, "in society" or in a "community" (p. 6). In discussion of power, Gutiérrez (2002) positioned the distribution of power in the contexts of the classroom, future schooling, everyday life, and the global society. In this paper, we use the classroom as a stepping-stone to discuss alignment of inquiry pedagogies to dimensions of equity. As such, we utilize these four dimensions of equity as a framework to discuss how active learning pedagogies, and inquiry learning in particular, have the potential to increase access, lead to higher achievement, provide opportunities for students to reflect on their identities, and attune students to power dynamics in their mathematical community: the classroom. We acknowledge that just using inquiry learning alone may not fully address equity, especially if there is not a change to the system outside the classroom or if students do not have opportunities to question power distribution and dynamics in the greater society. The purpose of our theoretical exploration is simply to investigate inquiry learning as an entry point towards a more equitable classroom, in order to move towards a more equitable society.

Active Learning

While this paper reports on teaching through inquiry, we see this pedagogy as a subset of a collection of pedagogies termed *active learning*. Although many different definitions exist, Prince (2004) noted "active learning is generally defined as any instructional method that engages students in the learning process" (p. 223). However, pedagogical techniques used in active learning vary between instructors and may include group work, think-pair-share, student presentations, project-based learning, and many other teaching techniques. Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, and Wenderoth, (2014) reported that active learning techniques have a strong positive impact on student learning as a result of the meta-analysis of 225 studies in STEM education. In addition, Kogan and Laursen's (2014) study indicates that "the benefits of active learning experiences may be lasting and significant for some student groups, with no harm done to others. Importantly, 'covering' less material in inquiry-based sections had no negative effect on students' later performance in the major" (p. 197). There is even strong evidence that active learning promotes student engagement and achievement when coupled with lecture; lecture is defined as "continuous expositions of a speaker" (Bligh, 2000, p. 4) where student activity is "limited to taking notes and/or asking occasional and unprompted questions of the instructor" (Freeman, 2014, p. 5). Prince (2004) found that incorporating several short active learning segments into lecture on a topic in an engineering course improved students' retention of the material and exam scores on that topic.

Overview of Inquiry Learning

Some major goals of inquiry learning are to "deeply engage [students] in rich mathematical tasks, [give students] ample opportunities to collaborate with peers (where collaboration is defined broadly)" (Academy of Inquiry-Based Learning, n.d.), "enable students to learn new mathematics through engagement in genuine argumentation, … empower learners to see themselves as capable of reinventing mathematics, and to see mathematics itself as a human activity" (Rasmussen and Kwon, 2007, p. 190). Despite the numerous studies on inquiry-based or inquiry-oriented learning, there is not a consistent definition of these pedagogies. However, one defining feature of inquiry learning seems to be the modified role of the instructor in the classroom, which Cook et al. (2016) label the *Student-Instructor Relationship*. Thus, in an inquiry course, part of the job of the instructor is to ask about student thinking (Kuster, Johnson, Keene, & Andrews-Larson, submitted). Laursen, Hassi, Kogan, and Weston (2014) found that students in IBL courses often reported being able to express their own ideas while the instructor

listens. Another facet of inquiry is student participation in authentic mathematical experiences, which Cook et al. (2016) refer to as *Doing Mathematics*. Kuster et al. (submitted) argue that "questions that require students to engage in problem solving activity affords the instructor opportunities to inquire into student thinking and reasoning" (p. 8). Thus, doing mathematics contributes to the student-instructor relationship.

Cook et al. (2016) also describe *Student Ownership* as the action of encouraging learners to create, generate, and developing their own knowledge. This knowledge is built from their prior knowledge, which is labeled *Knowledge Building*. Kuster et al. (submitted) also see this as a fundamental part of IOL and they refer to it as "building on student contributions". As part of knowledge creation, students are given opportunities to provide explanations and justifications of their thinking while others listen to and attempt to understand the ideas being discussed or presented, termed *Peer Involvement* by Cook et al. (2016). In Laursen et al. (2014), students in IBL courses reported often participating in activities such as asking questions, evaluating other students' work, and working together in class. Kuster et al. (submitted) also identified students' "being engaged in one another's thinking" as a characteristic of IOL.

According to Cook et al.'s (2016) exploration of existing studies, an outcome of their aforementioned features of inquiry is that inquiry-based or inquiry-oriented learning is better aligned to how people learn. Similarly, in a study that gathered data from over 100 sections of IBL and non-IBL courses taught between 2008 and 2012, Laursen et al. (2014) reported higher "cognitive gains in understanding and thinking, affective gains in confidence, persistence, and positive attitudes about mathematics, collaborative gains in working with others, seeking help and appreciating different perspectives" (p. 409) in students from IBL courses compared to those in non-IBL sections of the same courses. Notably, Laursen et al. (2014) also found that in IBL courses, both men and women's attitudes about mathematics improved as well as their interest in pursuing mathematics, but the women had greater gains in these areas than men. Cook et al. (2016) categorized this as *Student Success*.

In surveying authors of the papers that they reviewed, Cook et al. (2016) identified three foci in participants' definitions of inquiry. The first focus is on the student-instructor relationship and how it is different from a lecture-based course, which is an extension to the aforementioned *Student-Instructor Relationship* theme. Participants stated that the students should not look to the instructor as the sole mathematical authority in the classroom. The second focus is similar to the theme *Peer-Involvement*; that is, the class should include opportunities for peers to interact. The last focus is different from the aforementioned themes as it highlights the importance of valuing and nurturing curiosity in the students. This last focus (valuing and nurturing curiosity) and the first five themes (*Student-Instructor Relationship, Doing Math ,Student Ownership, Knowledge Building*, and *Peer Involvement*) can be classified as Classroom Climate, whereas the last theme (*Student Success*) is related to an outcome of the classroom climate.

The themes that we consider in this paper are not an exclusive list of IBL/IOL teaching practices; they are still under development and undergoing revisions. Hence, our theoretical exploration is only a preliminary start of a framework that aims to explore the alignments between IBL/IOL features with the Four Dimensions of Equity by Gutiérrez (2009).

Alignment of IBL/IOL with the Four Dimensions of Equity

With this proposed framework, we put forth the claim that, as a pedagogical practice, inquiry learning can be used to promote equity by providing students access and chances to explore their identities, with the hopes of both a shift in both power and achievement in the course. Our exploration originated from several reports, particularly Laursen et al.'s (2014) assertion that

"IBL benefits all students even as it levels the playing field for women" (p. 415). Their study documented ways in which IBL can increase achievement and attitudes among students. To explicate how described features of IBL/IOL provide a more equitable experience for students studying mathematics, within the Four Dimensions of Equity we describe some selected related features of IBL/IOL.

Access

Gutiérrez's (2009) definition of equity included a "classroom environment that invites participation" (p. 5) as a tangible resource to access. Civil (2006) reinforced this definition and stated: "equity to me is related to access by **all** students to opportunities to engage in rich mathematics" (p. 56). IBL/IOL pedagogies revolve around a classroom environment that invites and encourages all students' participation in doing, discussing, and presenting mathematics (*Peer Involvement*). When all students are given opportunities to be active participants in the mathematical community of the classroom (*Doing Math*), students are given an additional access point to learn because they are given the chance to provide explanations and justifications of their thinking processes while others listen and attempt to understand the ideas being discussed or presented. We believe that these opportunities give all students the chance to be exposed to other ways of thinking which can result in richer learning experience for them.

Nasir et al., (2011) provided characteristics of classroom practices that support equity: "Powerful classroom practices include those that foster student-centered discourse, student exploration of mathematical ideas, and on-going feedback (Davis, et. al., 2007; Boaler, 2002b; Fullilove & Treisman, 1990" (Nasir et al., 2011, p. 17). Inherent in the on-going feedback is the *Student-Teacher Relationship*: the instructor's responsibility of inquiring into student thinking and "fostering and facilitating productive student discourse" (Nasir et al., 2011, p. 17).

Achievement

Gutiérrez (2009) refers to Achievement as a measure of "how well students can play the game called mathematics" (pg. 6). In other words, this dimension relates not only to student performance on exams and standardized tests, but also considers a student's mathematical "story." This can refer to measures such as whether students continue taking mathematics courses or whether they choose a mathematical career.

When all students are encouraged to create, generate, and develop their own knowledge (*Student Ownership*), confidence in doing mathematics and participation in class may be positively affected. Laursen et al. (2014) demonstrated that participation in IBL courses does increase student performance as well as other measures related to this definition of achievement. Learning gains were found in IBL sections over non-IBL sections of the same course; not only improvements in course performance, but gains in confidence, persistence, and enjoyment of mathematics (*Student Success)*. Some of these outcomes may lead to Gutiérrez's (2009) measures of Achievement, namely "course taking patterns, majoring in math, and having a math-based career" (p. 5). Kogan and Laursen (2014) also reported that all students in IBL courses were positively impacted to enroll in more mathematics courses.

Identity

We claim that the *Peer Involvement* theme of IBL/IOL aligns with Gutiérrez's (2009) definition of Identity. When students are actively engaged with each other and each other's thinking (*Peer-Involvement*), it can lead to a shift in mathematical identity. Hassi's (2015) qualitative study of students reflecting on their IBL learning experiences supports our claim. In that study, students

talked about "the role of the social environment in an IBL class for gaining or verifying their self-esteem or self-confidence" (p. 60). In addition, Oppland-Cordell & Martin (2015) write that "the ways in which individuals continuously construct identities of participation and non-participation over time in [Communities of Practice] is related to how they position themselves, how others position them, and how such positionings are related to their histories and experiences in the broader contexts in which [Communities of Practice] are embedded" (p. 24). At the secondary level, Boaler and Greeno (2000) contrasted students who learned by working through rote problems in a textbook with students who learned through mathematical discussions (*Peer Involvement*). They found that in discussion-based classes, students were required to contribute more aspects of their selves (as compared to non-discussion-based), which can be done through reflecting on community participation and family relationships.

Power

Gutiérrez (2009) thinks of student voice as a fundamental part of the power dimension; inquiry is changing whose voice is primarily present in the classroom. Instructors are responsible for facilitating student discussion and presentation of the problems (Yoshinobu and Jones, 2012; Cirrillo, 2013). When given opportunities to provide explanations and justifications of their thinking while others listen to and attempt to understand the ideas being discussed or presented (*Peer Involvement*), power shifts to the students because they decide on "what counts as acceptable knowledge" (Adiredja et al., 2015, p. 66).

The instructor is the primary architect of the problems worked on (Laursen et al., 2011), and when the tasks assigned include problem-posing, students create and solve their own problems (*Doing Math*). In this scenario, students have power in deciding the curriculum.

The instructor's main role is not as a problem-solver, but as an expert participant (Levenson, 2013) that guides students to generate, create, and develop their own knowledge (*Student Ownership*). In this way, the instructor signals that the students' thoughts, beliefs and contributions are a valued part of the learning process and removes her/himself as the sole source of knowledge in the classroom. If we agree that *Doing Math, Peer Involvement*, and *Student Ownership* are components of inquiry teaching, then this represents a substantial shift of the power dynamic from instructor to students.

Future Steps

"Equitable classrooms are reflections of a pedagogical, political, and moral vision."
(Lotan, 2006, p. 526)

We acknowledge that changing the curriculum to include ways for students to use mathematics to critically analyze the society in which they are gendered, raced, and classed extends past our theoretical framework to provide a richer equitable experience. However, for instructors who are not ready to (fully) change the curriculum of their class, we claim that by merely engaging in practices of IBL/IOL, we can start to move towards teaching for equity and thinking equitably. That is, engaging in practices of IBL/IOL is a good entry point for people who are ready to begin embracing equitable practices.

We also see room to frame IBL/IOL in terms of culturally responsive pedagogy. Hernandez (2013) reviewed literature by seminal culturally responsive pedagogy researchers (Banks, Gay, Ladson-Billings, Nieto, Villegas and Lucas) and found five main themes within the research. To demonstrate how the inquiry themes posited by Cook et al. (2016) or the dimensions of equity

theorized by Gutiérrez (2009) may align with the five themes of culturally responsive pedagogy, we have added the inquiry themes in brackets to the definitions below:

- Content Integration: inclusion of content from many cultures, the fostering of positive teacher-student relationships, holding high expectations for all students, and the use of research-based instructional strategies [*Student Success*] that reflect the needs of a diversity of backgrounds and learning styles [*Knowledge Building*]
- Facilitation of Knowledge Construction: the teacher's ability to build on what the students know [*Knowledge Building*] as they assist them in learning to be critical, independent thinkers who are open to other ways of knowing
- Prejudice Reduction: teacher's ability to use a contextual factors approach [*Student-Teacher Relationship*] to build a positive, safe classroom environment [*Access*] in which all students are free to learn regardless of their race/ethnicity, social class, or language
- Social Justice: teacher's willingness ''to act as agents of change'' (Villegas), while encouraging their students to question and/or challenge the status quo in order to aid them in ''the development of sociopolitical or critical consciousness'' (Ladson-Billings) [*Power*]
- Academic: teacher's ability to ''create opportunities in the classroom'' (Villegas) [*Access*] that aid all students in developing as learners to achieve academic success [*Student Success, Achievement*] (p. 811-814) [emphasis added].

In preliminary efforts to give empirical evidence of our framework, we found some data that did not fit into the themes presented by Cook et al. (2016) describing IBL/IOL. For example, "limited involvement by instructor" or "instructor acts as facilitator/mediator" didn't seem to fit in the *Student-Instructor Relationship* category, which puts the instructor as an inquirer into student thinking or not as the sole authority. Additionally, the theme of *Doing Mathematics* seemed to intersect with the other themes so often that we may need to create a hierarchy of themes. Thus, we plan to continue refining the themes of inquiry, and the subsequent connections to equity, from student data we have collected and as other research emerges.

The theoretical framework we put forth in aligning inquiry pedagogies to equity teaching is merely a start to providing equitable experiences for all our students regardless of race, gender, ethnicity, social class, sexual orientation, or language. To deepen equity in the field of mathematics, educators can integrate content that uses mathematics to critically analyze the ways in which students are gendered, classed and raced. For example, to address the contentious "All Lives Matter" movement, students in a proofs or logic class can analyze the statement, "If you are black, then your life matters" to help people understand that saying "Black Lives Matter" does not mean that other lives do not matter. In the future, we aim to deepen our alignments of inquiry teaching and learning with equity through interviewing students who have experienced inquiry pedagogies. We also hope to explore pedagogical techniques to better integrate content that allows students to use mathematics to critically analyze social justice issues. Both future goals are considered with the intent to extend our theoretical framework beyond the classroom and towards the global society.

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