Transactional Writing and Its Effect on Student Attitudes and Understandings in the Middle School Mathematics Classroom

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Abstract: *The focus of the research design set forth in this proposal is to perform a pilot study to test the validity and credibility of the instruments used during data collection while assessing the effect of incorporating writing into the mathematics curriculum. There have been many proponents of writing across the curriculum and much research done within the various disciplines. However, the research dealing with the integration of writing into domains other than the traditional Language Arts/English curriculum tends to focus on student achievement. This research design proposes to investigate, through mixed methods, the effect that writing has on students' attitudes towards mathematics and their desire to increase their understanding. Although student performance is not a dependent variable in this study, it has been linked to students' attitudes towards mathematics; therefore students' grades will be used as a categorical independent variable. A control group will also be used to provide credibility to the findings of the study. This study will be comprised of a pre- and post-test of Attitudes Toward Mathematics Inventory as well as student and teacher interviews, observations and artifacts to develop an outcome of the investigation.*

Keywords: *writing, mathematics, students, attitudes, perceptions, mixed methods*

There have been many advances in education during the past century including a major focus on incorporating writing in all content areas, not just Language Arts or English classes.

This research will focus on the incorporation of writing into the mathematics curriculum as a means to improve students' attitudes about mathematics as well as increase their desire to understand the mathematics. Botstein (1989) believes incorporating writing into the mathematics curriculum "is essential to developing curiosity and comprehension in the learner" (p. xiv). Writing also allows students to put learned ideas into their own words, thus creating an understanding more meaningful to them (Botstein, 1989).

It has been my experience as a mathematics educator that many negative attitudes expressed by middle school students about mathematics arise as a result of incomplete understanding or misconceptions established in earlier grades. The incomplete understanding and misconceptions go unnoticed and therefore unaddressed because they often are difficult to identify directly in student work or common class discussions. Through writing, students are able to respond to questions/problems in a manner more comfortable for them than speaking in front of classmates, which can make them feel "dumb." When the writing is assessed, misunderstandings or gaps in understanding can found. These issues can then be addressed with students through class discussions (without focusing attention on the students in need) that allow students to learn from one another (Folkson, 1996) or in a one-on-one environment.

Langer and Applebee (1987) state "…the act of writing facilitates a logical, linear presentation of ideas, and to the permanence of writing (as opposed to the fleeting nature of talk), permitting reflection upon and review of what has been written" (p. 3). It is the ability for students to present their ideas logically and linearly that allows teachers to follow their line of thought and help them with misunderstandings or fill in the "gaps" in their understanding (Langer & Applebee, 1987). However, this is not the only type of writing that students should partake in. Connelly (1989) believes incorporating unstructured writing into the curriculum is

just as important to the learning process as structured writing. The types of writing students engage in can be varied (Langer & Applebee, 1987), and should be, so all learners have the opportunity to successfully acquire mathematical understanding.

There are two main forms of writing – expressive and transactional. My research will focus on transactional writing which is intended to "inform, persuade, or instruct" (Rose, 1989, p. 16), whereas expressive writing is informal (e.g., freewriting) and often written for the self and not for others to read (Panici & McKee, 1995). In order for students to write transactional pieces they must possess basic knowledge about mathematics that can be incorporated into their persuasive arguments, informational articles, or instructions to others. Teachers will be more capable of finding strengths and gaps, in students' abilities by reading their transactional writing pieces, than by reading expressive pieces. There are many types of transactional writing (e.g., reflections on problem-solving processes, questions about specific problems), but my research will focus solely on students' questions created during homework and their responses to weekly word problems. These two types of writing fit the criteria of transactional writing as the students will be required to write in response to a specific issue, thus creating a structured form of writing with an end purpose - to inform the teacher of their strengths and weaknesses in understanding the subject matter.

When a student creates questions while completing a homework assignment of any type, they are vocalizing their misunderstandings (Rose, 1989). Having the ability to write about misunderstandings is part of the process of learning and this can be done with two column entries (splitting a piece of paper into two columns – one for problem solving and one for questions) or through journal entries (students create entries about the lesson of the day and/or homework problems). The questions written by the students can be procedural ("How do I add fractions?")

or conceptual ("How does knowing the area of a square help you find its perimeter?"). The main objective is to have the students write any/all questions they have during the completion of math homework and/or classwork.

Many students struggle when presented with word problems and other math homework. Their struggles can vary from not understanding what is being asked to not knowing which math strategy (or formula) to apply to the problem; I conjecture this constant struggling creates negative attitudes about the mathematics being applied. Here writing becomes a tool for problem-solving. Students can rewrite problems into their own words, or break it down into parts. Students can then write about the process of solving *while* solving the problem. This form of writing becomes reflective as students re-read their entries and also helps them to gain understanding. Writing about word problems, and reflecting upon them, allows students to tie their learning to previously learned concepts as well as facilitating the act of finding, and correcting, their own mistakes (Marwine, 1989). Kenyon (1989) writes "[a]s students write down, reflect on, and react to their thoughts and ideas, they enhance the executive problem-solving abilities, and the problem-solving process becomes more effective" (p. 77). The most important fact about this type of writing is that there is always something to write about; even if the student does not know how to answer the problem they can still write about what they know (the given information), what they need to know (what the question is asking), and what information they feel is needed to solve the problem (Berlinghoff, 1989). With this type of writing, all students become capable and able to complete their assignments. Even if a student is unsure of how to apply a mathematical concept, they can write about the problem and their misunderstandings before becoming frustrated.

By adding writing components in the classroom, students will be better able to assess their strengths and weaknesses and may be more apt to state their misconceptions since they can be written and not orally stated. As students solve various problems in math they will make real-world connections which will provide evidence of future use. Student often ask, "When are we ever gonna use this?" This statement will be silenced through the students' writings and improved understanding of concepts.

The question that will guide this research is "how does incorporating writing in the middle school mathematics curriculum affect students' attitudes, if at all, towards mathematics and desire to increase their understanding?" I will answer this overarching question through the following sub-questions:

- How do students feel writing aids their mathematical understanding?
- How are students' attitudes about mathematics changed through the incorporation of writing?
- How are students' understandings of mathematics affected by writing? How does this understanding enable students to find math useful for future career goals?

Theoretical Perspective

Since I will investigate students' attitudes towards math, their increased understanding, and how that understanding influences their knowledge of future use, it is necessary to understand how attitudes and perceptions affect understanding. I will be using aspects of self-perception theory, as well as attitude theory. My research also investigates whether or not writing is correlated to the students' change in attitude and perception, if a change exists. For this reason, I am incorporating aspects of Vygotsky's sociocultural constructivist theory and Paul Connelly's

writing theory. I intend to show how these four theories merge to create a critical lens through which I can accurately analyze the collected data.

When a student claims, "I hate math!" or "I am not good at math!" it is our job as educators to determine why the student feels this way. This is the basis for self-perception theory. Why do these students perceive mathematics in that manner? The Merriam-Webster dictionary defines self-perception as the perception of oneself (Self-perception, 2011) and perception as a mental image or a capacity for comprehension (Perception, 2011) . Putting both of these definitions together in the realm of mathematics gives a working definition of self-perception as the mental image of oneself while performing mathematics or one's capacity to comprehend mathematics.

Bem (1972) states "the most important clues to an individual's inner states are found in his behavior. When we want to see how a person feels, we look to see how he acts" (p. 5). Bem (1972) continues to refer to students' self-perceptions when stating "the individual's own behavior will be used by him as a source of evidence for his…attitudes" (p. 8). This is most evident when a student continually fails to grasp a solid understanding of math concepts at the same rate as their classmates. This can lead to the student feeling inferior or "bad at math." Bem (1972) also believes it is possible to alter one's self-perception by "manipulating his behavior and apparent controlling variables appropriately" (p. 37). In this study, the student's behavior (e.g., mannerisms, facial expressions, engagement) will be observed with the controlled variable being inclusion of writing into the curriculum. When students no longer perceive themselves as incapable of learning math and understand the future uses of their learning they will alter their attitude to reflect the change in perception (Bem, 1972).

Attitudes are comprised of an affective component, like or dislike, and a cognitive component, perception or belief (Katz, 1960), thus creating the link between self-perception and attitude. For instance, if you feel math is useless then you will have a negative attitude towards learning mathematics and if you do not feel confident in math and have a bad attitude towards math you will not see a use for it in your future. Due to this interrelatedness it is important to include attitude theory in my critical lens. Katz (1960) defines attitude as "the predisposition of the individual to evaluate some symbol or object or aspect of his world in a favorable or unfavorable manner" (p.168). Attitudes are created by a students' perception of their environment and can be positive or negative, exist in varying degrees, and in a person's commitment to retain the specific attitude (Simonson & Maushak, 2001). Katz (1960) believes attitudes perform a function for the student to prevent them from embarrassment due to lack of understanding. "Attempts to change attitudes can be directed primarily at the belief component or at the feeling, or affective component" (Katz, 1960, p. 169); this study will determine if transactional writing activities can change student attitudes. As students' negative attitudes towards mathematics no longer serve the need of protecting them from others' opinions they begin to alter their attitudes (Katz, 1960).

Vygotsky's sociocultural constructivist theory is based on the premise that individuals construct their knowledge by working in their zone of proximal development (ZPD), with or without scaffolding from others more knowledgeable about the concepts being constructed ("Overview of Social Constructivism", n.d.). At times, the writing the students may undertake can be challenging and requires assistance from other class members and/or the teacher. Through these social interactions students are able to construct their knowledge and reflect upon it in their writing. However, the writing process alone, without the social interaction, can also scaffold a

student's understanding of the mathematical concepts. In the very least, it allows students to write about their feelings of the math and provides an avenue to voice their understanding or confusion.

Connolly's (1989) writing to learn theory focuses on writing that possesses little-to-no structure, is impromptu, and allows students to explain their thinking processes informally. This form of writing affords students the freedom to be less than stellar math students, but still find enjoyment in expressing themselves as individual learners. This freedom allows struggling math students to apply their strengths, which could be from other content areas, to increase their mathematical knowledge.

Figure 1 depicts how the four theories are relevant to one another and creates a more understandable merging of the influences on student attitudes and perceptions.

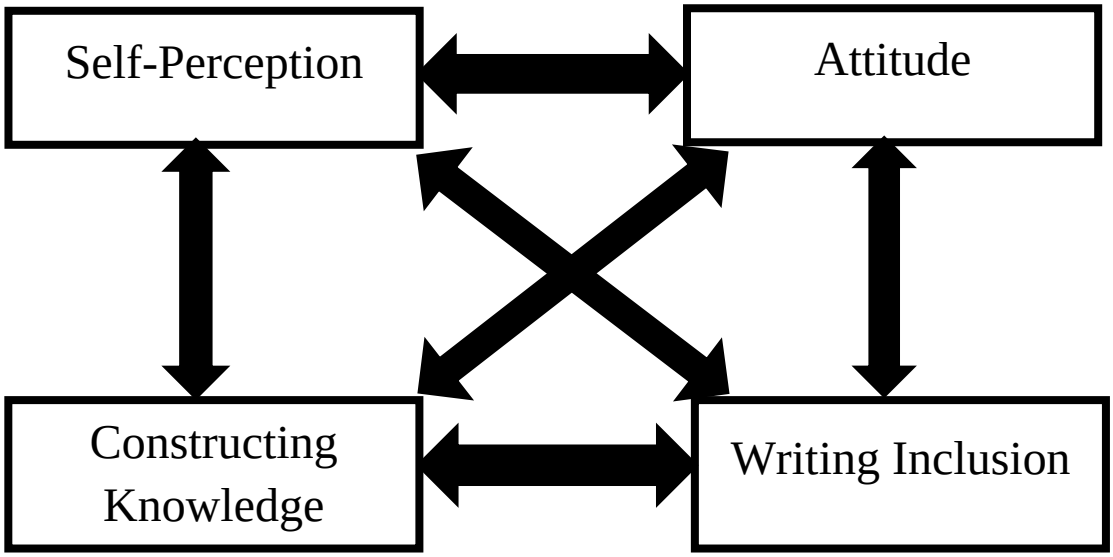

Figure 1: A model representing the interconnectedness of the theoretical perspectives.

Review of Literature

For many decades mathematical knowledge has been built upon numbers, letters (variables), and formulas. However, a true understanding of mathematics is not compromised by those facets alone. We have all seen textbooks, and although they include numbers, letters, and formulas, those letters are grouped into words that must be read and understood. Many of the words are related to mathematical vocabulary, which is an important aspect of attaining mathematical understanding. Not only should students understand the vocabulary of mathematics, but they also need to be able to gain conceptual knowledge, be able to reason, and should be able to reflect and represent their ideas (Draper, 2002; NCTM, 1991, 2000; Smith III, 1996, etc.; as cited in Huang & Normandia, 2009).

It is important for students to understand the *language of mathematics*, which will be strengthened through reading, writing, and speaking mathematically. Many individuals view mathematical language as verbiage used in math classes only; however, learning the language of mathematics can be, and often is, as difficult as learning a foreign language since it possesses many of the components of language – it is necessary for communication, provides information to describe and form concepts, and is unique (Usiskin, 1996). In addition, the language of mathematics can be written, spoken, read, and represented pictorially; it can also be considered a foreign, abstract, or native language (Usiskin, 1996) implying that to understand the language of mathematics, it must be learned through use, just as one would learn the languages of French or Spanish.

Many studies have been completed with results showing that "reflection and communication are the key processes in building understanding" (Hiebert et. al, 1996; MacGregor & Price, 1999; Mancouchehri & Enderson, 1999; Monroe, 1996; Warfiel, 2003; etc.; as cited in Huang & Normandia, 2009, p.2). Writing in mathematics allows students to reflect on their work

and is a form of communication allowing all students a voice. This is especially important for students who are shy or insecure about their abilities and, therefore, do not freely share their thoughts during class discussions or private conversations with the teacher.

Waywood (1992) states "mathematics is richer than a collection of algorithms, and writing must be a contender for a way of accessing this richness" (Journal writing and learning mathematics, p. 35). It is for this reason that writing should be as pertinent to mathematical understanding as the concepts being taught (e.g., area formula, multiplication facts). It has been shown in the field of education that in order for students to be able to teach classmates a concept they must first understand the concept themselves. Incorporating writing into the curriculum is another format for students to prove their understanding and teach others. I have had many instances in which I have asked a student, "How did you solve that problem?" only to receive the response "I don't know, I just did it." By having students write about their solutions they are not only reflecting, but critically thinking about their process of problem-solving. Phillips (1996) believes in addition to the experience of learning and understanding mathematics, writing about mathematics also allows them students to create mathematics in an understandable manner.

I believe when students are introduced to writing in mathematics at a young age (i.e, kindergarten) and this writing continues through every level, the students will benefit immensely. This continuity of writing will allow students to associate new ideas with previously acquired knowledge (Cooley, 2002) and will benefit the students as they progress into more complex levels of mathematics. One of the most important facets of incorporating writing into the mathematics curriculum is the metacognition required by the students as they reflect upon their problem-solving processes. Schoenfeld refers to metacognition as "knowledge about one's thought processes, [and] self-regulation during problem solving" (Schoenfeld, 1992, p. 332). In

order for learning, and writing, to be effective it is necessary for students to be reflective (Cooley, 2002) and it is this reflection that will promote learning, understanding, and improve student attitudes and perceptions.

Design

This study will incorporate mixed methods by merging both a phenomenological embedded case study and a quantitative measure of students' attitudes. The phenomenon to be studied is the incorporation of writing in the mathematics curriculum. The case will be one urban middle school math class and the embedded cases will be three students from the class, chosen purposely – a typical case, and two extreme, or deviant, cases to ensure maximum variation (Patton, 2002). I will choose either a seventh grade class or an eighth grade class from an urban school. I have decided to choose a middle school math class, as I feel it is important to create positive attitudes and understandings about mathematics at this level to ensure success in higher level math courses, and from an urban setting where I feel the need for attitude and understanding improvement is the greatest (Hannula, 2002; Ukpokodu, 2011).

The choice made for the cases, including the embedded cases, are a form of purposeful sampling, which will provide a wide array of data. This study will follow a pre-test, post-test format using the *Attitudes Toward Mathematics Inventory* (ATMI - see Appendix A) created by Martha Tapia in 1996. This part of the study will be quantitative as the letters will be given numerical values and analyzed using correlation coefficients and chi squared test. Student grades both pre- and post- writing intervention will be analyzed to determine if there is improvement. Student grades (received at the same time period as the experimental group) will also be evaluated from a control group of similar abilities taught by the same teacher to assess if/why differences in the results exist to further provide validity to the data. The remainder of the study will utilize

qualitative methods by analyzing the following data collection processes for emerging themes: interviews, observations, and artifacts. After compiling data from each case, it will be analyzed as individual cases as well as multiple cases using cross-case analysis techniques (Yin, 2009). The conclusions drawn from the data will be triangulated to ensure the reliability and validity of the study's conclusions since they will arise from different sources (Yin, 2009).

Data Collection

Protocols

Data will be collected through a three-interview process, a process that allows data to be collected in a contextual manner (Seidman, 2006), with the teacher and students (three students, three interviews each) chosen for participation in the study. All students in the chosen class will complete the ATMI, and the three embedded case studies will be chosen from the students who consent to be interviewed for the study. The first student interviews will focus on their self-reported mathematical abilities, feelings toward mathematics, beliefs of the importance of mathematical understanding for their future lives, and their feelings about incorporating writing in math. It is important to understand how the students feel about the above-mentioned factors at the beginning of the study in order to adequately interpret if changes in attitudes and understandings are positive, negative, or non-existent. The questions for the first interviews can be found in Appendix B. The second interview will produce data about the students' experiences in mathematics since the incorporation of writing into the curriculum, and the final interview (to be held at the end of the first semester of the school year) will focus on a reflection of the students' experiences throughout the semester and effects the inclusion of writing in the mathematics curriculum had, or did not have, on their attitudes and understandings (questions for the second and third interview will be created in response to artifacts and observations).

The teacher interviews will follow a similar design with the first interview focusing on general information about each teacher's curriculum and the integration of writing in mathematics. It is important to find educators who currently integrate writing in their curriculum or are willing to adopt into their curriculum a form of writing; if writing is not incorporated and no plans are made to begin incorporating writing I will not be able to collect relevant data for my research. The initial teacher interview questions can be found in Appendix C. The second interview will focus on the experiences of the teacher, as well as, student experiences noticed by the teacher. The final interview will be a reflection of the effect of the curriculum on students' attitudes and perceptions as witnessed and interpreted by the teacher.

The interviews will be conducted as a conversation to allow the interviewee an opportunity to guide the direction of the interview, as well as to provide a friendly, amicable atmosphere during the interview (Rubin & Rubin, 2005). This type of interview allows the interviewee and the interviewer to each possess an active role in the interview process and recognizes the individuality of each interviewee (Rubin & Rubin, 2005). In this type of interview the questions are phrased uniquely for each interviewee, therefore the interview questions represented in Appendix B and Appendix C are guiding questions which may be rephrased as necessary.

In addition to the interviews, class observations will be conducted once per week (minimally) throughout the semester to observe students' behaviors and artifacts (e.g., posed question responses, homework, classwork, etc.) will be collected periodically during the duration of the study. Since this is a pilot study, I will follow these classes for one entire school semester to properly interpret the students' attitudes and perceptions as they relate to the research question from which this study is based (I expect my final study to encompass an entire school year).

The classes will be observed to determine if there is an increase in student participation among the various students or if only a small number of students are vocal during class. The class observations will also allow me to determine the amount of scaffolding and instruction given to the students from the teacher, as well as, the amount of group work, group discussion, and student-student scaffolding that occurs. The classroom observations and periodical collection of artifacts will aid in question generation in preparation for the second and third interviews.

The interviews and classroom observations will be audio recorded to ensure accuracy of the interview responses and class discussions during transcription and analyzing. In addition, the interviews and classroom observations will be video recorded to observe body language during the interview to aid in data interpretation. Any members of the class who do not have parental permission to participate, or refuse assent, will not be video recorded during class observations.

I will begin the study by contacting the chosen school district to ask for permission to complete my study in their school; it is from speaking with the administration that I plan to elicit a teacher who is willing to participate in my study. I hope to contact the teacher prior to the start of the school year to meet with them informally to gain knowledge of their teaching philosophies, which will be important to understand while observing their class. I hope to meet with the class within the first two weeks of school solely for the purpose of introducing myself, my anticipated research, and to distribute parental consent forms (student assent forms will be completed after parental consent has been granted and prior to any interviews or class observations).

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Appendix A

ATTITUDES TOWARD MATHEMATICS INVENTORY

Name _____ *School* _____

Teacher _____

Directions: This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Enter the letter that most closely corresponds to how each statement best describes your feelings. Please answer every question.

PLEASE USE THESE RESPONSE CODES:

A – Strongly Disagree
B – Disagree
C – Neutral
D – Agree
E – Strongly Agree

1.	Mathematics is a very worthwhile and necessary subject.	
2.	I want to develop my mathematical skills.	
3.	I get a great deal of satisfaction out of solving a mathematics problem.	
4.	Mathematics helps develop the mind and teaches a person to think.	
5.	Mathematics is important in everyday life.	
6.	Mathematics is one of the most important subjects for people to study.	
7.	High school math courses would be very helpful no matter what I decide to study.	
8.	I can think of many ways that I use math outside of school.	
9.	Mathematics is one of my most dreaded subjects.	
10.	My mind goes blank and I am unable to think clearly when working with mathematics.	
11.	Studying mathematics makes me feel nervous.	
12.	Mathematics makes me feel uncomfortable.	
13.	I am always under a terrible strain in a math class.	
14.	When I hear the word mathematics, I have a feeling of dislike.	
15.	It makes me nervous to even think about having to do a mathematics problem.	
16.	Mathematics does not scare me at all.	
17.	I have a lot of self-confidence when it comes to mathematics.	
18.	I am able to solve mathematics problems without too much difficulty.	
19.	I expect to do fairly well in any math class I take.	
20.	I am always confused in my mathematics class.	
21.	I feel a sense of insecurity when attempting mathematics.	
22.	I learn mathematics easily.	
23.	I am confident that I could learn advanced mathematics.	
24.	I have usually enjoyed studying mathematics in school.	
25.	Mathematics is dull and boring.	
26.	I like to solve new problems in mathematics.	
27.	I would prefer to do an assignment in math than to write an essay.	
28.	I would like to avoid using mathematics in college.	
29.	I really like mathematics.	
30.	I am happier in a math class than in any other class.	
31.	Mathematics is a very interesting subject.	
32.	I am willing to take more than the required amount of mathematics.	
33.	I plan to take as much mathematics as I can during my education.	
34.	The challenge of math appeals to me.	
35.	I think studying advanced mathematics is useful.	
36.	I believe studying math helps me with problem solving in other areas.	
37.	I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.	
38.	I am comfortable answering questions in math class.	
39.	A strong math background could help me in my professional life.	
40.	I believe I am good at solving math problems.	

Appendix B

Questions for First Student Interview (may be reworded as necessary)

1) How do you feel about your mathematical abilities?

    1a) If student feels positive…What do you feel helps you find success in math?

    1b) If student feels negative…What do you feel prevents you from finding success in math?

2) Whether you are successful in math, or have trouble finding success in math, how do you feel about math as a subject area in school?

    2a) If you could change an aspect of the course, what would it be?

3) Do you feel that gaining a solid understanding of mathematics is important for daily living?

    3a) If not, what do you plan on doing when you are older? How will you react if confronted with mathematical concepts at work or in daily living?

    3b) In your opinion, why is math understanding important in daily living?

4) How would you feel if writing were part of your math class?

    4a) How would writing help you gain understanding?

    4b) How would you choose to use writing in math?

    4c) If required, how would you explain the process of solving a problem? For instance if you needed to solve $3x + 2 = 10$?

Appendix C

Questions for First Teacher Interview (may be reworded as necessary)

1) How do you currently integrate writing in your mathematics curriculum?

    1a) If not currently doing so, do you plan to at some point in the future? When?

    1b) If so, how did you decide to do so?

2) How do the students react to the writing assignments?

    2a) Have past students' attitudes changed about math when incorporating the writing?

3) How does the writing reflect the content taught in your curriculum?

4) Please describe a recent writing assignment you gave to your students?

    4a) Did you respond to your students by writing a response? If yes, how do your students react? If not, what type of feedback do you provide to your students?

5) How do your students know if/when their writing is acceptable?

    5a) How do you treat unacceptable submissions?

6) Can you tell me about any changes in students' attitudes towards math since you began incorporating writing into your curriculum?

7) How do your students react to math? What types of math related comments do you hear in or out of your classroom?