Part Two: Some Themes Emerged…

Although I implemented math games with all of my blocks, I focused my observations, analysis of data and chose my focus students from my second block. Over half of my second block consists of students with various learning disabilities and IEPS, or Individual Education Plans. There was a wide range of student readiness levels. Since many of my students had various learning disabilities, I noticed that many of them also had very little self confidence when it came to math. I felt this was a really great opportunity for me to try to "turn around" students' attitudes towards math and about themselves as mathematicians. Through analyzing student work samples, various interviews, results from the pre and post surveys and pre and post assessments, exit cards, along with my field notes and observations, there were four themes that emerged. This finding section is organized into the following four sections:

Games help students build more positive attitudes about math, while decreasing math phobia.

Games are tools for reaching all different readiness levels (differentiation).

Games encourage students to articulate their understanding and work together to solve problems.

Games help to increase student comprehension with various math concepts.

Theme One: Games help student build more positive attitudes about math, while decreasing math phobia.

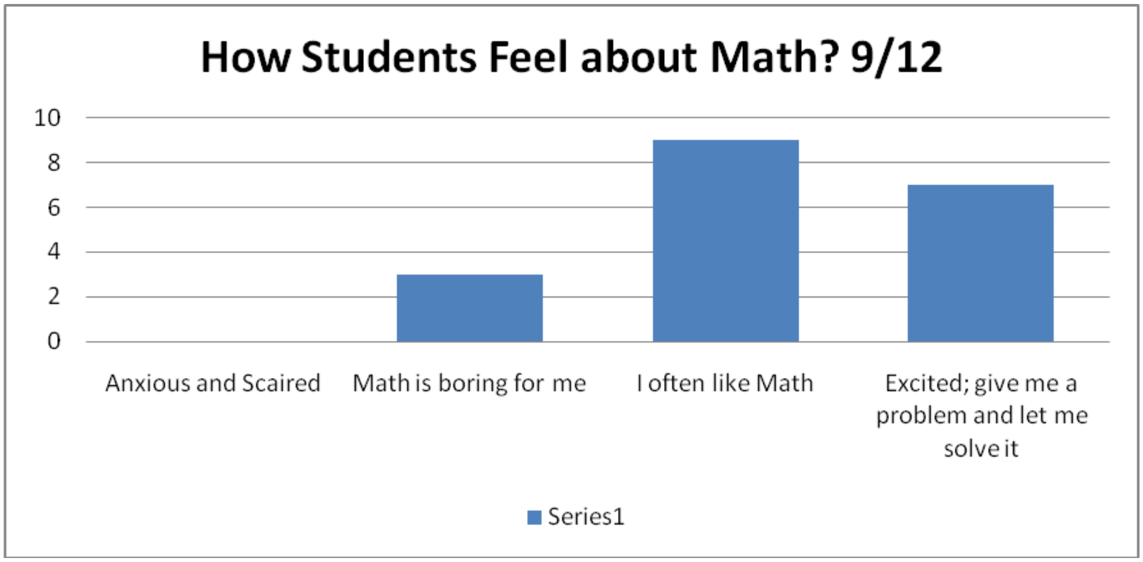
Math games helped to change student's feelings about math and their self concept, or how they view themselves as mathematicians, for the better. As students entered my classroom, there were a wide array of feelings and attitudes towards math that emerged. Some students have always loved math, others disliked it and thought it is boring, while another group might have even felt terrified and anxious when thinking about math. The latter of the three groups were my inspiration for making math games an integral part of my curriculum. My primary goal was to change these students' attitudes about math and help them to see that math can be not only fun, but beautiful as well.

Students initial feelings towards math

I administered three different tools in the beginning of the school year to help me delve into my students' heads and get to know their feelings about math and how they view themselves as mathematicians. First, students wrote "get to know you" letters that introduced themselves and discussed themselves as a student. Second, they completed a pre-games survey (Appendix 1) that helped me to learn about each student's previous experience with math. Finally, they did a writing activity where each student compared him or herself as a mathematician to another object or animal. This project is discussed later in greater detail.

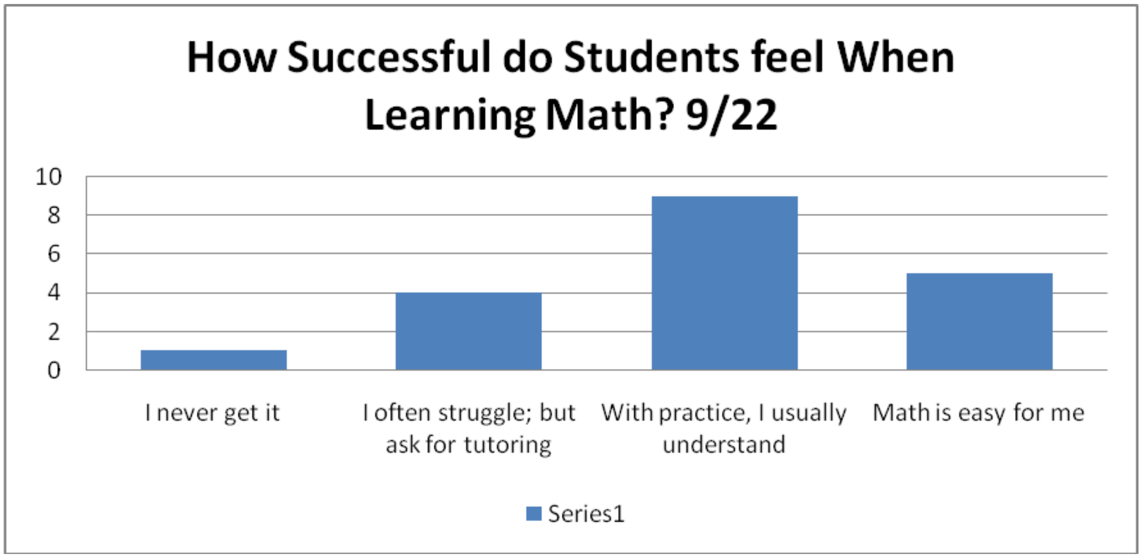
Through writing me "get to know you" letters in the beginning of the school year, I learned that there was a wide array of feelings towards math. In their letters, several students from my second block class expressed a strong dislike for math. Feelings about math ranged from, “Math has always been my favorite subject because it is so easy for me” (Dianna), to “Math is okay, but it is my least favorite subject in school” (Isaac), to, “I hate math, and wish I didn’t need to take it, no offence to you…” (Albert) to “I don’t get math, it is too hard. I like Language much better because I get it” (Oscar). Although I could see several connections between how students responded about math in their letters as well as in their surveys, there were also some distinct and surprising discrepancies that emerged as well.

Below is a series of graphs that demonstrates the connection between students’ feelings towards math and their confidence levels, or how successful they feel learning math.



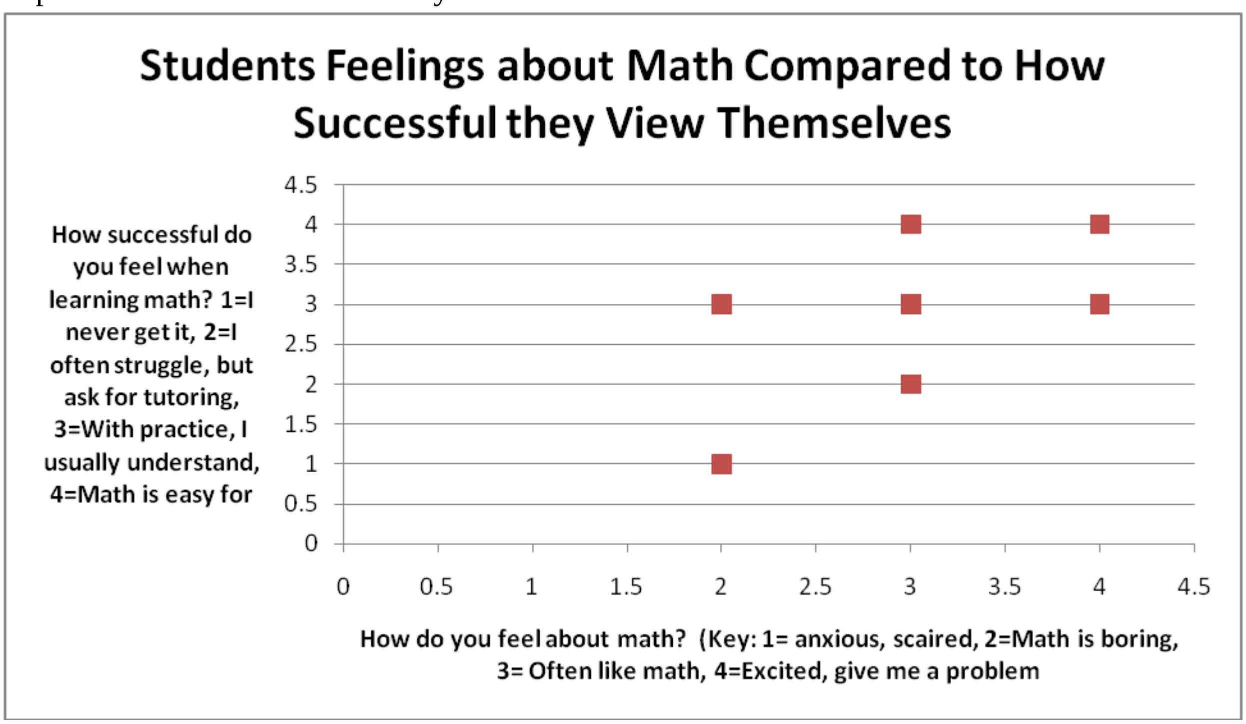
Above is a graph portraying how students feel about math.

When comparing student letters with my pre-games survey results, question number three on the pre survey surprised me. The question asks, “How do you feel about math?” Students circled only one of the following responses, 1= Anxious or scared, 2=Math is boring for me, 3= I often like math, or 4= Excited, give me a problem and let me solve it. I was surprised to see that not one student circled #1, and very few circled #2. Many of my students, 43% to be exact, circled #3. I wondered if students were not totally feeling comfortable answering this question honestly. Possibly because it was the very first week of school and they felt they wanted to impress me, they did not answer the question truthfully. Maybe students that do not like math do not quite realize why they do not like, but rather they just know they do not like it.



The graph above focuses on student's confidence levels and how successful they feel when learning math.

Almost half of the students (47%) chose, "with practice, I usually understand." You will notice that the amount of students who chose, "math is easy for me" is equal to the amount of students how chose either, "I never get" or "I often struggle…" These student's responses were fairly consistent with their math analogies and letters they wrote to me about their feelings about math. By comparing individual responses to the questions "How do you feel about math?" and "How successful do you feel when learning math?" I noticed a direct correlation between student responses in the Pre Games Survey.



Students' feelings about math compared to how successful they view themselves in math are displayed in the scatter plot above.

Student that liked math most often wrote that math was easier for them, while students that felt math was boring, expressed that they struggled with math and did not usually understand it. In the scatter plot above, you will notice that as there is a steady increase in the level of student enjoyment with students who feel they are more successful while learning math. Those findings did not surprise me since we tend to like things that we feel more confident in.

In the initial survey, when asked to circle all of the learning activities that students preferred, playing math games was circled most frequently. Below is a pie chart illustrating student's responses to the question, "How do you learn best?" Fifteen out of twenty students or 75% of students had circled playing math games on the survey. This showed me that the majority of students enjoy learning though playing math games, even if they strongly dislike math or find it boring. Resek and Rupley (1980) discuss that when students are having fun and playing, they are more relaxed and less likely to feel anxious. In turn, their self confidence often increases.

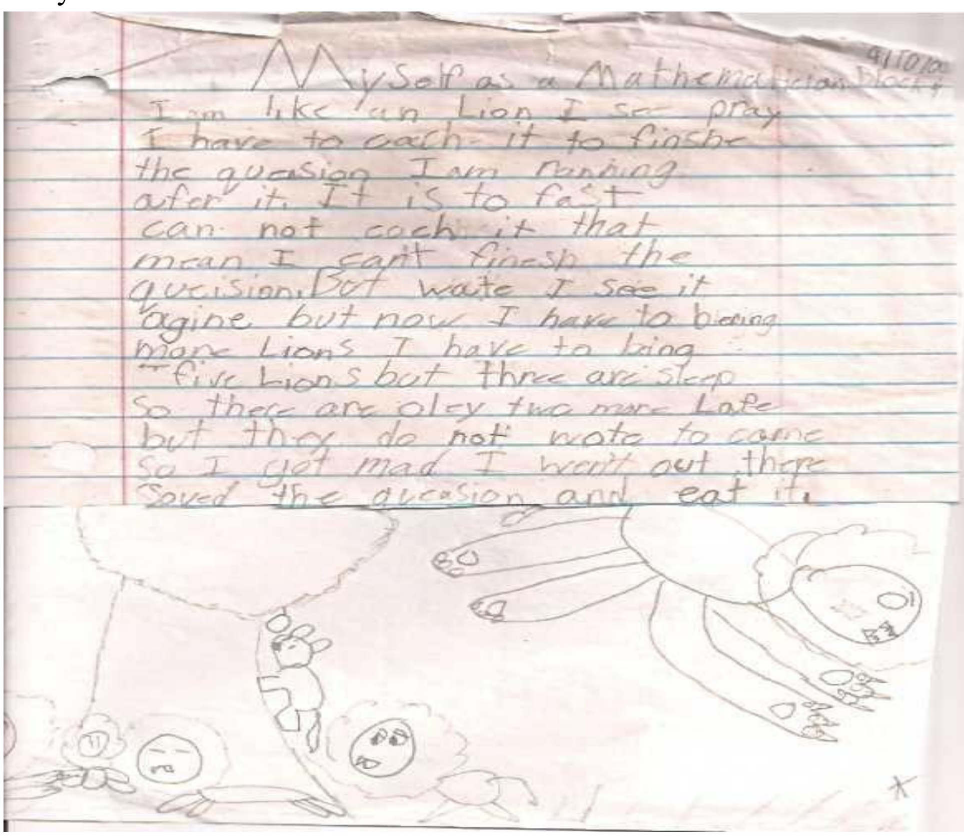
While analyzing the data collected through this survey, I was able to get a clear picture of individual student attitudes and confidence levels in math. It was evident that there were a variety of student opinions about math. One student, John, wrote, "I love math… When I do math, it is like playing outside!" Not surprisingly, he circled how excited he was about math and that math is easy for him. Another student, Albert, when asked why we learn math wrote, "So we can label ourselves as smart and do some basic things in our life." Much of the data I have collected on Albert in the beginning of the school year consistently showed that he felt math was boring and pointless. Not only did he circle that math is boring to him and he feels like he never gets it, but in his letter to me, he told me that he "hates math" and it is his least favorite subject. Often I find students who are very anxious about math, express their anxiety in different ways. While some shut down or get frustrated, others almost mask their anxiety and never let it show. For some of these students, I found their anxiety shinning through their math analogies. This anxiety towards math, or math phobia, that I have researched and written about in my Review of Literature section often stems from a previous lack of understanding.

During the first week of school, after brainstorming what an analogy was, I had students write their own analogies, comparing themselves as mathematicians to an object or an animal. At the end of the first semester, I had students rewrite their math analogies and then compare the new analogies with their initials writings. By doing this, I was able to note changes in how students viewed themselves as a Mathematician and whether their self confidence levels had indeed improved overtime. One great aspect of this assignment was that students could write as much, or as little as they desired. Like poetry, a short statement, can be very powerful and can send a very strong message. By reading their analogies and examining their illustrations they drew, I learned a lot about how students viewed themselves as mathematicians and their feelings towards math. This helped educate me on not only student attitudes towards math, but their pacing, their confidence level and also their writing skills. What a fantastic way to delve deeper into the minds of students! Students compared themselves to a wide plethora of objects and animals.

I have organized the following analogies into three categories; 1. Students demonstrating math anxiety or a lack of self confidence, 2. Students that feel they are strong at math, and finally, 3. Students that base their math analogy on pacing, whether it is fast or slow.

Students demonstrating math anxiety or a lack of self confidence

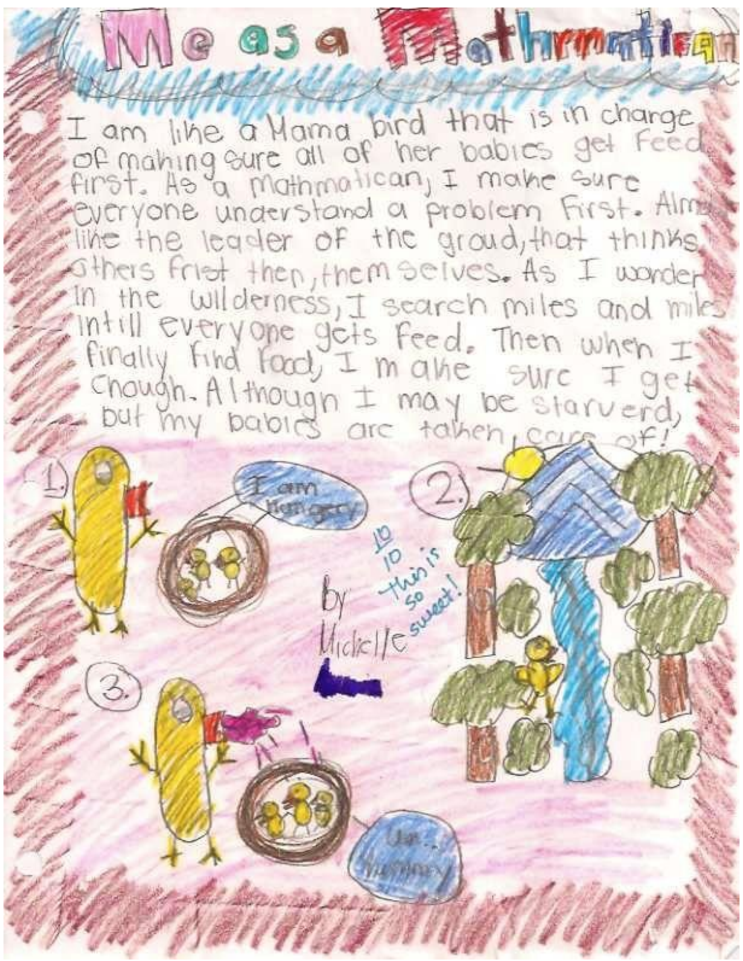
Albert wrote in his first mathematician analogy, "I am like an explosion because at first I am just a couple of sticks of dynamite but when the unmerciful flame of math comes and lights my fuse, then I explode with a loud boom!" That paints quite a vivid image of how he views math. You will find his analogy below in the section comparing his initial analogy with his more updated version. John, who stated in his initial survey, "I am not that good at math because I am not that smart," wrote, "I am like a lion trying to catch my pray. It is so fast that I can not quite catch it." Jazmin portrays her anxiety by writing, "I am like a racing heart beat. The teacher gives us a math problem and then I start. Next, I get so nervous that my heart starts pumping really fast…"



John's initial math analogy as discussed above portrays his anxious feelings towards math.

Students that feel they are strong at math

One student, Michelle, who not surprisingly stated she liked math in her survey wrote, "I am like a Mama bird that is in charge of making sure all of her babies get fed first. As a mathematician, I make sure everyone understands the problem first. Almost like the leader of the group that thinks of others first and then themselves. As I wonder in the wilderness, I search miles and miles until everyone gets fed. Then, when I finally find food, I make sure that I get enough. Although I may be starved, my babies are taken care of." This was stricking to me because this student demonstrates an enormous amount of self confidence. She strives to take on the role of the teacher and feels comfortable with her ability to do so, selflessly making her teammates' understanding a priority.

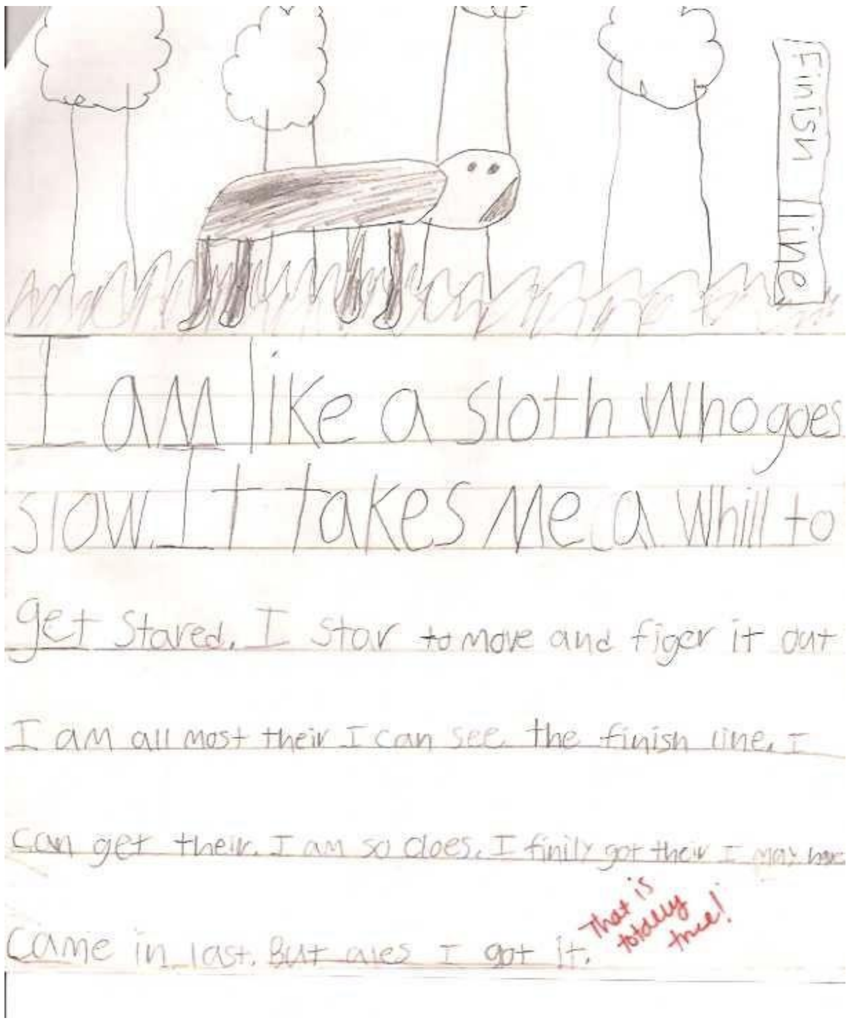


Above is Michelle's analogy.

It demonstrates her concern for others. David, a student who enjoys math, wrote, "I would compare myself to an eagle because an eagle has many strengths and I do too… an eagle likes to wait and take their time and then attack their pray."

Students that base their math analogy on pacing, whether it is fast or slow.

Ama described herself as a snail, "I am like a snail… Sometimes, when I leave I walk and leave word problems back in my saliva…" Annie also compared herself to a snail, "I compare myself to a snail because snails are very slow and me to." While Mary compared herself to a slow turtle, Oscar compared himself to a monkey, “I am like a monkey trying to peel a banana. I try to find a way to start and when I start, I peel it little by little.” Davan, a student who demonstrates a high level of confidence in math writes, “I am like a sloth who goes slow. It takes me a while to get started. I start to move and figure it out. I am almost there and can see the finish line. I am so close. I finally go there. I may have come in last, but at least I got it.”



Davan’s math analogy illustrates his pacing within learning math.

Irene, who is extremely proficient in math, wrote, “I am like a cheetah running fast to catch the math problem… I run faster and I get the right answer. I never gave up and I was always thinking positive.” Through reading these analogy quotes, you can see their feelings and attitudes about themselves as mathematicians emerge.

This initial assessment on student self confidence levels and attitudes towards math was extremely informative for me in beginning of my project. Based on student’s letters and surveys, I was expecting there to be a higher number of negative attitudes towards math. 42% of my students expressed some sort of anxiety or negative feelings about themselves as mathematicians, while the remaining 58%, expressed more confidence in themselves as a mathematician. These initial finding got me really excited to continue my action research on math games and reassess their feelings throughout the semester to see what changes might occur within my students and how they view math, and themselves as mathematicians.

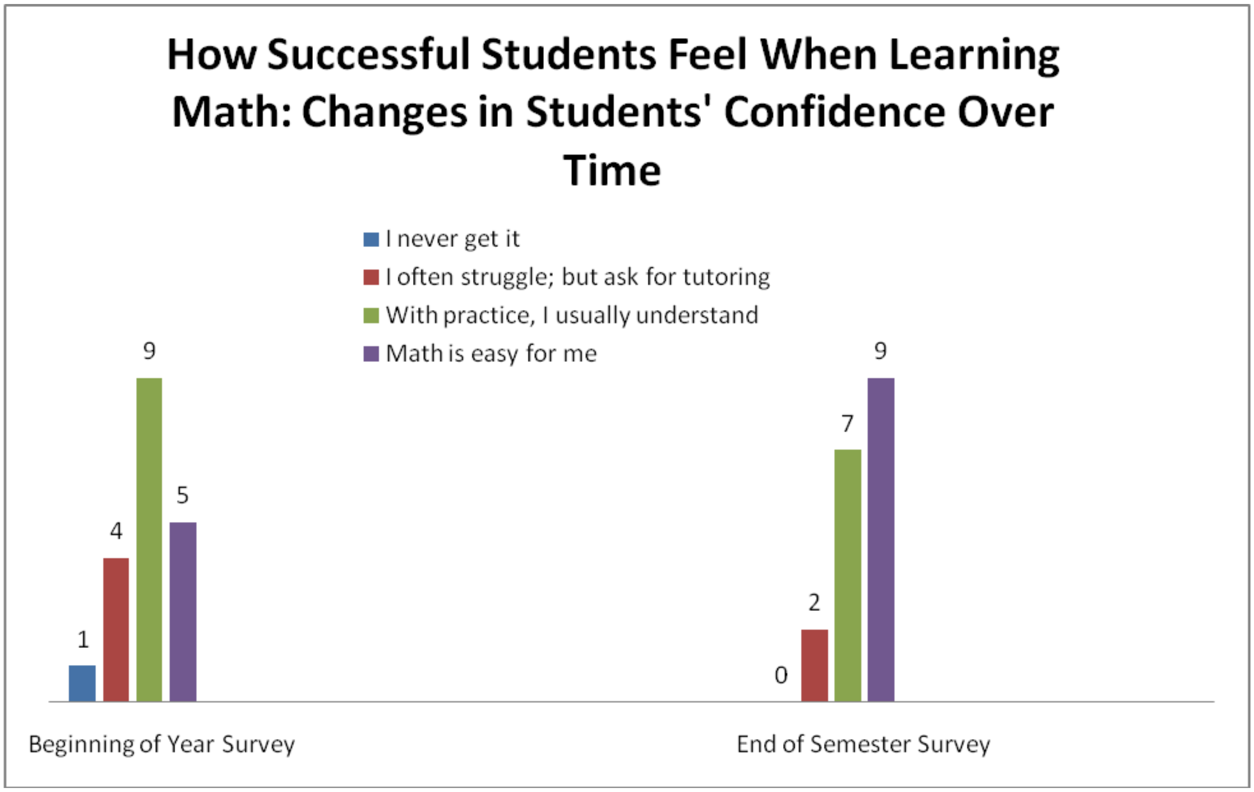
A Shift in Student Attitudes Overtime: From a ticking bomb, to a race car.

It was evident in the beginning of the year; many of my students not only lacked confidence in math but had a bad case of math phobia, or math anxiety. Throughout my action research project, I noticed that there were several indications that many students' attitudes were shifting in a positive direction. Was it possible that Albert, the ticking bomb of dynamite might change his original view on math? When Albert came up to me afterschool in November and said, "I can't believe I actually like math this year, the math games make it really fun," it became obvious to me that math games have transformed his attitude about math. Back in September, I could never imagine the words "fun" and "math" coming out of his mouth in the same sentence. By hearing students say they were surprised that they actually liked math this year, I was led to believe that this hatred or fear for math was beginning to change within them.

I wondered how many students shared in Albert's surprise for "actually liking math." I often like to touch base with my students about how they feel things are going in class. Through asking the question in an exit card, "How are you feeling about math class this year so far? Is there anything I can do to make it better for you?" students are given the opportunity to reflect, express their feelings and give advice on how I can make things better for them. Their responses help to paint a picture for me on whether or not students are enjoying my class. Since games are such an integral part of our math curriculum, if students are enjoying my class, I can assume they are also enjoying the games we are playing. The following are several students' responses to this question:

"I feel good in math and I like all of the games." "I feel good about this class, it's the best ever." "This year's math class is better for me than before." "Math is fun, I like how you are running it. I am surprised that I like it." "Math is hard for me, but I still like playing games too." While 80% of student's responses were positive, a few students were not enjoying math. One student wrote, "I never like math and I still do not like it," while another wrote, "math is just okay, you can't do anything to change that." Another student expressed that he feels he needs to be challenged more in class, which was helpful for me to know as well. Many of the students wrote that they enjoyed playing math games and want me to plan more games. Asking this one question gave me a wealth of valuable information to help guide my instruction and my action research project.

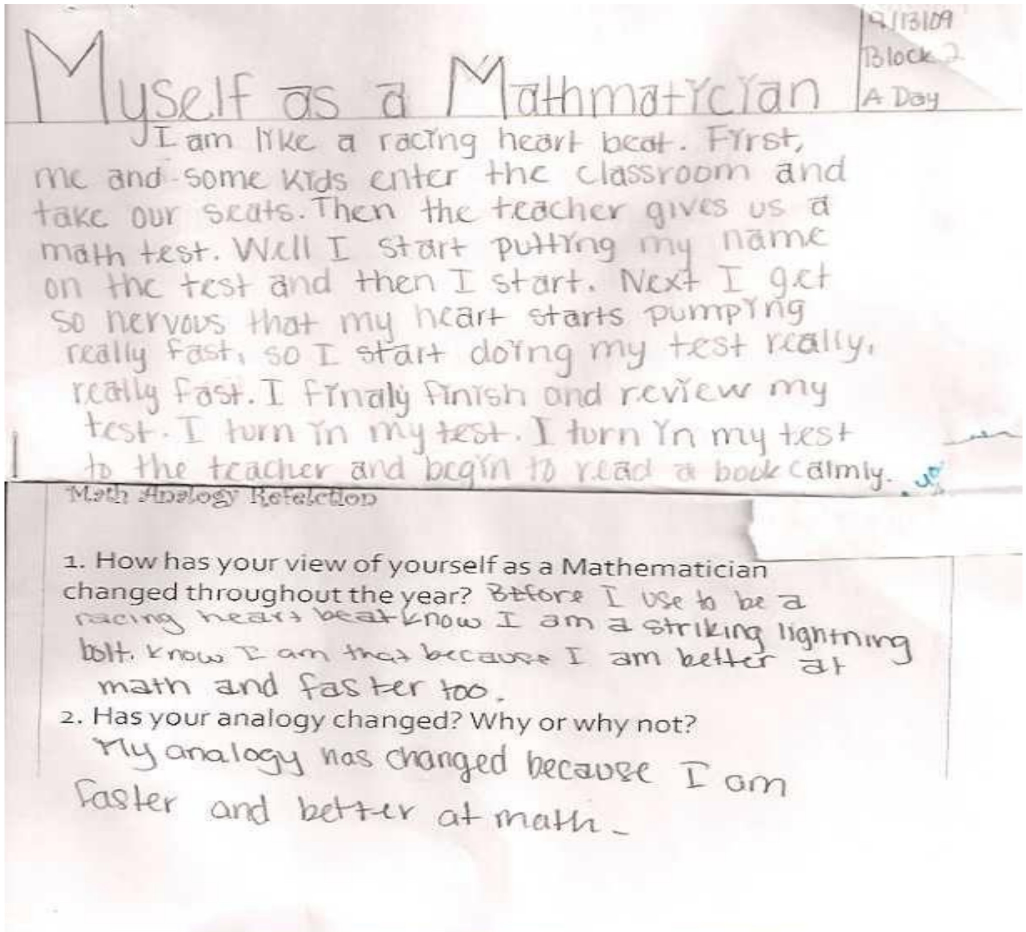
Towards the end of the semester, after months of playing various math games, I was anxious to reassess student's attitudes about math. Through student interviews, additional surveys and exit slips, my field notes and students' revised math analogies, I saw a positive change in many students' attitudes and an increase in students' self confidence levels. Below, you can see in the double bar graph a positive shift over time in students' confidence levels.



The graph above compares student confidence levels from the beginning of the semester to the end of the semester.

In September, 21% of my class felt they often struggled with math. At the end of the first semester, after playing months of various math games, this percentage decreased to only 10%. On the flip side, 47% of my class now felt that math was easy for them. This increased 21% from the beginning of the school year. This shows an extreme increase in student self confidence levels when learning math. One would assume when there is an increase of self confidence level, than there would probably be an increase in positive feelings towards math, decreasing student math anxiety levels as well.

At the closing of the semester and my action research project, I had students rewrite their math analogies. I did not show students their original math analogies before because I didn't want them to affect how they wrote their updated analogies. After they wrote their second analogy, I then gave them a copy of their original analogy from September. This gave students a great opportunity to reflect on how their feelings towards math had changed overtime. You can see below, a copy of a Jazmin's first math analogy along with her reflection that followed. In her reflection, Jazmin wrote, "Before, I used to be a racing heart beat, now I am a striking lightning bolt. I know I am that because I am better at math and faster too."



Myself as a Mathmatycian

9/13/09
Block 2
A Day

I am lyke a racing heart beat. Fyrst, me and some kids enter the classroom and take our seats. Then the teacher gives us a math test. Well I start puttyng my name on the test and then I start. Next I get so nervous that my heart starts pumpyng really fast, so I start doyng my test really, really fast. I fynaly finish and review my test. I turn yn my test. I turn yn my test to the teacher and begin to read a book calmly.

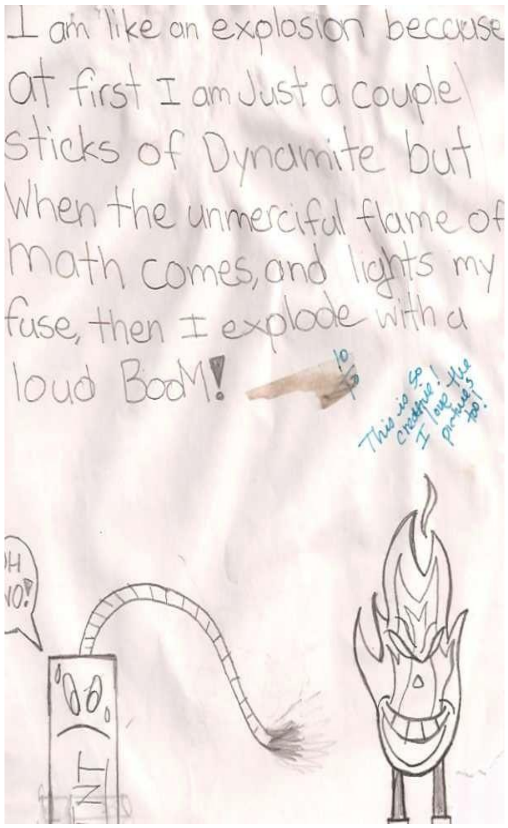
Math Analogy Reflection

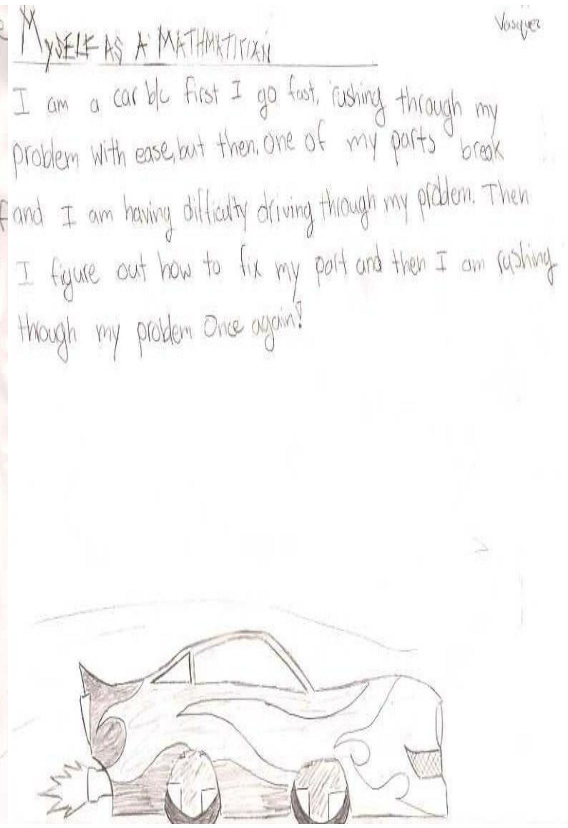
1. How has your view of yourself as a Mathematician changed throughout the year? Before I use to be a racing heart beat know I am a striking lightning bolt. know I am that because I am better at math and faster too.

2. Has your analogy changed? Why or why not?
My analogy has changed because I am faster and better at math.

Jamin's initial math analogy along with her reflection shows her change in confidence while learning math.

Through reading their reflections I noticed that 47% of the students wrote that their attitudes about themselves as mathematicians improved overtime since September. By comparing their pre and post math analogies, I also got a sense of how certain students' feelings and attitudes towards math have evolved throughout the first semester of school. Below is an example of both of Albert's math analogies, one from the beginning of the school year, and his latter writing from the end of the semester.





Above are both of Albert's math analogies.

You will see a definite change in his perception of himself as a mathematician. After completing his second math analogy, in a short reflection, Albert wrote, "…I feel like I am a better mathematician. I used to be some dynamite, but now I am a car." tell us more here about why he said this... what doesn't this mean to him... it's hard to read it above. John, who compared himself to a lion that could never keep up with his pray, now described himself as a monkey that goes back to help kids that are stuck and falling behind. Jazmin, who originally described herself as a racing heart beat, transformed into a Kangaroo that was hopping through Africa from one math concept to another. While Bryan originally compared himself to a turtle that liked to hide under his shell when he got frustrated, he now compared himself to a turtle that liked to take his time solving math problems. As you can see, there was a definite shift from fear and anxiety for math towards more comfortable and confident feelings about themselves as mathematicians.

While many students as mentioned above showed quite a positive shift within their views about themselves as mathematicians and math in general, there were six students whose series of analogies did not show much difference in their attitudes towards math and one student whose attitudes about math had actually decreased. This student expressed in his latter analogy that math was like a ticking clock where the time is not going by fast enough. In his initial survey, he compared himself to a lion, conquering math problems in the Sahara. In his reflection, he wrote that math is too easy for him and he finds sixth grade boring. According to his test scores and numerous work samples, he is extremely advanced in math. Since he is in a class with many resource students who struggle with math, he probably finds that the pace of the class is too slow. This also showed me that this particular student was not getting properly challenged in my class.

Thinking of my students feeling like a "ticking time bomb," one can only imagine how scared and frustrated they must have felt when learning math. It is most often at this point that a student will just shut down. My experience has shown me that it is nearly impossible for a student to learn once they have gotten to this point of frustration. Fillier (2005) discusses that as math anxiety increases, students academic achievement and performance often decreases. She also discusses that societal influences can play a big part on student attitudes towards math. People often believe that when it comes to math, you either have it or you don't, and that there is only one correct solution to a math problem. Throughout playing math games, there are many instances where students were exploring math and realized that there were multiple solutions to a particular problem. I believe this has also played a role in the increase of student's self confidence and a decrease of anxiety and frustration when learning math.

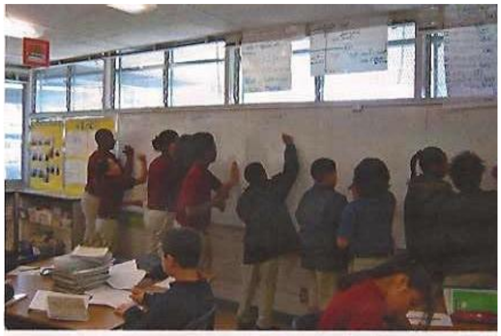
Theme Two: Games can reach all different readiness levels (differentiation)

How do math games allow for differentiation?

As I mentioned several times above in my math dictionary, math games are a great way to differentiate for student's readiness level, or independent learning level, as well as for student choice. Since my class consists of a huge variety of math proficiency levels, it is essential for me to differentiate for student's ability, or readiness level. Many of the math games that I included in my Dictionary of Math Games can be modified in order to differentiate for various levels of abilities. When giving a math problem, my goal is for students to be challenged, yet capable of solving the problem. When the material is too challenging, often students will shut down, whereas if the material is too easy, students will become bored. There is a fine balance between the two. Math games are a great way to achieve this balance. When planning and designing various math games, I tried to think of ways that I could modify the game so that every student feels the game is just right for them. Some of the games played accounted for more differentiation than others. The Game Show and Subtraction Football were two very different math games that evoked two very different responses from my students. After describing both games, I further explore student's feelings about both games and examine what specifically about the games might have affected this.

Painting a Picture of the Game Show

The first game I will discuss is called The Game Show. In this game, students are arranged in teams of five and each student in the team is given a different number, 1 through 5. I roll two die, and the two students from each team that are assigned those numbers go up to their team's section of the white board to solve their problem, competing against the other teams on the board. While two students from each team are at the white board, the rest of the team is solving the problem together at their table groups. The team that finishes first gets 500 points; second




team gets 400 points and so forth. This game was highly engaging, involving all students and encouraging teamwork among students since students are required to solve problems together. This game also involves ALL students equitably since students go up to the board to solve problems based on the randomness of the number rolled on the die. Adding in the bonus 1,000 points rewarded to groups that show ALL of their work on their resource pages helped to hold all students accountable for showing their work completely and accurately.

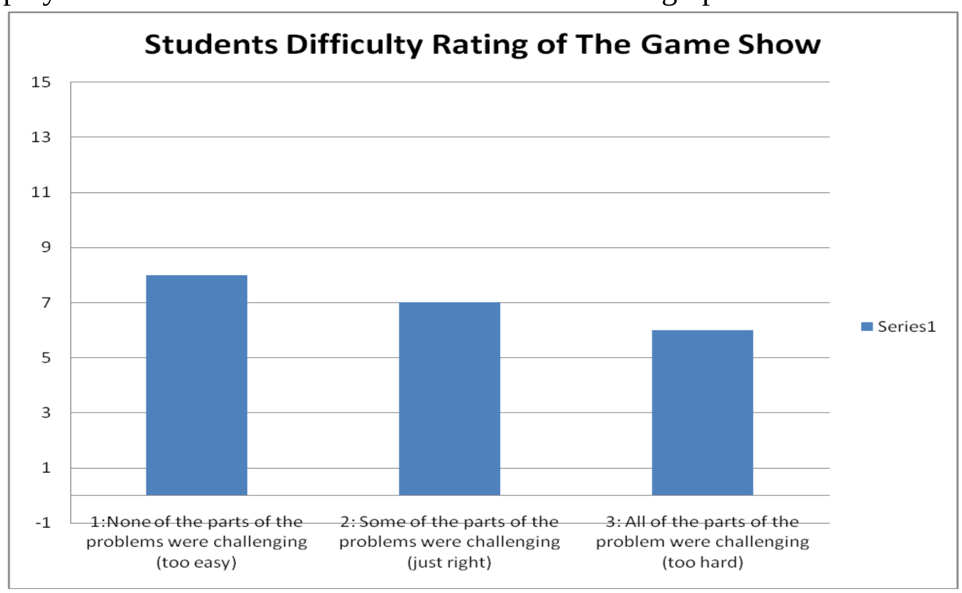
My administrator, Joel, came in to observe me lead a Game Show with my second block. The first comment that he shared with me during our debrief time was, "Wow, the whole class looked like they were having so much fun with you." He then went on to say, "I can tell you are also having a great time teaching your students. You seemed very relaxed." Joel also commented on the fact that throughout the entire lesson, I had nearly full engagement from the students. As he observed students, he noticed that most all students were involved and on task and he was impressed with the way students were discussing their math thinking with each other. He said, "It is evident that you have really developed high expectations for how students were to discuss their thinking with each other." He was impressed! The Game Show was among many other math games that helped to contribute to this high level of math discourse my students were partaking in. Since students were required to work together, they must discuss their solutions with each other. Students really enjoyed the Game Show. I am constantly having students ask me, "When are we going to play another Game Show?" or "Can we play a Game Show to review after every chapter?" When students enter the classroom and see it is set up for the Game Show, they get really excited. They often start cheering and giving each other high fives.

Painting a Picture of Subtraction Football:

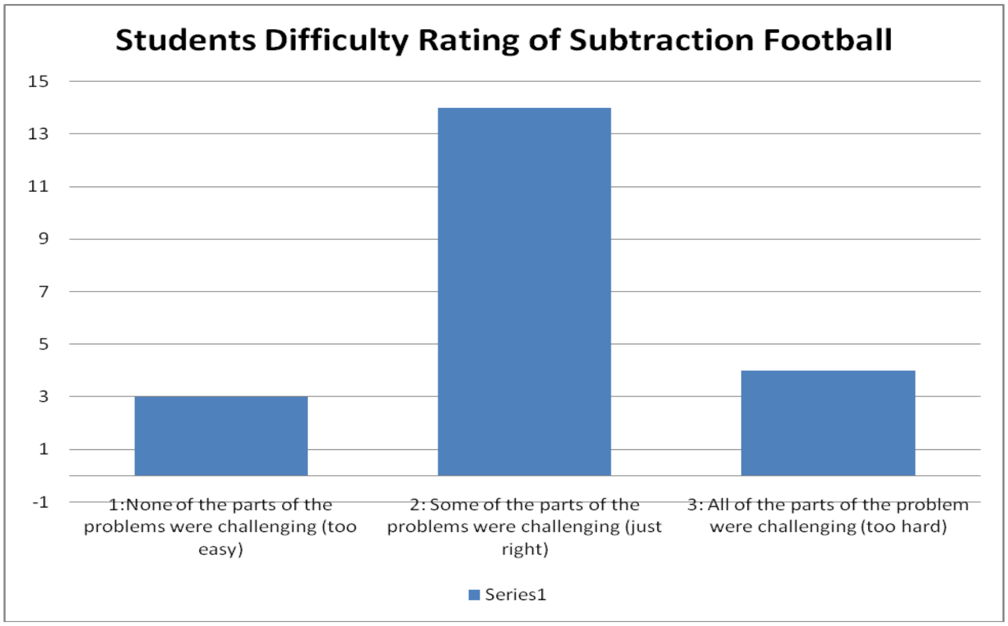
In subtraction football, students play with and against their partner. They each roll their die to come up with numbers they will be solving in a subtraction problem. Flipping a playing card, will determine whether their number is a negative (red) or positive (black). After students roll the die and flip the card to create their subtraction expression (i.e. -4 – 12=?), they draw a model using tile integers, which are manipulatives that are in the shape of minuses and pluses. These are used to help students conceptually understand subtracting negative numbers. Once each partner draws a model and solves their problem, they switch papers with their partner. Their partner checks their work and stars the problem if it is correct, or explains how to solve it if the problem is incorrect. The student with the largest difference moves their game piece ten yards on the football field game board. It is amazing how using a simple football playing field as a game board helps to increase student engagement and excitement levels! This game encourages teamwork and cooperative learning as it requires students to depend on one another before moving onto the next problem. Since students need to check each other's problems before proceeding to the next, they are held accountable to one another. This game also allows for easy modifications for differentiating according to student's independent learning levels. Students that need more of a challenge use two ten-sided die in order to come up with a more difficult double digit integer, or I will give students a six-sided dice rather than a ten-sided dice in order to create easier subtraction problems. Students loved this game. In fact, in a group interview I conducted, students said this was their favorite game. Davan said, "I like the game best because you get to draw pictures and use the football field. I like anything to do with sports." Nearly all students were engaged and the majority of students wrote in an exit card that they would like to play this game again.

Comparing the Game Show to Subtraction Football

As you can see from my descriptions above, both games were very different. Please refer to my Math Game Dictionary for more detailed descriptions and instructions for both games. The Game Show arranged students in teams of five students and presented the same problem to the whole class. This felt far more competitive due to student teams trying to beat each other's time in solving the problems. On the contrary, Subtraction Football was played in partnerships where each individual problem matched each individual student's learning level. After playing various math games, students filled out an exit slip including the question; "On a scale of 1 to 3, how would you rate the difficulty of today's game?" Their responses following the different games played on two different occasions are shown in the graphs below.



Above is a graph showing how difficult students felt the Game Show was.



The above graph portrays the level of difficulty students felt Subtraction Football was.

After analyzing student responses to this question following playing the Game Show, it was obvious to me that this game allowed for minimal differentiation according to student's readiness levels. Although students were working with partners and within teams, the majority of students felt that this game was either too challenging, or too easy. Out of twenty-one students, only seven students, or 33% of the class felt this game was "just right" where parts of the problems were challenging. Fourteen students or 67% of the class felt this review game was either too easy or too hard. This also emphasizes the variety of learners I have within my classroom.

When you compare the difficulty ratings from the Game Show with Subtraction Football, you will notice that the "just right" bar rose substantially. The majority of students, fourteen to be exact, or 67% of the class felt the Subtraction Football game was "just right" for them according to the level of difficulty. Only seven students or 33% of the class felt this game was either too easy or too challenging to them. I believe this is because in the Subtraction Football game, I was able to ensure the difficulty level of each problem that every student was solving. Since students were rolling the die to determine their subtraction problem, I could have one student who needed more of a challenge roll the dice twice to get a larger number, or I could have another student roll a six sided dice instead of a ten sided die to come up with easier integers to subtract. The Game Show was different because the same problems were presented to the class for everyone to solve. Although I differentiated the Game Show by grouping students together accordingly and encouraging them to work with their team, the majority of students still felt that the problems presented were not at their "just right" independent learning levels. Within the same exit slip, I also asked students to rate their overall enjoyment of the games by circling one choice below.

1	2	3

It was boring; I would rather do book work	I kind of liked this game	this game was fun; I would like to play it again

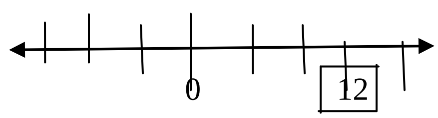
Following the Game Show, 33%, or seven students circled that they “kind of liked the game” where 57%, or twelve students circled “this game was fun; I would like to play it again.” 9%, or two of the students circled, “It was boring; I’d rather do book work.” This shows me that overall, students enjoyed the Game Show, where over half of the students would like to play it again. After playing Subtraction Football, five students circled “I kind of liked this game,” fifteen students circled, “This game is fun; I would like to play it again,” and one student circled, “It was boring; I would rather do book work.” Students seemed to enjoy the Subtraction Football game better than the Game Show. I also noted this when my crew of student leaders who were planning for the Family Math Game Night chose the Subtraction Football game as one of their top favorite games and wanted to make it available in the packets for families to play.

This discrepancy in enjoyment of games could be due to a number of factors. Firstly, they felt the Subtraction Football game was more at their independent learning level and, in turn, they possibly felt more confident while playing the game. Oscar, one of my “struggling” math students told me in an interview I conducted with him, “Subtraction Football is one of my favorite games because it is easiest for me.” Based on feelings of frustration that he expressed previously about math, I am thinking that Oscar does not have many “easy” experiences in math. Another factor that might affect students’ feelings towards the game could also be the competitive nature of the Game Show, as I mentioned earlier, which seemed to stress some of my students out, especially the less proficient students. Yury yelled out to me while playing the Game Show, “This game is not fair, that team keeps getting all the points. I don’t like the Game Show.” Although the engagement level was extremely high during this game, some students appeared to be stressed out because of the timing aspect of the game. Students who work at a slower pace were also perhaps frustrated that they could not finish the problem before others. The Subtraction Football game not only differentiated based on learning ability, but also for student pacing. Students had the freedom to work at their own pace and take as much thinking time as needed to solve a problem. This differentiation helped to make most of my students feel comfortable and confident while playing the game.

Theme Three: Games encourage students to articulate their understanding and work together to solve problems.

The games that we played in class were rarely played independently. This being the case, games provided ample opportunities for students to work cooperatively and discuss their math thinking with each other. Many of the games involved reciprocal teaching where students take turns teaching one another about how they solved a particular math problem. When students are given the opportunity to teach each other, then they are more likely to internalize and understand the concept on a deeper level.

In order to compare my student's conversation and engagement while playing math games, verses working in teams on a set of problems out of our CPM (College Preparatory Math) book, I recorded a five minute snap shot of students' conversations within both contexts. The game I recorded students playing was called, Scaling Adventures. In the game Scaling Adventures, each student had a game card that consisted of various number lines that were missing the numbers. There was a box on each number line that students would fill in according to which number they roll on their die. Students keep this number a secret from their partner. After they fill in the clue box, they switch papers and solve each other's missing numbers on that number line based on the clue their partner provided. After completing the problem, students switch papers back and check their partner's work. If their partner was correct, they would place a star on that problem, if they were incorrect, they would help their partner by asking questions and giving them clues to help them solve the problem. Students were not only solving problems, but they were creating problems for their partners to solve. For example, Angel rolled a four on his die. On his number line, he needed to figure out what his clue would be by skip counting in multiples of four. Here is an example problem from Angel's work after he rolled a 4. The empty box is where he filled in his clue (12) to help his partner solve the problem.



As I listened to the audio recording that was taken during the Scaling Adventure math game, I was amazed at how much talking the students were doing. I first focused on a five minute period and created a frequency table comparing the number of "on-task" verses "off-task" comments, or questions students made during that five minute period of playing the math game. I categorized "on-task" as anything said by a student that was directly related to the math game and the math involved in playing. "Off- task" comments were anything said by a student that was not related to the game or the math they were involved in. The next day, I recorded the same students' conversations, however, they were not playing a game with a partner, they were working in teams of four on a set of problems from our CPM books. As you read the following findings, keep in mind that the CPM curriculum is designed to promote team work and students discussion. By posing challenging problems that students are required to solve with their teammates, and prompting students to discuss their strategies with each other, CPM requires students to work cooperatively. Below are the two frequency tables that I have recorded.

While Playing Scaling Adventures partnerships (5 minutes of conversation)

On- Task	Off- Task
XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXX	XXXXX
Total: 33	Total: 5

While working in teams of 4 on CPM in problems (5 minutes of conversation)

On- task	Off-task
XXXXXXXXXX XXXXXXXXXX X	XXXXXXXXX
Total: 21	Total: 9

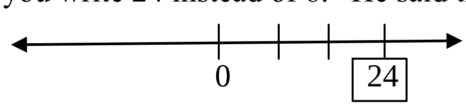
As you can see above, the ratio of off verses on task comments increased while working on the problems from the CPM book. What I found very interesting was the amount of conversation students were engaging in. Although students were working in teams of four on the CPM problems, the total amount of comments or questions spoken was considerably less than while playing Scaling Adventure; resulting in 30 comments or questions total. However, while playing the math game, although students were working only in partnerships, there were a total of 38 comments or questions spoken total. Although naturally some students speak more than others, each student on average spoke 19 times while playing the game. Working on the CPM problems, there was a total of 30 comments spoken, which means the average number of comments and/ or questions spoken was far lower at about 7 comments per student.

After listening to the audio recording and tallying the frequency of student speaking, I pulled a bit of a conversation between Carl and John while playing Scaling Adventure. This conversation demonstrates the deep level of math discourse and teaching occurring between the two students. John is one of the students that got the post-game problem correct on his exit slip after missing the pre-game problem. This means that while John did not fully understand the concept before playing the game, he demonstrated proficiency with this concept following the game. I believe his partner, Carl, helped him a lot in understanding this concept.

John: “Wait, you are going too fast… I almost got the skip counting.”

Carl: “You have to imagine the numbers before you write my clue in… Here use this scrap paper to help you.”

John: “Oh…, I get why you write 24 instead of 8.” He said this referring to the problem below.



Carl: “This isn’t right because you are not following the pattern… Try guessing different numbers and then just plug them in and check if they work.”

John: “I don’t get what you put the number under zero to?”

Carl: “Look at the number line up there. The zero is already given to you.”

By listening to their conversation, it is clear which roles they both assumed. While John was learning from Carl and comfortable asking questions about the game and the math, Carl took the role of a teacher, which is said to be the best way to really internalize a concept and demonstrate a deeper understanding. It was a win- win situation for both students. According to Johnson and Johnson (1994), cooperative learning exists when students are working together to achieve a shared goal. They state that the goal is for students to not only understand math, but to ensure that all group members are successful as well. The various partnerships’ conversations during the game demonstrated cooperative learning at its best. Since each partner needs to give the correct clue according to their scale, Carl and John were both helping each other with the scaling and neither student could successfully solve the scaling problem if their partner did not give them a proper clue. This helped to develop a mutual understanding and accountability between students and required them to work cooperatively. Johnson and Johnson (1994) also discuss that when students are given ample opportunities to verbalize their math thinking, they will acquire a deeper conceptual understanding. In a CPM conference I attended last year, our presenter stated that when students are teaching each other, they retain up to 95% of a particular concept.

While tallying students’ on-task verses off task comments for the five minute period of both the game and CPM problems, it was evident that the level of student engagement was higher while playing the math game. According to Dotzel, Welsh, Pressley, and Vincent, engagement is defined as, “… a high degree of on-task behavior with tasks that are appropriately academically demanding and worthwhile for students” (2003, p.243). Since the ratio of on verses off-task comments spoken by students decreases during the math game, I can conclude that students were more engaged during the math game than during the CPM problem set.

Theme 4: Games help to increase student comprehension with various math concepts.

Student engagement and achievement are so closely connected to one another. While students are engaged and involved in their learning, they tend to be more successful in understanding a particular concept. Through continuous observations and field notes, student’s surveys, interviews and assessments, I have seen an incredible improvement in student’s ability to articulate their math thinking through writing and speaking as well as solving math problems with increased accuracy.

Articulating math thinking through speaking and writing

In the beginning of the school year, a student, Lupita, raised her hand and asked, “Why do we have to always share our thinking with each other?” Other students began to chime in, agreeing with Lupita, some almost seeming angry about sharing their thinking with the class. I felt this was a great opportunity for me to step back and listen to my students. While some students expressed that they never used to have to share their thinking before, another student chimed in by saying, "Since there are a bunch of us, and only one teacher, it would be boring to hear just our teacher talk all the time." Listening to my students' fears and apprehensions about speaking in front of one another and sharing their math thinking, not only gave me an idea about my student's previous experience with sharing their thinking in front of a group, but also their comfort and confidence level with math in general. I could also detect that many of my students haven't yet experienced the value and importance of each other's ideas. I believe this may also stem from a lack of experience with working with teams while exploring mathematics. I hoped that slowly, as our classroom community began to evolve and a culture of collaboration and trust began to form, students would begin to feel more comfortable speaking about their math thinking and sharing their solutions with the class.

As time went on, this classroom norm of sharing and speaking and writing about their math thinking became a natural occurrence that students no longer questioned, but expected and embraced daily. Students not only shared their responses to various math problems with the class, but they also presented chapter summary posters they created to review particular concepts. They also wrote various responses in which they discussed their thinking about a certain problem and they were constantly sharing their thinking with a partner. I created an equitable system of sharing by creating a class set of cards with each student's name on them. Students chose cards randomly to pick who would be presenting their thinking and solutions to the class that day. From the beginning of the class, students began with three "Quick Questions." These questions were meant to either review previous concepts learned or launch the class into learning a new concept. Many of the QQ's I designed also helped students make connections between different learning experiences. Often when students were sharing their responses, they shared responses that connected back to various math games they have played. For example, Jeff discussed in his explanation to his solution, "I came up with these possible answers, because I remembered in the Dart Booth game, we found that there were more solutions to a problem when you add parenthesis to the equations, you can change the answer by doing that, so that is what I did."

As we played math games, students became more comfortable with each other and got more practice in speaking about their math thinking and explaining their solutions to one another. Student's ability to articulate their thinking improved. This became obvious when students began to include the word "because" into their daily math talk. For example, when Carl was sharing his answer to a math problem about percentages, he said, "They spent $24 on lunch *because* first I found the percentage of their tip and then added it to their bill. That's how I got it." I no longer had to remind students to justify their answers. I even noticed students reminding each other to explain how they came to a solution. It was great! During the majority of math games we played, students wore the hats of both the student and teacher. They were expected to discuss their thinking with their partner and/or team as well. This helped to make sharing student thinking a natural occurrence within the classroom. I believe that speaking about their thinking in more playful experiences, such as playing games, helped to open up my more shy students and in turn helped them to be more comfortable with sharing their thoughts with the class as a whole.

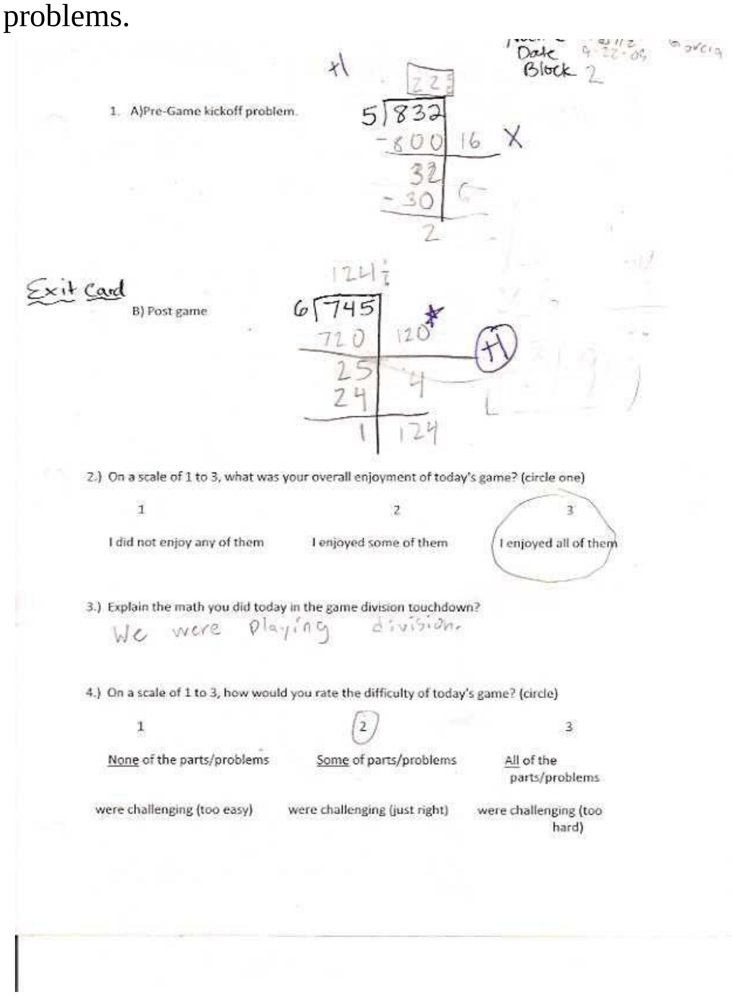
In the beginning of the school year, I also noticed that students were not accustomed to articulating their math thinking through writing. When asked to do so, I would get responses that included eye rolling, or heavy sighs, or even "Why do we write in math class?" After many of the math games that students played, I gave students a quick exit slip. Many of the exit slips included a question that involved them writing about the math concept they were exploring while playing the game. I believed if students could verbally articulate the math involved in solving a particular problem or playing a specific game, than they would be demonstrating a deeper conceptual understanding. This also helped to associate writing about math with something that they thought was fun, such as a math game. At first, after playing the game Division Football, student's responses to the question, "Describe the math that was involved in the game you played today," were extremely vague. Students' initial responses were as follows, "I do not know," "We were dividing numbers," "We had to do the use Partial Quotients to divide." I noticed there was over half of the class that simply wrote, "We had to divide." There were little to no details about the process students used to solve problems, but instead, they were just spouting back the math concept they were exploring.

After modeling what a more detailed response would look like and having students practice this kind of articulation after playing various math games, students were soon able to write more detailed responses that represented a much deeper conceptual understanding of a particular concept. After playing the Pig Race game, Juan wrote, "In today's game, we were using the Order of Operations to build equations that would give us many different answers. We saw how when we changed the order of the numbers and the plus, minus, multiply and divide signs, then our answer would change." Susie stated after playing Scaling Adventure, "We had to speak with our partner about how to spread the numbers out evenly on the number line. My partner and I looked for patterns that helped us." After playing Subtraction Touchdown, Oscar wrote, "I had to draw pictures to help me subtract negative numbers. The pluses we draw are positive and the minuses are negatives. I had to teach my partner when he was wrong what to do."

As you can see, students were not just listing a topic, but instead breaking down what the actual math was and strategies needed to be successful in playing the game. This clear articulation improved their writing and speaking not only about the math games they were playing in class, but throughout a variety of learning experiences. By the end of the first semester, I noticed the culture of the classroom had become much more student directed where they were sharing their thoughts and ideas with one another and helping the rest of the class understand their solutions. I now have students that are begging to go up to board to share their Quick Questions with the class, and when we run out of time for the summary, where students share what they "took away" from the day, I hear students yelling out, "Hey I didn't get to share my "take away" today with everyone!" What a great and refreshing transformation for both me and my students!

Students are problem solving with more accuracy after playing math games.

I found measuring the affects math games have on students' achievement and conceptual understanding to be somewhat challenging. The biggest challenge I ran into was pinpointing which learning experiences helped students improve their conceptual understanding. For example, if students understand the math concept better, was it the direct instruction that I gave students, was it other students sharing their solutions and strategies, was it working with their team on a CPM problem set, or was it the math game that they played that helped them to better understand the concept? The question I had to further examine was, "How can I pin-point whether their learning improved through solely the math game?" In order to measure the affects of specifically the math games, I had to come up with a way to assess what students knew directly before and after playing a particular math game. I did this by giving students a short and quick math assessment before playing a game and then a similar one in difficulty directly after playing the game. The assessments consisted of one or two short math problems relating to the concepts they were exploring in the math game. For your reference, I have inserted an exit card that students filled out. The upper half of the exit card includes the pre and post assessment problems.


Date
Block 2

Exit Card

1. A)Pre-Game kickoff problem.

B) Post game

2.) On a scale of 1 to 3, what was your overall enjoyment of today's game? (circle one)

1	2	3
I did not enjoy any of them	I enjoyed some of them	I enjoyed all of them

3.) Explain the math you did today in the game division touchdown?

We were playing division.

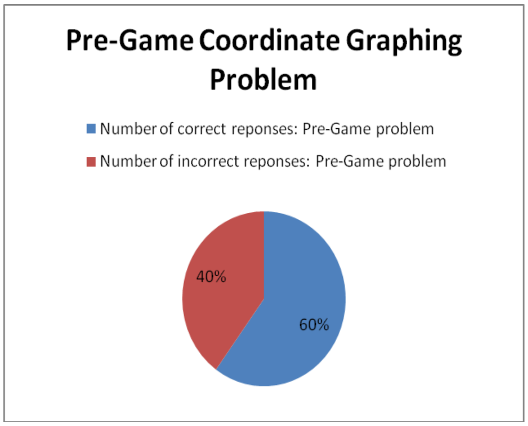
4.) On a scale of 1 to 3, how would you rate the difficulty of today's game? (circle)

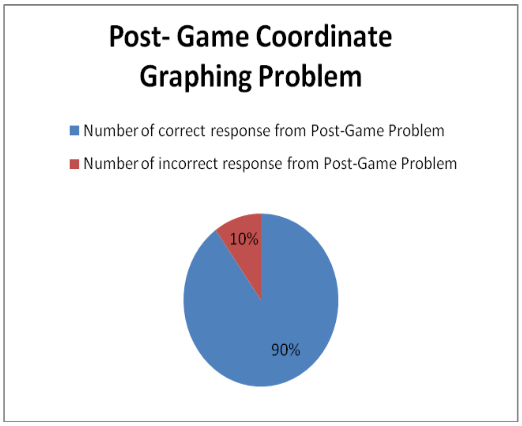
1	2	3
None of the parts/problems were challenging (too easy)	Some of parts/problems were challenging (just right)	All of the parts/problems were challenging (too hard)

Above is an exit card that includes the pre and post assessment problems.

They would solve these problems independently before and then again directly after playing the game. This was one way I could see the actual affects the math games had on their conceptual understanding. I did this before and after three different games students played and the results were quite astounding.

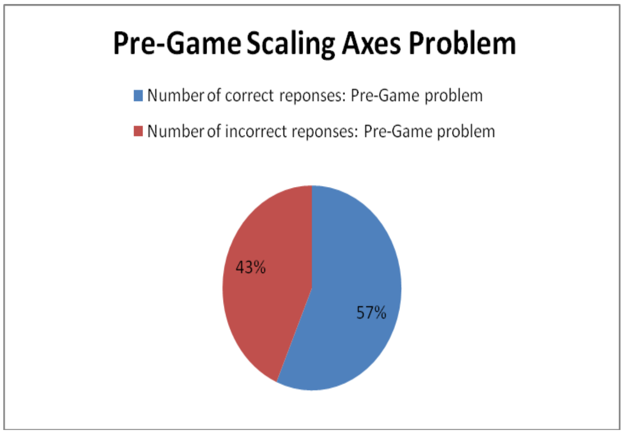
Before playing the Hidden Treasure/ Battle Ship game, I gave students a pre-game problem in which they had to graph three different ordered pairs on a coordinate plane. Twelve students answered the pre-game problem correctly, and eight did not. In other words, 60% of students were correct. Directly after playing the game, as part of the exit card students were to complete, I gave them a similar coordinate graphing question for them to answer. Eighteen students correctly solved the problem, or 90% of the class answering correctly, where only two students still got the problem wrong. This means there was a percent increase of 30% from before to after playing the game. This data shows me that the game was effective in helping students become more proficient in graphing an ordered pair. Below, you will find two pie charts comparing the data from the pre and post game problems mentioned above.

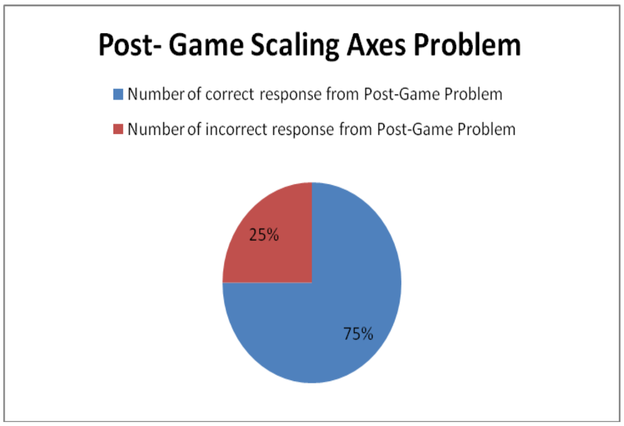




The two pie charts illustrate the results from pre and post problems students answered before and after playing the Hidden treasure/ Battleship game.

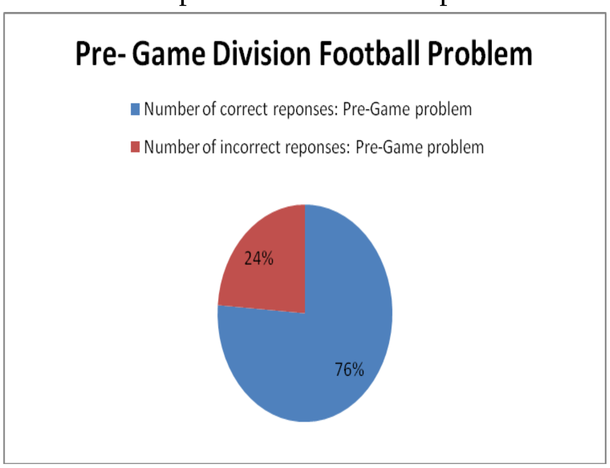
Through most of pre and post assessments I gave students, there was a consistent increase in student's comprehension from before playing the game. The pre and post assessments also helped me to see which games were more effective than others. Below, you will see another pre and post assessment for the Scaling Axes Adventure game. Nearly half of the class, or 57% of the class answered the pre-game problem correctly. After playing the game, 75% of the students answered the problem correctly. This game was very effective because students had to practice problem solving with accuracy while working with their partner. If they were not accurate with their calculations, then their partner would not be able to answer the questions posed. I observed a huge amount of peer tutoring while playing this game. I believe this increase in math discussion helped with student accuracy in problem solving and also helped students become more confident and proficient within their ability to problem solve.

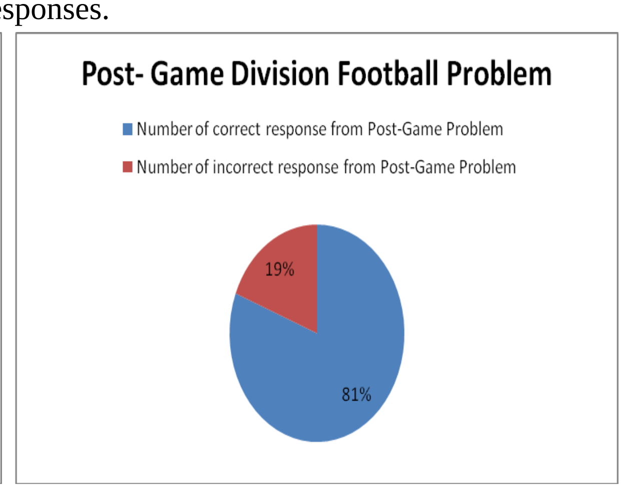




Above are the results from the pre and post- game problems from the Scaling Adventures game.

Students also answered a series of pre and post questions before and after playing Division Football. The pie chart below compares their responses.





These are the pre and post assessment given to students before and after Division Football.

As you can see above, there was only a slight increase in student's performance from the pre to post game problem during the Division Football game. Although I found this game to be very effective in practicing division, this game is a post-instruction game, or a game that is played after students have already learned a concept. I used this game as a tool to reinforce a concept already taught. Therefore, many of the students were nearing proficiency before playing this game.

As you can see throughout my findings sections, there is a time and place for different math games. They have the potential to serve many different purposes. Whether it is to teach a new concept or reinforce what was already learned, math games helped to transform the culture of my classroom and the way my students felt and thought about math.