2020

Equitable Mathematics Classroom Discourse

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Recommended Citation

Bondurant, Liza (2020) "Equitable Mathematics Classroom Discourse," *Journal of Practitioner Research*: Vol. 5 : Iss. 2 , Article 1.
<https://doi.org/10.5038/2379-9951.5.2.1146>

Available at: <https://digitalcommons.usf.edu/jpr/vol5/iss2/1>

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Abstract: *In this article the author shares a self-study investigation into how the quality of talk and opportunities to participate are distributed across individual students based on race and gender in my college math class. Readers will learn how to conduct a similar investigation in their classroom. A discussion of ways to use the information gathered from equitable mathematics classroom discourse investigations will follow.*

Background

In the United States researchers have found that women and non-Asian minority students persistently face inequitable access to educational opportunities, such as insufficiently funded schools, poor teacher quality, inadequate curriculum, and large class sizes (Darling-Hammond, 2010; Oakes, 2005). Not surprisingly, these inequities lead to low academic achievement in mathematics and underrepresentation in math-related professional fields. There exists a desperate need to create equitable educational opportunities for each and every mathematics student. Gutiérrez (2002) argues that equity is achieved, in part, when we are unable to predict students' participation and achievement in mathematics solely on demographic characteristics or proficiency in English.

The National Council of Teachers of Mathematics (NCTM) and the Association of Mathematics Teacher Educators (AMTE) are the leading professional organizations for mathematics teachers and mathematics teacher educators. As the leading professional organizations, NCTM and AMTE have a strong influence on math education policy and practice. The NCTM strategic framework states "NCTM advances a culture of equity where each and every person has access to high-quality teaching empowered by the opportunities mathematics affords" and the AMTE goals include "Equitable practices in mathematics teacher education, including increasing the diversity of mathematics teachers and teacher educators" (2019). Clearly equitable mathematics instruction is a high priority for mathematics educators.

The author conducted a self-study into how the quality of talk and opportunities to participate are distributed across individual students based on race and gender in my math class. For at least five years prior, I have been asking myself whether I was consistently using the equitable teaching practices that I trained my pre-service teachers (PSTs) to use. The EQUIP rubric and self-study methodology seemed like a perfect way to get to the heart of this lingering

dilemma. After sharing my self-study with colleagues, I discovered that many other mathematics educators and mathematics teacher educators are also interested in self-investigating the same topics. The purpose of this self-study is to help mathematics teachers and mathematics teacher educators learn how to collect and analyze data about their own discourse patterns using the EQUIP rubric in order to discover more about their own instructional practices.

There are two main assumptions for this study. The first assumption is that all students should participate in classroom discourse. Participating in classroom discourse facilitates learning. Engaging in mathematics during class will improve student academic performance. Additionally, participating in classroom discourse benefits student identity development. If only White or Asian, Males, who are native English speakers participate in discourse in math class, everyone else in class begins to associate students with these social markers as “smart” and/or good at math. By default, students of other races, genders, or language statuses who are not participating, begin to think of themselves as not “smart” or good at math. The second assumption is that all human beings have implicit bias. We tend to interact most with people who are like us, people who look and talk like us. This is usually not intentional. However, it may have an influence on classroom discourse patterns.

Methodology

The characteristics of self-study methodology include openness, collaboration, reframing, paradoxical nature, postmodernism, and multiple and multifaceted perspectives (Lassonde, C., Galman, S., & Kosnik, C., 2009). Throughout the study the author’s disposition was open to ideas from others. Collaboration played a critical role. Through dialogue and collaboration, I was able to frame and reframe problems and situations from different perspectives. Additionally, there were opportunities to change how I looked at what was going on in my classroom and ultimately change my practices. The study was paradoxical in nature, because it was about the individual, yet it involved collaboration (“critical friends”). Moreover, the study employed the postmodern assumptions that it is never possible to divorce ‘self’ from the research process or education practice and that I do not claim to know the answers, but rather I seek a deeper understanding into my practice. The study was multiple and multifaceted, because in preparing for this study I conducted a literature review of math equity studies that informed my self-study. The studies that I reviewed had various theoretical orientations and used multiple and diverse qualitative methods (Lassonde, C., Galman, S., & Kosnik, C., 2009).

The question that this self-study aims to answer is: How are the quality of talk and opportunities to participate distributed across individual students based on race and gender?

This study has two main goals. I aim to provide equitable opportunities for students to participate. Additionally, I hope to share my findings with other math teachers and mathematics teacher educators.

A growing body of research has investigated equitable discourse in math classrooms. Equitable mathematics discourse investigations predominantly use qualitative methods, such as analysis of interviews, observations, and focus groups (Esmonde & Langer-Osuna, 2013; Herbel-Eisenmann, Choppin, Wagner, & Pimm, 2011; Moschkovich, 2011). Reinholz & Shah (2018) developed a classroom observation tool that focuses on dimensions of classroom discourse, which are cross-tabulated with demographic markers (e.g., gender, race) to identify patterns of more and less equitable participation within and across lessons. This observation tool, the EQUIP (Equity QUantified In Participation) rubric, provides investigators with equity analytics that they can combine with qualitative approaches. Together this data can paint a fuller picture of the degree of equitable discourse that is occurring in the given mathematics classroom.

Herbel-Eisenmann & Shah (2019) investigated implicit biases in teacher questioning using the EQUIP rubric for quantitative data as well as traditional qualitative methods. Implicit biases are the unconscious attitudes and stereotypes that impact our actions in an unconscious manner (Staats, Capatosto, Tenney, & Mamo, 2017). Research shows that all people have biases. The study focused on helping educators acknowledge their biases and learn to address them. In their study, the teacher-researchers learned who needed to participate more and they were able to incorporate new practices to include students in discussions in high-quality ways to mitigate biases (Herbel-Eisenmann & Shah, 2019).

Context and Participants

The author gathered data for my study during the Spring 2019 semester in my Quantitative Reasoning class. The class is taught at a regional public university in the southeastern United States. Quantitative Reasoning is an alternative to College Algebra that my institution offers. It fulfills the General Education mathematics requirement and is commonly taken by liberal arts majors (whereas STEM majors typically take College Algebra). The author chose to conduct the study in this class because it was my most diverse class and because the students in this class have the most difficulty with mathematics.

There are ten students in the class. In this class 40% of the students are Male and 60% are Female. Additionally, 30% of the students are Black and 70% are White. The class met twice a week for 75 minutes. The author video recorded four classes throughout the semester (300 minutes of total observation time) and later used the EQUIP rubric to code the observations. To ensure that my coding was valid and reliable, the author consulted with a critical friend, Dr. Shah, who graciously provided me with feedback throughout my self-study. As the co-developer of the rubric, Dr. Shah has extensive experience using the EQUIP rubric. As a critical friend, Dr. Shah acted as a sounding board, asking challenging questions and supporting me in my professional growth (i.e. making changes in my teaching practices, discussing possible interpretations of the results, discussing how I define equity).

Analysis

Daniel Reinholz and Niral Shah created the EQUIP rubric as a research tool for understanding patterns of participation in mathematics classrooms (Reinholz & Shah, 2018). The EQUIP rubric has been developed into a free, fully customizable web app (<https://www.equip.ninja>). The tools on this site have many applications for teachers, teacher educators, and researchers.

The EQUIP instrument includes seven discourse dimensions (see Table 1), each supported by prior equity research (Reinholz & Shah, 2018). At the classroom level, my goal was to avoid Initiation-Response-Evaluation (IRE) discourse patterns with all students. To investigate this, I focused on the following discourse dimensions: Teacher Solicitation Type, Wait Time, and Student Talk Length.

Table 1
Dimensions of EQUIP

<u>Dimension</u>	<u>Levels</u>
Discourse Type	Content Logistics
Student Talk Length	21 or more words 5-20 words 1-4 words
Student Talk Type	Why How What Other
Teacher Solicitation Method	Random selection Called on Not called on
Wait Time	More than 3 sec Less than 3 sec N/A
Teacher Solicitation Type	Why How What Other N/A
Explicit Evaluation	Yes No

The levels of the Teacher Solicitation Type dimension are: Why, How, What, Other, and N/A. According to *Principles to Action*, “Effective teaching of mathematics uses purposeful questions to assess and advance students’ reasoning and sense making about important mathematical ideas and relationships” (NCTM

2014, p. 10). Why and How questions are more open-ended than What questions. Why and How questions provide teachers with more quality information to assess and advance students' thinking. My goal was to ask more Why and How questions and less What questions. When coding this dimension, I focused on the first word of my questions to determine the level. For example, "What is the probability of..." "How do we find the probability of..." "Why did you add the probabilities of..." or "When do you add and when do you multiply probabilities?"

The levels of the Wait Time dimension are: more than 3 seconds, less than 3 seconds, and n/a. *Principles to Action* points out effective teachers allow, "Sufficient wait time so that more students can formulate and offer responses" (NCTM 2014, p. 41). A common societal misconception is that to be good at mathematics you need to perform your calculations quickly. Dunleavy (2018) found that consistently affording time and space to value multiple solution strategies enhanced students' mathematical achievement. My goal was to wait more than 3 seconds for students to respond to my questions. When coding this dimension, I watched the recording time stamp to see whether or not I waited at least three seconds.

The levels of the Student Talk Length dimension are: 1-4 words, 5-20 words, and 21 or more words. *Principles to Action* notes, when teachers pose purposeful questions, students "explain, clarify, and elaborate on their thinking" (NCTM 2014, p. 41). My goal was to have student's responses consist of at least 5 words (fall into one of the following ranges: 5-20 words or 21 or more words). When coding this dimension, I transcribed students' responses and counted the number of words to determine the level. For example, "Wouldn't you just multiply eighty by point seven three" would be coded as 5-20 words, but "Use a proportion" would be coded as 1-4 words. I did not code (count) off-topic student talk.

The EQUIP analytics take three forms: (1) a classroom-level summary of student participation, (2) an individual-level comparison of how much each student participated, and (3) group-level comparisons (e.g., by race, gender).

At the group-level, EQUIP analytics provide the equity ratio, the ratio of actual participation to expected participation. Actual participation is the actual number of times a discourse dimension occurs (e.g., the actual number of high-level questions asked by a teacher). Expected participation is the number of times we would expect a group of students to participate based on that group's demographic representation in a particular classroom. Equity ratios can be greater

than one, less than one, or equal to one. Overall, equity ratios help account for the raw numbers of students from different demographic groups in a given classroom.

To illustrate how equity ratios are calculated and what they mean, in my classroom 30% of students are Black. First, suppose that of all of the high-level questions that were asked, 60% of those questions were asked to Black students in the class. The equity ratio would be 60 divided by 30, or 2. An equity ratio of 2 indicates that Black students in the class received a disproportionately higher share of high-level questions. Secondly, let's assume that of all of the high-level questions that were asked, 15% of those questions were asked of Black students in the class. The equity ratio would be 15 divided by 30, or 0.5. An equity ratio of 0.5 indicates that Black students in the class received a disproportionately lower share of high-level questions. Finally, suppose of all of the high-level questions that were asked, 30% of those questions were asked of Black students in the class. The equity ratio would be 30 divided by 30, or 1. An equity ratio of 1 indicates that Black students in the class received a proportional share of high-level questions. For more on the equity ratio, see <https://www.equip.ninja/faq>

EQUIP does not evaluate educators. Rather it provides a starting place for deeper conversations about race, gender, and other social markers and how they play out in the classroom. Also, the analytics don't prescribe how an educator should teach. There is no "target distribution" for EQUIP analytics. EQUIP does not establish a particular goal, such as equal participation for all students. It is up to the educator to make sense of the data and what they will do with them, based on how they conceptualize "equity."

At the individual level, I looked for extremities in participation, both at the high end and students with zero participation. I asked myself: Why did these 1-2 students dominate? Why did these students have zero participation? How were those patterns allowed to emerge?

At the social marker level, I checked equity ratios for minority social markers (Females and students of color). I checked to see if any equity ratios were grossly under 1. Examining equity ratios also led me to reflect on my definition of equity, how my definition of equity overlaps with the concept of equality, and what my goal equity ratio was (equal to 1 or above 1).

Results

Classroom Level Results

My findings at the classroom level were somewhat surprising and led me to set new instructional goals. I was pleased to find that my equity ratio for how (1.3) and why (1.7) questions for Black students were above 1. However, I also noticed that my equity ratio for what (1.1) questions for White students was above 1 and below 1 for how (0.8) and why (0.7) questions. The equity ratio for wait time more than 3 seconds (1.4) was significantly above 1 for Black students, but below 1 for White students (0.8). The equity ratio for Black students talking 5-20 words (1.3) or 21 or more words (1.5) were both above 1. However, the equity ratio for White students talking 5-20 words (0.9) or 21 or more words (0.8) were both below 1.

Individual Level Results

My findings at the individual level also led me to reevaluate my initial goals. The total student contributions were 133. As seen in Table 2, (from least to greatest) the number of contributions of the ten students were 3 (White, Male), 5 (White, Female), 5 (Black, Female), 10 (White, Male), 11 (White, Male), 15 (White, Male), 17 (Black, Female), 21 (White, Female), 23 (White, Female), and 23 (Black, Female). With one Black student in the top, middle, and bottom of the total contribution rankings, the results do not indicate a significant racial bias. If anything, the Black students dominated the top three quarters of the range of total contributions. A gender bias was observed, with Females dominating the upper half of the participation range. This is evidence of my implicit bias and I need to work on calling on males more frequently. I do not like to see any students with less than 10 contributions across four 75-minute classes. Therefore, I feel that I also need to make more of an effort to get all students to participate.

Table 2
Student Contributions by Race and Gender

Student	Contributions				Total	Final Exam Grade
	1st	2nd	3rd	4th		
Black, Female	7	10	2	4	23	55
White, Female	6	11	0	6	23	81
White, Female	10	7	4	0	21	88
Black, Female	3	9	2	3	17	83
White, Male	6	3	3	3	15	98
White, Male	0	0	2	9	11	80
White, Male	3	5	2	0	10	75
Black, Female	2	0	1	2	5	83
White, Female	0	0	2	3	5	70
White, Male	0	1	2	0	3	78

Figure 1

EQUIP Analyses of Teacher Solicitation, Wait Time, and Student Talk Length by Race and Gender

Comparison to Course Grades

The results led me to investigate whether my favorable treatment towards Black and Female students impacted other outcome measures. To investigate whether there was a connection between discourse patterns and student performance I analyzed students' final exam grades. I chose this outcome measure as opposed to a qualitative measure, because it is objective and not influenced by any potential implicit biases I may have. As seen in Table 2, White, Male students did very well on the final exam despite the equity ratios below 1. Additionally, White, Female students also did well on the final exam despite equity ratios below 1. Moreover, despite equity ratios above 1, Black, Female students did not outperform their peers, but still did well on the final exam.

Discussion

Although I consider the approach presented in this article promising, I also acknowledge that limitations exist with the current study. For one, the sample size ($n = 10$) was small. I hope to replicate this study in future semesters with larger classes. Additionally, I did not control for a variety of factors, such as personality, prior math achievement, math attitude, or social connections within the class that may have had an impact on student participation. Moreover, as Reinholz & Shah point out: "a classroom observation tool cannot gather data on students' subjective experiences of equity. Although the equity analytics generated by an observation tool might indicate equality in terms of students' opportunities to learn, the students themselves might not perceive the classroom to be an equitable space" (p. 148). Despite these limitations I argue that equity analytics can provide practitioners with information that they can use to reflect on their practices and begin the journey of making their teaching more equitable.

This study led me to reflect on my definition of equity. Before conducting this study, I defined equity as everyone participating equally. This definition would result in equity ratios of 1 across all seven discourse dimensions and all demographics. My findings indicated that equity ratios were more favorable for Blacks and Females. Initially, I thought this may represent a problem in my teaching that needed to be remedied. However, after conferencing with my critical friend, Dr. Shah and reviewing the literature on equity versus equality, I began to think that favorable treatment may be necessary to remedy the years of inequity that these groups commonly face. As Reinholz & Shah describe it: "For students from marginalized groups, it may be insufficient to receive the same resources as classmates from dominant groups. This is because all students do not enter a classroom with the same backgrounds. To account for this history of

marginalization, ensuring fairness in opportunities to learn for students from marginalized groups might actually require allocating them more resources and different resources than students from dominant groups” (p. 146).

I compared the number of times students participated to their final exam grades to see if students who participated more outperformed their peers who participated less. I found that White students (Males and Females) did very well on the final exam despite having equity ratios below 1. Additionally, despite equity ratios above 1, Black, Female students did not outperform their peers. I cannot definitively say whether these findings indicate that Blacks and Females require additional participation opportunities to level academic playing field. The findings could be attributed to a testing bias. Another possibility is that a direct correlation does not exist between participation and exam grades. I hope to explore these unanswered questions further in my future research.

A goal of this paper is to inspire the reader to embark on a similar inquiry into the participation patterns in their classroom. The reader can choose whether they would prefer to conduct a self-study alone and then consult with a critical friend or if they would prefer to work with a professional learning community (PLC).

If the reader is interested in using the EQUIP rubric in a PLC, the author recommends reading the blog written by Daniel L. Reinholz, Robin Wilson, and Amelia Stone-Johnstone on the American Mathematical Society Blog (Reinholz, Wilson, Stone-Johnstone, 2019). In the blog the authors share that their professional learning community (PLC) began with each participant sharing their goals for the semester individually with the developer team. Next, they held a series of four meetings during the semester that focused on EQUIP analytics and change over time. Each educator set a goal for their teaching, recorded their teaching, and coded it with EQUIP. They agreed that they would discuss the results in a safe, group-based setting. During their discussions the educators in the PLC created action plans for making changes in their teaching, which they hoped to observe in the next round of analytics. In this way, EQUIP made it easier for educators to see improvements to their teaching over time. The blog provides reflections by each member of the PLC. The members of the PLC all shared that the experience was beneficial and rewarding.

The author hopes to inspire the reader to use EQUIP to analyze participation patterns in their classroom. The EQUIP rubric provides educators with data that they can use to understand when biases are impacting their teaching. The conscious awareness of their implicit biases enables educators to

correct the issue(s). EQUIP allows educators to reflect on who is participating and how, and how this participation could relate to larger systemic factors and our own implicit biases. I have become much more aware of my own biases and how they could impact my teaching. This awareness has pushed me to teach more equitably in every single class I teach.

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