The Mathematics Enthusiast

Volume 14
Number 1 *Numbers 1, 2, & 3*

Article 12

1-2017

Critical Examination of Ways Students Mirror the Teacher's Classroom Practice: What Does It Mean to be Successful at Mathematics?

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Abstract: In this paper, the authors report the mathematical learning experiences of "successful" female students in secondary mathematics classrooms taught by a "successful" teacher with the traditional mathematics' behaviorist approach. The authors' claim that the traditional view of mathematics held by the teacher and supported by the school system could not promote rigorous mathematics for girls to understand the importance of mathematical thinking as a foundation for success in mathematics-related professions. The authors recommend future studies creating opportunities for discussion in the field about the teacher's view on mathematics, classroom practice, and how these resonate with girls' experiences of learning mathematics.

Keywords: gender; teacher beliefs; teacher attitudes; mathematics teaching practices; female students in mathematics; girls' experiences in mathematics

Introduction

Research shows that there is no significant gap of inherent cognitive ability between boys and girls (Campbell, 1995; 1997; Hyde et al., 2008). Although girls' latent mathematical intuition and skills are not in question, the concern still remains about their underrepresentation in science, technology, engineering, and mathematics (STEM) fields (Clewell & Campbell, 2002; Boaler, 2010; Hyde et al., 2008; Dasgupta & Stout, 2014; Gamse et al., 2014; MacPhee et al., 2013).

Researchers have examined the learning environment and how girls are taught to explain the discrepancy of performance found between boys and girls at higher grades (Fennema & Carpenter, 1998; Boaler, 2002; Clewell & Campbell, 2002; Battey & Kafai, 2007). Fennema et

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The Mathematics Enthusiast, **ISSN 1551-3440, vol. 14, nos1, 2&3**, pp. 175 – 206

al. (1998) argued that a difference exists between girls and boys regarding particular methods used for solving mathematics problems; more specifically, girls used more taught strategies than boys, and boys used more invented algorithms than girls.

Essentializing this issue by calling it “the girl problem” (Campbell, 1995) begs a solution to the problem of closing the STEM gender gap. The authors of the study dismiss the notion of a problem with girls themselves and inquire why academically successful female students still opt out of STEM-based careers. Pajares (1992) argued that the type of mathematics classroom environment the teacher provides for students can contribute to student beliefs about mathematics, and these beliefs cemented early in schooling will be difficult to change and may serve as lifelong beliefs about mathematics. In particular, the teacher influences students to conceptualize success in the classroom. For example, girls who follow the rules of the classroom more closely than boys do, especially in mathematics, will likely be influenced by the teacher’s conception of the norm of *success* so that they can rate themselves according to that norm used by the teacher and by the school system at large (Boaler, 2010; Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Hyde, Lindberg, Linn, Ellis, & Williams, 2008).

Currently there are many studies examining the nature, role, and impact of teachers’ mathematical beliefs in instruction. The field has recognized that it is important work to examine how teachers, schools, and the larger society influence the learner behaviors and affect girls’ learning of mathematics and science—especially teachers who have a major influence on the schooling experience of children (Perry, Howard, & Tracey, 1999; Barkasas & Malone, 2005). However, there are few studies that illustrate ways the teacher’ belief influences *girls* with *high socioeconomic status* through multiple dimensions of their conceptualization of mathematics. Girls’ school experiences could shape their decisions about future careers, so the way a teacher conducts his or her class has the great impact on those decisions; therefore, it is crucial that teachers and school systems identify the *current* norm of success and mathematics success in classrooms and reflect upon the experiences of girls with fewer advantages during schooling and those who avoid choosing a future career in STEM.

In this paper, the authors analyze the views of mathematics held by a teacher in a suburban area in the Southwest of the United States and the view of mathematics his female students demonstrated. We used the term the successful teacher to indicate a mathematics classroom teacher who is perceived successful by administrators and students; and the successful students to indicate those who are performing high academically in the school and the school system. In essence, the authors aimed to find answers why “successful” female students in secondary mathematics classrooms who are taught by “successful teachers” and who have the cultural capital to continue studying with fewer obstacles than peers from high-poverty urban schools still opt out of STEM-based careers. The following question guided our study: How does the kind of mathematics favored by the teacher in the classroom (1) influence the views of mathematics that girls presumably develop and (2) consequently foster or hinder their potential for a serious interest in mathematics and science? In the following sections, the authors will present their theoretical lenses, a review of the literature, the methodology used to complete the study, their findings highlighting emerging themes through vignettes, and a discussion of those results including future directions for research.

Theoretical Perspective

Theory

This study explored the ways in which girls experience and conceptualize mathematics, focusing on girls’ stories of learning mathematics with a successful teacher. The study also addressed the issue of whether girls are properly equipped with the tools and ability to successfully participate in the field of mathematics, where there continues to be an increase in demand of STEM knowledge.

Girls are typically considered “the other” in the domain of mathematics. In fact, women are traditionally regarded as being successful in mathematics and engaging in STEM careers at a much lower rate than their male counterparts. By regarding the data of girl participants in their study through lenses permitting the “others” to express their stories, the authors were able to distinguish the characteristics that constituted them as this “other” delineation. These girls in particular were considered as having achieved success by the measures of the school system. However, as stated previously, because girls can achieve success in performance but still “choose” not to participate, the authors recognized these girls as still part of “the others.”

Anzaldúa (1999) once stated that one hidden weapon that the dominant classes have is the inability of the “others” to tell their story. The authors of this paper gave space for the participating girls of the study to tell their stories because particularly in areas such as mathematics education and STEM, it is imperative that girls speak their stories and build their participatory space. It is also imperative to educate dominant cultures so that they readily give up part of their power to those who are oppressed. Chaldra Talpade Mohanti (2003) stated that “privilege nurtures blindness to those without the same privilege” (p. 231), which goes to show how necessary it is for the oppressed—in this case girls and women being underrepresented in STEM—to find ways to share their experiences and move toward change. As in Freire (1970) and Villenas (2006), it is girls who are able to find this space (liberating themselves and problematizing the struggle) and help those in dominance (oppressors) to learn and accommodate more equalitarian practices. Because we are talking about oppression and the need of women to speak their minds protecting and proclaiming the changes that need to take place, considering feminist approaches were key in the same way that hooks (2000) considered this ideology crucial in eliminating any kind of oppression. If we as a society are to teach mathematics and attend to the needs of all students, we must find ways to value diversity in knowledge (Calabrese-Barton, 1998), hear everyone's stories, and use knowledge in the classrooms.

In the paper, the authors use Latino critical theory (LatCrit) as the lens through which they analyzed, collected data, recorded stories shared by the girls and teacher, and noted observations during the investigation period.

Since LatCrit, according to Solorzano and Yozzo (2002), attends to individuals as a whole while taking into account their experiences as individuals within the realities of gender, race, and social class, the authors thought it would be helpful in providing a more complete and realistic picture of the experiences of these girls. It is not often that upper-middle-class girls' experiences are problematized through such a lens, but their realities are also influenced by their gender and class. As stated by Solorzano and Yozzo (2002), LatCrit "… offers a liberatory or transformatory solution to racial, gender, and class subordination" (p. 24). It is in the overlapping of those subordinations that LatCrit can offer a lens of analysis, and for that reason the authors of this paper found it crucial for their study. LatCrit positions girls at the center of multiple intersections of gender, class, and race. In this way, LatCrit served to answer important questions like what it might mean to be a Caucasian upper-class girl who is "successful" at mathematics. The authors of this paper found LatCrit useful for the particular problem at hand, because the experiences these girls have are connected to who they are as females belonging to the upper class. The same way LatCrit would have been helpful to understand the experiences of females of color, who would have probably been found at an urban school which may have not been able to call itself "successful" as the school of the paper does, LatCrit can help understand the relationship of these girls with mathematics, with their teacher, and with the fact they can call themselves "successful" unlike their counterpart of color. LatCrit also helps to problematize that notion of success, while at the same time opening the door to questions about the realities for girls of color attending urban schools who do not have the economic support that other girls, such as the girls in this study, are provided.

Another reason the authors of this paper used LatCrit was their shared commitment to social justice (Solorzano & Delgado Bernal, 2001; Solorzano & Yozzo, 2002). The fair representation and participation of women in STEM fields is imperative—not only for issues of fairness but also for the development of new technologies that both represent the voices of women and also better serve them.

Literature Review

Because beliefs about mathematics are crucial when considering mathematics teaching (Perry, Howard, & Tracey, 1999; Barkasas & Malone, 2005), and learning, the research on teachers' beliefs about mathematics is central to the beliefs students develop in classrooms. Just as important is the research on students' beliefs about mathematics. In the following sections, the authors review the literature on teachers' beliefs about mathematics, as well as the students' beliefs about mathematics.

Teachers' beliefs about mathematics. Regarding teachers' beliefs, Carter and Norwood (1997, p. 63) wrote, "It is evident that what the teacher does in the classroom influences students' beliefs about mathematics and the teaching of mathematics influences what they do in the classroom and that their beliefs may be translated into students' beliefs." They provided an example where teachers who believe competition is a way to motivate children to learn mathematics supported competitive and individualistic behaviors in their teaching, and the educational benefits of cooperative strategies were valued little. This illustrates the connection between teachers' beliefs and their practices, which also was substantiated by Stipek et al. (2001). Pajares (1992) added that beliefs have a strong affective component and that beliefs act independently from knowledge: "Belief is based on evaluation and judgment" in contrast to knowledge, which "is based on objective fact" (p. 313). But this is not the only way to think about mathematics teachers, teaching, and beliefs.

Stipek et al. (2001) explained that inquiry-oriented mathematics educators need more knowledge of mathematics for classes that do not follow the typical pattern (reviews or introduction of a new concept, step-by-step instructions, and then practice). According to these authors, teachers who subscribe to a more traditional format for mathematics and whose emphases is on performance, which Perry, Howard, and Tracey (1999) label as "content focused," have three core beliefs: (1) mathematics is a set of operations and procedures to be learned; (2) teachers should be in complete control of student learning; and (3) extrinsic reinforcement increases understanding. Ernest (1989) found that there is a popular "instrumentalist" view of mathematics among teachers, where mathematics is a set of unrelated and utilitarian rules.

These beliefs about mathematics were negatively associated with understanding, student autonomy, and teacher enthusiasm (Stipek et al., 2001). Furthermore, these researchers found that the more teachers focused on "correctness," the less they were likely to consider effort and creativity in instruction, and that a majority of American teachers share these conceptions about mathematics. The authors went even further and added that teachers embracing more traditional beliefs and practices in mathematics had lower self-confidence.

Ernest (1989) claimed that there is a "Platonistic" view of mathematics as well, where this content area is unchangeable as a body of knowledge that already exists to be discovered, not created. Ernest (1989) considered a third view of mathematics with problem-solving at the core, which is dynamic and an invention or a cultural product. Similar to Ernest's "Platonistic" view of mathematics, Gonzalez-Thompson (1984) reported that some participants in his study believed that mathematics was prescriptive in nature and also that "certainty" is a central quality of mathematics, where methods are valued when they guarantee an answer; therefore, mathematics was "cut and dry," predictable, logical, and free of emotions.

Students' beliefs about mathematics. Student beliefs toward mathematics play a key role in their schooling experiences and results in the decisions they make for their future careers. How these beliefs relate to their teachers' beliefs can explain in part why students, and specifically girls, choose a future career outside of STEM fields.

Schoenfeld (1992) claimed that even though students might have believed that mathematics are creative, they still thought most of mathematics learning involved memorizing pre-established rules. About half of the students assessed nationally agreed that learning mathematics was mostly memorizing, which requires practice to use the rules, and most of these students also found that there was always a rule to follow when solving a mathematics problem. Therefore, children over time came to believe that a good teacher makes sure students recall the right rule in memory and avoid mistakes in applying the rules.

Boaler (1998) also found that views of mathematics that emphasize remembering rules and formulas had a negative impact on students' performance. For example, she found that children completing mathematics tasks did not find it appropriate to think about the problematic situation, but rather "they had to remember a rule or method they had used in a situation that was similar" (Boaler, 1998, p. 47). Furthermore, her study found that students could not apply the mathematical knowledge they were learning in contexts outside of school. She called this knowledge "inert" and said it was procedural in nature, and of little use.

All of these ideas are in opposition to the articulation of National Council of Teachers of Mathematics (NCTM) about the practice of mathematics and exemplary mathematical tasks (National Council of Teachers of Mathematics, 2001). The reform-oriented mathematics supported the perspective that mathematical learning provides opportunities to process concept construction and participate in sense-making and social learning within various meaningful contexts; so that effective teachers develop imaginative and creative mathematical thinkers in classroom (Brownell, 2004; Smith, 1996).

However, when teachers "step away," even a little, from the traditional approaches to teaching mathematics, Schoenfeld (1989) found that students enjoyed problem solving. Schoenfeld (1992) clarified that even though the rhetoric of problem-solving was present in classrooms in general, opportunities for students to experience authentic problem-solving were scant. When teachers subscribed to NCTM recommendations for teaching mathematics, stepping away from traditional practices and moving into meaningful problem solving (Ernest, 1989), teachers felt that they gave up power and control in the classroom, and appropriate implementation of problem-solving tasks required in-depth content knowledge and extensive experience with students with various backgrounds.

In addition, researchers warned that teaching focusing on the standard textbook questions only leads to the development of procedural knowledge that is limited in non-school situations (Schoenfeld, 1988; in Boaler, 1998). This was clearly exemplified in a study (Boaler, 1998) in which children described doing mathematics. A group of students provided the textbook page and example number, while in another school, students described the problem they were working with, what they had discovered, and the applications of the learned concepts. Students in the second school were more flexible about their mathematics knowledge and had a predisposition to think about mathematics in new ways and use their learnings in new situations. They believed that active and flexible thought were part of mathematics, and they were willing to explore new mathematical contexts. Similarly, Carter and Norwood (1997) found differences in the orientations toward mathematics that students in a reform and a traditional school held. For example, students from the reform school claimed greater satisfaction from solving challenging problems and from working hard while doing mathematics. These researchers found differences in task orientation, work avoidance, and understanding between these two groups of students, with the students whose mathematics aligned with the NCTM standards demonstrating positive development toward the ideal practice of mathematics.

Methods

Context

The study took place in a suburban school in the Southwest of the United States. Observations took place during the fall semester of the school year, with a total of seven observations. Each time they visited the school, researchers observed two classes taught by the same teacher.

The school population was not diverse, with 81% White, 11% Latino, 3.7% African American, and 4.3% others. Only 18% of the student population was considered economically disadvantaged. The school had no migrant students, and 1.7% of the students had limited English proficiency. The school was rated as a high performer for the previous three years, with a rating of adequate No Child Left Behind progress as well. The school's mission is to "promote excellence within a safe and respectful community." A secure entrance prevented unauthorized entry; hallways were polished, clean, and calm; and the campus boasted green spaces. The school's mission statement says that it seeks to cultivate students who aspire "to encourage leadership within [their] school and community, to treat others with respect and dignity, to set challenging and realistic goals, to always do [their] personal best, to promote equitable opportunities and resources for all, to ensure the use of technology for staff and students."

The campus landscape was very different from another school the researchers were observing in an urban area about 20 miles away from this school. Another contrast with those urban schools is that about 50% of the teachers had worked there for more than four years, and about 70% of them had advanced degrees. About 60% of 7th graders met the standards for mathematics, and 26% of the students exceeded those standards. For 8th graders, 60% met the standards and 14% excelled in mathematics standardized testing. Out of the 7th-grade girls, 90% met and exceeded the mathematics standards compared with 80% of the boys, and in 8th grade the numbers were 77% for the girls compared with 71% for the boys. In the school system's terms and based on those results, the girls in the school were successful in mathematics.

The Teacher

The teacher, Mr. Oreo, was a white middle-aged man who was enthusiastic about his job and friendly with his students. They approached him at all times, coming before class and staying late to talk about mathematics and their lives in general. Clearly, he had a positive relationship with his students.

He was a qualified teacher, with a bachelor's degree from a university in the Midwest of the United States, a master's degree from another university in the same area, and a counseling certification from a university in the Southwest of the United States, which allowed him to provide counseling for K–12 students. After his first teaching job, he had a job in counseling for five years, but then decided to go back to teaching since he “missed working with students.”

Mr. Oreo taught middle-school mathematics and science for 15 years. He was a certified trainer of a youth development program. The program is a K–12 youth program that supports social and emotional learning and character education, which includes bullying prevention, drug awareness, and service learning. The school district was implementing the program in all grade levels, and Mr. Oreo, along with another trainer, was in charge of providing training for teachers in the school district. According to Mr. Oreo, the program teaches “skills for life,” from being a good listener to saying no to drugs. This teacher also reported that he was involved in developing the mission statement for the school district, believed in the idea of “equity” when distributing funds for schools, and talked about “personal growth” as being important to academic growth.

Mr. Oreo was interviewed twice for this study. One was an exploratory interview to see the students through the teacher’s eyes and to investigate his conception of mathematics teaching. The other interview was at the end of the project, to get more information and clarifications on students’ interview data or observe events in the study.

After observing his class during the semester, researchers agreed that he demonstrated a strong passion for teaching and that his teaching styles contributed to a welcoming environment. In particular, he used a variety of general strategies to motivate students, including motivating messages in the pictures on the walls; and the teacher was caring and respectful towards students who responded to him positively.

The Students

Two groups of students were observed in this study: an algebra class with a mix of 7th- and 8th-grade students, and a 7th-grade mathematics’ class. The algebra class had 34 students, half boys and half girls. Students were required to pass the state proficiency test on pre-algebra to be able to enroll in the algebra class. Students in the algebra class were able to get high school credits. The 7th-grade mathematics class consisted of 28 students, 12 boys, and 14 girls.

Observations, Data, and Analysis

The researchers observed the classes and did not interact with the students during class. The students rarely acknowledged researchers in their classroom, where the researchers spent almost 20 hours making observations. Seven female students were interviewed. Four of them were from the algebra class, and the rest were from the 7th-grade class. These interviews were short and semi-structured. They took place after school and took about 15 minutes each. The conversations with the students revolved around how they perceived mathematical learning after seven or eight years of schooling and the level of their interest in mathematics in their future studies. These conversations were guided by the following questions:

- What do you think mathematics is?
- Do you enjoy doing the mathematics you've just described?
- Do you enjoy mathematics in general?
- What do you think you will be majoring in during college?
- Do you think you will use mathematics in the future?
- What kind of mathematics do you think you are going to be using then?
- In addition, the researches asked the participants to draw a "mathematician."

The data collected were repeatedly read in order to uncover common themes that supported conclusive assertions. Once prominent themes were identified, the data were studied again to support or refute the proposed assertions. The following vignettes are presented to support the emergent themes from the analysis of the data based on observations and interview data.

Limitations

This study is a case study of one teacher and one class of learners (whose views likely were influenced by many previous years of teaching and teachers). One teacher's belief is examined, and his students' limited learning opportunities are attributed to the teacher's limited perspectives of mathematics. This study examines how girls respond to the environment (i.e., teacher), and whether boys respond similarly is not considered in the study. Therefore, only girls are included in the sample, and there is no attempt at comparison with boys. There is no evidence that the teacher only impacts the female students in the way as reported in the study. The task of knowing whether this phenomenon holds true for other girls in similar settings should be further investigated.

Themes and Vignettes

The observations in Mr. Oreo's class provided information about how mathematics teaching was conceptualized by him. Classroom procedures were repeated multiple times like a military drill and practice. All of this happened in an atmosphere that cannot be considered anything but safe under the teacher's control, where students offered their numerical answers to questions the teacher asked, filled in the blanks that the teacher presented orally, and followed all the rules that were provided by the teacher.

The class would start by Mr. Oreo calling out answers to exercises (from the textbook) assigned the day before as homework, and students checked whether they got them right or wrong. After that, the teacher would move to his computer, and students called out how many answers they got correctly. The teacher used the self-scored grades to decide whether or not students would have to do over the homework. Students got to know their peers' scores. After this, when students or the teacher had interests in one of the problems, the teacher solved the problems for the class with detailed explanations. This classroom practice was consistently implanted for all observations.

An introduction of new materials was made in a similar fashion. The teacher would stay up front near the board, and students would answer questions that were stating a specific procedure of algorithms or looking for numeric answers. It was the teacher who was in total control of the mathematics done in the class. Whole class work as described above was followed by individual work, which consisted of repetition and drilling. During individual work, the teacher went by those who called him for help and had one-on-one conversations with students.

The classroom observations helped the authors understand Mr. Oreo's philosophy of teaching. The ways in which female students in Mr. Oreo's class translated this philosophy into the conceptualization of mathematics became clear when the researchers interviewed seven females students. Two themes emerged from the interview data: (1) an impoverished view of mathematics; and (2) the lack of ownership of ideas while talking about mathematics.

Impoverished View of Mathematics

Whatever comes from numbers are numbers. When the authors interviewed Mr. Oreo, he talked broadly about his goal of not only providing mathematics instruction but also helping students become better people. The counselor in him came out several times with passion to demonstrate that he cared a lot about his students. However, he said little about mathematics and his role teaching mathematics. For example, the title of this section comes directly from his interview: "Whatever comes from numbers are numbers" (Mr. Oreo's interview). The interviews with students also supported this view: "Well, I think [mathematics] is like numbers that you do like ... You do something with the numbers, like combine them or whatever" (13-year-old female student interview). Students stated that mathematics was numbers, addition, subtraction, multiplication, and division, as well as “stuff” to figure out problems. The kind of problem-solving to which they referred was, for example, adding numbers in the store to know how much a buyer spent, or calculations such as “the square root of 144 is 12,” as one student told me when she was prompted to give the researcher an example of mathematical problem-solving. Students’ conception of mathematics was mostly about computation. A representative quote to indicate a student’s perception of the number sense in the teacher’s classroom follows: “Well it’s like numbers and ... like ... like figuring stuff out with numbers and ... Everything in life kinda grows on it” (12-year-old female student interview).

Mathematics is cut and dry. The majority of students interviewed considered mathematics in the classroom to be “a series of steps.” They explained to the researchers that in order to do mathematics, they must be very organized, memorize a lot, and be “on top of it.” Some of the girls who were interviewed presented something more about mathematics than the dominating view: “[Mathematics] kinda depends on what it is, but I think in class [it] is definitely following a set of rules. Because you have to, and that’s how you are being taught” (13-year-old female student interview). This student claimed that she is being taught to understand what mathematics is.

When students were re-voicing either teachers or parents, the researchers noticed a unique word choice, “you,” and assessed how students’ statements excluded themselves from the context. For example, when one student mentioned algebra, by talking about “x’s and y’s,” she said, “You don’t really do that in the real world,” making clear the disconnection between school mathematics and her life. Students used “your” life instead of “ours” or “my” in order to distance themselves from mathematics. Furthermore, students did not explain how much of mathematics they were going to use in the future, but their statements about mathematics always became reduced to measuring, counting, basic arithmetic, and "stuff like that."

The following describes a typical scene of the classroom that demonstrates a lack of mathematical thinking and reasoning:

> *The researcher arrived to the classroom in the morning for the first period. Some students were in the class chatting. Some were talking to the teacher. The bell rang, and the researcher observed that the class went on exactly as usual, on time. Students self-graded homework, and then they called their grade to the teacher, who recorded them in his computer. The homework typically consisted of practice problems in the textbook. There were a couple of word problems that were used only to pose a small challenge to students since the design of the problem requires numeric information to be extracted. During self-grading, the teacher stated two numbers: one was the number of the problem, and the second was the numeric result. Later, he would tell the students the points for each item, so the students could tally the earned points to report. For example, he stated, "Number four is negative two. Number five is positive ten." Sometimes, students raised questions to know more about the solutions. A boy, for example, asked about question number 6:* $\frac{x+3}{4} = 12$. *This dialogue between teacher and students took place:*
>
> *Teacher - Which do I get rid of first?*
>
> *Whole class - 4.*
>
> *Teacher - Do I divide or multiply?*
>
> *Whole class - Multiply.*
>
> *Teacher - 12 times 4 equals...?*
>
> *Whole class – 48.*

Teacher - "x" plus 3 divided by 4 times 4 equals...?

Whole class - "x" plus 3.

Teacher - What do I need to get rid of next?

Whole class - The 3.

Teacher - Do I need to add or subtract?

Whole class - Subtract.

Teacher – 48 minus 3 equals...?

Whole class - 45.

Teacher - "x" plus 3 minus 3 equals...?

Whole class - "x."

Teacher - What does "x" equal?

Whole class - 45.

Teacher - Remember what we need to get rid of first.

The dialogue that the students and teacher had was a fill-in-the-blank type of conversation, where the students were limited to saying only a word or two.

A lot of counting and calculating. It was noticeable that the female students interviewed struggled to express their views toward mathematics and their descriptions of what mathematics is, which were repetitive. An example is this excerpt from the interview with one of the 12-year-old girls in the mathematics class:

> Cause like medicines you always have to, like, you can't like prescribe more … like an overdose, like … So you have to be really precise. Or like … when like … give like … I don't know. [laughter] Just like when you give someone like a shot, and you can't give them too much or too little.

Students were unable to provide a definition for mathematics with which they felt comfortable, and reduced it to calculations: "I'll probably say math is … I don't know, just calculations and trying to figuring something out in a certain order and following steps" (13-year-old female student interview). For these girls, mathematics is a very limited thing, hence the use of the word "just" like she did, or like this other example from a 12-year-old girl from the math class:

> Here you are doing it just like homework, but like you don't do any more than just homework. You just… You just… You just... The teacher just gives you what to do, and you just do it, and then you don't think about math the rest of the day.

This girl tried to offer the researcher a more in-depth explanation of what mathematics was, but then resorted to what they do in class, again describing it as limited, but also adding the fact that once that hour is done, they don't have to think about mathematics any more.

Asked about mathematics in general, students were not sure whether there was something more to mathematics outside the classroom. The interviewed students also talked about "science mathematics." Five out of the seven wanted to become doctors and stated that the mathematics they would use in that profession consisted mostly of counting, measuring, and calculating by primarily adding and subtracting. These girls did not see mathematics as a tool they could use in various disciplines including social sciences.

Creativity, fun, and mathematics. Perhaps because the power of mathematics was limited in their views to following a set of rules, students struggled to imagine mathematics as something creative:

> Like if you are doing graphing and that kind of stuff, sometimes you are doing like coordinate grids and stuff like that with points, I think ... it's more like ... you can't be as

> creative with it [be]cause you have to be on top of it. And same if you are doing like ... um ... order of operations, then you have to be ... you can't be as creative (13-year-old female student interview).

One student stated that brains better at "more creative stuff" are not good for mathematics. This student tried to convince the researchers that everybody could do mathematics, perhaps re-voicing what her teacher had said, but then contradicted herself by speaking about special people who have a "math brain." Part of that re-voicing about mathematics success included statements where mathematics success meant doing hard work. However, some students emphasized that certain people can remember steps in the right order better than others, and they are thus more successful in mathematics than others, disregarding the hard work.

Mathematics was a non-creative activity for students. Additionally, students stated that mathematics was a lot of fun; however, the students could neither provide examples nor elaborate on this idea of fun in mathematics. On the other hand, students became more expressive when they described the lack of fun in the mathematics they had experienced so far. For example they said that "it can actually be fun sometimes," or "it is even fun." Both sentences show a kind of surprise at the idea of mathematics being fun, and the first one clearly states that there are other times when mathematics is simply not fun.

Absence of Language to Describe Mathematics

Countless times the researchers heard the interviewed girls say (with no exemption) "stuff like that" and "like." It made the researchers felt that the whole interview was an enthymeme, where the girls were assuming the authors knew what "stuff like that" was. The interviewees acted as if there was a shared understanding about mathematics and as if saying more of the subject was unnecessary. They suggested that they did not have to go into further details in the conversation to discuss their conceptualization of mathematics. Did they assume these details were known to all, or did the students avoid talking about something they knew little about? Given the wall that was erected that the students erected between themselves and the researchers, it is hard to believe that they assumed a shared understanding. Researchers, who were not greeted by the students in any of the visits, or who were rarely acknowledge in any way except on the interview day, believe the students were not comfortable talking about mathematics and tried to mask their lack of fluency in their mathematics “talk” by using phrases like those above.

Discussion

The analysis of the interviews gains relevance when it is considered along with the fact that the classroom practice captured in this study could be the norm of mathematical instruction by a teacher who is widely perceived as successful teacher who teaches academically successful students in the school system. According to the teacher, the school, and the district, these girls achieved high in the kind of mathematics that the school is teaching. These girls are similar to the students in Schoenfeld’s study (1989), who were expected to memorize the mathematics they were learning. The “fill in the blank” modality in the class might have had the effect of depriving the students of opportunities to create productive classroom discourse. Students may believe that they do “get it,” and that they understand the mathematics, because as Boaler (2010) explains, the clear explanations of the teacher and the repetition create this illusion. This way of “getting it” will not allow them to use the mathematics some time later, when it is demanded from them in a real-life situation. The difference between “understanding” the mathematics and “seeing something that appears to make sense” will be clear soon enough. Boaler (2010) states:

> To know whether students are understanding methods as opposed to just thinking that everything makes sense, they need to be solving problems—not just repeating procedures with different numbers—and they need to be talking through and explaining different methods. (p. 43)

This method of teaching mathematics is in opposition to that demonstrated in the vignette where the classroom is solving an equation. A method like the one utilized by Mr. Oreo is called "silent" (Boaler, 2010), and students do not get a chance to talk through or explain any of their thinking.

The classrooms that concern this paper that did not fulfill the requirements of being a good mathematics or science classroom according to Boaler (2010) were classified by no students coming to the front of the classroom to discuss ideas and to add to each others' reasoning while working on a real-life problem. It was quite the opposite of the vignettes presented previously. The interaction among students was minimal and could not offer learning to create knowledge and meaningful experience to connect mathematics to lived experiences, science, or any other meaningful contexts. Gonzalez-Thompson (1984) presented a similar case in which students in the class "were intended to elicit short, simple answers" directed at the teacher or the board, not communicating with the other students in the class.

The importance of memorization was clear in the classes with this teacher. About this, Boaler (1998) said:

> The students' views about the importance of remembering set rules, equations, and formulas seemed to have many negative implications. For example, in mathematics situations, the students did not think it was appropriate to try to think about what to do; they thought they had to remember a rule or method they had used in a situation that was

similar. (p. 47)

Just like in Boaler's study (2010), the students observed and interviewed in this paper also though that mathematics was "numbers" and "lots of rules." When connecting problems to other problems solved before is part of problem-solving (Polya, 1957), this is not the same as remembering the routines or formulas that solved a previous problem. Garner and Engelhard (1999) stated that achieving in algebra by relying on algorithms or "following the rules" was not enough for the meaningful learning of mathematics.

Yet the girls in this classroom were considered very successful, and so was the teacher. This begs the question of whether school success is in any way related to what will be required from girls to succeed outside of school. Do school indicators of success draw a valid snapshot of "successful girls"? However, achieving in this class and in this school—and also in this district and in the state—when the school was considered to be "highly performing" was clearly confined to the likes of following the rules and remembering algorithms, as the researchers observed in this study. The misrepresentation of mathematics that Boaler (2010) talked about is an equal misrepresentation of "success" by the school regarding students and their learning of mathematics.

These girls need instruction where non-routine problems are present on a daily basis so they can participate in problem-solving with a balanced focus on the how's and the why's of mathematical process (Hiebert & Lefevre, 1986). Problem-solving, a view of mathematics that according to Ernest (1989) is dynamic, a process of inquiry, and "coming to know," will lead the girls to much-needed conceptual knowledge in addition to procedural knowledge in mathematics (NCTM, 2000). If classroom instruction provides opportunities for the girls to experience problem solving and learn the conceptual knowledge in the process, the procedural knowledge should be developed as a byproduct (Hiebert & Lefevre, 1986), resulting in these girls both being knowledgeable about mathematics and flexible with their strategies in problem solving. Concerning this, Boaler (1998) stated that students who were taught with a less-traditional approach to mathematics in a project-based-environment developed conceptual understanding and performed better on tests. The same author also claimed that traditional teaching with teachers asking good questions and proposing good problems can also offer a good mathematics experience for students (Boaler, 2010). But this was not the case in the classrooms observed for this paper. The learning of mathematics experienced by students in these classrooms was more of the "passive learning" type (Boaler, 2010).

One female participant stated, "I think there is more to math than they are teaching us. There needs to be more things of it." Her choice of words was interesting. It showed some disappointment with what mathematics is today in her life, but also hope that there is more out there. The reason for her disappointment is placed in others, those who are teaching mathematics. She doesn't know what else there is out there, but she knows the reality for mathematics presented to her at school is not complete. Maybe girls like this already know something that Boaler (2010) discussed:

> There are two versions of maths in the lives of many people: the strange and boring subject that they encountered in the classrooms and the interesting set of ideas that is the math of the world, and is curiously different and surprisingly engaging." (p. 7)

Girls could be introduced to the second type of mathematics described by Boaler (2010) too late to be able to make it their own, and their attempts during their study to talk about something other than what they were introduced to in school were unsuccessful. Moreover, the female participants did not recognize mathematics as a powerful tool to understand the world. These girls did not seem to be aware of such a side of mathematics.

The simple or simplified mathematics the girls in these classes were conceptualizing remained disconnected from the real world for the most part. The applications of mathematics that the participants could explain were almost non-existent. This case is not different from those in Schoenfeld's study (1989):

> Perhaps the most troubling aspect of the present study is the suggestions that these students have come to separate school mathematics—the mathematics they know and experience in their classroom—from abstract mathematics, the discipline of creativity, problems solving, and discovery, about which they are told but they have not experienced. (p. 349)

The participants in this study not only saw mathematics outside of school as counting and calculating, but also as being in opposition to fun and joy, which showed a very limited view of the content area. This was also similar to Gonzalez-Thompson's study (1984), where a teacher who was interviewed stated, "Mathematics is cut and dried. This is the answer. Follow this procedure and this is the answer." A very similar view of mathematics is held by the teacher in this study. The view they had of mathematics was mostly "Instrumentalist" (Ernest, 1989), where mathematics is a set of facts, rules, and skills. Ernest went on to say, "Thus mathematics is a set of unrelated but utilitarian rules and facts." There was nothing "Platonistic" about this mathematics either, where mathematics is discovered (Ernest, 1989).

During the interview, the girls hid behind language that allowed them to pretend they were talking about a subject that they actually prefer to avoid. The girls in the study were giving the researchers the authority in the mathematics conversation by resorting to certain phrases such as "like," "I don't know," or "whatever." Is the use of "stuff like that" providing a shield for the girls to hide from their disinterest or lack of awareness of mathematics? When girls spoke in vague language, they avoided discussing the real thing. They were able to stay in a safe territory, talking about things they could handle or provide what the researchers wanted to hear from the participants: mathematics in school and outside of it. The reason for this could be that the girls lacked the ability to articulate their conceptualization of mathematics. Alternatively, it could be that the subject is too intimidating for them. Boaler (2010) stated, “Math, more than any other subject, has the power to crush children’s confidence” (p. 1). In either case, this reveals an attitude that these girls have of avoiding mathematics in their discourse with the researchers.

Should we wonder whether this avoidance was magnified unnecessarily? During the interviews, it was noted that students consistently quoted others such as parents and the teacher. This use of authority figures’ voices demonstrated that they did not own the language or the knowledge they were discussing with the researchers. In Bakhtin’s words, “Heteroglossia, once incorporated into the novel is *another’s voice in another’s language,* serving to express authorial intentions but in a refracted way” (p. 324). When it is expected that anyone will have embedded in his or her speech traces of those who have touched his or her life, it is obvious in some of the answers the students gave the researchers that the speech they were reproducing had no meaning under it—it was just words.

The view of mathematics held by the teacher had an impact on how he taught his class and in how his female students conceptualized mathematics and the vision of mathematics in their future. According to Pajares (1992), it is the teachers’ classroom practice that can change their beliefs about teaching. However, if there is no space for communication between students and teachers, how can we expect teachers’ beliefs to change? And in this particular case, how can we expect this teacher’s belief to change when he is told he is successful at his job?

Therefore, an entry point to generate change is for schools to examine how the conservative nature of their learning environments hinders the developments of the types of skills and dispositions essential for STEM-related disciplines and to redefine their positioning toward success, and value a different kind of development and learning in their students. A teacher that can help girls understand the power of mathematics and the possibilities that it could bring to their lives is someone who opens doors for those girls in their future.

Future Research

Our findings point to the opportunity for discussion in the field about the extent to which the story and relationships drawn between the teacher's and girls' views resonate with their experiences and what research avenues this opens up for studying the topic further. For example, it is necessary to conduct a longitudinal study to follow students similar and dissimilar with the participants of this study and investigate whether their vision of mathematics changes over a longer period of time. If it does, it is worthwhile to examine why it changes and the factors contributing such changes. For example, what do these girls think they are able to do with mathematics as a tool when they go into careers that demand sophisticated knowledge and skills of mathematics? Do these students in the future think they can achieve these levels, and how can they overcome the difficulties?

It is important to reflect on what it means to be a "successful teacher" and "successful female students" of mathematics. In our study, the convenient criteria were reputation on campus, administrators' perception; school grades; enrollment status in advanced coursework. Future research and interventions should address how to help teachers like Mr. Oreo to consider other possibilities and alternatives of mathematics teaching in which students not only do school mathematics but also have opportunities to experience various ways of thinking and reasoning in mathematics and recognize the power of mathematics for investigating the world. When this line of work is more detailed and delineated, our field would be better informed to unfold the relation between the teachers' traditional classroom practice and the female students' avoidance of mathematics-related professions.

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Discussion and Reflection Enhancement (DARE) Post-Reading Questions

1. How can we begin to re-define "success" in the Mathematics classroom to include more than memorization and rule following?

2. What kind of experiences should teachers (and teacher candidates) be exposed to, to build a richer conceptualization of Mathematics for teaching?

3. What teaching approaches can help girls develop and pursue interest in STEM-related careers?

4. How can we use what we learn in this study in this particular setting, to also motivate girls of color in urban schools to pursue interest in STEM-related careers?