Mathematics Taking The Stage

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I am Emily Harper, a student who took a large bite out of what Georgia College had to offer her and chose to double major in mathematics and theater, with a concentration in teaching. I have been told an overwhelming amount of instances that this combination, mathematics with theater, is a surprising and strange one. While only a handful suggest that they go well together once you get over the initial strangeness.

My sights for the future are set on becoming a teacher in secondary mathematics and theater, a fate I believe brought on by the oddness of my family line since I will be the 5th generation straight to work in education. There are thoughts of becoming more involved in theatre, but most importantly my heart is set on what I want to bring to mathematics education and the students I will teach.

I have been dismayed by mathematics a variety of times, but problems in mathematics fascinate me as if they are a puzzle or creation coming to life before my eyes. Before my career as a student at Georgia College my relationship with mathematics was not always a lucrative one. If you are able to do mathematics, most people will say that it must come easy to you, but that was not my history in this field.

My decline in education was a series of rocks thrown to make a land slide. In elementary school I remember as much as any child would of their experience in the classroom. I remember, not what was written on the hand out, but how I felt while I sat in that desk. My most vivid memory is walking up to the teacher's desk to ask her a question about a math problem. Before I realize what I did wrong I was dragged in front of the board to be stared upon by my classmates while the teacher, began to berate me. I do not remember her name, but I certainly remember how she made me feel as a math student. 'Why didn't I understand?' A hard grip on my arm and

the burn of shame so scorching it scared flesh. I was humiliated for not knowing the answer and my question was never answered.

I left that school soon enough because my family moved to another state. I then switched from a private to a public school. When I arrived I was grossly behind with respect to the material being presented, and the move was a rough transition academically. As luck would have it, soon enough, my grades were on the rise, except for in math. It was thought that I did not understand the material well enough, so I was placed in an after hours, school-sponsored tutoring program. When the letter grade stubbornly refused to rise, a visit to a private math-tutoring center was added to my schedule. I gained knowledge and a passing grade but had yet to gain any confidence in learning mathematics. I remember one of the teachers in that school attempted to teach us Algebra by having the class watch a show called *Numb3rs* and then give us worksheets over what we saw. That was one of the most difficult classes for me, because if this was math done by a brilliant mind on a television show, what hope did I have of understanding it?

A change in my attitude towards mathematics did not occur until high school. I was gifted with amazing teachers who made what I was learning interesting, while keeping our activities productive. It took one class of mathematics where I felt pride and confidence to put me well on my way to becoming a math teacher. The next year I decided to drop an elective and double in math. In this class I showed my step by step process in problem solving, which the teacher rewarded by telling my classmates to study with me from now on. Although the fear of asking my teachers questions never truly faded, I found that I could actually succeed in figuring out math.

I look back on what made such a difference in my education in order to find the different techniques that made my love of teaching possible. There were still lectures, handouts, and plenty of tests with homework, but the way the teacher interacted with the classroom is what I believe made a difference. I had a teacher that introduced herself with a red pitchfork, stating that she was the evil giver of math homework. The woman was constantly cracking jokes with the students while allowing us to discuss questions with groups and then call her over for further validation. It was the first math class I ever received an A in. Afterwards there was the Algebra II teacher that donned the best tests with a custom stamp saying 'Gooder Than Grits' and the Trigonometry teacher that used a portable tablet to write questions on the promethean board so that she could write and work the problems while walking through the room, discussing with us what we should do next.

The relationship between student and teacher is what I believe makes the difference. A teacher could have the best materials but not understand how to apply them in a way to interest the students. There is the feeling of understanding that drives me to want to teach and to conduct this research. More that anything, whether I am in a math classroom or having students move across a stage, I want to see the light in a person's eyes when they realize they aren't a failure. That yes, you can learn and do anything if you take the right step, and I believe my unique areas of study are what I need to give students exactly that.

The question I chose to delve into is, if you mix theatrical aspects into a mathematics classroom, such as kinesthetics and manipuatives, would it at all affect a student's aversion to the subject.

Method of Study

For my capstone, *Mathematics Taking the Stage*, I looked to the theatre department for the students who would participate in my study. I knew that pulling from this department would give me a higher likelihood of having a group of students diverse in their opinions and experiences with math education. For my theatre capstone this semester I was the teacher's assistant to the freshmen class, Stage Craft. I discussed with my professor the possibility of using the students in an out-of-class lesson for my mathematics capstone. I was then able to secure a time and a space for my research activities. The scene shop provided ample space as well as an outdoor area for the larger activities if we chose to use it.

I used in my lesson; chalk, markers, and a large presentation board, a spool of yarn, two foam balls, and recording equipment that I rented from the library at Georgia College. With the students, space, and materials in place I was ready to begin my activity.

Quizzes

After knowing where I was going to get my volunteers, I laid out my methods with my lesson plan. compiled and adapted several surveys concerning mathphobia (Mia, 2013)(Freedman, 2009) This quiz was to be presented to the students at the very beginning of the lesson to see the predisposition towards math in the observed pool of students. The questions I ended up choosing could be rated on a level of 1 to 6 from 'does not apply at all' to 'very much applies'. The questions included were;

1. I get emotionally upset when doing or thinking about math
2. I have trouble sleeping after working on math or the night before math class or a math test

3. I feel like I have no control over my grades in math
4. I tend to do very poorly on math tests
5. I feel like I need to prepare much more for math tests than for other subjects
6. Math tests are much more stressful to me than other math tests
7. I do not feel confident taking math tests no matter how much I study
8. I feel like I will never be able to lean math no matter how hard I try
9. I find myself worrying about other peoples' math abilities and comparing them to my own
10. I have been punished or embarrassed in math class for not understanding something.

I felt that these questions, taken from sources and my own experience, properly reflected the thoughts of mathphobia, and would be able to properly gauge the students' opinions. I also created an after assessment phobia quiz to see how the students felt during the activity. It was only six questions with the prompts being closely related to the last quiz, additionally the students could rate once again on a scale of one to six. The questions were;

1. I was emotionally upset while doing this activity
2. I found the process of this activity frustrating and the math uneasy to comprehend
3. I feel if I were to participate in future lessons like this one I would feel frustrated trying to learn mathematics
4. I feel if future lessons were composed like the activity I will never be able to lean math no matter how hard I try
5. I do not feel confident learning math in the way this activity was structured
6. my life regarding mathematics was not changed at all today.

Activities

To show the students what aspects of theatre I wanted to integrate into the math classroom, I developed four activities that I felt blended the two subjects. To set up for the activities we worked on the outside area of the theatre's scene shop, a concrete paint deck used for large painting projects for the departments sets. There I used painter's tape, a 30, 60, 90 triangle, a 45, 45, 90 triangle, a bent corner iron ruler, and chalk to construct a large unit circle's axis and radians on the ground (Insert picture?). Then with an assistant I tied chalk to a piece of yarn and traced the circumference of the circle while my helper held the other end of the yarn down at the origin. I labelled the x and y axis with chalk and finally had a large unit circle to use for the activities.

The first activity was an exploration of the radians of the unit circle. Every student chose to stand on a radian and then we would divide the unit circle into 4ths, 8ths and 12ths, counting them out to understand why each radian was named the way it was. The second activity was 'Why Pi' where the students would discover why there are 2π in a unit circle. Using a piece of yarn they would measure out the radius of the circle and then see how many times they could fit the radius around the circumference of the circle. The third activity was 'When I Go to Math Class', an adapted theatre warm-up and a precursor for the last activity. In this, the student standing on the zero radian would begin the game by saying, "When I go to math class I'm bringing zero." then the next

student would say, “When I go to math class I’m bringing pi over six and zero.” The pattern would continue like this until the last student, standing on 2π would recite the circle. This was done so that students can remember who is where, and if not all radians are taken which ones are occupied.

The last game is “I Like Pi”, also an adapted theatre warm-up , a movement filled way to have the students remember where radians are in the unit circle. There is a foam ball given to a student and they begin the game by singing, “I like pi, yes I do, throw it to …!” Then the student will call out a radian and throw it to the student standing on that radian. This game in theatre is used for energy and focus, in the math classroom it is an enjoyable way to internalize where the radians are in the unit circle.

Discussions

The largest part of my methods that would give me data to work with were the interviews that went on after the activities. With the sound equipment I rented earlier in the week I held a focus group with the students, gathering their thoughts of my study and how it related to math education. The talk’s direction was designated by the students, but guided it with prompts to bring on conversation. The questions asked were;

1. The lesson I showed you today involved aspects of manipulatives (using a variety of tools to aid with teaching students. This can include anything from graphs to unit blocks to cans and strings) and kinesthetic which involves students learning through physical activity. Have you ever had lessons like this in the past?
    a. If so, did you enjoy it?
    b. If not, would you have liked to have it?

2. How would you feel if these methods were integrated into future math classes?
3. Do you feel you would have enjoyed math classes more if more of these methods were used?
4. Do you have any other suggestions of what is missing from a mathematics classroom?
5. How do you think these methods would affect the mathematics classroom?

I combined input from the students with my literature review to analyze my data and determine implications.

Literary Review

Teaching & Learning

To ensure success for all students, The National Council of Teachers of Mathematics(NCTM) recently released standards in *Principles to Actions: Ensuring Mathematical Success for All* (NCTM, 2014) focuses on the teacher in the classroom, following the belief that, "Standards do not teach; teachers teach"(Leinwand, Heinker, 2014, p.656) By focusing on teachers instead of simply standards they aim to ensure that all students are able to learn.

In the Principles to Actions the NCTM lays out guiding principles for school mathematics and teaching practices that they believe will lay the groundwork for a well-functioning classroom. They go on to explain a math program "requires effective teaching that engages students"(NCTM 2014, p.5). In Mathematics Teaching Practices they outline standards, including;

1. <u>Implement tasks that promote reasoning and problem solving:</u> Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical

reasoning and problem solving and allow multiple entry points and varied solution strategies.

2. Use and connect mathematical representations: Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving
3. Facilitate meaningful mathematical discourse: Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.
4. Pose purposeful questions: Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships. (NCTM, 2014, p. 10)

The new release of standards call for a reevaluation, pushing math educators to explore the why's and how's of mathematics. It challenges teachers to create their own models and to think about their relationship with their subject. They go on to say that with these standards, "teachers and administrators of high schools are encouraged to rethink the way the mathematics curriculum is designed" (Leinwand, Heinker, 2014, p.656).The authors Leinwand and Heinker are opening a door to new ways to teach mathematics in the classroom.

A not so new view of learning and teaching is Constructivism, "a philosophy of learning that offers a perspective on how people-all people-learn, all the time" (Clements, 1997, p. 198). Constructivism focuses more on the ideal that more knowledge is generated from interaction between experiences and ideas than being simply fed information (Daniel, 2004). This teaching philosophy focuses on the role of the teacher and how to interact with students to enable a positive learning experience. "Teaching is about weaving together knowledge about subject

matter with knowledge about children and how they learn, about the teacher's role, and about classroom life and its role in student learning"(Ball, 1990, p.12).

A theory, founded by Jean Piaget and focused on in the 1930's through the forties. It has been researched by plenty involved in math education and its ideals, focusing on the importance of communication between teacher and student can be seen in the standards put forth by the NCTM *Principles to Actions: Ensuring Mathematical Success for All* in their 2014 publication. Constructivism and teaching styles inspired by it "…suggest that teaching mathematics, even to young children may be less straightforward than it looked before" (Ball, 1990, p. 14).

The Revamp

With the new standards encouraging teachers to explore in the classroom one might wonder why introduce constructivism into the system and threaten stability? The truth is, while the NCTM were correct that the success of the classroom relies on the teacher, it also relies on how the teacher and administrators view mathematics as a whole. "Mathematics is perceived by most people, as a fixed body of knowledge" (Romberg, Kaput, 1999, p. 4). Romberg and Kaput(1999) describe the expectations for mathematics of the school systems as a "layered cake"(p.4), an ideal that has been deeply imbedded in our society. This layered cake is a way of describing the fixation of learning concepts and skills in a certain order, designed to meet the prerequisites for the next course. "This layer-cake filtering system is responsible for the unacceptably high attrition from mathematics that plagues schools" (Romberg, Kaput 1999, p. 4).

Instead of a layered system, Romberg and Kaput describe mathematics as something not fixed, but evolving. They state the layered system actually has more of a negative effect on the education of students, making mathematics appear to be "a tedious, uninteresting path to follow,

with lots of hurdles to clear – bears little resemblance to what a mathematician or user of mathematics does"(Romberg, Kaput, 1999, p. 5). Because mathematics evolves, so must the curriculum.

The truth is with the need for satisfying prerequisites there is more talking to the students and not letting them develop the meaning for themselves. Instead they are regularly taught algorithms and go on never being asked for their input. Instead of a layered system, or a linear line of thought it is can be more accurately described from nature. "Mathematics isn't a palm tree, with a single long straight trunk covered with scratchy formulas. It's a banyan tree, with many interconnected trunks and branches – a banyan tree that has grown to the size of a forest, inviting us to climb and explore" (Thurston, 1990, p. 7).

The need for exploration by the students is something Romberg and Kaput write extensively about. Stoppard's play *Arcadia* in 1993 included a mathematical biologist that spoke of the unknown and exciting future the changing of mathematics offered "The future is disorder. A

door like this has cracked open five or six times since we got up on our hind legs. It's the best possible time to be alive, when almost everything you thought you knew is wrong." A new way of thinking of mathematics is not something to fear, but an opportunity to further the acceptance and understanding of mathematics.

Listening:

A new form of education involving Constructivism does not only call for a new view of mathematics, but a new way for the teacher to perceive the classroom. A new and better way for teachers to understand their practice, this new view involves focusing on how the teacher listens to their students. Davis (1997) defines three types of listening.

The first is Evaluative Listening – a type of listening defined by searching for something particular rather than listening to the speaker. "the primary reason for listening in such mathematics classrooms tends to be rather limited and limiting"(Davis, 1997, p.359). Davis describes his forms of listening by running a study with a teacher, the evaluative listening is observed before introducing the teacher to constructivist values. In the activity Evaluative Listening was sited, there was no real purpose for the students to give their views on what was happening in the lesson. The teacher was looking for a particular answer to know that the students answered the question correctly. "In every case, she already had a "correct" answer in mind, and if those expected responses were not readily given, she often "filled in the blanks" herself" (Davis 1997, p.360). It was listening, but on a trivial level because there was no real communication between the teacher and student.

Interpretive listening was observed after Wendy, the teacher Davis was conducting the study with, was introduced to the language and ideas of constructivism. The introduction to Piaget's

theory incited a change in Wendy's teaching, "I'm beginning to see how constructivism can help me understand teaching. I should be more careful with the way I interpret what I hear students saying" (Davis 1997, p. 361). After being introduced to the ideas of constructivism. Interpretive listening was described as having opportunities for more discussion between student and teacher and, "an awareness that an active interpretation- a sort of principle that , through interaction, we can affect one another's thinking" (p. 364). The activity turned out to be more information seeking, instead of wanting the correct response from the students. But while there was more discussion taking place, there was also persisting instances of filling in the blank and searching for the correct answer from students. "Important distinguishing characteristics between conventional and constructivism- informed teaching is not to be found in the way the teacher speaks or structures her lessons…but in the manner in which he or she listens" (Davis 1997, p. 364).

The last form of listening Davis covered was Hermeneutic Listening, described as the "absence of a clearly structured format and a pre-specified set of learning outcomes…jointly exploring a mathematical issue rather than attempting to master already formulated bits of knowledge" (Davis 1997, p. 368). Hermeneutic listening came after Wendy and Davis discussed the question of why teach mathematics. With introducing listening Wendy was already finding difficulty in the realization of the needs of each individual student to be able to understand a concept, but now they researched the boundaries of the subject of mathematics. The lesson paired with this lesson incorporated asking the students to draw out what they saw in the fraction problems. There was no more pre-chosen answers for the students to reach. Wendy was a participant in the lesson and in the exploration, making the authority of the classroom more dispersed. "The mode of teaching thus seems to be more a matter of flexible response to ever-

changing circumstances than of unyielding progress toward imposed goals. The importance of listening in enabling the teacher to respond is evident" (p. 369).

Constructivism affects the way the teacher listens and reacts to the students, and therefore the structure of the classroom and lessons. Romberg and Kaput (1999) reason that "rather than just providing paper-and-pencil tasks…" classrooms need to incorporate tasks that involve the students working with each other must be provided to explore and solve problems (p. 12). There should be inventing new techniques and justifying the conclusions the students come to, developing mathematics into a more human activity. "Most important, it stresses the creation of knowledge" (Romberg, Kaput 1999, p. 7). Teachers must now listen to the students, encourage collaboration while knowing that they need to rethink what the students think. There is a need to examine what learners bring to the classroom; what they know, assume, and are inclined to do. (Ball, 1990)

Reinhart explains successful listening in the classroom as "I concluded that if my students were to ever really learn mathematics, *they* would have to do the explaining, and *I*, the listening" (2000, p. 478). Reinhart's goal is to have the students explain concepts so well that they can be understood. "Students should not only know the concepts and procedures for some parts of mathematics but also understand how mathematics is created and used" (Romberg, Kaput 1999, p. 7).

Reinhart's (2000) goal was to teach in nontraditional ways motivated by the research he and colleagues gathered. Romberg and Kaput (1999) shared their own opinion of the education system by stating "Traditional school mathematics appears thin, lifeless, and isolated" (p. 7). The

authors go on to state that traditional teaching of mathematics has not enabled students to learn with understanding and the first step to change this must be to redefine the system we have.

The problem with the traditional practices is that while children need to be self-reliant by deciding what makes sense and what doesn't (Kamii, Housman, 2000) when the teacher says an answer is correct, thinking in the classroom stops because there is no reason to think anymore (Ball, 1990). When math teachers in Ball's class were asked to describe problems they had this reaction "However when I had to explain how I *understood* the problem, I could not. I was merely a victim of rules and procedures" (1990, p. 14). If the teacher is simply looking for an answer thinking amongst the students is not fostered. Instead if the teacher expresses no opinion students are then motivated to continue thinking and explore the concept (Kamii, Housman 2000). This motivation will incite the students to find new ways of solving the problem, and coming to a fuller understanding what they're learning.

Questions to ask the classroom in these circumstances are; "What does the question ask?" "Would it help to read the problem again?" Note that the teacher is asking questions, and it is up to the child to decide whether a suggestion is worth taking" (Kamii, Housman, 2000, p. 201). In this way there is not one way of getting an answer and is opening the door to seeing math as less rigid of a subject and more flexible. (Ball, 1990) "It is risky business to foster the kind of conceptual change that Petrie[1981] describes, for it entails changes in the meanings, ways of seeing, and ways of acting, but within a very familiar world. The old world view is comfortingly just around the corner should the new one prove inadequate" (Ball 1990, p. 15).

Manipulatives

Why do we need them. Even with manipulatives in the classroom, a teacher can still not be listening to the students' understanding but instead be looking for particular answers and ways of representing from the students. "The traditional process of symbol manipulation involves only the deployment of a set routine with no room for ingenuity or flair, no place for guesswork or surprise, no chance for discovery; in fact no need for the human being" (Romberg, Kaput, 1999, p. 4). When the classroom isn't using manipulatives, "classrooms are dominated by a recitation and seatwork pattern of textbook-centered instruction" (Ball 1990, p. 11). Workbook mathematics dominates math curriculum homework and drill work, "giving students little reason to connect ideas in today's lesson with those of past lessons or with the real world" (Romberg, Kaput, 1999, p. 4). "The portrayal of school mathematics- a tedious, uninteresting path to follow, with lots of hurdles to clear-bears little resemblance to what a mathematician or user of mathematics does" (Romberg, Kaput 1999, p. 5).

Misconceptions. Clements (1997) dispels several myths about constructivism, one being is the myth, which suggests the use of manipulatives in a classroom is automatically a constructive activity. (1997, p. 199) Working with manipulatives in a classroom is not immediate constructive thinking, "This vignette illustrates the fallacy of assuming that students will automatically draw the conclusions their teachers want simply by interacting with particular manipulatives" (Ball 1992, p. 5). Manipulatives can be used to assist in understanding, but instruction, guidance and other tools must be used. Concrete experience must be provided in order to learn. (Ball, 1992, p. 4)

Drill. Working with manipulatives in the classroom to perfect the idea of a concept may appear as drill. Although the drill we see today is extensive and dominated by paper-and-pencil assignments. Yet, instead "when homework is assigned for the purpose of developing skills, students should be sufficiently familiar with the skills so that they do not practice incorrect procedures. Only by becoming independent learners can students come to see mathematics as doable and useful" (Kilpatrick, Swafford 2002, p. 26).

The most important aspect of using drill in a classroom is determining whether it is appropriate. The question to ask is, by assigning it is the skill necessary to be performed efficiently and effectively (Van de Walle, Karp, Bay-Williams 2008). Drill is only appropriate when the skill is already possessed, but there remains a need to perfect it. Clearly this happens outside of mathematics all the time, with sports and music as good examples. We learn how to dribble a soccer ball or play the chords shown on a sheet of music. At the outset of instruction, we are given the necessary bits of information to perform these skills. Initially, the skills are weak and unperfected. They must be repeated in order to hone them to a state of efficiency. However, if the skill is not there to begin with, no amount of drill will create it" (Van de Walle, Karp, Bay-Williams 2008, p.70).

Instead of assigning hours' worth of drill work, it is best limited to 5 or 10 minutes. "Devoting extensive time to repeating a procedure is not effective and can negatively impact students' perceptions, motivation, and understanding" (Van de Walle, Karp, Bay-Williams 2008, p.70). Manipulatives paired with drill can create active, encompassing, and interesting ways of exploring a concept in mathematics.

Implementation and Effectiveness. Instead of finding drill and assignments on worksheets, the teacher can use games with repetition. Children are intrinsically motivated in games and the activities allow for immediate feedback while being offered an several different levels of difficulty (Kamii, Housman 2000). In games students are also more likely to construct a network of numerical relationships by interacting with others, making decisions together, and learning to resolve conflicts. (Kamii, Housman, 2000)

Working with manipulatives and constructivist listening allows students to think about and understand concepts in ways they never have before (Ball, 1990). "With appropriate guidance from teachers, a student's informal models can evolve into models for increasingly abstract mathematical reasoning. The development of ways of symbolizing problem situations and the transition from informal to formal semiotics (called progressive formalization) are important aspects of the instructional assumptions" (Romberg, Kaput, 1999, p. 11). Even though students should not be expected to reinvent mathematics, they can be expected to invent routines, formulas, or expressions through their investigations (Romberg, Kaput 1999).

Ball (1990) discusses a teacher's reaction after an activity with fractions. The teacher stated, "I realize now that I didn't really understand many of the manipulations that I could produce the correct response for. Working with the [fraction problem] was a real eye opener for me. While I could quickly come up with a correct answer to the problem, I had no idea how to write a story for it. Finally, through discussion with others and my own thinking out loud, I realized what the problem was asking me to do. After 16 plus years of school I understood division of fractions for the first time" (Ball, 1990, p. 14). After engaging students to think deeper about what they are learning, and having them work together to demonstrate it, a student can gain much more thorough understanding than they had before.

Mathphobia

Math anxiety is a phenomenon that is sited in mathematics classrooms. Ashcraft (2002) describes math anxiety as "a feeling of tension, apprehension, or fear that interferes with math performance" (p. 1). The persistence of paper and pencil work in mathematics can be attributed to math anxiety, "when [the students] think mathematics needs to be learned by memorizing rather than by making sense of it, they begin to lose confidence that they can solve problems" (Kilpatrick, Swafford, 2002, p. 16). The reason the students feel anxious or incompetent with mathematics is not due to some shortcoming on their part. The reason they feel the way they do, believing that they lack the understandings they do, may instead by the product of the math classrooms in which they were students (Ball, 1990, p. 14).

To bring students to success in mathematics learning requires that they are positively disposed toward the subject. "Students who are engaged with mathematics do not believe that there is some mysterious "math gene" that dictates success. They believe that with sufficient effort and experience they can learn. They need to see it instead as a subject in which things fit together logically and sensibly, and they need to believe and they are capable of figuring it out" (Kilpatrick, Swafford, 2002, p. 16).

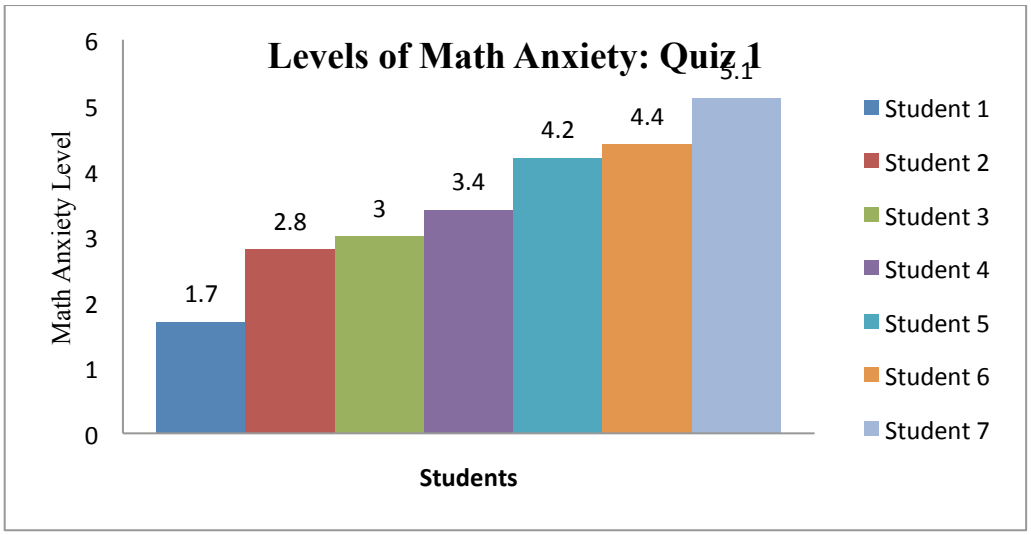
Mathematics is a living, dynamic discipline, making changes in school mathematics inevitable (Romberg, Kaput, 1999). Mathematics continues to change even more rapidly than ever before (Romberg, Kaput, 1999), so while previously when "students studied number for number's sake, or algebra for algebra's sake" now they can begin exploring mathematics and how it operates while gaining confidence in their abilities (Romberg, Kaput 1999, p13).

Analysis

Anxiety Quiz 1

Before the lesson for my study, I gave out to the students a math anxiety quiz to see what kind of group I was working with. There were ten questions, all could be rated on a scale of 1 to 6 where 1 was "Does not apply at all" and 6 was "Very much applies". If the student scored 1 to 2.5 the student was not very anxious about math, if the student scored 2.6 to 4.5 they were moderately math phobic, and if the student scored 4.6 to 6 they had high math anxiety.

The graph below of the results to the primary math anxiety quiz reveals that I had a very diverse group of students regarding math anxiety levels. The vertical axis indicates the student's math anxiety level from 0 to 6, 0 meaning no anxiety and 6 being the highest level of anxiety. Each different colored bar indicates a student, the quizzes being anonymous. This graph shows that I had a range of students with relatively no math anxiety to very high math anxiety, the mode of my data coming out to be 3.514, moderate math anxiety.



Activities

After the quiz I presented my activities to the group. The aim of my activities were to involve the students, in physically and mentally engaging activities that represent a blend of mathematics and theatre. There were aspects of my activities falling under several of the NCTM's Mathematics Teaching Practices including; Implement tasks that promote reasoning and problem solving. I feel I satisfied this standard by putting the students in a large model of the unit circle where they can work together to understand the activities. My activity satisfied Mathematics Teaching Practices of using and connecting mathematical representations by have the students being able to see and jump about a unit circle for the games. Facilitating meaningful mathematical discourse and posing purposeful questions I feel were met during the naming out the radians, 'Why Pi', and 'I Like Pi' activities where the students and I played through the activities, firing off questions and coming to an understanding of how the unit circle operated.

There were exciting discoveries and outcomes in every activity. When I divided the unit circle into 4ths, 8ths and 12ths I received exclamations from the students that they never knew the angles in radians followed the pattern of the circle simply being divided and then using that unit fraction of pi to count with. The shocking aspect to me was that I was not aware of that pattern either until I was exposed to it by Dr. Abney. The situation reminded me of Ball's study published in 1990 where a teacher, after doing an activity with fractions realized what the question was actually asking for.

> I realize now that I didn't really understand many of the manipulations that I could produce the correct response for. Working with the [fraction problem] was a real eye opener for me. While I could quickly come up with a correct answer to the problem, I had

> no idea how to write a story for it. Finally, through discussion with others and my own thinking out loud, I realized what the problem was asking me to do. After 16 plus years of school I understood division of fractions for the first time. (p. 14)

It was a first-hand experience that proved to me what walking through an activity and being questioned about properties could show a student. It was discoveries like these that led me to deciding to teach students with games. Children are intrinsically motivated in games and the activities allow for immediate feedback while being offered an several different levels of difficulty (Kamii, Housman, 2000, p. 203). In games students are also more likely to construct a network of numerical relationships by interacting with other, making decisions together, and learning to resolve conflicts. (Kamii, Housman, 2000)

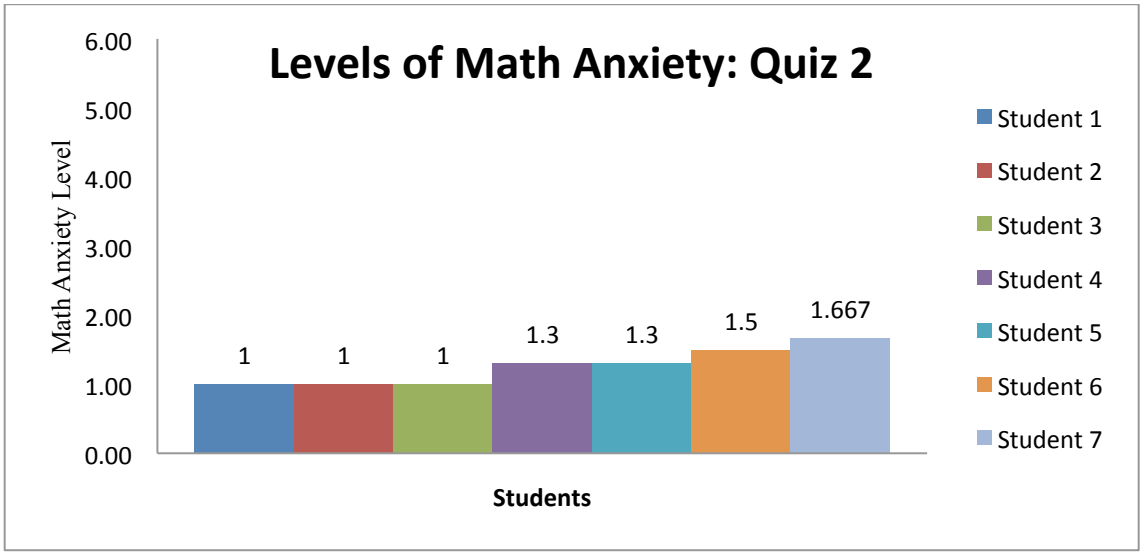
In the activity 'Why Pi', after the students had discovered that the radius could be fit around the circumference a little more than 6 times I had a student say, "Almost like six and a quarter." Dr. Abney and I agreed and I asked the student what would that number be close to if divided by two. After a moment of thought the student said back that the number would be around 3.12. Looking back I realize I could have asked more questions to slowly lead them to the answer but I wasn't long before I revealed two pi to be the goal of our journey.

The most exciting display of discovery and group work I saw amongst the students was in 'I Like Pi'. It wasn't long into the activity when a student who was confident in the unit circle multiplied a radian by the multiplicative identity and called its equivalent before passing the ball. That show of knowledge excited the students and gave them an opportunity for a competition. It was not long until several of the students were finding equivalent radian values or coterminal angles. When a student would become confused or call out the wrong equivalent the game would

come to a natural pause and the students and I would explain how multiplication of one or adding a multiple of 2Pi radians worked and what we were doing. In all I did not need to do much explaining, the students become teachers for each other. It was exactly the type of listening I was hoping to conduct. I was truly a participant.

Anxiety Quiz 2

After the activities I gave the students a post anxiety quiz to gauge how they felt about the type of instruction shown through my activities. In this quiz there were six questions, and once again could be rated on a scale of 1 to 6 where 1 was "Does not apply at all" and 6 was "Very much applies". The average for this quiz was 1.25, a drop from the 3.514 average the first anxiety quiz came back with. More importantly, looking at the graph not one student felt even moderately anxious about the activity.



Focus Group

After the post assessment I brought the students together and conducted a focus group. One of the first questions I asked was how did this activity compare to ones they had done in the past. I received a rather interesting reply from a student,

> My teacher taught me the unit circle and taught the whole class in a sort of trial by fire method where each day she'd give us increasingly less time to fill it out until she expected us to fill the entire thing out in about fifteen seconds. And frankly instead of learning the unit circle all it did was fill the class with panic and fear and now it's like the thing is I probably figure it out now…but not thinking about what is was. (a student in the study)

His reply reinforced Kilpatrick's and Swafford's opinion that for students to be successful at mathematics that needed to be positively exposed to it, and while drill could be successful to perfect a skill there are smarter ways to promote mathematical proficiency. "Devoting extensive time to repeating a procedure is not effective and can negatively impact students' perceptions, motivation, and understanding" (Van de Walle, Karp, Bay-Williams 2008, p.70).

I next asked the students what their past experience in math has been. The general consensus among the students was that they did not enjoy the way it was taught. The following student brought the group's opinions together nicely by explaining the lack of interesting instruction.

> Just endless repetition to learn the basics of it, it took forever, I didn't enjoy it, but it got me through well enough and most of my math professors were amongst the most boring and or bored people on the planet. It was a mixture of both. I don't think it would have been as boring if they weren't as bored about it. (Z-Student in the study)

When I asked the students what parts of math lessons they did enjoy they expressed that something they could apply to their lives and use was what got them interested, “I simplified trig and geometry to carpentry…what could I base this stuff off. For me being able to have a teacher that understood how it could be used outside the classroom rather than just teaching what was on the test, really helped me person”(D -Student in the study). On the other side of the coin when I asked what they did not enjoy a second student followed with “It doesn’t apply to your life so you just tune it out”(J-Student in the study). The two opinions of these students coincided with the belief of the applications of manipulatives could help students focus and expand on abstract ideas. Their opinions also helped me come to the conclusion that not only play, manipulatives, and kinesthecis assists students, but applying it to something they could encounter in their lives was something that interested them. While I am focusing on moving and going into a concept of mathematics, I should also be thinking about applying and relating it to real life, such as physics or carpentry. If the students know they are not simply learning for the sake of the test, but for a real life application, they might show more interest.

I then went on to ask the students about how they perceived my activity. First of all, not any of them could really remember an instance they were exposed to manipulatives in the classroom and remembered what it was for. Secondly when a student mentioned food, a common manipulative in classrooms, they stated they could not concentrate because they were too focused on getting to eat the food. A student’s opinion of my study remarked that there would be higher likelihood students would want to participate because it would not be in the same dry, repetitive format. Another stated it would be easier to approach the teacher if you knew they were open to trying a different style instead of the teacher, “[standing] at the board and basically yell at you.”. “It would get students a lot more interested in getting involved in finding out

exactly how and why this works instead of getting a lot of random factoids thrown at you." For the last question, I asked the students what math education was missing.

> I think what's really missing is a lot of math teachers approach is just saying 'well this is what we're going to be working on and this is how it definitely is" and there's not allot of listening seeing where people are, what their frame of reference is. Z

From my the results of my study I have come to the conclusion that while you cannot put any 'Magical Hopes' into manipulatives, focusing on constructive listening and working with the students to find a solution and meaning would help the understanding of all students. During my presentation I was asked about the students that did not enjoy getting up in the class. While I stated a quote from the NCTM about the need for different kind of construction for All students, I truly wanted to rebut with, What about the students who cannot learn from the strict, unimaginative worksheet based drill we have in classes? Kamii, and Housman stated that proper drill be kept under 5 to 10 minutes, not dominate the classroom. There should be more opportunity for the students and teacher to grow and learn together, all through the use of listening, play, manipulatives, and kinesthetics.

Discussion

This capstone has been a continual work in progress for several years in my education. A constant thrum of an idea threading through my actions as I built my teaching style. From my junior year of college, in a theatre education class, I toyed with the idea of mixing my majors, and now in my fifth year I was able to grasp something concrete. Reaching for this goal, this concept, was at the same time easier and more difficult than I originally perceived. I was surprised by the amount of research already out there and how these concepts were easily

attributed to theatre. I hit obstacles in the middle of sprints of creation, weights grasping on with the strength of gravity to slow my pace. Only have one session to test out my theory with students was something that limited my research.

I am proud of what I have been able to bring together but at the same time I wish for more. I want to scourge novels on the use of listening and manipulatives in the classroom, I want to conduct classrooms in new and exciting ways to see their reactions, but I think my want to continue this study is the best outcome of all of this. After my graduation in the spring, I will hopefully be on my way to graduate school for my Masters in Teaching. Depending on the program I decide on, I will hopefully be able to experience the setting of a high school math class where my teaching style will be able to develop. An outstanding requirement for my research to continue is classroom experience. I have not yet been able to experience a high school math classroom in the role of an instructor and having an idea on paper is much different than executing it with students.

When I enter the classroom, I will be the 5th generation straight to enter the teaching profession, carried down through the women on my mother's side. While I take pride in this fact I am more so looking forward to what I plan to bring to the classroom. My goals are to teach math and theatre, whether it be calculus, shop, algebra, and/or drama. I hope to bring an exciting and comfortable atmosphere to my classroom, connections between disciplines that do not often seem to go together, and a room where when the students enter they know this is a place they can grow and speak their ideas.

In high school, my drama teacher was often seen teaching calculus on the green room couches in the back of the theatre. If I could have my dreams come true I would love to have a lesson a week, or maybe every other week in the theatre, doing large activities that incorporate

play and drawing interesting concepts into what we are covering. I would make my classroom something students did not want to miss because they knew when they entered the room they would not have to worry about being ridiculed if they did not know something, but instead look forward to the new discoveries of the day.

There is an intimidating factor about mathematics and it can be an overbearing feeling I want to strive to remove. I would love to look into how to integrate this style of teaching, even be able to observe or work with educators that have the goals to see what works and what doesn't. Sometimes there are still days in my math education where I am downtrodden enough to believe I do not belong in mathematics, that I do not belong in the classroom because I am not intelligent enough to make discoveries as successfully as other students.

I more than anything want to foster a positive environment for students, through both the mathematics and theatre classroom. In mathematics I want students to become confident in the intelligence they are capable of, to know that they are capable problem solvers; in theatre I want to foster the growth of talent and creativity. Perhaps the research I have done here is the start of it all.

For the math education world I find that this research calls for more to take notice of the research already available to us, this idea goes also towards people studying to become teachers. Through this semester I found so much already existing on the studies of constructivism, listening, kinesthetic learning, manipulatives, and play. There should be future educators delving into these resources and furthering the research with their own experiences. If there is a possibility to bring a more successful and enjoyable education to students there is no reason it should not be investigated systematically.

There should also be an exploration for educators into the area between theatre and education and how they can assist each other. Recently the class Theatre Games for the Classroom Teacher was removed from Georgia College and I am going to begin lobbying to bring that back. There is a sense of creativity and interaction that theatre can provide while specific content knowledge can provide focus and direction. It would be amazing to see what would happen if classes of this kind were developed

For the world as a whole I would love for the idea of this to spread, for already existing research to be shared and new avenues explored. I do not know yet if this dream is too far-fetched to be possible but I would like to believe it isn't. Mathematics is described to be an ever changing body of exploration. Why can't mathematics classrooms be the same?

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