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Equitable discourse in middle school mathematics classrooms: With emphasis on girls and the mathematically gifted

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EQUITABLE DISCOURSE IN MIDDLE SCHOOL MATHEMATICS CLASSROOMS:

WITH EMPHASIS ON GIRLS AND THE MATHEMATICALLY GIFTED

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Abstract

Discourse is a tool used by mathematics teachers to help deepen mathematical understanding and build students' mathematical identities. Teachers face the challenge of establishing and maintaining classroom norms that help discussions deepen mathematical understanding as well as meet the needs of all of their students. The researcher focused on what girls and the mathematically gifted need from discourse and how to create an equitable environment for all students. Girls need to be given equitable opportunities to voice their thoughts, and mathematically gifted students need to be adequately challenged, not just given more work. The researcher interviewed three teachers who employ discourse in their classrooms to understand how they implement equity in discourse and their thoughts on its effectiveness for building mathematical identity. Teachers utilized similar classroom norm establishment methods and agreed that students need constant reminders of these norms in order to maintain them. How the teachers defined equity in discourse directly influenced how they viewed its usefulness in building mathematical identity.

Keywords: equity, discourse, mathematics, middle school, girls, women, mathematically gifted, gifted students, TAG, classroom norms

Introduction

Mathematical discourse in its simplest form is talking about mathematics. Secondary teachers across the country are being encouraged to get their students talking about mathematics by organizations such as the National Council of Teachers of Mathematics (NCTM). Small group work, whole class discussions, mathematical journals, and individual presentations are some tools teachers use to create mathematical talk in their classrooms. However, I will focus on small group work and whole class discussion in this study.

While on the surface, mathematical discourse seems simple to implement, teachers must tread carefully. Mathematical discourse differs from discourse in English classes for example. In an English classroom, questions rarely have objectively right and wrong answers. The subjective nature of literature provides ample room for students to have differing viewpoints and opinions. Teachers are able to reassure their students that "There are no wrong answers. Share your opinions." Mathematics, however, is for the most part an objective discipline, and teachers do not have the luxury of allowing their students to carry around misconceptions.

Teachers must carefully walk the line between preserving mathematical correctness and preserving their students' mathematical identity. Mathematical identity contains three components: how students feel about their place in the mathematics community, their confidence in their ability to do mathematics, and their beliefs about the worthwhileness of mathematics. Simply telling a student that they are wrong in front of their peers risks making students feel as though they are not valued in the mathematical community and that they incapable of doing mathematics. To compound matters, American culture views mathematics with anxiety and trepidation. Mathematics is seen as hard or scary, and this cultural tone influences students' attitudes about the worthwhileness of mathematics.

The idea of equity adds further complexity to the job of teaching mathematics. Equity is fairness, not equality. Equality in the classroom means that every student gets identical resources and instruction regardless of their needs. However, equity in the classroom means that every student gets what they need in order to reach their full mathematical potential, while not neglecting the needs of others. Equity means that struggling students get extra help, mathematically gifted students get cognitively challenged, and students with other exceptionalities receive modifications and accommodations according to their needs.

Teachers face the challenge every school year of establishing classroom norms (the rules, climate, and culture of a classroom) that help foster discourse that is mathematically sound, equitable, and nonthreatening for their students. Once a teacher has established these norms, they must maintain them. Little to no research has been done on how recommended strategies for establishment and maintenance of classroom norms actually work in real world classrooms.

While there are certainly many groups that deserve specific attention when discussing equity, I have chosen to focus on girls[1] and mathematically gifted[2] students in middle school, because they are vulnerable at this time. Underachievement[3] in girls and mathematically gifted students starts in middle school (Ritchotte, Rubenstein, & Murry, 2015). This underachievement that carries into high school can impact how many math courses a student takes in high school. Research shows that the number of mathematics classes taken in high school predicts earning

[1] The term "girls" refers to biological females. Transgendered students will not be taken into account, because their gender dysphoria creates new variables that are outside of the scope of this study.
[2] "Mathematically gifted" is a carefully crafted term that is meant to represent the student that "gets it" faster than their counterparts, receives top grades on tests without having to study much, and is bored by concepts that their peers struggle with. This definition does not include Talent and Gifted (TAG) students as they may be identified as TAG based on other non-math related qualities. Nor does it include high achieving students, who through hard work and practice earn top grades. Honors students may or may not be classified as mathematically gifted, but these terms are not synonymous.
[3] Underachievement is defined as not reaching one's potential. It is not synonymous with poor performance. The underachieving student has previously demonstrated that they are capable of more than their current performance.

potential, with upper level classes predicting up to a 19.5% increase in earnings (Rose & Betts, 2004).

Underachievement in mathematically gifted students by definition means that they are not reaching their full potential. They either opt out of math classes in high school and their earning potential suffers, or they take the courses but do not reach their potential and do not move onto STEM careers. When mathematically gifted students underachieve, society misses out on the contributions they could have made to mathematics and the student loses out on potential earnings.

In 1994, Sadker and Sadker in their book *Failing at Fairness* revealed that girls were not being treated equitably in schools. This inequitable treatment extended to discourse. As a result of their research, more research was done in the 1990s. Now the focus in research and discussion is on getting more women into STEM (Science, Technology, Engineering, Mathematics) careers.

Discourse is communication. In general, females value communication more than males (Merchant, 2012). Acknowledging this value does not mean that I am stereotyping women as "talkers" and men as "doers." Both men and women talk; both men and women do. I am simply recognizing that a discourse heavy environment would, in general, be preferred by girls than an instruction heavy or worksheet heavy environment, because of the value they place on communication. If we want to make mathematics appealing to girls, we need to give our highly communicative students ample chances to communicate in mathematics. Even if a girl does not pursue a STEM career, making mathematics more appealing to her is still a worthwhile task, because of the potential boost to her earnings that additional high school mathematics courses would provide.

In this study, I continue the discussion of equitable discourse for girls and for the mathematically gifted. In addition, I examine the relationship between mathematical identity and equitable discourse. Finally, I investigate how establishment and maintenance of classroom norms works in real world classrooms.

Literature Review

The Push for Discourse

Perhaps the most compelling reason teachers should invest time in facilitating discourse is that it promotes mathematical learning. The National Council of Teachers of Mathematics (NCTM) in *Principles and Standards for School Mathematics* states that teachers should enable their students to organize their thinking through communication, to communicate their thinking clearly to teachers and peers, and to analyze and critique the thinking of others. The Common Core Standards Guidelines of Mathematical Practice state that students should construct viable arguments and critique the arguments of others. These two institutions clearly call for math teachers to implement discourse in their classrooms, because it is seen as an integral part of learning mathematics.

But discourse is important not only as a tool to learn mathematics, but also as a tool to help students hone their employability skills. Within Employability section of the 21st Century Skills Standards of the Iowa Core, students are required to "[c]ommunicate and work productively with others." In large group discussions, students gain practice communicating productively, and in small group work, students gain experience working productively. So by investing in discourse, teachers help their students learn mathematics and become more employable.

Techniques and Strategies for Effective Discourse

Discourse can be a daunting practice to implement well, but one key part of facilitating is simple and can be done by any teacher. This key part is a concept called “wait time.” Wait time is the time from when a question is asked by the teacher to the time the teacher either calls on a student or gives up on the question and moves on. Since teachers already know the answer to the question they are asking, most do not realize how much time their students need to think about the question and its answer. Simply increasing one’s wait time to five-nine seconds can dramatically change the amount of participation in a discussion. Teachers should not be afraid to tell their students to put their hands down and allow other students a chance to think (Frykholm & Pittman, 2001).

While whole class discussions are a large part of discourse, cooperative learning (students working together to solve problems or learn new concepts, also known as small group work) is also important. In order for cooperative learning to be successful, four things must be present at same level in the lesson. First, the teacher has to provide instruction to introduce new material (Nelson & Others, 1993). This instruction can be as simple as asking students to think about what they have been learning throughout the week and then providing directions for the activity. Or it can be as involved as the teacher teaching a short lesson about the subject matter of the problem or concept.

The remaining three pieces are not chronical in nature, meaning they can come in any order. In the small group itself, team practice, team recognition, and group rewards and cooperative peer relations must be present (Nelson & Others, 1993). Team practice allows all students to learn from each other (Nelson & Others, 1993). Team recognition gives all students an opportunity to feel successful and competent, which helps to motivate low ability students (Nelson & Others, 1993). Group rewards (giving out rewards based on the effort of the group

instead of the individual) and cooperative peer relations give students experience working interdependently and help students build mutual friendships (Nelson & Others, 1993).

Before discussing the practical ways classroom norms can be established, it is important to discuss the idea of "mathematical authority" or who is able to discover and do mathematics on their own. In order for students to build their mathematical identities through discourse, students must be able to see themselves as mathematical authorities. However, teachers tend to view themselves as the sole mathematical authority in their classrooms. Teachers must let go of their need to be "in charge" of the mathematics before any other classroom norms can be truly effective in promoting effective discourse (Frykholm & Pittman, 2001).

Middle school students are, in general, very good at talking. So the reason discourse is unproductive, is not because students do not want to talk about what they are thinking, but rather that they do not know how to talk about their thinking (Sherin, Louis, & Mendez, 2000). In order to create productive discourse, teachers must help their students become comfortable talking with each other and must show by example what a productive and equitable discussion of mathematics looks like.

Having students complete one on one interviews with their peers is a highly effective way to build a classroom culture of positive discourse (Rawding & Wills, 2012). These interviews start by asking students to talk about themselves, their interests, their hobbies, etc. (Rawding & Wills, 2012). Students typically do not feel anxiety about sharing about themselves. These interviews help students build relationships, so as the interviews shift to mathematical topics (a more anxiety inducing topic) students are already in a comfortable environment and can offer up their thoughts more freely (Rawding & Wills, 2012).

After students are comfortable in talking with their peers in the classroom, teachers can stage “mock discussions” in which the teacher and another adult have a mathematically driven conversation(Rawding & Wills, 2012). During these discussions, students are encouraged to look for certain aspects of the discussion, such as the amount of time each person speaks, how they let the other person know that they do not agree with them, etc. This gives students an example to follow when they are involved in discourse and makes them more likely to exercise equity (Rawding & Wills, 2012).

Mathematical Identity and Discourse

Mathematical identity and discourse go hand and hand. A classroom where some students dominate the conversations demonstrates to the students who are not allowed into the conversation that their contributions are not important and therefore harms their mathematical identity (Hung, 2015). But if students are allowed into the conversation, they learn that their thoughts about mathematics matter (Rawding & Wills, 2012), and thus, their mathematical identities benefit.

The Silenced Girl

In classrooms all across America, girls are experiencing the frustration of having something to say, but not being able to say it. In elementary and middle schools, girls raise their hands only to watch one male peer after another get called on before them (Sadker & Sadker, 1994). Many female students quickly grow to feel that their contributions are not valued as highly by their teachers or that the effort necessary to make a contribution is not worth it (Sadker & Sadker, 1994).

When boys become inpatient and blurt out answers, teachers, according to Sadker & Sadker, will still recognize their contribution and even praise them for making the contribution

(1994). Thus, teachers are reinforcing (making a student more likely to repeat the behavior in the future) the behavior of not waiting one's turn and dominating the conversation. When girls blurt out answers, they may receive some praise for their contribution, but they are also likely to receive an admonishment for breaking the rules (Sadker & Sadker, 1994). Thus, teachers are punishing (making a student less likely to engage in a behavior in the future) the behavior of making mathematical contributions and being a part of the conversation in their female students.

Students of both genders are told very little of significant contributions that women have made to mathematics (Sadker & Sadker, 1994). Newton, Pythagoras, Archimedes, Euclid, and La Grange are a few male names that come immediately to mind as having made significant contributions to mathematics. We challenge the reader to think of five women who have made significant contributions to mathematics. If our girls do not see women who have contributed in significant ways to mathematics, how are they to know that they too can be part of the discovery and wonder of mathematics in meaningful ways?

While Sadker and Sadker's research was done in the 1990s, it is clear that the problem has not been entirely resolved. If girls are still becoming apathetic about STEM and are underachieving in middle school (Ritchotte, Rubenstein, & Murry, 2015), then there is still a disconnect between a girl's potential in STEM and her beliefs about her place in it.

The Forgotten Mathematically Gifted

There is a widely held belief that gifted students prefer to work by themselves or that gifted students are less successful in cooperative learning environments (Joyce, 1991). However, research suggests that it is not as simple as that. Depending on how the questions are asked, gifted students may respond that they actually want to work in groups (French, Walker, & Shore, 2011). And according to the same study conducted by French, Walker, and Shore, students who

reported the strongest preference to work with others were those who felt that their peers and teachers valued their work (2011). However, even if students wish to work alone, teachers do them a disservice if they allow them to work by themselves. Just because a student is mathematically gifted, does not mean that they do not need to work on employability skills.

Another misconception about gifted students and cooperative learning is that if it works for gifted students it only works in heterogeneous groupings (putting students of significantly different ability level together). But this is not the case, gifted students learn and gain employability skills even in homogeneous groupings (putting students of very similar ability level together) (Joyce, 1991). This takes away the worry from teachers who teach in districts that track students (placing students in certain classes, sections of classes, or schools based on ability level or interests) that if they implemented cooperative learning it would be in vain.

Methods

Research Questions

1) How are classroom norms that are conducive to productive mathematical discourse established and maintained?

2) How do teachers use discourse to meet the needs of girls?

3) How do teachers use discourse to meet the needs of mathematically gifted students?

4) In teachers' opinion, how does the presence of equitable discourse in the classroom affect students' mathematical identity?

Data Collection

Data was collected from three middle school teachers (1 female and 2 male). The female teacher used to be a high school teacher (hence forth known as Teacher A). One of the male teachers used to be an elementary teacher (hence forth known as Teacher B), while the other has

only taught in the middle school (hence forth known as Teacher C). All three teachers are from different districts, and each of these districts has a different philosophy and procedure for tracking students (grouping students according to ability into different classes or paths).

The research team interviewed each of these teachers either in person or via Zoom meeting. The interview questions are attached below. Handwritten notes were taken at each interview by the research team. Each interview lasted between 30 minutes and 1 hour.

Questions revolved around getting to know the teachers' personal philosophies, how they implement equity and discourse, and their personal experiences with discourse and equity. Follow up clarifying and deepening questions were asked when the research team found them necessary.

Data Analysis

Each interview was examined with respect to each of the following categories: establishment and maintenance of classroom norms, equity for girls, equity for mathematically gifted students, and the relationship between mathematical identity and equitable discourse." Then the findings in each of these sections were compared across teachers for commonalities, differences, and other things of note. Then select quotations were transcribed by the primary investigator.

Results

Establishment and Maintenance of Classroom Norms

The teachers all had slightly different ways of establishing classroom norms. But all three felt that it was important that students could see why the norms were necessary. Instead of just giving students a list of rules on the first day of school, the teachers created practice discussions and activities for the students. After the completion of these activities over the course of a few

days (usually three), students were then either given the list of rules or got to create the list of rules as a class.

Even though students are able to experience why the rules are important, every teacher expressed that the students needed reminders almost constantly. Problems still arise. Teacher A spoke about a recurring problem in her classroom. She said, ““If a student presents an idea, and then another student presents a counter to that idea...some of the students will say, ‘You got slammed!’” Clearly, this is not acceptable behavior according to the norms in her classroom, but her students still do it despite daily reminders of the norms.

Involving students in the establishment of classroom norms is not a substitute for classroom management techniques. All three teachers said that when there was problematic behavior, they simply redirected students to the norms that they established at the beginning of the year. Therefore, while maintaining the classroom norms necessary for productive equitable discussion is a constant and sometimes discouraging process, it is not a laborious one.

All three teachers were eager to talk about whole class norms, but Teacher A was the only teacher to discuss small group norms without prompting from the research team. Teacher A’s small groups each contain four students with each student playing one of four roles. These roles rotate regularly, and a description of the roles is clearly visible on a poster in the classroom.

The four roles are: Facilitator, Team Capitan, Resource Monitor, and Recorder. The Facilitator makes sure that the group understands the task and keeps track of the time. The role of the Team Captain is to make sure that everyone is participating and following the rules and norms. Resource Monitors are in charge of making sure the group has all the necessary materials for the task (i.e. worksheets/handouts, rulers, calculators, etc.) and is also tasked with getting

Teacher A's attention should they need her assistance. Finally, the Recorder records the group's work and answers. If the group has nothing written down with one minute left in work time, the Recorder makes sure that they get something written down before the end of the work time.

Teachers B and C both employed the "Popsicle Stick Method." In this method, a teacher takes Popsicle sticks and writes one student's name on each stick. Then the sticks are placed into a cup or jar. When a teacher needs someone to respond to a question, they randomly pick a stick from the jar. Whosever name is on the Popsicle stick is supposed to answer. This stick is then placed aside. Once the teacher has worked through all the sticks, they place all the sticks back in the cup, and the process restarts. Both teachers liked the fact that the students were chosen at random and all had an equally likely chance of being called upon.

Girls: Building Confidence

Teacher C mentioned that during his student teaching experience his cooperating teacher stood in the back of the room and counted how many times he called on girls and how many times he called on boys during his lesson. Not only did he call on boys more than he called on girls, but when he did call on girls, he would allow them less time to answer the question correctly before answering the question for them or moving on to the next student. He commented on how this changed his teaching practice saying, "I now make it a [point] to call on males and females in my classroom, and to not let females off the hook, because that's quote 'the gentlemanly thing to do.'"

While there was a certain element of making sure to call on both genders equally, the greater concern for the participating teachers, regardless of their gender, seemed to be building up their shyer students' (they identified both male and female students as shy) confidence. Some strategies that they employed were: not placing shyer students with highly confident students,

prepping shy students before calling on them, requiring the small group to work together before they will call on any student, not just a shy student, and praising every answer (especially the incorrect ones) as an opportunity to learn.

Teacher B explicitly stated what was implicit in Teacher A and Teacher C's interview. He talked about how some students will never gain confidence no matter what he did. This did not mean that he did not still try to build their confidence, but he recognized that middle school is a tumultuous time in a student's life and that factors outside of the classroom and school play a huge role in a student's confidence levels.

Redirecting Mathematically Gifted Students

When the subject of mathematically gifted students came up, each teacher immediately thought of the student that answers all of their questions right away. As with classroom norm establishment, teachers had slightly different strategies for dealing with these students, but the basic premise was the same. Instead of silencing these students and not allowing them to speak, each teacher redirected them a different form of participating in the discussion. Teacher A asked mathematically gifted students to ask questions of others instead of answering her questions. Teacher C directed mathematically gifted students to more challenging problems. Teacher B allowed mathematically gifted students to act as a "tutor or checker."

Teacher B had a table in his classroom set aside for students to compare work and receive help from other students. He describes one situation that happened recently in his classroom: "I had two boys and a girl that were over here one day leading a small group, talking them through it. They showed me that they had all of it done. They could explain it to me well enough where I thought, 'Here's a few kids that are really close to getting it. Maybe if you explain it to them, it will make more sense than coming from me for the fifteenth time.'"

Acting as a support for other groups or struggling students, gives the mathematically gifted student an opportunity to think about the concepts in different ways and to work on employability skills (speaking to one's peers, explaining concepts and processes so that someone else can understand, an appreciation and understanding of interdependency, etc.). This also gives them something productive to do, instead of doing more worksheets or problems or even worse, sitting bored at their desks or disrupting their neighbors.

The Relationship between Mathematical Identity and Equitable Discourse

The idea of linking equitable discourse and positive mathematical identity was where the teachers differed in their opinions and experiences most. No two teachers came to the same conclusions about how equitable discourse affects mathematical identity. Their differences seemed to be related to, if not caused by, their definitions of equity.

Teacher A defined equity as people getting what they need and access to those supports. She described how she received letters from former students who struggled with math that said words to the effect of, "Thank you for believing in me and making me believe that I could do math." She attributes their feelings of success to the fact that she so heavily emphasized discourse.

However, this same teacher (Teacher A) saw a shift once she moved from a struggling classroom to an honors classroom, that the worthwhileness of discourse seemed to fade in relation to mathematical identity. She spoke about how honors students already see themselves as mathematically competent and do not want to be challenged. In her perspective, honors students are used to getting the right answers quickly and then not being pressed to justify their answers.

Teacher B defined equity simply as “equal.” He was cautious to say that equity was actually helping the mathematical identities of his students. Although, he did recall hearing students say to him, “I actually like math this year.” Overall, he seemed to think that equitable discourse does not help, nor does it really hurt, mathematical identity.

Teacher C defined equity as “equal opportunity,” i.e. equal chance of being called on. Teacher C had yet another perspective on the relationship of equitable discourse and mathematical identity. He noted that he could see a circumstance in which a student who had a largely negative mathematical identity might actually be harmed by equitable discourse. If the student is giving wrong answers often, then the sharing of wrong answers may actually reinforce their belief that they are incapable of learning mathematics.

Recommendations and Conclusion

I recommend that teachers should continue to add in discourse to their classrooms. However, when they do implement discourse in their classrooms, they should be mindful of equity issues. Also, they should not become discouraged when classroom norm maintenance seems to be constantly needed. Teachers should be encouraged to regularly examine their definitions of equity in addition to their teaching practice.

The Popsicle Stick Method appears to be prevalent enough in practice to warrant further research, as two of our three interviewees use it in their classrooms. Since the method appealed to these teachers because of its random nature, I suggest that further research focus on whether or not random is fair and the effects of random selection on students’ mathematical identities.

Implementing discourse in a mathematics classroom is a far more challenging task than just asking students to talk about math or work together in a group. Teachers must keep in mind promoting mathematical understanding and correctness, fostering positive mathematical identity,

and upholding equity for all students. Norms are not just established on the first day of school and then never spoken of again, but rather they must be reiterated continuously throughout the school year.

To add further complexity to the matter of discourse, our definitions of equity are not inconsequential. How you define equity influences your teaching practice, and your teaching practice influences students' mathematical identities. A positive mathematical identity can provide lasting opportunities for students, while a negative one can limit students in career options and earning potential for the rest of their lives.

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Appendix

This interview is being recorded so the research team (Dr. Hughes and I) can go back and review your answers for the purposes of our study. This interview is designed to be low pressure, but if you feel uncomfortable with a question, you may choose to answer only part of the question or skip the question entirely. Do you have any questions before we begin?

Please describe what mathematics is to you.

Please describe your core beliefs about teaching mathematics.

Why do you emphasize discourse in your classroom?

How do you maintain these norms?

Are there ways in which you are implementing equity in your classroom? If so, what are they?

Do you actively try to challenge and engage girls in discourse? If so, how? If not, why not?

Do you actively try to challenge and engage mathematically gifted students in discourse? If so, how? If not, why not?

Do you feel like equitable classroom discourse affects how your students feel about mathematics? If yes, how does equitable classroom discourse affect students, in your opinion?