RELATIONAL PROBLEM-BASED LEARNING: ADOLESCENT GIRLS' EXPERIENCES WITH AN INCLUSIVE PEDAGOGY FOR MATHEMATICS

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Although the Gender Achievement Gap is closing in mathematics, the "interest gap" in pursuing STEM fields is not. One recommendation for encouraging young women to continue on in mathematical studies is to find instructional methods that allow them to feel more included in the learning process – fostering attitudes such as self-confidence, empowerment and agency. In this study, the journeys of five adolescent girls who were currently studying secondary mathematics with a pedagogical approach that sought to encourage such attitudes named Relational Problem-Based Learning (RPBL) were explored and analyzed to describe the relationship between the pedagogical approach and the girls' attitudes.

Keywords: Gender, Affect, Emotion, Beliefs, and Attitudes, Instructional Activities and Practices

In recent decades, mathematics educators have been called upon to not only change mathematics education to ensure accessibility for the diverse range of students in our culture but to allow for equitable learning environments, including changes specifically focused on underrepresented and underperforming students in our society due to gender, race/ethnicity, class or socio-economic status (SES) (Leder, 2003;McGraw, Lubienski, & Strutchens, 2006). Correspondingly, others have recognized the importance of alternative instructional methods for marginalized groups in the discipline of mathematics and ways in which they might best be served in the classroom (Gutstein, 2007; Ladson-Billings, 1995; Lubienski, 2007; Spielman, 2008). The overall goal here being to increase the number of total underrepresented students interested in continuing with future mathematical studies and increasing the diversity, both in people and ideas, in the field of mathematics, and STEM (Science, Technology, Engineering and Mathematics) fields in general – creating a better field for America and the future.

It is true that for the past decade, the achievement gap in mathematics education has been closing remarkably. Females have higher grades in math and science courses in secondary schools than males, scores between male and female students on the NAEP exams have grown closer than ever (although males are still slightly higher) and the number of women choosing certain mathematics and science undergraduate majors has increased annually (Hill, Corbett, & St. Rose, 2010). However, it has also become evident that men still outnumber women in STEM fields in graduate degrees and professional work in STEM fields. In their 2010 report, *Why So Few?,* one of the American Association of University Women researchers' conclusions is that girls' achievements and interest in mathematics are "shaped by the environments around them" (Hill, Corbett, & St. Rose, 2010). For girls especially, it seems the mathematics classroom environment has a great influence on their attitudes towards learning and it is greatly affected by the relationships and beliefs that are forged in those classrooms. Ideally, the instructional methods that are used would allow all students, regardless of gender, race/ethnicity or SES, the safe, secure space to build those relationships and beliefs that would make their learning experience optimal. Therefore, it should be a goal of mathematics educators to find instructional approaches that satisfy the relational needs of a diverse group of learners. However, given the

Martinez, M. & Castro Superfine, A (Eds.). (2013). *Proceedings of the 35th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Chicago, IL: University of Illinois at Chicago.

inequities that persist in STEM fields and the problems that exist in retaining women in STEM careers, it remains of crucial importance to examine girls' learning and paths to STEM fields of work and study.

In this qualitative study, I investigated the attitudes of adolescent girls who experienced one such instructional approach designed to satisfy these relational needs of many types of learners. Based on a fundamental theory of interhuman connection of learning, a problem-based learning classroom at the secondary level was found in which one sub-population of underrepresented students (adolescent girls) experienced mathematics in an alternate learning environment. Specifically, I desired to explore the five attitudes of enjoyment, self-confidence, value, empowerment and agency towards learning mathematics and the mathematics classroom. I addressed the following research question:

> What is the nature of the relationship between girls' attitudes towards mathematics and their learning of mathematics during and after experiencing it in an Relational Problem-Based Learning (RPBL) environment? How do they describe their experiences?

Theoretical Framework

To situate this study, and hence my own framework for mathematics education, I must put forth the following two premises as stated by Burton (2002):

- Learning in the mathematics classroom is social, not individual
- Coming to know mathematics depends upon active participation in the enterprises so valued in that community of mathematics practice that they are accepted within that community

Within this view, mathematics knowledge is understood to be constructed within the classroom community in which it exists and a learner "knows" mathematics based on the values that are prescribed within that community. Further, and in contrast to a more traditional view of learning mathematics, I situate mathematical learning, and learning in general, within the context of the greater relational approach to knowing – where "knowers are social beings-in-relation-to-others", and these relationships must be built on respect and care, not oppression and power (Thayer-Bacon, 2004). According to this view, education has a relational character and it is just that relationship between the teacher and the student, and even possibly the student and her classmates, that affords the community the opportunity for the interaction in education (Biesta, 2004). The task then is to craft a pedagogical framework for mathematics instruction that facilitates relational learning and construction of knowledge and it should incorporate the ideologies that enable as many students as possible the freedom to create those connections and relationships.

A Pedagogy of Feminist Relation

My theoretical framework , which includes relational trust (Bryk & Schneider, 2003; Raider-Roth, 2005), relational authority (Bingham, 2004), relational equity (Boaler,2008), voice and agency (Taylor & Robinson, 2009), has at its roots what was historically known as Feminist Mathematics Pedagogy, stemming from the gender difference movement of the '90's (Becker, 1995; Boaler, 1997; Burton, 1995; Solar, 1995; Willis, 1996). The intersections and overlaps of these constructs are not coincidental and therefore, I cannot ignore the feminist influence which initiated the concept of valuing learning from a humanistic standpoint and appreciating

individual differences and voices within the mathematics classroom. Solar (1995) posited an inclusive pedagogy based on a postmodern epistemology and identified concrete attributes that characterized the "four dialectical aspects" of feminist pedagogy : (a) passivity and active participation, (b) silence and speech, (c) omission and inclusion, and (d) powerlessness and empowerment. The framework is also corroborated by another model of a feminist mathematics classroom (Anderson, 2005) in which empowerment, agency, development of authority, valuing of intuition, and honoring of voices were key components. The characteristics described in both of these models are consistent with the main tenets of postmodern feminist epistemology that resists dichotomous thinking and focuses on subjective thought and multiple perspectives (Hesse-Biber & Leavy, 2007). Further, it is well known that most traditional pedagogies in mathematics include process-driven and rather objective perspectives of mathematics which create "environments in which most students surrender agency in order to follow predetermined routines" (Boaler & Greeno, 2000).

However, it is important to point out the focus on the humanistic and inclusive aspect of the feminist pedagogy and not the dichotomous "feminine" view on learning. At one point in educational theory this concept of "connectedness" was specifically formalized to support women's and girls' ways of knowing and learning, and specifically in mathematics education (Becker, 1995; Belenky, Clinchy, Goldberger, & Tarule, 1986). However, more recently opponents of gender difference theory in mathematics education promote an "unfixing" of the differences "to see mathematics as an opportunity to develop relations with others and re-make themselves" (Mendick, 2005b). Mendick goes on to say that

> By aligning separate-ness with masculinity and connected-ness with femininity, these approaches feed the oppositional binary patterning of our thinking and in the final analysis reiterate it (p 163).

Supporters of this more humanizing approach to the multiplicities of student relationships with mathematics agree that rethinking gender differences in a larger framework would benefit both boys and girls. It may be possible to do this if mathematical learning were viewed in less of an oppositional way (male vs. female, objective vs. subjective, etc.) and in more of a interhuman relational way – appreciating all of the various needs of connection including being "authentic" and "feeling seen" by the other (Raider-Roth, 2005). So although this framework has its roots in and draws support from Feminist Mathematics Pedagogy based on "women's ways of knowing" it is in not fully dependent on or continually presumptive of it.

Recent interest in fostering mathematical practice standards of perseverance and reasoning through problems has motivated many teachers to investigate the instructional method often referred to as Problem- or Project-Based Learning (PBL). Originating almost thirty years ago in medical schools, PBL has made its way into secondary school classrooms because of its ability to engage students in the multi-disciplinary skills that are needed; including communication, collaboration, reasoning & sense-making (Savery, 2006). In secondary mathematics, little research has been done to date regarding the development of the use of this pedagogy, however implementing PBL in the high school classroom can have many mathematical advantages for learners (Schettino, 2011/2012). The discourse and opportunities for open-ended questioning are just some of the many characteristics of this pedagogy that has many intersections with the feminist and relational pedagogies described above.

Methods

For the purpose of this study, I have defined RPBL as an approach to curriculum and pedagogy where student learning and content material are (co)-constructed by students and teachers through mostly contextually-based problems in a discussion-based classroom where student voice, experience, and prior knowledge are valued in a non-hierarchical environment utilizing a relational pedagogy. A narrative inquiry methodology was chosen for consistency with the theoretical framework and for a relational way of viewing the student's learning experience in both a personal and social way. Because of my intense and intimate relationship with the school, students that were potential participants and the teachers in the study, it was important for me to be as transparent as possible in my research methods and to triangulate the data. I had been involved with the curriculum writing of the PBL materials, training of the teachers and instruction at the school in which the study was being conducted. To maximize validity, I constructed methods of data collection that covered many different perspectives of the student experience. The five young female participants in the study diversely represented the population of girls that were registered in the course that year ranging in age from 14-17. Figure 1 below shows the overall plan of data collection over a six month period for all participants who were adolescent girls in the second term of a year-long integrated algebra and geometry course at Greystone Academy – an independent, single-sex boarding and day school in the northeast United States.

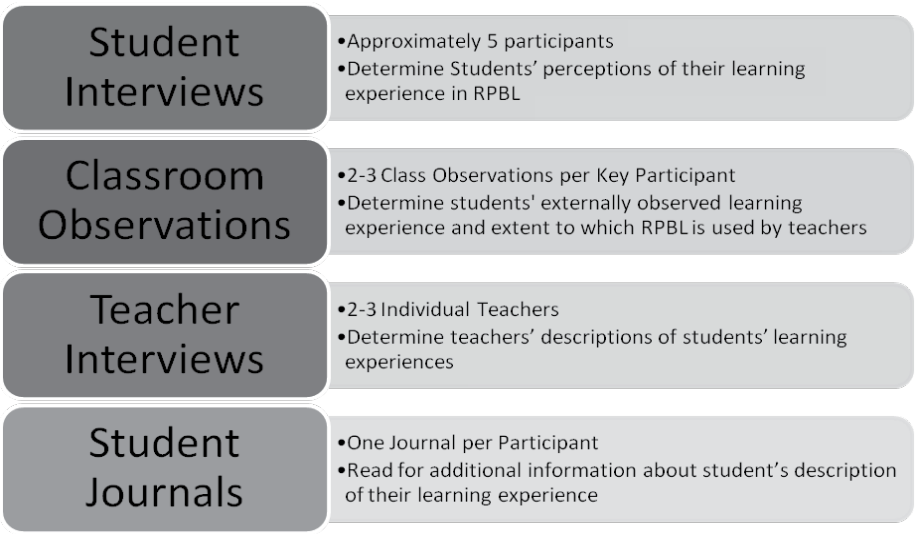

Figure 1: Summary of Purposes of Collected Data

Data Analysis: The Listening Guide

In keeping with the theoretical framework of education as a relational phenomena, I used the Listening Guide (Brown & Gilligan, 1991, 1992; Gilligan, Spencer, Weinberg, & Bertsch, 2003), a voice-centered, relational approach to narrative data analysis. With this method, a researcher employs multiple readings – or "listenings" - of interview transcripts, in each reading a different perspective of the participant's voice is identified and "listened for" (Doucet & Mauthner, 2008) because one's discourse has multiple layers. "I-Poem"s are "written" from first and second-person pronoun phrases from interview transcripts. One researcher stated that the "I-Poem" attends to an associative stream of consciousness carried by the first person voice running through a narrative, rather than being contained by the full structure of sentences" (Kiegelmann, 2009, p.77). In other words, the I-Poem allows you to see a secondary structure to the story that

is brought out by focusing on only the pronouns and how the participants is describing her experience through those voices alone. After creating and coding the I-Poems, they would start showing patterns of alternating voices, but in the third or fourth listenings, you could actually *hear* the voices in tension with each other. The themes of these poems and the poems themselves were member-checked with the participants for accuracy and meaning.

Results and Discussion

Listening to the stories of these five girls, speaking with their teachers (of whom I was one) and reading through their journals allowed me to get an intimate and full portrait of their complex experience not only within the classroom, but of their relationship with mathematics presently but from their past as well. Each girl had different experiences from their past, but it was clear, and probably not surprising, that those past experiences had ramifications on their attitudes at the present. Table 1 shows a summary of the students' varied characteristics and interests in mathematics, as well as their abilities.

Table 1: Student Participant Information

Name	Leona	Isabelle	Kacey	Sarah	Alanna
Grade	10	9	10	9	9
Teacher	(Author)	Johnson	(Author)	Brown	(Author)
Race	White	Mixed	White	White	African-American
SES	Upper	Middle	Middle	Upper Middle	Lower
Ability	Low	Middle	Low	Middle	High
Interest	Low	Medium	High	Low	Low
Boarder/Day	Boarder	Boarder	Boarder	Day	Day

The Listening Guide allowed me to code each of the pieces of data for different aspects of their stories. Their I-Poems gave descriptions with their voices both from the first and second person standpoint giving perspectives on the five attitudes that helped complete the pictures that the plot listening outlined. Although in different ways, each girl attributed some positive change in their attitudes towards learning mathematics to some characteristic of the pedagogy of the RPBL environment.

For example, Sarah, Leona and Alanna had all had prior experiences where they had not been asked to inquire in mathematics. However, when exposed to that type of thinking, they did enjoy it, especially in a relational way. Leona's innate talents of communication and debate made her a natural for discussion and when she realized she could apply this to mathematics class, it became much more fun and comfortable. Once Sarah was encouraged to follow her natural sense of inquiry and extension questions, she enjoyed being valued for those skills. Alanna needed to know that her high intelligence was of use in a problem-based classroom by allowing her independence to work for the class instead of being a distraction in a direct-instruction classroom.

With respect to confidence, the only girl in the study who was of high mathematical ability was Alanna and she claimed to have strong self-confidence ("I was never not confident"), but

would also claim inconsistently her fear of some types of mathematics. So even in a girl with high ability, there was some residual feeling of uncertainty or cultural norm that she wasn't supposed to feel secure in her skills in mathematics. The other girls grew in their concept of self-confidence throughout the year to different places, but their sense of strength seemed to stem from their experiences relating to their peers in the classroom. The more the internal process of learning was made external by discussion, problem presentations, verbal questioning and answering by students, the more they were able to "see" that process unfolding and being constructed and feel more confidence that everyone was on the same page, or least that it was out in the open. Kacey's confidence, which was such an integral part of who she is, allowed her to make the most of the relational aspect of this course. She questioned freely, conjectured regularly and took risks openly in almost every class. It was extremely natural for her and she showed others how to "do mathematics" in many ways.

The girls' sense of empowerment seemed to change by viewing mathematics through a lens of multiple perspectives, valued inquiry and connection to prior knowledge. All girls expressed appreciation for the opportunities to look at problems from multiple solution methods that originated with student presentations. One of Alanna's I-Poems moved from the second person disassociative "you" voice towards the first person, showing more ownership for her learning in the class.

more opportunity for you to affect your own learning
you get another idea
you just do it
you see something
you notice things for yourself

I like to see it
I notice things for myself
I have a better grasp
I'm just learning
I'm just that person
I think
I think I'm that independent
I want to learn it for myself

Agency was viewed differently by many of the girls depending on how much agency they had come to this RPBL class with initially. All of the girls' views of the five attitudes that were triangulated with their teachers' comments, my classroom observations and their journal writings are summarized in table 2.

The RPBL Framework

From the stories these girls told I could draw conclusions about certain aspects of the RPBL that connected to each of their attitudes, as they mentioned them over and over. The tenets of RPBL pedagogy that coincided most often with the codings from the girls' stories were: 1) Connected Curriculum 2) Justification not Prescription 3) Ownership of Knowledge Production and 4) Shared Authority. It is imperative that the curriculum used be based on scaffolded problems that are decompartmentalized such that students can appreciate the connected nature of the mathematics they are learning. The instructor also needs to set a culture of a natural focus on "why" in solutions and foster inquiry with interesting questions that value curiosity and assess creativity. The whole classroom community and structure needs to encourage individual and

group ownership by the use of journals, student presentations, extension questions, teacher wait time, and other discourse moves. The purposeful dissolution of any authoritarian hierarchy with deliberate discourse moves to improve equity and send the message of valuing risk-taking and all ideas will created a sense of shared authority.

Table 2: Cross-Student Comparison of Five Attitudes in Learning

Student	*Relationship with Enjoyment*	*Concept of Self-Confidence*	*Vision of Value*	*Realization of Empowerment*	*Journey towards Agency*
Sarah	With support and praise, surprisingly enjoyable when allowed to follow her own inquiry	Still developing, mending the damage of comparison, competition and silence	Math is more of a tool for science, but problem solving is a life skill that is valuable	Realized strong voice of inquiry for extension questions, leadership skills and ability to take risks	Still dependent on teacher for validation, but strong increase in independence and interdependence in directing learning
Leona	Enjoyment comes from deeper understanding, reasoning – knowing the "why" and communicating	Improvement because the class played on her strengths of communication and relational skills	Math is 'something you must do', but the problem solving skills help in other disciplines	Strong newfound sense of her own voice in the classroom, but grappling with her power in her learning	Relational nature helped bring out her own agency in learning, appreciated multiple perspectives immensely
Isabelle	Views problem solving as fun, like doing a puzzle, enjoys relating others by helping and being helped	Sense of confidence not necessarily related to mathematics, but gave her an advantage in discussion and risk-taking	Sees the relevance of big picture problem solving or calculation skills, but does not see its necessity	Realized the possibility of the subjective nature of mathematics and how voicing her own ideas and/or listening to others added to the learning experience	Students can be more agentic because their understanding is "out in the open" - no one "keeping up appearances of understanding since they are constantly questioning
Alanna	Pride, satisfaction and fulfillment from accomplishing learning independently, in her way and above her expectations	Confidence in her ability remained constant, but concept of self as a student changed drastically (see empowerment and agency)	Mathematics is a worthwhile subject to study, but the class was always boring until RPBL	Being an independent learner doesn't mean working alone, it means collaborating with your peers and building knowledge together.	Seeing things with "her own eyes" is more meaningful than "being told" by a teacher, found appreciation for agency in her learning
Kacey	Enjoyment flourished even though her achievement did not	Initial strength did not wane and allowed for risk-taking and sustained inquiry	Mathematics value is in its "beauty" not necessarily in its everyday usefulness or applications	Grows from a individual and group sense of ownership of knowledge that is co-constructed, stems from connections made through the problems	Juggled balance between independence and interdependence in her learning – but the agency and direction in learning came from her and her peers.

Implications for Future Research

Because of the positive nature of the experiences of these girls in relation to mathematics and the mathematics classroom, it would be wise to do a larger scale study on these attitudes with respect to RPBL pre- and post- classroom intervention. Clearly, no intent of generalizability is implied from the narrative inquiry, only obtaining a rich description of their experiences in the hope of understanding it and their perspective of it better. However, should further research find that RPBL is an effective means by which girls' attitudes towards learning mathematics can be improved a great deal of professional development will be needed for teachers as well as curriculum work and support. All of which will need to be assessed for effectiveness and delivery within the classroom potentially for underrepresented groups of all students.

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