HTH GSE PROGRAM

Action Research Project

How do math games affect student engagement and achievement?

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Within our country, there is an increasing population of people that seem to suffer from mathphobia. Their lack of self confidence in their math abilities causes many to experience feelings of frustration and fear towards the subject. I have observed this fear of math within my 6th grade, San Diego classroom year after year. My action research project explores how math games affect student engagement and achievement in the classroom. By observing students' behavior, analyzing work samples, and conducting various student interviews and surveys, I discovered the effects of math games on student learning. Through experiencing math in a more playful manner, I have found students' fear of math seemed to dissipate, instilling a higher confidence in their own abilities. These findings have inspired and transformed my teaching practice.

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Introduction

The many teachers I had encountered from elementary school through high school helped shape who I have become as a teacher. Of course I remember the really strong teachers, those that I have always admired and aspired to be like, and I still remember those who have taught me what I do not want to mimic as a teacher. Although most years of my schooling took place in alternative, hands-on, non-traditional schools, the ways teachers taught math always seemed to share some commonalities. Tracking was not a common practice, except in math. In all classes we learned through projects and cooperative teams, except for math. We rarely used textbooks as a primary resource, except for math. I always loved learning math, but recognized that math was often taught differently than other subjects. When I decided I wanted to teach math, I realized that I wanted my students to explore and discover the beauty of mathematics in a "non-traditional" way. I knew that although I always "got it" many others around me were slipping through the cracks. I never want my students to feel like they are slipping through the cracks.

I have always acknowledged that in order for all students to learn and understand math, it is essential for them to be involved and engaged in the learning process. This is something that I continue to struggle with daily in my teaching practice. I am constantly planning my lessons while thinking about how I can involve and engage my students in *every* part of the lesson. I began to become more aware of a pattern occurring this year in my classroom. Students that naturally love math, often the more proficient and confident math students, seem to always be enthusiastic about the math they are exploring, no matter what the lesson entails; students who lack confidence in math and for some reason have always disliked math, tend to "tune out" in class, causing them to slip further and further behind. These students often show signs of feeling overwhelmed and anxious about learning math. One of my primary goals in teaching is to shift these students' attitudes about math, giving them more self confidence and showing them that math can be fun, playful and exciting all at the same time. I do not want any of my students to be anxious or scared by math.

Transforming student attitudes about math begins from day one of the school year. At the beginning of each year, students write me letters about themselves, ways they learn best and their feelings towards math. While reading these letters in the Fall of 2008, I realized just how many students begin my class already scared and anxious about learning math. I always let my students know that although I expect them to work hard and try their very best in my class, I also want them to have fun with math. I want my classroom to not only be rigorous, but also to be a playful place where all students can feel comfortable and look forward to being a part of. A few months later, after the first progress report grading period, I gave my students a teacher and class report card. I wanted to get feedback from my students on how they felt the class was going and ways that I could make their experience learning math even better. Although the curriculum that Keiller Leadership Academy has adopted called CPM (College Preparatory Mathematics) includes many different hands-on exploratory lessons, the majority of my students all said that they love playing math games and wanted me to plan more games for them in class. This is what

initially sparked my interests in creating a curriculum that integrated more math games. I originally wondered if these playful experiences could help reduce student anxiety about math and help increase student engagement, therefore increasing student achievement as well. Children like to play, thus it makes perfect sense to have my classroom be a place of learning in playful ways.

After receiving student feedback and incorporating more games into my lessons that year, I made some observations and comparisons of student engagement and attitudes throughout different math lessons and activities. For starters, I noticed when students spotted the agenda included a math game; they would get really excited and enthusiastic about class. While playing math games, nearly *every* student was involved and participating. I did not have to remind students to stay on task because they were self motivated and wanted to participate. I thought, "What a breath of fresh air this is!" This excitement produced from both me and my students led me to the research question I would spend the next year exploring, "**How do math games effect student engagement and achievement?"** I hoped that by creating more experiences like this that allow for students to explore and practice different math concepts in a playful manner such as a game, students would be more engaged in their learning, causing their achievement level and comprehension to increase. I also hoped that my findings on this question would help me create a more enriching classroom that motivated and engaged students to learn, and helped solve the continuous issue of students "falling through the cracks." Math teachers in particular need to take an active role in breaking this cycle in order to help close the achievement gaps that exist in many classes today. The following is my journey.

Understandings

"Young people learn a great deal about the world through play, and games are one source of play" (cited by Cavanagh, 2006, p. 46)

Student anxiety about math

Our country is facing an epidemic in many schools called math-phobia, an extreme fear of mathematics. Students who have had bad experiences learning math often develop this phobia and, in turn, struggle learning various concepts because they feel they are unable to do the math (Resek & Rupley, 1980). Many researchers have found that after fourth grade, students' attitudes about math often change and they begin to dislike and avoid math. This fear and avoidance of math often gets carried with them throughout their schooling and can limit their career opportunities later in life. As math anxiety increases, their academic achievement and performance inevitably decreases (Fillier, 2005). Students who suffer from this anxiety are often afraid of making mistakes and of asking what they think are dumb questions (Johnson & Johnson, 1991). Teachers must work towards breaking this cycle of math-phobia in order to insure the success of all students.

There are several causes of math anxiety including parent and teacher attitudes, teaching methods, previous experiences and societal influences (Fillier, 2005). Both teachers' and

parents' attitudes about math often get passed down to students. If they feel anxious about math, or do not value its importance and relevance, then often the students will pick up on that attitude as well. There are several teaching strategies that can also perpetuate this math anxiety, such as being taught directly from a textbook without differentiating for a variety of learning styles or abilities, or if students are made to feel there is only one way to solve a problem, inhibiting creativity. Certain societal stereotypes can also inhibit a student's performance in math. The idea that men are better at math than women, math ability is inherited and you either have it or you don't, and math problems only have one correct answer, all affect a student's attitude towards math. It is essential for people to become aware of these causes of math anxiety in order to limit and prevent them (Fillier, 2005).

As teachers, we need to be sensitive to this anxiety towards math and continuously work towards building students' self confidence. There are many ways that we can reduce or eliminate math anxiety in the classroom. Studies have found that allowing students to work on math in a less traditional environment often eases their fear about learning math. When referring to a less traditional classroom, I mean a classroom that does not follow the model of teacher lecture followed by students working independently on answering a set of math problems. A less traditional classroom might include more math projects and games where students explore various math concepts as opposed to just learn a procedure. When students are having fun and playing they are more relaxed, which will help them learn math concepts as well as increase their self confidence and the belief that they are capable (Resek & Rupley, 1980). When certain students of mine feel overwhelmed with a math concept we are learning, they will often shut down, therefore retaining minimal content. For these students especially, we need to boost their self-esteem and confidence by showing them difficult math concepts can be fun to learn, and they will be successful in doing so.

Creating a math curriculum that incorporates multiple opportunities to explore math through games will ease students' fears about learning math (Cavaneigh, 2006; Allen & Main, 1976). Since children learn best through hands-on exploration, games are one strategy to increase student understanding in math. Published in the journal, *Teaching Exceptional Children* (2005), Shaftel, Pass, and Schnabel wrote:

Mathematic games allow the learner many opportunities to reinforce current knowledge and try out strategies or techniques without fear of getting the "wrong" answer… Games can provide an environment for experiencing incorrect solutions not as mistakes but as in steps in connecting pieces of mathematical knowledge. (2005, p. 26)

Math games also help spark interests in math within students that otherwise might not feel confident. This type of math community that sparks students' interests, will also allow students to embrace the many mistakes from which mathematicians learn and grow.

Research has proven that math games help to close the achievement gap in minority schools. Studies have found that students' performance in math is generally lower among ethnic minorities and lower income schools. The 2003 Trends in International Mathematics and Science Study (TIMMS) found eighth grade achievement was 57 points higher in schools with fewer

students coming from low income households. Cavanagh (2006) refers to a study by Seigler, Geetha, and Ramani which introduced various math related board games into Head Start Preschools, a program that primarily serves children from low income areas. Students played these board games four times a week for a two week period of time. They found that students' knowledge of number sense increased greatly by the end of the two week period. I hope that making math games an integral part of my math curriculum will help to close the achievement gap that I have observed within my own classroom. I also believe that if I can plan opportunities for students to play math games with their families at home, not only will this reinforce specific math concepts, but the cycle of math-phobia might come to a close. As I further research the effects of math games on student engagement and achievement, I will continue to uncover new and old games that can help transform students' attitudes about math and aid in breaking down the math-phobia that exists today.

Traditional Math Education vs. Math Games

Although there has been much reform in the way math is taught, many math curriculums are still structured for the purpose of teaching students a plethora of isolated math concepts, often incorporating a "drill and kill" method of teaching. This does not encourage students to develop a strong conceptual foundation, making it very difficult for them to make relevant connections. It also does not teach students how to problem solve and reason mathematically (Johnson & Johnson, 1991). The 2003 TIMMS study found that the most commonly used instructional activities in math classrooms were teacher lecture, teacher-guided student practice and students working independently on a set of problems. Through numerous classroom observations and interviews, Stodolsky, Salk and Glaessner (1991) also found that in the typical math classroom, especially found in public school classes, the math teacher explains a concept or math algorithm to the whole class, followed by students working individually at their seats in their text books or on worksheets. There is little to no team work, and everyday often follows a similar pattern. Students frequently experience feelings of high anxiety and shame in these classes and tend to become extremely bored. Many students in turn adopt the attitude of either, "I can do it" or "I can't do it." This attitude, along with commonly accepted societal beliefs about math ability being inherited, cause students to give up and shut down, often following this pattern through their entire life (Stodolsky, et al, 1991).

Studies have found only nine percent of American 13-year olds could understand certain math concepts compared to forty percent of their Korean counterparts (Kadijevich, D., 2003). Johnson and Johnson state in *Learning Mathematics in* a *Cooperative Classroom*, "Children born today will enter a work force where knowledge about mathematics is crucial to their career opportunities, their participation in society, and their conduct in their private lives" (1994, p. 1). If we want our students to be successful members of society, we need to reform the way we teach math in order to close this math achievement gap. Teachers and curriculum developers must acknowledge that math is more than memorizing rules and procedures. These findings help me to understand the negative baggage that my students often bring to my math class. As a

teacher, I need to break up the monotony of what many students have experienced in math class and show them that they will not only have fun in my class, but also feel successful learning math.

Research has shown that students are more likely to be actively engaged in learning math while playing games and doing hands-on projects rather than learning in the traditional math classroom. Educators have been researching the effects of math games verses traditional math instruction for many years. In 1976, Allen and Main conducted a research study in the inner city of Detroit, Michigan where high student absenteeism rates plagued the school. The essential question they sought to answer was whether or not a learning environment organized around games has a positive effect on students' attitudes towards learning. In order to increase student learning in math, they felt it was essential for students to attend school in the first place. This led them to focus on ways they could minimize student absenteeism within their school. They studied two types of untracked traditional seventh grade math classes. One continued with their usual, more traditional math curriculum daily, while the other implemented an equations based math game and tournament two days a week. The math tournament, called *Equations*, allowed for students to compete against each other based on their own mathematical ability, while cooperating with teammates in order to create challenging questions for their opponents to answer. This study continued for two semesters and the ratio of student absences to the total number of days was compared among both groups of students. The teacher noticed that students were pushing themselves to create and answer challenging problems that were purely student generated, and many students playing this tournament developed an "I can do it" attitude. During cooperative team activities such as this game, students were working problems out together, explaining their ideas to each other and discussing their strategies for the *Equations* tournament with one another. Allen and Main found a dramatic decrease in the number of student absences within the classroom consistently playing the Equations Tournament. In fact, they found the non-absenteeism rate was over three times higher than that of students in the traditional math classrooms. They suspected that the main reason for student absenteeism rates decreasing in classrooms that involved math games was because these students developed more positive attitudes towards math.

Students are more apt to achieve and grapple with difficult math concepts if they are engaged in their learning. When students dislike school or a particular class, they are less likely to grasp concepts being taught. Stodolsky, Salk and Glaessner write, "As educators, we must seriously assess the presumed contribution schooling itself makes in the development of attitudes, beliefs, and conceptions that students hold toward different school subjects" (1991, p. 113). The strategies we use to teach different subjects greatly impact the students' attitudes towards that class and that subject matter.

Implementing Math Games

Games are one form of math instruction and should be implemented along with other learning experiences. In a 1985 monograph, Bright, Harvey, and Wheeler write about the effects

of learning through math games and categorize games into three categories; pre-instructional, post-instructional, and co-instructional. A pre-instructional game is played to introduce and launch a concept before it is explicitly taught. Post-instructional games are played in order to review concepts previously taught and co-constructional games are played to teach new concepts or accompany direct instruction. Most games involve a challenge against a task or opponent and require following a set of rules and structures. Bright and his colleagues stress that it is essential for the teacher to determine and state the instructional objectives clearly and explicitly to the students before playing the game. The rules and format of the game need to be clearly modeled and taught to the students as well, prior to playing the game. This helps to eliminate any student confusion about the game. As with all great teaching practices, it is vital to know exactly what students' academic abilities are and group them together accordingly.

There are several variables that affect the quality of an instructional math game, such as the format of the game, the content of the game, the instructional level of the game and the level of peer interaction and competition. Many teachers use games to "…trick students into paying attention before the 'real teaching' starts, or as a reward for students who finish their work early" (Klawe & Phillips, 1995, p. 2). This does not allow for games to become an integral part of the curriculum. Instead, it sends the message to students that games are not important or worthwhile. In *Math Games for Adolescents*, Shaftel, Pass and Schnabel (2005) state specific cautions for using math games in the classroom. In order to continue to motivate students, they argue it is important for teachers to not over-use math games. Like anything in the classroom, students will get bored by having the same experiences over and over again. Teachers should also watch out for excessive competition and over stimulation among students. Games should be fun for students and not stressful. It is also imperative to consider the complexity of the rules and the math content covered in the game as well as the physical requirements and social skills needed for students to be successful while playing. One challenge I have come across is the difficulty of pin pointing exactly what my students are achieving while playing a math game. In order to hold them accountable for their learning, I have used multiple strategies for assessing student knowledge during math games. When discussing how to present challenging, yet accessible math problems, Resek and Rupley write:

A very delicate balance must be sought where students are pushed and challenged, yet do not become so frustrated that they give up. If they are not challenged, they will not gain the self confidence they need to survive future courses, and, more importantly, they will not feel the sense of mastery, which makes doing mathematics enjoyable. (1980, p. 428)

Through the implementation of my action research project, I worked towards creating this balance.

Benefits of Math Games

There are countless benefits of math games. According to research, math games can increase student engagement in the classroom, provide ample opportunities for cooperative learning, and help to increase student achievement levels. I discuss each of these below.

Engagement

A recent study on how teachers motivate and engage their students conducted by Dolezal, Welsh, Pressley, and Vincent (2003) explores a variety of strategies to increase student engagement in the classroom; they define engagement as, "…a high degree of on-task behavior with tasks that are appropriately academically demanding and worthwhile for students" (p. 243). They observed nine teachers over the course of the year, interviewing them and their students and tracking students' engagement and achievement levels. Students were determined to be engaged if they were actively participating in the task at hand and doing what the teacher asked of them. Based on their findings and results, teachers were classified into three separate categories; low, moderately and highly engaging. Researchers observed negative classroom management, students not being challenged or interested in what they were learning and unenthusiastic teachers in the five less engaging classrooms. Creative thinking and problem solving were rarely encouraged and students were most often off task. The four moderately engaging teachers used many highly motivating teaching strategies, but they were assigned to low difficulty leveled tasks. However, the two highly engaging teachers used numerous motivating strategies and required students to accomplish cognitively challenging tasks. Students' desks were arranged in table groups that promoted collaboration and cooperation, and within both of these classrooms teachers tried to make content interesting, challenging, and playful.

When referring to highly engaging activities, Dolezal, Welsh, Pressley, and Vincent state, "These activities often captured students' attention by providing opportunities to use manipulatives, play a game, create a skit, or design art. As a result, students were enthusiastic as the teacher introduced lessons" (2003, p. 252). Projects were planned and games played that actively involved all students. When describing a highly engaging teacher, the authors also claim, "Ms. Irving's lessons were not just hands-on but minds-on as well" (p. 254). Students in these extremely engaging classrooms were consistently focused on the task at hand (Dolezal et al., 2003). Although this study focused solely on student engagement, I looked at both student engagement and achievement. Throughout my action research project, I sought to prove in my classroom that higher levels of student engagement and on-task behaviors will lead to an increase in my students' achievement levels. Students must be active, rather than passive, in the learning process.

I do not want my math classroom to be a boring and dry place for my students; instead, I want to show students that learning math can be fun and playful. I believe students are more likely to remember their colorful math experiences, such as playing games and doing projects rather than the more dull and dry "drill and kill" methods of teaching math. My 6th grade students are so active and playful with each other. Many of them are constantly tapping on the desks or moving around in their seat. Shouldn't we make learning math more active and playful for them? Children's brains and bodies are not wired to sit in their seats for long periods of time and listen to their teacher talk. This is not how they learn best. They learn through doing and

talking and playing (Dolezal, et al., 2003). In order to increase student engagement in my classroom, I created more playful experiences that provide opportunities for my students to be "doing" math in a fun and energetic way.

Cooperative Learning

Teaching various math concepts through playing games will give students numerous opportunities to work cooperatively with each other. There is evidence that cooperative learning helps students learn math, while increasing student engagement. For the past 40 years, math classrooms have been structured for students to work primarily independently; competing against their peers for higher grades and test scores. This not only creates a negative community atmosphere, but is also detrimental to a student's self esteem and helps to perpetuate anxiety about math (Johnson & Johnson, 1991).

According to Johnson and Johnson (1991), cooperative learning exists when students are working together to achieve a specific shared goal. The goal of the team is not only for each student to learn the math, but to ensure that all group members are successful as well. In an effectively structured cooperative learning math lesson, students have the opportunities to explain what they are learning to each other, hear other points of views, and observe a variety of ways to solve a problem and give and get support from their peers. Giving students opportunities to communicate about math is essential in helping them acquire meaning and leads to a deeper understanding about a concept. Evidence also suggests that cooperative learning helps to promote positive social relationships among students, increases students' self esteem about math and creates more positive attitudes towards mathematics (Johnson, Johnson & Holubec, 1994). Students who might feel anxiety sharing their ideas with the entire class often feel more comfortable sharing in smaller groups. These are among many of the benefits of cooperative learning.

Implementing more cooperative learning opportunities through games in my math class helped to fight the anxiety many students feel about the subject. Research supports the notion that students gain more self confidence in their own math abilities while working cooperatively, rather than working independently in more competitive classroom environment (Johnson, Johnson & Holubec, 1994). Since students are receiving, as well as giving, each other immediate help and feedback, they are more likely to develop an "I can do it" attitude about themselves, increasing their confidence in their ability to learn math. In cooperative group settings, students are more comfortable making mistakes and taking risks. Risk-taking is extremely important for students to be successful in learning math, as it reaffirms the idea that mistakes make for valuable learning opportunities.

To further explore the effects of cooperative learning, the Electronic Games for Education in Math and Science (E-GEMS) conducted a study at an interactive science museum called Science World, in 1993. Whether in a classroom, or at a child's home, they noticed that children naturally gather together in groups around video games and computers. This is what guided their research. They set up a computer exhibit that involved playing a game called The

Incredible Machine (TIM), requiring players to build "Rube Goldberg" machines out of an assortment of parts to perform various challenges the computer would pose. An example of a challenge is building a machine to shoot a basketball in a hoop while trapping a mouse in a cage. Children could choose from various parts such as ropes, pulleys, trampolines, elastics and so forth. The exhibit was set up into three different sections; one solo play machine where a child could play by his or her self, another parallel play section where two children played on side-by-side machines and finally, an integrated play machine in which two children played together on one machine. Throughout this two month long exhibit, over ten thousand randomly chosen children participated and hundreds of children were interviewed. The partnerships formed were single gendered. Inkpen and colleagues (1993) found that both boy and girl partnerships playing on the one integrated machine solved considerably more puzzles than those individual children playing on the solo and parallel machines. They also noticed that girls solved fewer puzzles competing against each other on the parallel machine compared to the solo machine. They seemed to be most successful while working cooperatively, yet least successful when put in more competitive situations. They also observed that more children would play for the entire 30 minute session on the integrated machines. This led them to believe that the different stations affected the children's motivation and engagement (Inkpen, K et al., 1993). If used effectively, cooperative learning, particularly while playing math games, can be used to increase motivation and engagement within the classroom.

Achievement

Andy Isaacs, the director of the third edition of *Everyday Mathematics* stated, "Not only do games engage students, they also present the opportunity to present "high level" math concepts in a colorful and simple way" (Isaacs as cited in Cavanagh, 2006 p. 46). Since student participation levels are higher while playing games, retention of math concepts overtime is also higher (Shaftel, Pass, & Schnabel, 2005). In order to present challenging math concepts in "colorful" ways that lead to increased math achievement, I feel it is essential to include math games throughout my curriculum.

Using technology is a very efficient way to incorporate math games throughout my curriculum. Although I do not have a class set of computers readily available within the construct of my classroom walls, I do have access to a computer lab. As it is evident that educational reform must occur within our country, there have been extensive studies on the impact of educational technology on student achievement. In 1998, Harold Wenglinsky assessed the effects of computer simulation and higher order thinking technologies on a sample of 6,227 fourth graders and 7,146 eighth graders throughout our country. He emphasized the importance of higher order thinking because he found that while many teachers use technology throughout their curriculum, they use computers for drill and practice methods that do not require students to apply higher order thinking skills. He sought out to verify that if computers were used effectively for learning games that require higher order thinking, then student achievement would inevitably increase. His report examined and interpreted the results of a national study

conducted by the National Assessment of Educational Progress (NAEP). This is a national study that is given every two years to evaluate trends in student performance and achievement over time. The NAEP includes surveys and questionnaires that are given to students, teachers, and principles and encompass various subject areas. For the first time ever, the NAEP included in depth questions about technology.

Wenglinsky (1998) examined the relationship that technology played on both the academic achievement, measured by standardized tests as well as the social environment of the school, encompassing student tardiness, teacher and student absenteeism and student and teacher morale. He found that the use of computer learning games that required students to use higher order thinking skills positively affected academic achievement. He also found a positive relationship between teachers receiving professional development in the use of computer learning games to their students' academic achievement. When both professional development and higher order computer learning games were utilized within fourth grade classrooms, students' academic achievement level increased by about a tenth of a grade level, or a few weeks of instruction. This growth was far more substantial in eighth grade classrooms, with an increase in academic achievement of about one-third of a grade level. However, this study does not take into consideration the characteristics of the different teachers, therefore making it difficult to pinpoint the results solely on higher order thinking computer learning games. It is evident that computer learning games are one of many different teaching tools that can help increase student achievement in the classroom (Wenglingsky, 1998). If when used for higher order thinking skills, computer learning games help to increase student achievement, then it is vital to increase school funding for not only computer access in the classrooms, but professional development that will enable teachers to feel more confident using technology in an effective manner.

In the study described above, math achievement was measured by the use of standardized testing, however, achievement can be measured in a variety of other ways, including tests, quizzes, projects, and student observations. One example of measuring achievement is found in the 2003 TIMMS research study. Four benchmarks levels that described math achievement on an international level were created based on what students knew and could do mathematically. The categories developed were Advanced, High, Intermediate and Low. Eighth grade students in the advanced category demonstrated their knowledge of a variety of mathematic concepts in more complex problem solving situations. They could "organize information, make generalizations, solve non-routine problems and draw and justify conclusions from the data" (p.62). Students in the High benchmark "can apply their understanding and knowledge in a variety of relatively complex situations" (p.62). In the Intermediate Benchmark, students "can apply basic mathematical knowledge in straightforward situations" (p. 62). Lastly, students in the Low Benchmark "have some basic mathematical knowledge" (p.62). The results of the study demonstrate the idea that successful problem solving is a result of mastering the math concepts and skills needed. Results of the study show that in both the fourth and eighth grades, Singapore was the top performing country with their average achievement levels considerably higher than any other country. So what does a typical math lesson look like in Singapore? What math

instructional strategies do they implement in order to increase their student achievement levels? These are crucial questions for me to further explore in order to learn and grow from other countries' successes in teaching math. Through my journey into researching the effects of math games on student achievement, I have found a significant gap in the research. This gap has inspired me to design my action research around specifically games and achievement in order to provide educators with concrete data that can help fill this void I have observed.

Why examine students' attitudes towards math?

Within most facets of life, personal attitudes are often what drive us towards success or failure. Math is a subject that evokes very strong feelings that greatly influence a student's ability to learn and develop a deep conceptual understanding. The TIMS study mentioned above examined the relationship between three dimensions of mathematics attitude to math achievement. This study included 137,346 eighth graders from thirty three countries. An instrument was developed to measure how students' attitudes towards math affected their academic achievement in math. There were numerous statements in which students scaled their answers from 1-4. Mathematics attitudes were categorized into three separate groups: students' perception on learning math or self-confidence; whether the students liked or disliked math; and lastly, how useful the students felt math was for them. Although results from this study varied from country to country due to the varying mathematics instruction practiced in the classrooms, there were important findings which remained consistent across the study (Kadijevich, 2003). Self confidence in learning math was directly related to math achievement in thirty one countries studied. Students in countries with higher levels of math achievement demonstrated higher self confidence and were more likely to believe they were capable and successful when learning math. Researchers also found a positive correlation between students who liked math and math achievement. Because self confidence is so directly related to students' academic performance and achievement, it is vital for teachers to design curriculum around building students' self confidence. We need to arrange our classrooms in a way that allow students to experience success and not failure when investigating math.

As my students leave their elementary schools and enter my sixth grade classroom, I can usually pick out the majority of students that feel negatively, or anxious, towards math. As they write me a "get to know you" letter about themselves, these students are the first to express their concerns and apprehensions about math. Identifying a student's initial attitude towards math was essential to helping them break the math-phobia they may have developed throughout their previous years of schooling. Math-phobia creates a wall that needs to be broken down in order for students to be successful learning math. Their attitudes about math seem to be directly linked to their academic successes or failures in the classroom. Because of this, I examined student attitudes about math along with their achievement and engagement levels in various learning contexts. Since students' attitudes are strong predictors of levels of engagement and achievement, it was essential for me to explore their attitudes towards mathematics over time and use my findings to drive my action research project. When students are exposed to a curriculum

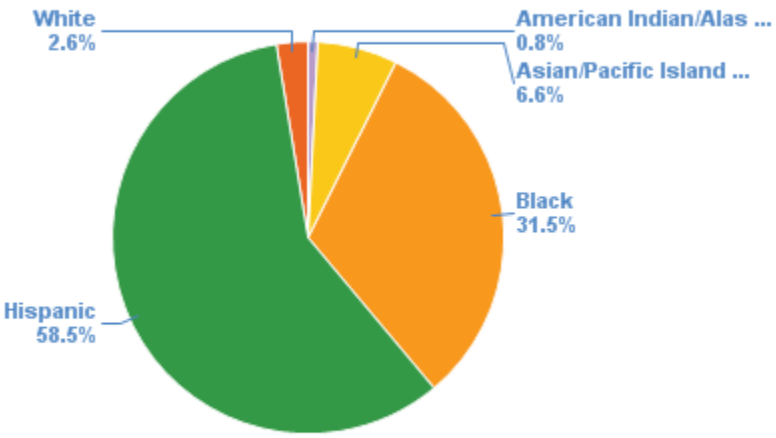
that is centered on various math games, my hopes was that there would be a shift in students' attitude and an increase in student achievement.

Description of Setting

School Setting

Keiller Leadership Academy (KLA) underwent an amazing transformation in 2004 as it broke free from San Diego Unified School District and became its own public Charter school. Once one of the most dangerous middle schools in Southern California, parents, teachers, administration and community members rallied together to turn this gang infested and violence ridden school from Keiller Middle School into Keiller Leadership Academy. After much resistance, KLA won and opened its metal sliding gates, otherwise known as the "Gates of Wisdom" to over 500 middle school students in 2005. Within the first two years of becoming a Charter School, KLA's test scores had risen almost 100 points, and the school exited "Program Improvement."

One can only imagine how these incredible achievement gains affected the community of Keiller Leadership Academy. Parents and guardians lined up to enroll their children at our school. News reporters wrote articles, conducted television news shows, and interviewed students and staff about the many successes we were experiencing. Because of the strong culture of learning that exists at KLA, parents continue pulling their students from other neighborhood schools and enrolling them at KLA. Any child can attend KLA, as it is a public charter school. Because of this, the majority or our student population comes from its neighboring Jamacha and Skyline area. However, as KLA becomes more and more popular, the number of students commuting from outside neighborhoods is increasing. Since KLA hosts mostly neighborhood children, the student population is very similar to its community schools: mainly minority students with almost 70% of students receiving free or reduced-priced lunch.



Above is a pie chart of the student demographics at Keiller Leadership Academy.

While the first three years at KLA were very stable, the fourth year included a considerable administration change and the resignation of numerous board members. However, as we begin to close the current school year, we move towards a path of stability and recovering KLA's shared vision. Through this transition of leadership, the mission of KLA has become a bit muddled; however, teachers and staff are actively working on rebuilding KLA in order to reach its full potential. KLA remains a Leadership Academy that holds its' students and their achievement at very high expectations. It is evident that most teachers working at KLA really want to be there, and since becoming a charter school, teacher absences have decreased significantly.

KLA is built upon five values we call REACH; Respect, Enthusiasm, Achievement, Citizenship and Hard Work. Students, as well as all staff are expected to follow the REACH values. Teachers model the REACH values as well as design curriculum centered on them. Every day, teachers teach an advisory, referred to as REACH class. KLA has allotted extra funding to extend our school day by an hour from that of the district. Within this extra hour of REACH class, students do various lessons and activities to promote the REACH values as well as choose other electives such as Art, Drama, Avid, or Journalism. The mission of KLA is *to create student leaders that take an active role within their education and their diverse community*. Through student governments and various plays and activities, KLA students have numerous opportunities to take on a leadership role within their school. Parents and guardians are also encouraged to take an active role within their child's education. This may include volunteering their time in the classroom, attending various school events or even shadowing their child for the day.

Since KLA is a fiscally independent Charter school, we have flexibility in how we spend our money. Money is allocated for reduced class sizes, with the goal being no more than 25 students in one class. Enrollment at KLA is now about 500 students, as compared to over 700 students that were previously enrolled when KLA was a part of the district four years ago. Although it is considerably more expensive, KLA also implements a block schedule, allowing me to teach each student one and half hours of math a day. What a difference that makes!

One of the ways in which I am blessed at KLA is that we do not have to follow the district's policy on curriculum. Because of this, the entire math department adopted a more hands-on math program called CPM (College Preparatory Mathematics). This curriculum teaches math more conceptually instead of procedurally, allowing students to gain a deeper level of understanding and meaning. Through much exploration, students are able to come to their own conclusions on why we do the things we do in mathematics. Although CPM is not centered on project based learning, it does require students to work in teams in order to discover and uncover various math concepts. As far as math curriculums go, CPM is a fairly hands-on curriculum. It also encompasses numerous math games that help students practice and reinforce various math concepts.

Classroom Setting

I currently teach sixth grade pre-algebra. As I mentioned earlier, KLA runs on block scheduling. However, unlike many block schedules, I get to teach each student every day. I teach three 1 ½ hour blocks of math and one hour of REACH/ Art class. In my classroom, students are arranged in teams of four and work daily on exploring various math concepts within their teams. Each student is assigned a role within their team. For example, there is a resource manager, task manager, team leader and a recorder/ reporter. Within each of these roles, students have numerous jobs to uphold throughout the lesson. This helps hold individuals more accountable when working as a team.

After shaking each student's hand and greeting them at my classroom door, they begin class everyday with three warm up Quick Questions. Not only does this help students review previously learned concepts, but it also launches my class into the lesson for that day. While students are working on their Quick Questions, student homework checkers record their teams' homework while I take attendance and circulate the classroom to check in with individual students. After Quick Questions, students join me at the rug in a semi circle of chairs and we launch into our lesson for the day as a large group. This is when I frontload specific vocabulary or introduce new math concepts. After about a twenty minute launch, students then go back to their teams in order to explore various math concepts. They might be working on a problem set of about three to four problems that help guide them towards discovering a certain math concept or perhaps a math project or game that reinforces specific math content area. During students' explore time, I can work with small groups on various math concepts and give more individual instruction to my students. After this time, we then rejoin as a class to summarize and share out what we have learned that day. This is when students form conjectures and conclusions about various math concepts.

Methods

Observing student engagement levels while playing math games in my classroom is what inspired me to create and build more games into our CPM curriculum. I have always believed that students learn best with their hands and through active exploration. It is only natural for children to want to play. Throughout my action research project I incorporated more playful math experiences in hopes of increasing my students' engagement, therefore increasing their achievement levels too. Students explored and reinforced various math concepts through playing games two to three days per week. I surveyed and interviewed students throughout my study and analyzed how math games changed their attitudes, engagement and achievement levels over time. Using these results, I modified and created more playful math experiences to help increase student engagement and achievement levels within my classroom. Although I collected data on my entire class in order to provide me with an overall picture of my students, I also selected four focus students. This helped me to gain a deeper understanding of how kids of different math abilities experienced math games. I conducted various interviews with these students and made

continuous observations and field notes over the period of my action research project on their behaviors, attitudes, discussions in my classroom, and achievement data.

Data Collection:

Beginning/ End of Year Assignment: The entire group of sixth grade students comes from various neighboring elementary schools, all new faces, and ready to begin their middle school career at a new school with a fresh, blank slate. In order for me to embark on the journey of answering my research question, it was necessary for me to get an idea for my students' attitudes about math, as well as their previous experience learning math. I had my students create illustrated math analogies comparing themselves to an object when thinking about how they perceive themselves as a mathematician. This helped me to get to know their feelings towards math as they began my class. In addition to this reflective math project, I had students write "get to know you" letters in the beginning of the year, giving them the opportunity to share anything about themselves and their learning with me.

In order to assess students' change in attitudes about math overtime, I had students look at their initial math analogies and revise and/or recreate them at the end of the semester. Towards the end of the semester, I also had students choose a math concept and create their own math game that reinforced the concept chosen. Afterwards, students had the opportunity to play each other's games in order to practice various math concepts we have explored together.

Surveys: I surveyed all of my students in the beginning of the school year. I used the result of those surveys to choose my five focus students of various math abilities and varying attitudes towards math. I also surveyed all of my students in the end of the semester in order to examine student attitudes and their self confidence about math. I searched for any trends or changes in attitudes overtime. This provided me with valuable feedback on what students like and dislike about math class, and how I could help them to be successful.

Student Interviews: Student interviews were a great way to delve deep into the minds of my students. Based on the results of my surveys, I interviewed five students, three girls and two boys of various math abilities, who had varying attitudes about math. I also conducted a group interview with my focus students as well. I designed a set of interview questions that focus around students' experiences in my math class as well as their previous experience learning math (See Appendix 4). I interviewed students periodically throughout the semester in order to get feedback on the various games we are playing in class verses other math activities. Speaking with students about their feelings and experiences provided me with qualitative data and student quotes that helped offer my action research paper a powerful student voice. I also interviewed students to assess their understanding of various math concepts they explored while playing games.

Student Observations, Anecdotal Records and Field Notes: I kept a journal for field notes and observations of students in a variety of learning contexts in the classroom, focusing on peer interactions, academic language being used, students' general attitudes towards math, their participation, their engagement level in a particular task and the roles they assume within their partnerships and/or teams. Observing various student behaviors and interactions and recording their conversations during cooperative learning allowed me to explore different patterns, or trends that occurred within a variety of learning contexts. This helped me to assess the levels of student engagement throughout various learning activities, such as math games, CPM problem sets, cooperative versus independent learning and so forth. On four different occasions, I audio taped student teams and partnerships and transcribed their conversations and "math talk" in two different learning contexts, working with teams on a CPM problem set and playing math games.

Student Work Samples: By collecting and analyzing student work samples, I was able to assess both the quality of their work and their acquired knowledge of a particular math concept. This also served as an indicator for their engagement level in a specific task. I gathered work samples prior to playing math games, during math games and after. I asked students key questions before playing a math game and then had them revisit similar questions after playing the game in order to see how their learning had progressed. I created various graphs and charts that display this data I have collected.

Exit Slips: Weekly exit slips were a great way for me gather data about students' experiences and gave them opportunities for feedback about various math activities, including different math games. I asked students which games they liked and games they didn't and why. The exit slips also provided me with a quick assessment of student understanding and mastery of particular math concepts. If students were able to explain and articulate the math behind the various games they were playing, then their conceptual understanding was demonstrated.

Data Analysis:

Surveys: Data collection was an ongoing endeavor for me throughout my action research project. The quantitative data that I collected from my students' surveys was entered into an excel spreadsheet. After entering student data, I created different graphs and tables to provide a visual representation of various trends that appeared among student's attitudes, self concepts, and feelings about math. When analyzing my students' surveys, I color coded the results of their surveys according to different categories or trends that have emerged. I also made note of various themes that emerged within the surveys, student interviews and exit slips.

Student observations: During student observations I focused on student engagement levels, and tallied in the form of a frequency table, all "on" verses "off" task comments spoken within a 20 minute period of time. I conducted this observation and frequency table with the same students in

two different learning contexts, one while playing a math game and the other while answering a set of problems out of our CPM book. I compared the results of "on" verses "off" task comments between the two different contexts. I did this on two different occasions.

Student Interviews: Interviewing my four focus students provided me with valuable feedback about their experiences in class. I carefully tracked their attitudes, engagement and progress throughout the semester. I also pulled student quotes that correspond with both qualitative and quantitative data collected, looking for themes, trends and connections between attitude, engagement and achievement. These quotes added depth and student voice to my research and findings. I transcribed and/or logged the interviews on the following weekend.

Student Observations, Anecdotal and Field Notes: I transcribed relevant parts of the audio recordings I gathered from students' conversations and interviews. I also transcribed audio tape recordings of students "on" verses "off" task behaviors and dialogues and compared results from the same group, or math team across a variety of learning contexts (math games, CPM problem set, ext.) Weekly, I read over my field notes journal and observations, "cooking," or analyzing, my notes and adjusted the direction of my research accordingly.

Student Work Sample, Exit Slips, and Journal Entries: I analyzed exit slips, journal entries and student work samples in order to assess whether or not the objectives of the lesson were met. By looking at student work and quick assessments such as exit slips, I could see whether or not students mastered the concepts being taught and decide if they needed further practice, or if they were ready to move on. This helped to guide my instruction in the classroom. Examining and assessing these also allowed me to make connections between student achievement and math games. I compared how students demonstrated what they learned from days they played math games along with other learning experiences. I also compared their mastery of math concepts across the board. Since I had students give me feedback on various math games, including a self assessment of how well they mastered a particular concept while playing the game, I was able to judge how effective certain math games were in teaching various concepts.

Examining change over time: In order to help answer my essential question, *How do math games affect student engagement and achievement?,* I needed to compare student's attitudes and engagement levels overtime in order to measure any changes that occurred. I examined the beginning and end of the semester math analogy assignment, results from both student surveys and various anecdotal records and notes on my focus student's engagement patterns and levels.

My Findings

Throughout my years as an educator, I am constantly amazed at how many resources are available to teachers. We all know, that it is easy to spend hours, evens days, weeding through the helpful lesson ideas, and the not so helpful ones. Throughout my project, I dedicated hours

upon hours sorting through the hundreds of math games that I have stumbled upon and modifying them to fit my students' needs and the classroom culture I have created. In the first section of my findings you will find a compilation of math games that students enjoyed and that were useful for teaching various math concepts. You will not only see detailed instructions on how to play the game, but helpful tips for implementing them, as well as ways you can modify the game in order to differentiate for your students. This can be the beginning of your journey of making math games a part of your classroom culture. If you are not so interested in the nitty gritty of each game, feel free to skip ahead to the second part of my findings to learn about how games have transformed my classroom culture, my teaching and the ways my students now view mathematics. I hope you enjoy!

Part One: Dictionary of Math Games Along with Notes from the Field

Division Football

Essential Question: How do you divide using partial Quotients (Super Seven) strategy?

Materials: Each pair of students will need a game board (Appendix 7), a scratch paper to show all of their work, a two-in-one die (one larger see-through dice with a smaller dice in the center) and a ten sided die and two game pieces. I use the yellow and red counter circles for game pieces. If you do not have a two-in-one die, then they can roll a regular die twice.

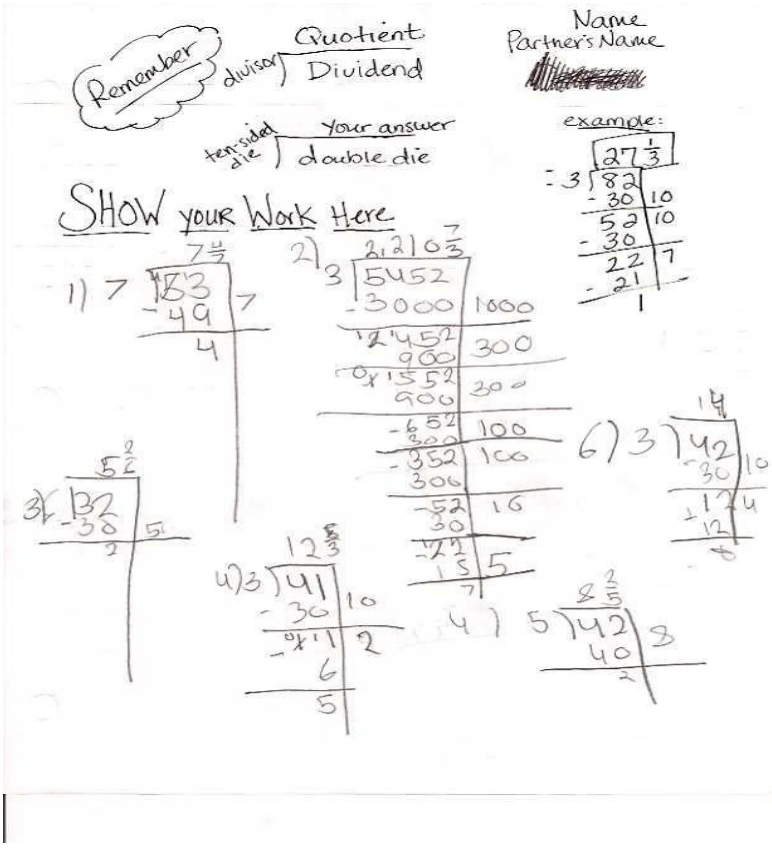
Procedures:

1.) Student rolls the two sided die first to get their dividend.
2.) Then, they roll the ten sided die to get their divisor. Each student rolls separately and records their work on separate paper.
3.) Each student solves their division problem. After they solve their own problems, they switch their papers with their partner's and check each other's work to make sure their solutions are correct. The student with the larger quotient moves their game piece ten sides down their football field. The object of the game is to score a touchdown.

Benefits of the Game: This game provides opportunity for differentiation because students that need more of a challenge can roll the two-in-one dice twice to get a larger dividend to divide. Division Football is a great opportunity for students to discuss their mathematical reasoning with each other and use the teaching strategy, reciprocal teaching. If a student gets the problem or the process incorrect, then their partner teaches them how to solve the problem and helps that student understand where they made their mistake. Since students know that their partners will be checking their work, this helps to increase the student's accuracy in their calculations. It seemed that the novelty of competing against one another in the form of a football field, as well as using the "new" two-in-one die, helped to motivate students and increase their engagement.

Notes from the field: A large portion of my students begin sixth grade not fully understanding how to divide. Most often, they have learned the division algorithm that most of us learned when we were younger, "divide, multiple, subtract, and bring the number down." A more conceptual

approach to teaching division is called Partial Quotients. It seems more and more math teachers are teaching this method of division. Instead of breaking the dividend apart, you look at the number as a whole. I teach students to think about the number being divided as a whole and ask themselves this question, “How many times does ___ fit into ____?” Choosing easy numbers to work with, such as numbers that are multiples of tens, makes it easier for students to understand the concept of division in order to accurately solve the problem. Please refer to the student work sample from Division Football below as an example of the Partial Quotients method of dividing.



Above is an example of a division problem using the Partial Quotients strategy.

Division football was the first game that we played in our class this year. After introducing the Partial Quotients way of dividing, students had a chance to practice what they learned and help teach each other when they got stuck. There was an extremely high level of student engagement throughout this game and students were asking me when we could play it again. When I gave my two minute warning before clean up time, students were sighing, expressing they were bummed that they had to stop playing. Several months later, students were planning our “Family Math Game Night.” They were deciding which games they wanted to make available for families to play. I overheard one of my students, Ricky, say, “Let’s add Division Football to the packet and put it in the front.” This was a student favorite. It is amazing how a fun game board such as a football field can get students so pumped about math work!

The Dart Booth:

Essential Question: How does the order of Operations affect the solution to a problem?
Materials: A Dart Board chart that you will prepare prior to playing (Appendix 8), each student will need to bring their imagination to this game since you; the teacher will be throwing invisible darts towards their dart board chart. The darts are invisible for obvious reasons.
Procedures:

1. Introduce the dart board. Let students know that you will be throwing three darts and that you will let them know which numbers they hit on the board. (You may use four to make the game more advanced)
2. Give students a target number. This is the number that their equation should equal. Students can either multiple, divide, add, subtract and use parenthesis in order to create an equation using all of the numbers hit on the dart booth that equals the target number specified.

Benefits of the Game: This is a great game to either launch, or practice the concept of Order of Operations. Students will explore how they can manipulate numbers and operations in order to get different values. They will also learn that by moving the parenthesis around within an expression can give you a different value. The Dart Booth game also allows for numerous solutions, which helps to increase student's confidence levels and allows for more differentiation. This game helps to meet students at their independent learning level since students can create simple or more elaborate equations as their solutions. I usually allow students to work in partnerships or teams so there are more opportunities for discussion about their math thinking and students can then rely on each other for help. This game is flexible and can be modified to fit your students' needs. For example, if your class is just beginning to explore the Order of Operations, then you might want to open this game with a question like this, "I have just thrown three darts. They have landed on ___, ___, and ___ number. Using the four operations to create different equations, how many different values can you find?" Maybe you don't give them a target at first and have the students come up with many different values or targets? Lastly, another benefit to this game is that is can be quick if you want it to be. Sometimes, I will play one quick round to summarize the lessons.
Notes from the field: Students loved this game and often if we have a few minutes left at the end of class, a student will ask, Can we play a round of Dart Booth?" I first introduced this game before introducing the concept of Order of Operations. I explained the rules, and began to throw my imaginary darts. Students definitely loved this part, especially when I created my funny sound effects for throwing my darts, or accidently hit a student whom was sitting near the dart board with my imaginary dart, and had to go and remove my imaginary dart from them. Relax, it was imaginary, no one got hurt! I began with a more open ended approach where students could use the three numbers along with any operation; add, subtract, multiply or divided in order to come up with as many different equations as they could think of. This allowed a variety of math readiness levels to access the problem. Students then came up to the board to share their many different equations with their peers. Once we compiled a long list of equations, we discussed

whether or not it mattered which order students solved the problem. This was a great lead in to a discussion about the Order of Operations and which operations we need to solve first.
As our class continued to explore the Order of Operations, I began to make different variations of the Dart Booth game. Students had to come up with equations that hit a specific target number. This was more challenging; however, they worked with a partner to solve this. I learned through experience, that some targets can be very difficult to solve, so I planned accordingly. As I threw my darts, I already had my plan in mind with exactly which numbers my imaginary darts would hit, along with a specific target value planned. Once I threw my darts, sixteen out of twenty-one students began to rapidly record their different equations they tried. The remaining five students seemed to ponder the numbers for a few minutes before actually writing down their equations. I try to get student in the habit of writing down their thinking, even if their answer is wrong, this way they can solve a problem in a more systematic approach. The five remaining students seem to need a bit more time to think before diving into the problem. However, after a few minutes, every student in the class was engaged in trying to figure out an equation using the numbers thrown that equal the target number chosen. The great thing about this game is that since there are numerous solutions, no one is really done, until I choose when time is up. After about five minutes, students shared out their responses with their peers. As we drove a bit deeper into the Order of Operations, we began to explore how parenthesis can impact the value of an equation. For example, 3 X 5-2= 13, whereas 3 (5-2)= 9. Students then focused on manipulating parenthesis, along with numbers and operations to create an equation with a specific target value. This game continues to evolve and get more complex, the more the students learn and explore the concept.

Win-A-Row:
Essential Question: How do you add positive and negative integers?
Materials: One Win-A-Row game board per partnership (Appendix 9)
Procedures:
The object of the game is to strategically place your numbers on the game board so that you can win the largest number of rows. Players decide who is going to have the positive numbers and which one will be negative. Let's pretend that player one is positive and player two is negative.

1. Player one places any of their positive number on the game board and crosses that number out from their list. They may use each number once.
2. Player two places one of their negative numbers on the game board and then crosses that number from their list.
3. Players alternate back and forth until all of their numbers have been placed on the game board.
4. They then add the numbers in each row and column and record the sum on the appropriate line. If the row or column is positive, then player one gets a point and if it is negative, then player two gets a point.

5. If there is a tie, then students can add one diagonal line downward from left to right in order to break the tie and determine who wins.

Benefits of the Game: Students really enjoyed this game and it requires very little prep and materials. One of the great aspects of this game was that students were able to play the game at their own mathematical level. You will notice students that are more advanced will create more elaborate strategies on how to win the row.

Notes from the field: This is a game that can be played to review adding positive and negative numbers. At the point that I gave students this game, they had previously learned how to add positive and negative numbers by drawing tile integers, or pluses and minuses. At this point in their learning, Win-A-Row helped students to calculate the sum mentally. My intentions were for students to move from concrete math thinking into more abstract thought.

Scaling Adventures

Essential Question: How do you use patterns to help scale a number line properly?

Materials: Each student will need one Scaling Adventure Game board (Appendix 10), and one ten-sided dice per partnership

Procedures:

1. In the game Scaling Adventures, each student had a game card that consisted of various number lines that were missing the numbers. There is a box on each number line students fill in according to which number they roll on their die.
2. 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.
3. 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.

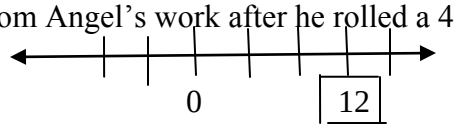
Benefits of the Game: This is a game that would be called co-constructional. This means that it can be played alongside minimal direct instruction in order to teach a new concept. This game engaged my student in a lot of conversation about the math concepts of scaling axes and number patterns. Another benefit to this game is that there was little competition, therefore, students that get anxious during competitive activities, felt more relaxed.

Notes from the field: I have been having math game days as least one day a week. During math game days, I have been recording various table groups and partnerships. This week I listened to students' conversations while playing the math game, Scaling Adventures.

While students were playing, I made several interesting observations on the overall attitudes and affect of the students. This game did not have the competitive aspect that other games often have. This seemed to have affected students' attitudes while playing the game in different ways. Students that often get worked up and frustrated if they are not winning at a particular game, seemed more at ease and less stressed out. I also noticed on the contrary, a

couple of students that usually get really pumped and excited while playing more competitive games, did not quite seem as motivated during this game. In the case of this game, Scaling Adventures, the competition was a bit more subtle, which both motivated some students while almost inhibiting others from reaching their full potential.

As I walked around students were very involved in "math talk" and the game involved a higher level of thinking. 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.



I felt by creating their own problems students bought into the game more and this also helped to hold them accountable for the math they were doing. If they did not give the correct hint, then most often times, their partner could not solve the problem.

In order to assess the effect this math game had on students' academic and achievement level, I gave students a pre-game and post-game problem to solve. These two problems were similar in difficulty level and helped me determine how much this math game affected their knowledge about Scaling Axes and graphs. Independently, students solved one problem before playing the game and then directly after finishing, they solved a different, yet similar problem. I was happy to see the results I found on these two problems. Eleven out of twenty-one students answered the pre-game problem correctly, while seventeen out of twenty-one students answered the post problem correctly. This led me to believe that the Scaling Adventure math game helped to increase students' proficiency level on this topic since five students that didn't quite understand the concept before playing the game, answered the post-game problem correct.

Game Show Review Game

Purpose: To review previous concepts learned.

Materials: Each student will need a resource paper, (I often have students use graph paper, or loose leaf lined paper to show all of their work on), one chart that includes all of the rules (Appendix 11), two die per class, one white board marker per team, one copy of game show questions to be projected for the class to see, and an answer key for the teacher to check if students problems are correct. Be sure to make the answer key before you play the game.

Procedures:

1.) *Preparation*: This game is teacher led and involves a little bit of classroom preparation before playing. I have one long white board that I divide into 5 or 6 sections, depending on how many students I have and how many teams I split the class into. I write the different team names on the top of their section of the white board. Each team gets one section of whiteboard they will use to solve their problem. I color code their sections by giving each team a different color white board marker. You should also make a large

chart that displays the rules and expectations of the Game Show and share this with the students before the game begins.

2.) Students get their resource page (either graph or lined paper). They split their paper into 8 sections. This will allow for them to solve 8 problems on one side and then 8 problems on the back. I tell students that teams that have shown all of their work on their resource pages correctly will receive 1,000 bonus points.
3.) Arrange students in teams of four to six students. Each team will choose one score keeper who will keep track of their team's points on line paper. Have the score keepers keep a running total of points as they go as this will be easier at the end of the Game Show when they are calculating their total points earned.
4.) Be sure each team knows where their spot on the white board is. Count off students so that each student has a different number. If there are four students per teams, then each student should have a number from either one to four. Each team member will receive a different number.
5.) The teacher rolls two die. Two team members from each team that have been given that number will solve their problem together on the white board, while their remaining team members will solve the problem on their resource pages.
6.) At this point, the teacher is watching teams at the board. If a team is done solving the problem and has clearly shown all of their mathematical reasoning, then they raise their hand and cap their white board markers. The team who finishes first, gets 500 points, the next team to follow, gets 400 points and so forth down to 100 points. If you have six teams, then the first place team will receive 600 points. Teams that are finished and have checked in with me, then erase their section of the white board and report back to their score keeper with their points earned for that problem. You can either give students a few minutes before beginning the next problem to update their resource page, or you can have students that go to the board write "at the board" on that problem.
7.) Continue rolling the two die before each problem to determine which students go up to board.
8.) At the end of the Game Show, the score keepers write the total points earned, staple their score cards along with their team member's resources pages and pass into me. I will later review their scores and teams that have filled in their resource pages will receive a 1,000 point bonus.

Benefits of the Game: This Game is a great way to engage and motivate your students. You can use a Game Show when reviewing or teaching any new concepts. It is also a fun way to take an ordinary math problem and present it in a more exciting way. This game involves all students and encourages 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 helps to hold all

students accountable for showing their work completely and accurately. This was also a great motivator. However, since students love novel things, I would not overuse the Game Show idea.
Notes from the field: My administrator, Joel, came in to observe me lead a Game Show with my first 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." I have never had so much fun while teaching. In all my four years of teaching math, this year is by far the greatest for me. I feel already this year, I have developed stronger connections with my students and have looked forward to teaching more than in the past. Last year, I felt like I was getting bored and I didn't find that I had enough energy to make math always fun and exciting. Now, along with my students, I also find myself thinking, "Yes… this is a game day, awesome!" Math games have rekindled my passion for teaching and seem to be refreshing for my students as well. Joel also commented on the fact that throughout the entire lesson, I had nearly 100% engagement from the students. As he observed students, he noticed that ALL students were involved and on task and he was really 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 math thinking with each other." He was impressed! I believe math games have helped to contribute to this level of math discourse my students are partaking in. Many of the games they have played require students to explain their thinking to their partner and teach their partners about different math strategies they are using.

Hidden Treasure/ Battle Ship
Essential Question: How do you plot an Ordered Pair on a coordinate plane?
Materials: Each student needs a Hidden Treasure Game board (Appendix 12) and some sort of privacy board to place in between themselves and their partner
Procedures:

1. There are two coordinate grids on each game board. The grid on the right is for students to mark their ships on, and the grid on the left is for students to record the guesses they have made in order to hit their opponents' ship. This allows them to keep track of their guesses so they do not repeat them more than once.
2. Students first create different battle ships and mark them on the right coordinate grid on their game board. I usually have students plot three ships, one that is five points long, one that is four points long and another that is three points long. You can vary this depending on your students.
3. To keep their ship's locations secret, they are not allowed to see each other's board. I have them put up a privacy board in between them and their partner.
4. They then take turns asking their opponent a particular ordered pair. Their opponent will either say, "You hit a ship" or "You missed." If you hit, student puts a star on the left coordinate grid and if they missed, they can put an X over that point.

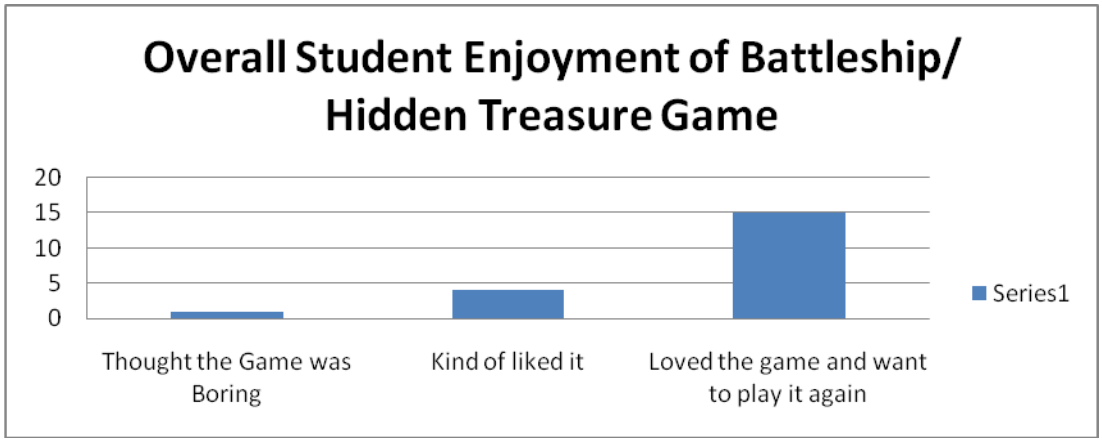
5. The object of the game is to find the other player's hidden points and be the first player to sink all of their opponents' ships.

Benefits of the Game: As you will see in the graph below, students loved this game. Many of them have played the game called Battleship before; therefore, they were already familiar with this game. This was a major benefit of this game. Another benefit of this game was that students have to articulate to their partner which point they are trying to hit. This helped to reinforce the concept of ordered pairs and that the X goes over to the right or left before the Y goes up or down.

Notes from the field: Many of the games students have played thus far have required a certain level of cooperative learning with their partner. Since students were not allowed to see their opponent's game board, this game was more centered on individual learning and did not allow for much cooperative learning. Students were not discussing their thinking, but instead, they were just announcing their ordered pairs. This posed a bit of a problem for the students who needed more guidance on plotting an ordered pair correctly. There were two students in particular, who were getting their X and Y coordinates confused as well as their positive and negative directions. For example, Albert asked his partner if there was a ship on (-3, 2). His partner, Isaac, started at the origin, went down three spaces and then over to his left two spaces. He replied that his partner missed his ship. However, he should have started at the origin, gone left three spaces and then up two. Since I was circulating the room, I was not able to help him with this at the time. Finally, Albert called me over to ask me why he did not hit any of his ships yet. This is when I noticed that Isaac had been plotting the coordinates incorrectly.

The important part of the game that kept each other's ships secret, also posed a challenge in that students could not help their opponents throughout their learning. This happened with a few different groups. When I have my students play this game again, I will have the partner that is listening for the ordered pair, say the direction of the point out loud. This way both partners can check each other's ordered pairs and articulate how to plot the ordered pair aloud. For example, if John asks his partner, "Is the ship at (3,-4), his partner will reply, "No I do not have a ship at 3 over to the right and 4 down." This will solve the problem that Albert experienced and hopefully eliminate any confusion or miscommunications that arise when a student is not plotting the points correctly.

As you can see in the graph below, the majority of students enjoyed playing the game, while only one student thought the game was boring. Interestingly, this student, John, happened to be one of the student's that was graphing the points incorrectly. I wonder if he might have felt like he was frustrating his opponent and needed more help in graphing.



The above graph demonstrates students overall enjoyment of the Battleship game.

When analyzing question #2 on student exit slips, “Describe the math this game involved,” I can see there are definite misconceptions about what students consider to be “math” related work. I got extremely vague responses to this question. Some responses were, "You may need to know how to graph positive and negative numbers." “I graphed points.” “…how to plot an ordered pair.” This showed me that I need to model what my expectations are for articulating math thinking and when pin pointing exactly what math tools they are using.

Subtraction Football

Essential Question: How do you use tile integers to draw a picture representation of subtracting negative and positive integers?

Materials: a copy of the key for what different cards represent, various dice for differentiating (I use a ten sided and a six sided), a deck of cards per partnership, one football field game board per partnership, a subtraction football resource paper for each student (Appendix 13)

Procedures:

1. Each partnership receives a football field, two playing pieces, a deck of cards and a dice. I posted the key that tells students which cards represent which integer.

2. Student rolls the dice and flips a card. If the card is black, their integer rolled is positive, if their card is red, their integer is negative.

3. On their resource page, they draw a picture representation using pluses and minuses (tile integers) and solve the problem. Some students may still use the manipulatives to help them draw the picture representation.

4. Their partner then takes their turn. After, they switch paper to check each other’s picture representation. Whoever has the larger difference moves their game piece ten yards down the football field.

5. Whoever scores a touchdown first, wins.

Benefits of the Game: 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. I have students that need more of a challenge use two ten-sided dice 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.
Notes from the field: 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 use 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 it again. They were just previously introduced to subtracting positive and negative numbers. This game would be considered a co-constructional game, or a game that is used along with minimal direct instruction to teach a concept. Students hadn't yet discovered any rules or procedures for subtracting integers. Instead, they learned how to model this concept using pictures or tile integers of positive and negatives. By drawing the models for multiple subtraction problems throughout the game, as a summary after students played the game, they were able to look back to their picture representations and make observations about what they notice was happening when, for example, you take away a negative from a positive. From there, students were able to come up a rule for subtracting integers, Stephanie said to the class, "Oh, it is like the same thing as adding the opposite." This game provided a great lead into the formation of the rule "Keep-Change-Change" for subtracting integers, where you keep the first integer the same, change the sign from subtraction to addition and change the sign of the second integer.

Pig Race
Essential Question: How does the Order of Operations change the solution to a problem?
Materials: four die per class, one pig race resource page (Appendix 14) and scratch paper for each student
Procedures:

1. Student work either in teams or with partners to come up with their equations. I go over the various solutions and how many yards they move their pigs for each solution before we play.

2. I roll four dice, one being the "special target" and students come up with equations that have either the target solutions, or one of the other solutions listed on their resource page. They shade in the yards that they move after each round on their pig race game board on their resource page.

3. I have students come up to the board to record their solutions after each round.

Benefits of the Game: The pig race is very similar to the Dart Booth. It also can be used to either launch the concept of the Order of Operations or to further explore and extend student learning within this concept. Unlike the Dart Booth Game, this game takes a little more time in order to completely travel through the game board race. One great aspect to this game is that there are multiple solutions to one problem. Students can pick from various target numbers, some harder to reach than others in order to come up with their equation. This also helps to differentiate for a variety of students learning levels. This game also encourages cooperative learning and gets students sharing their math thinking with one another.
Notes from the field: In order to ensure that every student is engaged, be sure to group your students accordingly. The first time I played this, I noticed that although all students were working on coming up with the equation to match a specific target number, there were the same one or two students in every team that was getting to the equation first. When we played the game again, I had students grouped according to their pacing, or how quickly, or slowly they work. This helped to keep students from zoning out and waiting for their partner to come up with the solution. This also worked well because in the pig race game, once students come up with one equation that equals the special target, they can continue to work towards coming up with alternative equations. Therefore, they can never say, "I'm done, now what?"

Rock- Paper- Scissors
Essential Question: How do you use tile integers to add positive and negative integers?
Materials: a key for the values of rock-paper-scissor combinations, one bag or tile integers (positive and negative math manipulatives) and a rock-paper-scissors resource paper per partnership (Appendix 15)
Procedures:

1. Review the key that tells students what the value for each rock, paper, and scissor combination is. Students play rock paper scissors for five rounds and record their negative and positives received for each round.

2. At the end of the five rounds, each student finds the sum of the value of positive and negative numbers. The student with the higher value wins that game.

Benefits of the Game: This pre-instruction game can be played to introduce the concept of adding integers, or positive and negative numbers. Students will explore the concept of a Zero Pairs, or that a positive and a negative integer together equals zero. Students are drawn to this game, because many of them have played rock-paper-scissors before. This game seems to invoke positive feelings from students due to their previous experience with playing this non threatening game. Because students are motioning rock- paper- scissors with their hands, this game is also great for more kinesthetic learners that learn best through movement. You will see this game is highly engaging and students will get excited before even beginning to play, just by looking at the title of the game!

Notes from the field: This was one of the games that students played during our family math game night. As I walked around to observe all of my students playing our math games with their families, I sat down with one of my students, Tyrel and his mother. Tyrel's mother said to me, "Oh this game… Tyrel's already made me play this game before with him. I think I have probably spent three nights playing it." This shows that Tyrel enjoys the math game enough to play outside of school with his family members. How cool, students are bringing these math games home and forcing their tired parents to play with them. I told Tyrel's mom thanks for playing with him at home. This helps to reinforce the concept of adding positives and negative numbers.

Family Math Game Night

Back in November, at the end of class, I had a group of about four students that walked up to me to ask me if they could come after school to plan a family math game night. Although I had planned for this happening, I hadn't yet mentioned it to my students. I thought, "This is great, now students can take ownership in planning and leading our family math game night. So…I had a group of six students that came after school to begin the planning process. I spread out a copy of all of the games that we have played so far this year. Students discussed which games were their favorites and which ones they wanted to include in our family game night. I tried to just sit back and listen to their talk and absorb the feedback they were indirectly giving me about the games we have played.

As they chose various games to play, they showed a lot of excitement for the idea that many people would be brought together to play math games. This happened all because of their hard work and planning. Ricky asked John, "How many people do you think we can get to show up?" John replied, "Let's try to put up signs around the school and get all our friends to show up." They were determined to create a successful night and took pride in their planning. This also showed me that games are a big part of our math curriculum and that students see that too. They wanted a chance to show off what they do in the classroom to their families. "This is awesome," I thought. "These six boys are going to continue to plan for our upcoming family math game night in December." Students were taking a leadership role. They are attending Keiller *Leadership* Academy! What a great way for our students to exhibit what we do to their families. I thought that if this could bring math games into my students' households, then not only could this reinforce the math concepts we were exploring, but it might also help break the math phobia that many of their parents and family members experienced too.

As students began to create flyers to hang up around the school, others worked on typing up the invitation that was to be passed out to all of my students. As the rsvps began to trickle in, I started to get a little worried about the numbers being too large for the space we were to hold the Family math game night. Many of my students were attending and bringing their entire families along with them. My student planners and I were very excited. I realized that instead of having the event in my classroom, I better reserve and set up the auditorium. With a little help from other teachers, the auditorium was set with plenty of large tables, math games displayed

throughout and student-created welcome posters. We were all ecstatic to have this night come finally come to fruition.

As I looked around the crowded auditorium on the night of our family math game night, I felt an overwhelming sense of family and community in the room. Over eighty parents, guardians, relatives, siblings and students were engaged in playing math games. How amazing, parents that probably worked all day and were exhausted took one hour out of their busy night's schedule to come and play math games with their children. What a great way to involve my students' families in their schooling.

I noticed a tremendous sense of leadership and pride within my students as they wore the hat of the teacher and taught their family members how to play their favorite math games. There was an overwhelming energy present in the auditorium as students conversed with their little brothers and sisters, their parents, aunts, uncles, and grandparents. Students and families were excited about math! I felt a sense of pride both in my students, as well as in myself as a teacher. The math games were working! By listening to students' conversations with their families, it was evident that they had mastered the math concepts because they were able to teach it to their families. Students were also asking me if they could take home and keep their packets. I replied, "Of course you can, I would love to see you playing these games at home!"

Thirty out of sixty of my math students showed up to Family Math Game Night. Of those thirty students, many of them were students that originally expressed that they did not enjoy math in the beginning of the year when they took their surveys in September. As I walked around, I had two different parents that came up to speak with me. Albert's dad said, "Albert used to hate math… but he is so good at it. He seems to really enjoy math year. He likes the games." For me, one sign that Albert likes the math games we are playing is that he chose to bring his Dad to our Family Math Game Night. He was a student who previously said in his initial survey that there was no point to learning math. He also referred to himself as a ticking atomic bomb that was about to explode when writing his math analogy in September. I can see his attitude towards math has made a tremendous shift.

Another student, Oscar, told me back in October afterschool during tutoring, that he hated math and wished he didn't have to take it. I replied, "I am so sorry to hear that, I hope that I can change your mind about math this year." Well… his mother found me during family math game night and said, "Oscar really struggles with math and gets frustrated when he doesn't understand something. He seems to get it more this year. He told me he actually likes your class. He has never liked math before. So… thanks for whatever you are doing." I then went on to tell her that the math games that we play in class are really fun and Oscar is more than welcome to take home the games we play to share them with his family at home too. Well, if that doesn't make a teacher smile, I am not sure what will!

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:

1. Games help students build more positive attitudes about math, while decreasing math phobia.
2. Games are tools for reaching all different readiness levels (differentiation).
3. Games encourage students to articulate their understanding and work together to solve problems.
4. 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.

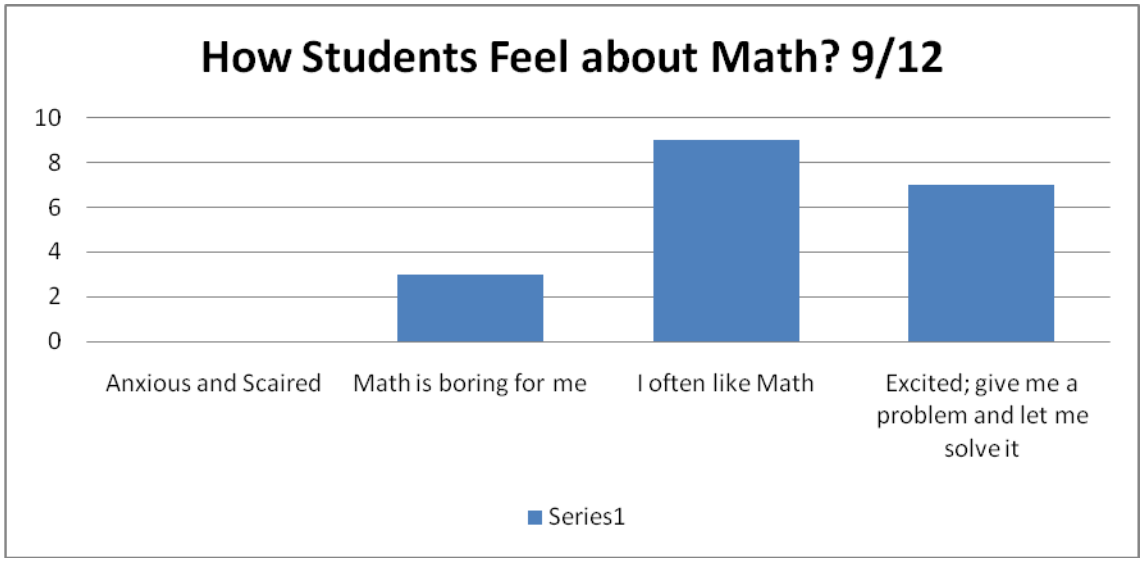
Math games helped to change student's feelings about math and their self concept, or how they view themselves as mathematicians, for the better. As students entered my classroom, there were a wide array of feelings and attitudes towards math that emerged. Some students have always loved math, others 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.

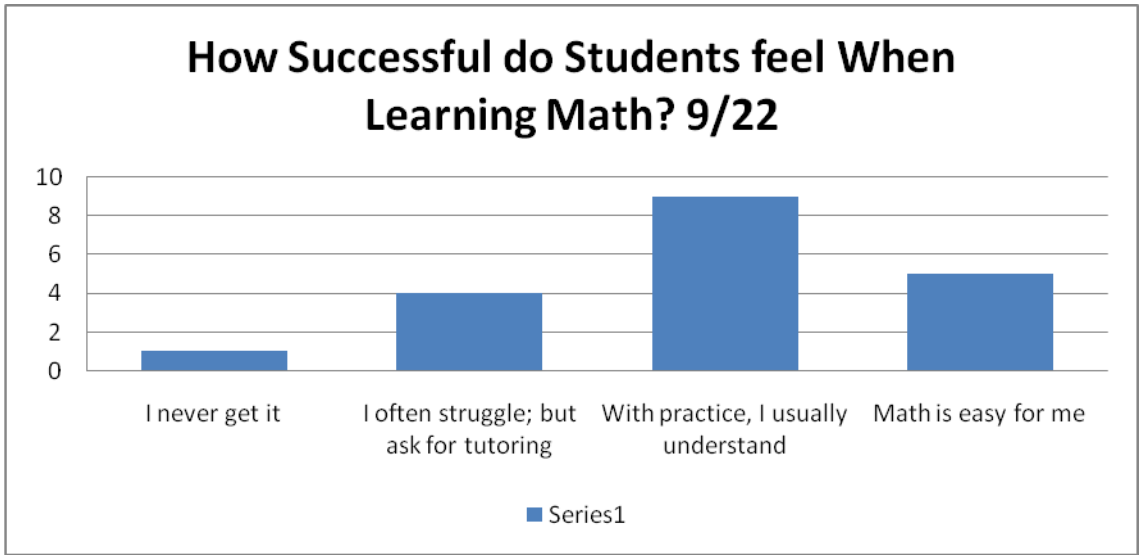
Through writing me "get to know you" letters in the beginning of the school year, I learned that there was a wide array of feelings towards math. In their letters, several students from my second block class expressed a strong dislike for math. Feelings about math ranged from, "Math has always been my 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.



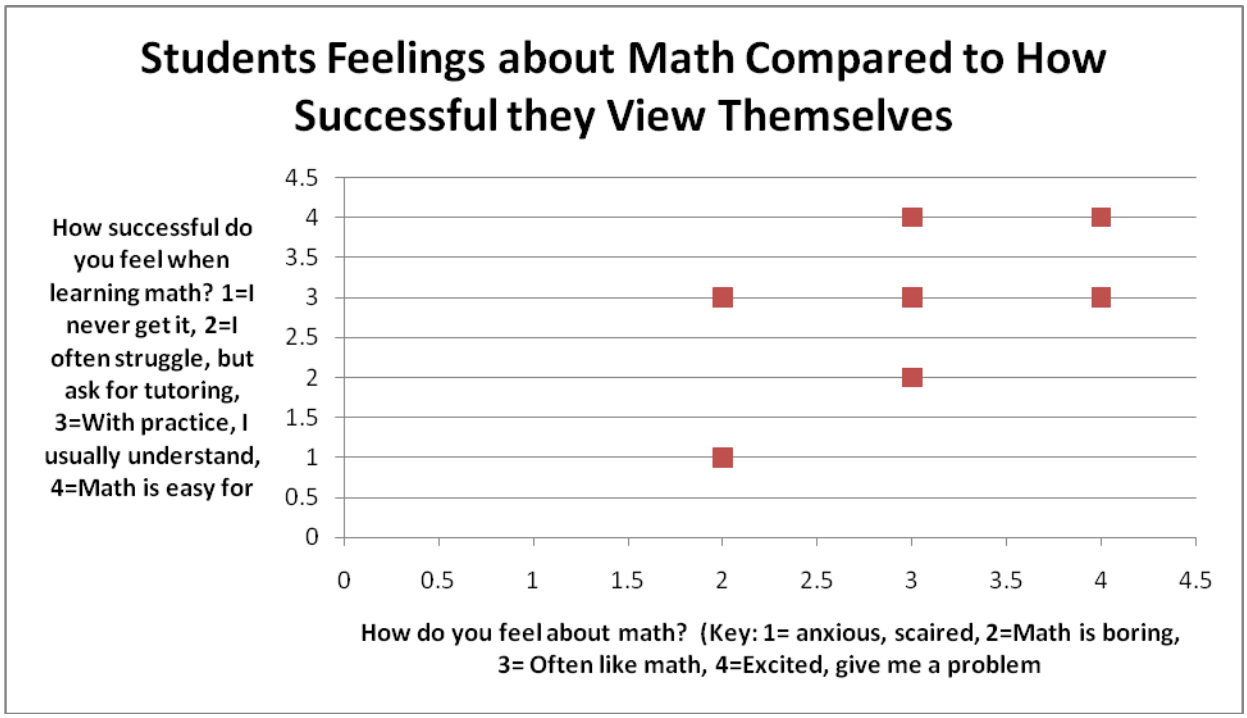
Above is a graph portraying how students feel about math.

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.

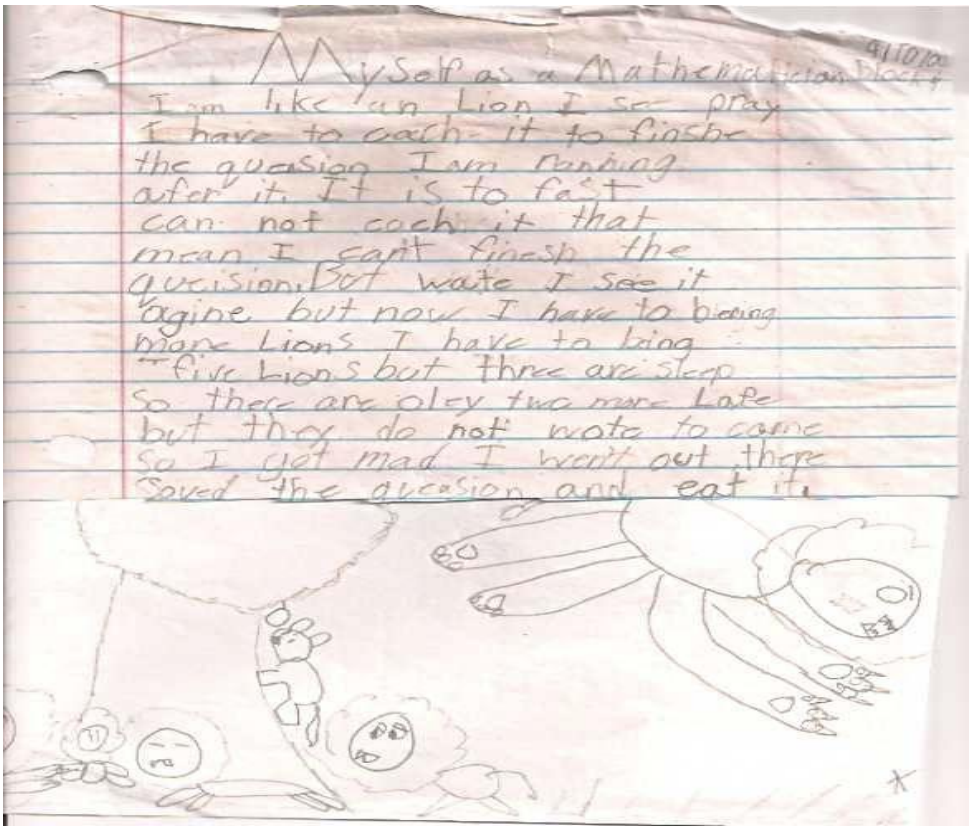
While analyzing the data collected through this survey, I was able to get a clear picture of individual student attitudes and confidence levels in math. It was evident that there were a variety of student opinions about math. One student, John, wrote, "I love math… When I do math, it is like playing 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…"

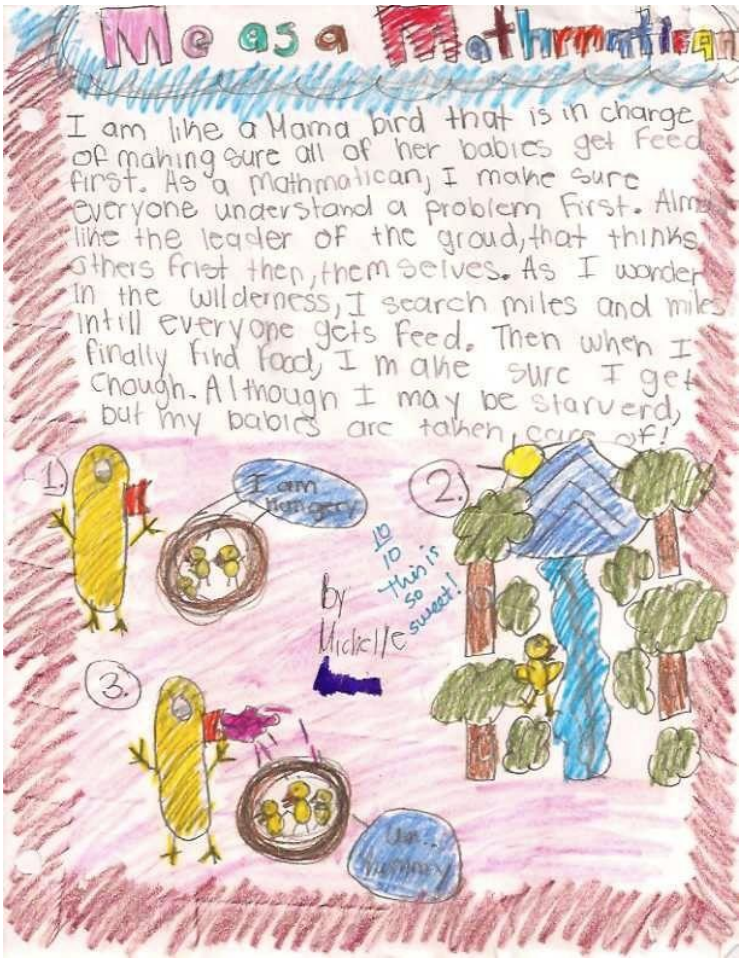


John's initial math analogy as discussed above portrays his anxious feelings towards math.

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.



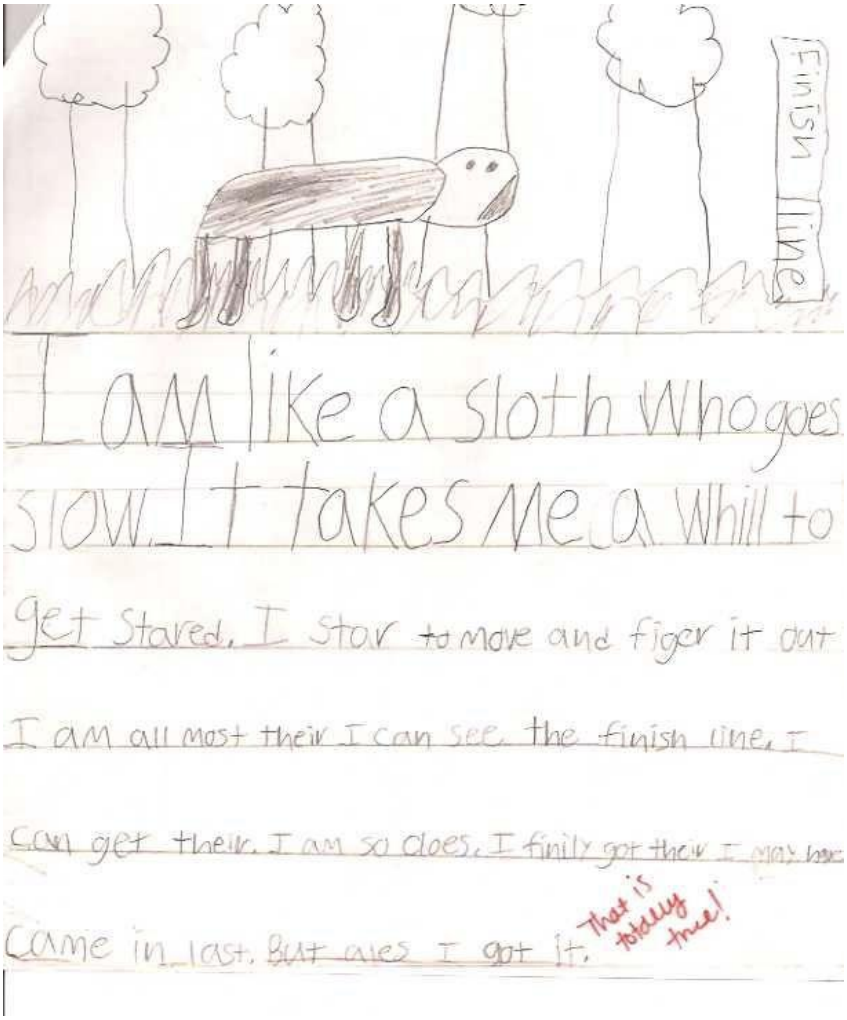
Above is Michelle's analogy.

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.

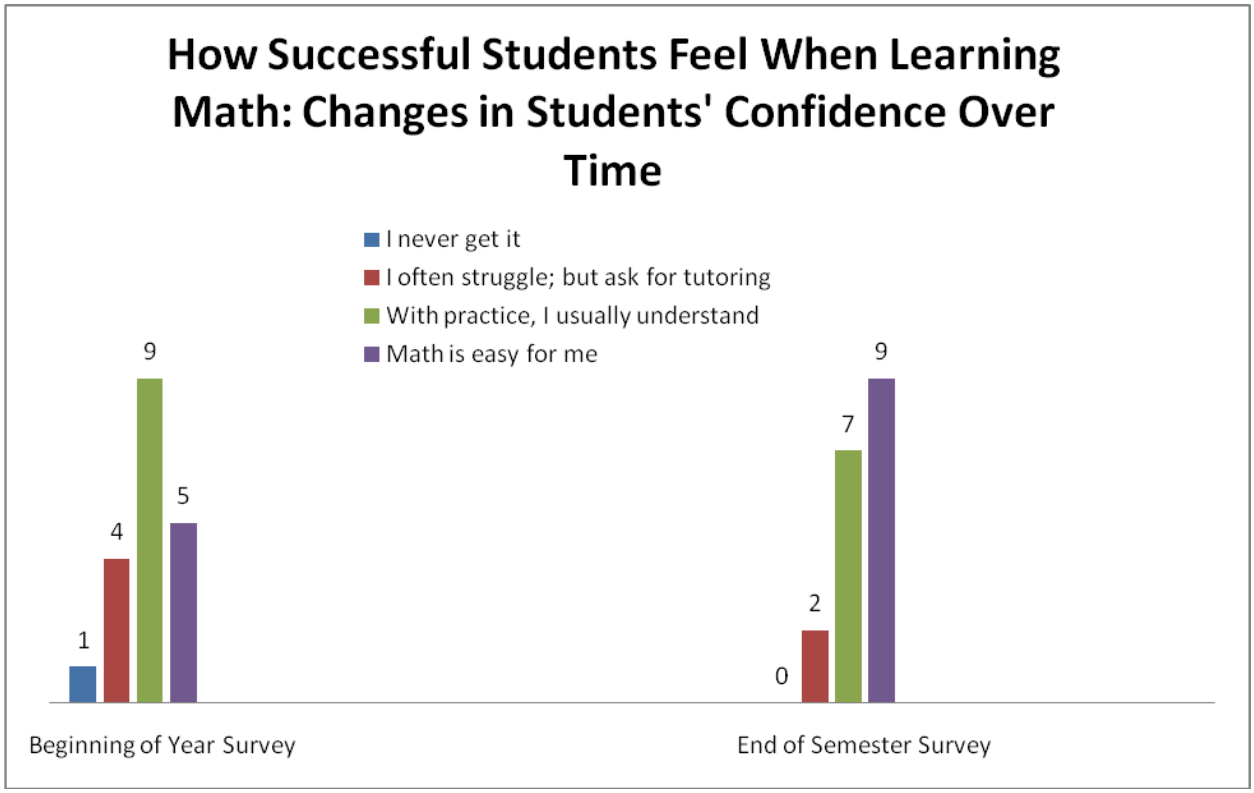
It was evident in the beginning of the year; many of my students not only lacked confidence in math but had a bad case of math phobia, or math anxiety. Throughout my action research project, I noticed that there were several indications that many students' attitudes were shifting in a positive direction. 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.

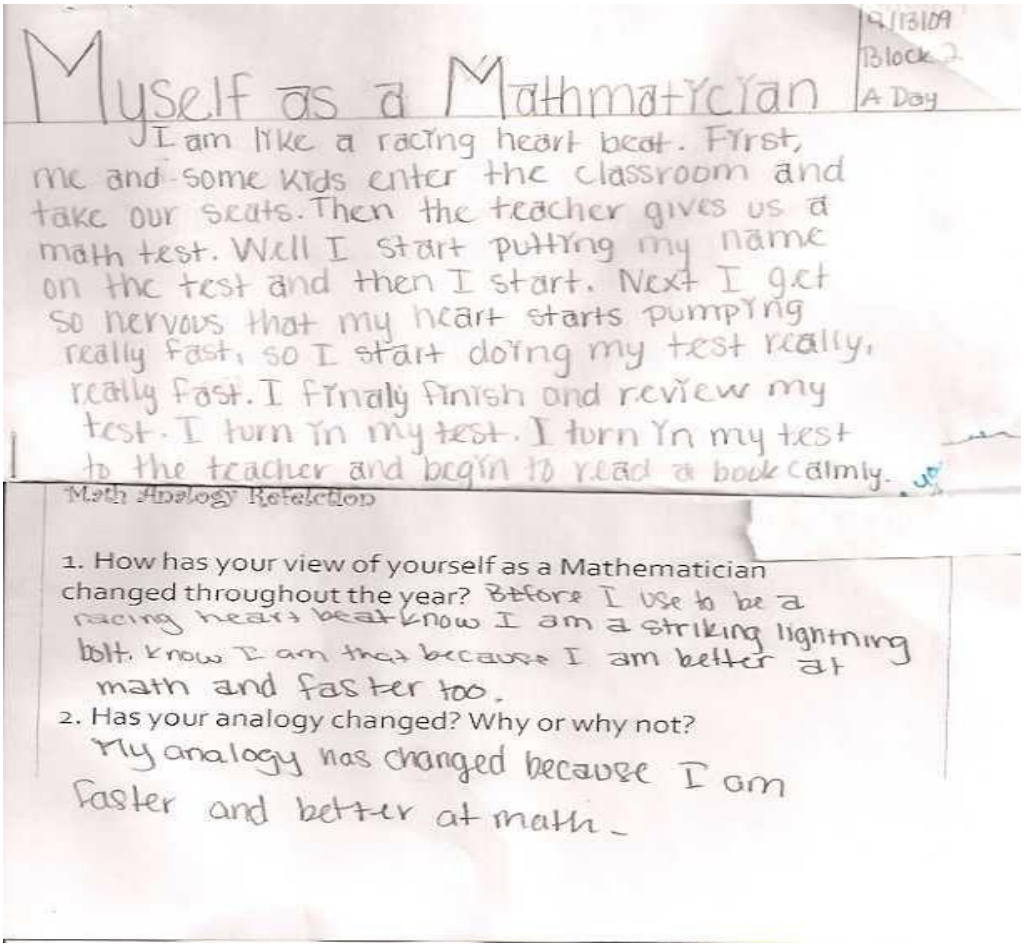


The graph above compares student confidence levels from the beginning of the semester to the end of the semester.

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 Mathmatician

9/13/09
Block 2
A Day

I am like a racing heart beat. First, me and some kids enter the classroom and take our seats. Then the teacher gives us a math test. Well I start putting my name on the test and then I start. Next I get so nervous that my heart starts pumping really fast, so I start doing my test really, really fast. I finaly finish and review my test. I turn in my test. I turn in my test to the teacher and begin to read a book calmly.

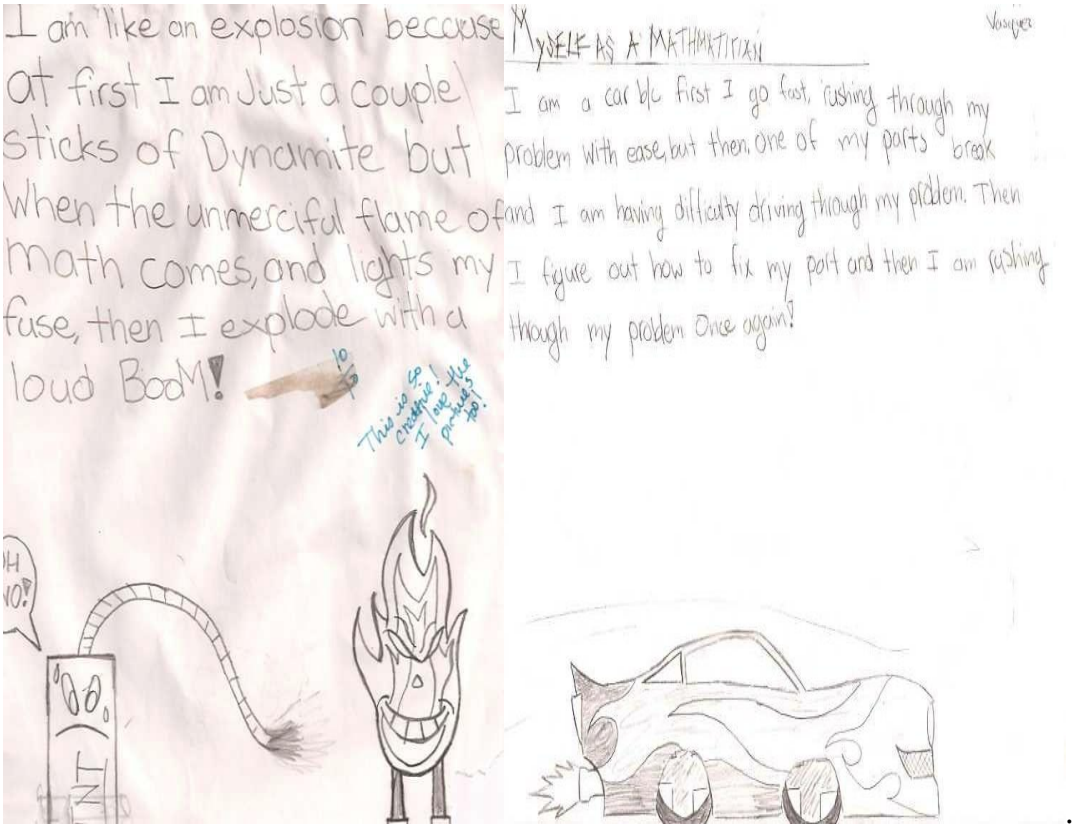
Math Analogy Reflection

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.

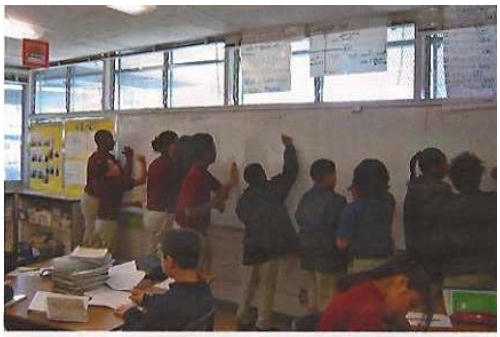
Theme Two: Games can reach all different readiness levels (differentiation)

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.

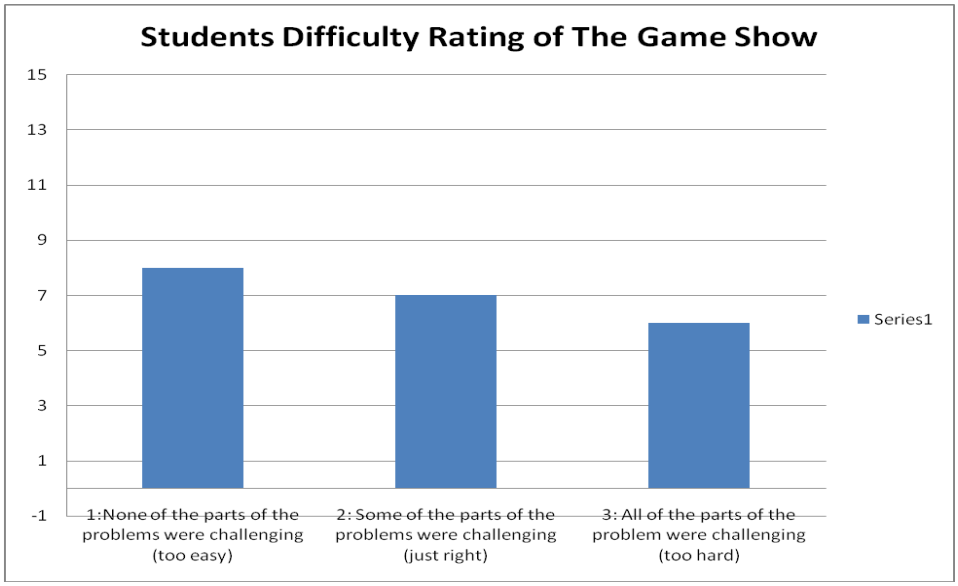
Painting a Picture of Subtraction Football:

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

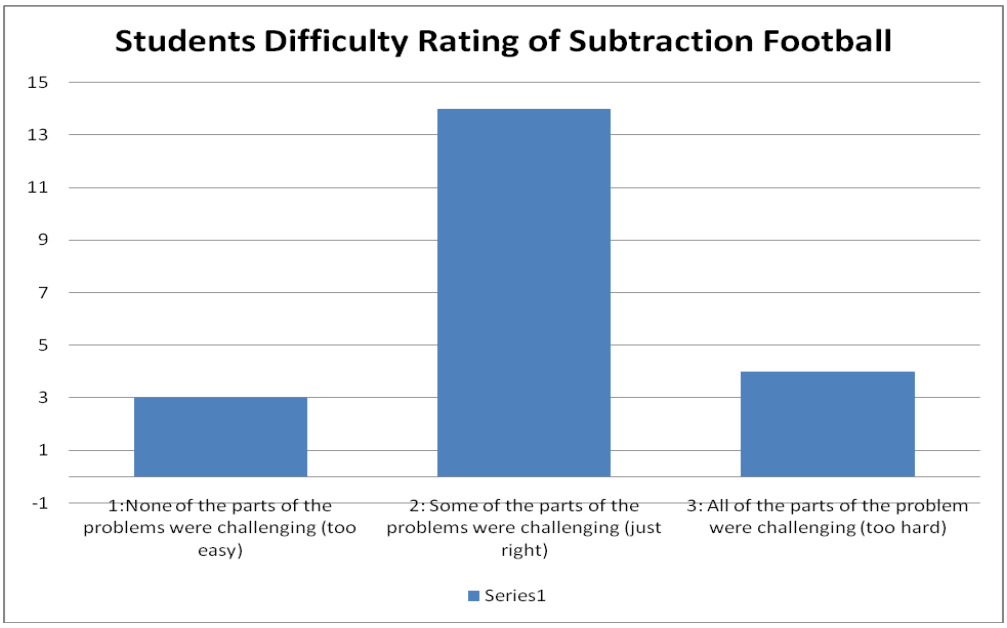
proceeding to the next, they are held accountable to one another. This game also allows for easy modifications for differentiating according to student's independent learning levels. Students that need more of a challenge use two ten-sided die in order to come up with a more difficult double digit integer, 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 kind of liked this game this game was fun;
I would rather do book work I would like to play it again

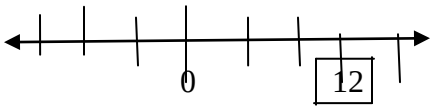
Following the Game Show, 33%, or seven students circled that they "kind of liked the game" where 57%, or twelve students circled "this game was fun; I would like to play it again." 9%, or two of the students circled, "It was boring; I'd rather do book work." This shows me that overall, students enjoyed 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

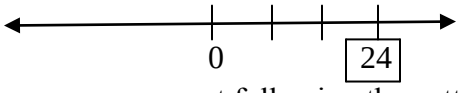
As you can see above, the ratio of off verses on task comments increased while working on the problems from the CPM book. What I found very interesting was the amount of conversation students were engaging in. Although students were working in teams of four on the CPM problems, the total amount of comments 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.

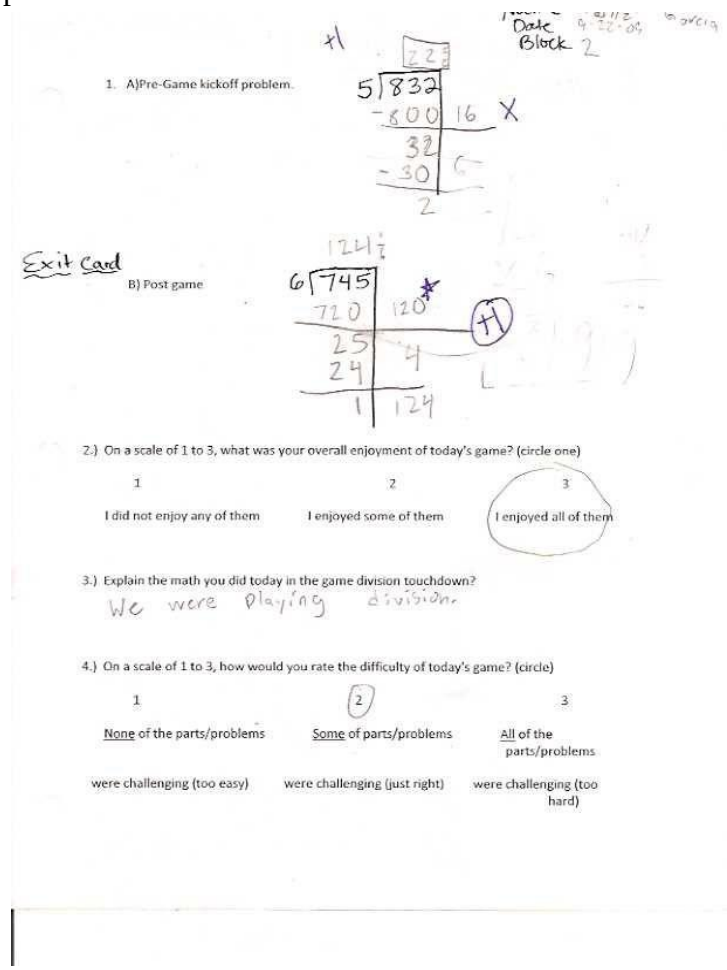
In the beginning of the school year, I also noticed that students were not accustomed to articulating their math thinking through writing. When asked to do so, I would get responses that included eye rolling, or heavy sighs, or even "Why do we write in math class?" After many of the math games that students 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

1. A)Pre-Game kickoff problem.

Exit Card

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.

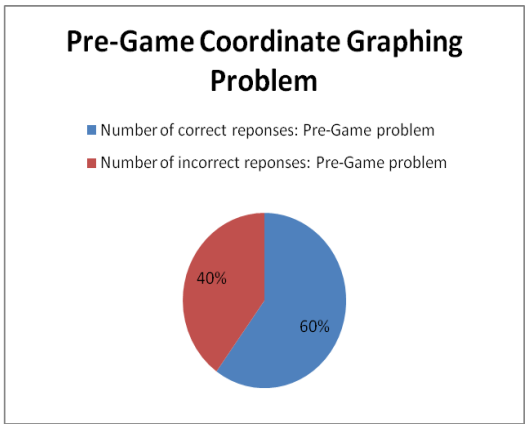
4.) On a scale of 1 to 3, how would you rate the difficulty of today's game? (circle)

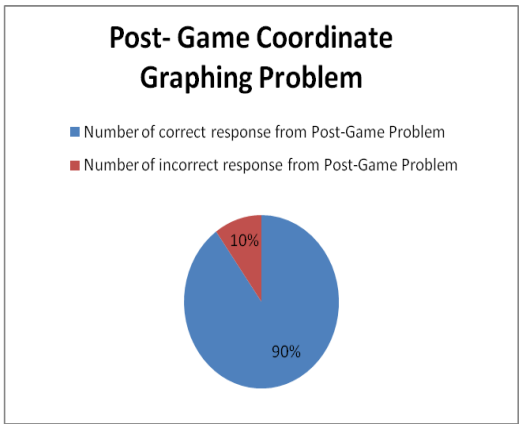
1	2	3
None of the parts/problems were challenging (too easy)	Some of parts/problems were challenging (just right)	All of the parts/problems were challenging (too hard)

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.

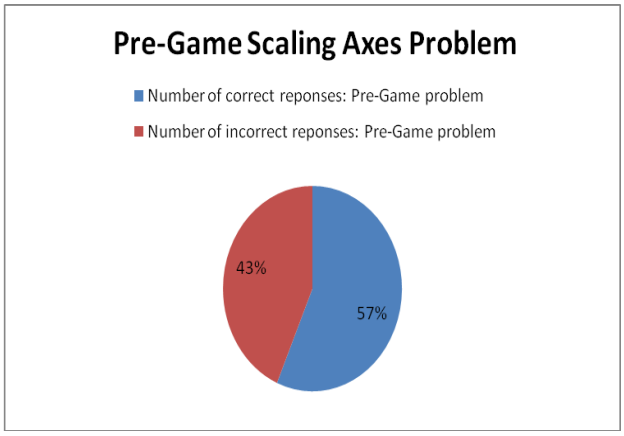
Before playing the Hidden Treasure/ Battle Ship game, I gave students a pre-game problem in which they had to graph three different ordered pairs on a coordinate plane. Twelve students answered the pre-game problem correctly, and eight did not. In other words, 60% of students were correct. Directly after 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.

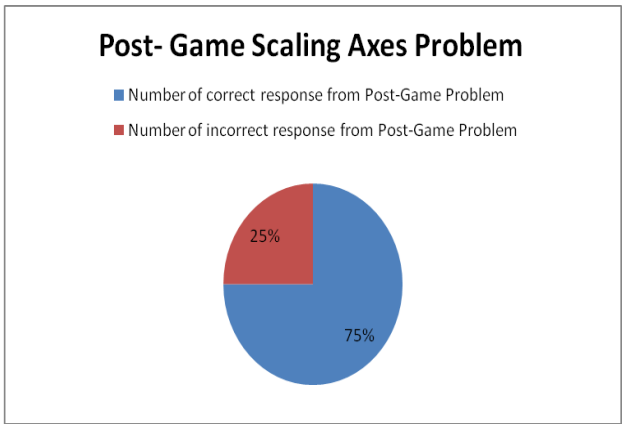




The two pie charts illustrate the results from pre and post problems students answered before and after playing the Hidden treasure/ Battleship game.

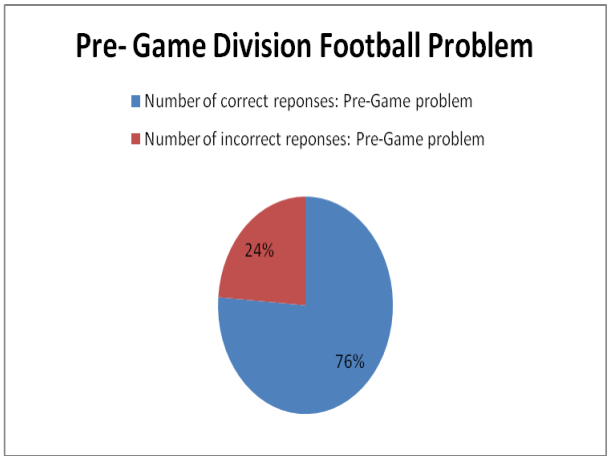
Through most of pre and post assessments I gave students, there was a consistent increase in student's comprehension from before playing the game. The pre and post assessments also helped me to see which games were more effective than others. Below, you will see another pre and post assessment for the 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.

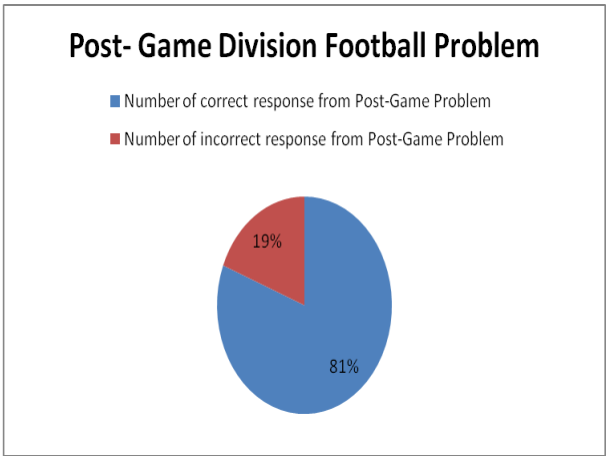




Above are the results from the pre and post- game problems from the Scaling Adventures game.

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.

Conclusions

In my action research project, students explored various math concepts through a curriculum that was centered on playing different math games. Some of the games were used to

introduce new concepts, some were used to practice a math concept following a short mini-lesson, while others were meant to help students review math content they previously learned. In a 1985 monograph, Bright, Harvey, and Wheeler categorized these games into three groups; pre-instructional, co-instructional, and post-instructional. Many of the math games involved cooperative learning, either working in teams of three or four students or in partnerships. My primary goals of implementing a curriculum centered on math games were as follows:

- to provide students with fun and playful, yet rigorous experiences in math that would help to improve their attitudes towards math.
- to present learning opportunities that reached a variety of readiness levels.
- to engage students in more cooperative learning.
- to increase student comprehension in math.

As I analyzed various data collected throughout my project, and observed how students responded to different math games, some common themes surfaced. I used various tools such as surveys, exit slips, student work samples, interviews, and anecdotal observations to gather data about how students felt about math and how they viewed themselves as mathematicians. From my initial data, it was clear that there was a high level of what Fillier calls "Math Phobia," or a complete fear of mathematics (2005). From within the first week of school, I noticed many of my students initially did not like math and experienced extremely low self confidence in math. When asked in a survey which learning experience students preferred to learn through, the majority of students chose games as their response. This led me to believe that when students were learning math through more playful experiences, they would begin to enjoy the subject more, rather than fear it.

Indeed, this is exactly what I found happened as my study progressed. Students' attitudes began to shift from strongly disliking math, or even feeling fearful towards math, to actually enjoying it and looking forward to coming to my math class. Through various exit cards, interviews and surveys, students responded extremely positively about the math games we played and said they wanted to play more games. As students entered the classroom and saw a game planned on the agenda, I would hear hoots and hollers of excitement. Many students expressed a strong desire to play math games and have stated that until this year, they did not like math. Students were having fun and their confidence in their own math abilities grew. The feelings of fear and hatred towards math shifted in a positive direction towards enjoyment. When I asked students for feedback about how math was going for them, often students would state that they would like to play even more math games. I used their feedback to help guide and direct my action research project. This gain in student's self confidence within their own math abilities carried over to a variety of learning experiences in math. Hopefully, they take this new found self confidence though their future years of schooling.

After analyzing various exit cards students wrote after playing different games, I realized that games provide a great tool for differentiating for students' various readiness level. However,

I learned through this process and by reading student feedback that some games did not differentiate as much as others. This had a direct correlation with how students felt about a specific game. Students tended to enjoy the games that offered more differentiation; one student wrote, "The problems were just right for me and I could solve them. It was a fun game." I noticed that with games that allowed for students to work at their own pace and were differentiated to match their readiness level, such as the Subtraction Football game, students exemplified more self confidence and seemed to feel more comfortable while playing the game. Whereas other games that were timed and more competitive, that usually involved students answering identical problems, seemed to rush students and cause more student anxiety. As a whole, students tended to not enjoy these games as much as others. Prior to planning a math game, it is essential to plan ways to differentiate for a variety of learning styles and abilities in order to address a wide spectrum of readiness levels found within one classroom of students. Since one of my primary goals was to increase students' self confidence, differentiating for my various students was a necessity. I began to lean towards games that focused more on cooperation, rather than competition.

In life, it is essential for people to learn how to work cooperatively with one another. Few careers or jobs do not require this skill. Many students begin my class having little to no experience with working in a team setting within math. The majority of math games I planned required students to work cooperatively in either teams of three or four, or in partnerships. I found many connections between student engagement levels and cooperative learning. I observed and documented the amount of "on task" comments verses "off task" comments spoken within the following two contexts: firstly while students were playing a math game with a partner and secondly while students were working with a team of four to solve a problem set out of our textbook. 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). The amount of students' "on task" comments were considerably higher while playing a math game compared to working on a set of problems out of our text book. Therefore, one can conclude that student engagement is considerably higher while playing math games verses working out of a text book. On another instance, I had my principal come in to observe my teaching. I had planned a math game show for that day. He wrote me a letter raving about the high levels of student engagement during the lesson and how nearly every student seemed focused and determined to solve the math problems presented in the game show. I have found that math games not only increase cooperative learning, but also raise student engagement levels within a cooperative learning setting.

One of the biggest challenges for me throughout this project was finding a way to pinpoint the affects of math games on student achievement. I measured student achievement while focusing on two different aspects of student learning; the students' ability to articulate their math thinking and the students' ability to accurately solve problems. Since math games provide an abundance of opportunities for students to teach their problem solving strategies and discuss their solutions with one another, students became comfortable sharing their math thinking with

the class as a whole. They transitioned from saying something like, “I got ___ as my answer” to “I got ____ as my answer because I know that…” As students began to feel more comfortable explaining and writing about their thinking, their confidence grew and they began to comprehend various math concepts at a much deeper level.

Another way I measured the affects of games on student comprehension was through quick pre and post math problems. After answering the pre math problem, students would play a math game and then answer a similar math problem directly after playing the game. I found that most students that answered the problem incorrectly before playing the game would no longer make the same mistake during the post game math problem. I think this increase in accuracy for problem solving was due to a combination of things. First, students were working closely with their partner or teams and often times, the game required them to teach their partner how they came to their solution. I also contribute this gain in student comprehension to a higher level of student engagement. Dozel described a teacher as “…lessons were not just hands-on, but minds on as well” (2003, p.254). When students are involved in their learning, they are far more likely to understand.

Tips for Teachers: What are some essentials when planning a math game?

My journey through creating a classroom culture of collaboration where math games were an integral part of our learning was not always a smooth journey. There were many road blocks and bumps along the way. Below, are some pointers to help set up a classroom culture built on collaboration where kids are doing math together, sharing their learning and relying on each other for success. These pointers will also hopefully help you avoid the bumps and road blocks I encountered along my journey. In addition to my own pointers, I also met with a small group of students to cooperatively create a list of aspects about various math games they have played that they really enjoyed and found useful. Some ideas are more student generated than others. Here is what we have come up with.

It is important to play a variety of games. Some students like games that involve a component of competition, while others respond better to games more geared to cooperation and collaboration. A healthy balance seemed to work for my students. There are so many different types of games, see what your students respond best to and be sure to mix the type of games up for them.

While planning for a math game, think about your students’ readiness levels. I found it helpful to group students heterogeneously, or with mixed learning abilities. However, if the gap between each students’ comprehension level was too wide, I observed that often one of more students would either get bored, frustrated, or discouraged. You know your students best. As you observe your students actually playing the game, don’t be afraid to modify a game on the spot for students that seem to be struggling, or need more of a challenge. Some ways to do this include,

giving students more challenging or easier numbers to work with, changing student groupings, encouraging students to work together in order to problem solve, and creating various leveled problems according to your students current readiness levels. At times, if I noticed a group of students struggling with a game, I would join their group and play with them. This would help provide students with a model on how to play the game effectively and how to communicate and behave while playing the game.

Be sure to "close the loop" with your students after playing a math game. With every math lesson I teach, including playing math games, I always save a few minutes at the end of the class to summarize what we have learned that day. This helps students reflect on and solidify their understanding about a particular concept. I find often students can summarize what they have learned in more effective ways than I can. By having students share one "take away" from that class, or something they learned that they will take with them, students not only begin to look at math concepts from different perspectives, but also become more proficient in articulating their math thinking. When students listen to how their classmates think about a particular concept, hmany will gain a deeper level of comprehension, or have an "ah ha" moment where things begin to click for them and make sense. I know that often times, we are pressed for time. We look at the clock and think, "Ah, class is almost over!" For these occasions, I would often have my students partner up with another group and do a quick "take away" pair share. This allows them to still share their thinking while hearing another group's perspective on what they learned for the day. Other times when time permitted, students shared what they learned with the class as a whole.

Building a Culture of Teamwork: You may encounter certain groups that are not working effectively together. I know at times, I did. Here are some helpful ways to either prevent this, or help remedy these types of teamwork problems. Remember, building a respectful classroom culture of collaboration begins on day one of the school year and is a process that happens over time.

Be flexible with your grouping: Experiment with ways that students are grouped together. At times, I would choose my students' teams, while other times, I would let students pick their partners. See what works best for your students. When students join together in new teams, I try to plan some sort of ice breaker, or get to know your teammates activity. Often, we assume that students in our class all know each other well, which is in fact not always the case. Brainstorm with your class what an effective and supportive team looks like and sounds like. I also have students give non examples as well. Be sure to acknowledge respectful behaviors that you observe while students are working with their teams. Point these examples out to the entire class. When I notice students are having disagreements while working together, I first observe them to see if they can come to an agreement. If not, I might intervene by joining their group to help diffuse, or mediate the situation. There have been occasions where two students are just not

getting along with one another and my interventions do not seem to help. As a last resort, I have switched groups around according to who I believe will work well together.

Games that involve "cool new things" are more fun: When you introduce new materials, such as the double sided dice, or a new spinner, students become more excited and involved. However, you want to be sure to not overuse these novelties, or students might become bored. A teacher's enthusiasm and excitement about playing a math game in contagious. This will spread like wild fire to the students. Pump it up, teachers!

I have found that games not only help students enjoy math, but they also make teaching math more fun. Who doesn't like to play? It is easy for teachers to become comfortable in their ways of teaching and fall into the patterns of repeating the same curriculum year after year. However, as I had previously experienced, this can become very boring and monotonous for both the students and the teacher. Making games an integral part of my math curriculum has totally rejuvenated me as a teacher and also refreshed many of my students who did not yet realize that math can be fun. Many teachers think that math games are frivolous or just "time fillers." While some are, many are not. Playing math games can provide invaluable learning experiences for our students, while making them fun as well. We need to challenge the notion that "rigorous" equals working from a text book If more schools began to see the value in not only a curriculum that included various games, but also a culture of collaboration and teamwork, then less of our students would enter our classes fearing math and not seeing the importance of it. We live in a world run by technology and math. Johnson and Johnson stated, "Children born today will enter a work force where knowledge about mathematics is crucial to their career opportunities, their participation in society, and their conduct in their private lives" (1994, p.1). Having the skills and knowledge mathematics nurtures can help our kids to become successful, contributing members of our society.

Final Reflection

When I first began our GSE program, I had no idea what I wanted to focus my research on. It was when I was looking through a chest of old pictures and memorabilia from my childhood that I realized I wanted to center my project on making math fun, yet challenging for my students. After perusing through my elementary and middle school report cards, I noticed some significant trends, not only in the teacher comments portion, but in my own personal reflections written on my report cards as a child. It was quite hilarious to read my own written reflections from as far back as second grade. I noticed that while math was always my strongest subject, I did not always enjoy it. In one of my third grade reflections, I wrote, "Math is boring this year because we never do anything fun. Last year, Mrs. Wisely used to play games with us and teach us about Hungry Herby [the greater than or less than symbol]. This year, we just work." This was when the thought of implementing a program centered on games was born. I thought that it was peculiar that I associated math games with fun and that "work" in math did

not involve games. I figured since I felt this way as a child, many of students probably shared the same feelings about math.

The idea of making the work we do in math class more fun was the direction that I knew I wanted to take my project. I wanted to adjust my teaching and curriculum, and light a flame of passion for math within my students. This action research project could not have come at a better time in my teaching career. I now realize that over the past couple of years, I have felt bored myself as a teacher. If I felt bored, than certainly some of my students felt bored learning in my class as well. I needed to be inspired to make a change within my practice. If something within me as a teacher did not change, I did not feel I would last long in this profession.

I then thought of all of my students in the past that expressed through their behaviors, writing, or conversations with me that math has always been boring to them. These students reminded me of myself as a child. This was not only my inspiration to teach math, but also to transform my students' attitudes about math. I thought at first, "If I can set up my class in a way where students are having fun learning math, than hopefully this can change their views on math and help them become more successful." I also hoped that teaching through math games would help to liven up my own teaching practice. This led me to the formation of my action research question, *"How do math games affect student engagement and achievement in the classroom?"* I found while exploring my action research question, math games surely affected a lot more than just student engagement levels and achievement. There was a huge transformation within my teaching, my students' views on math, and the culture of the classroom as a whole community.

When looking back to previous years of teaching, I now realize how teacher-centered the culture of my classroom was. I was doing much more talking than my students throughout a typical class period. One of the biggest impacts my action research project has had on my teaching is that my class has become tremendously more student-centered, where students are leading discussions and teaching each other through exploring various math concepts, with me acting as more of a facilitator rather than the sole "teacher." This was not even something that I intentionally sought out to change. I began the school year excited to teach through math games, yet I had no idea how my teaching and view of learning would transform so dramatically.

The use of math games in the classroom increased my students' engagement and involvement throughout their learning. Games created a classroom culture where students are more comfortable sharing their thinking about math concepts, whether right or wrong. Whether it was with a partner, teams of students or with the class as whole, students realized that this was a norm in our class community. Unlike other years, students did not challenge this notion, but instead, they seemed to embrace it. Math games helped to create this culture because so much of our time together, students were learning about difficult math concepts through playing games. Not only did the amount of math talk increase dramatically, but also while playing, students were more relaxed and less anxious about making mistakes. This helped students see that math can be fun and provided them with more confidence. I take great pride in this transformation of both students' attitudes as well classroom culture and believe that this change in students' attitudes

may carry them throughout their remaining experiences learning math. I can't imagine my classroom any other way.

This transformation of my classroom culture, curriculum and teaching as a whole, will continue to evolve throughout my future years of teaching. I will continue to teach math through math games and I am excited to add to my collection of games in the years to follow. After reflecting on each game that we played in class, I have learned which games are more effective than others and which ones students have enjoyed, as well as which ones have totally flopped. One thing that I would like to add to my classroom for next year is having my students keep a journal in which they reflect on the various math games they have played and their feelings about math. I want them to feel that they can write freely about whatever comes to mind in their journals. This can be a place for them to safely write their feelings about math without any judgment from me or others. Through many of the exit slips students filled out after playing different math games, I always questioned whether students wrote honest responses, or whether they wrote what they thought their teacher, myself, wanted to hear. I think this reflective journal will help to make students feel more comfortable with being honest about their feelings. While students wrote and reflected about their thoughts on various math games and themselves as mathematicians, they did not keep these written entries together. By keeping a journal throughout the year that is more reflective, and not necessarily centered around the learning of different math concepts, students can reread their writings in order to reflect upon their own journey as a mathematician throughout the school year and learn more about themselves.

This process of collecting data for our action research project has really helped me to refine my teaching for the years to come. Requiring me to reflect more on my practice and take copious notes on the ways students respond to various experiences in the classroom has transformed my practice. I've become a more reflective teacher who uses research to drive my instruction. This continuous growth in my teaching practice will not only continue to inspire me in my future years of teaching, but I also hope it reaches out to other teachers that felt they were in need of some inspiration as well. By continuing to share my experiences and findings throughout my project with other educators, I hope to help change an exponential amount of students' attitudes about the way they view math in general and themselves as mathematicians. Let the math revolution begin!

References

Allen, L., & Main, D. (1976). The Effects of Instructional Gaming on Absenteeism: The First Step. *Journal for Research in Mathematics Education. 7 (2),* 113-128.

Bright, G., Harvey, J., & Wheeler, M. (1985). Learning and Mathematic Games. *Journal for Research in Mathematics Education. Monograph. (1),* 1-189.

Cavanagh, Sean (2006) "Playing Games in Class Helps Students Grasp Math." *Education Week*, Nov 2008, 43-46.

Dolezal, S., Welsh, M., Pressley, M., & Vincent, M. (2003). How Nine Third-Grade Teachers Motivate Student Academic Engagement. *The Elementary School Journal*. 103 (3), 239-267.

Fillier, K. (2005) Math Anxiety: Strategies for Preventing, Reducing, and Overcoming the Problem. Faculty of Ed. Submitted to Professor Robert Kelly of Memorial University of Newfoundland.

Inkpen, K., Booth, K., Klawe, M., & Upitis, R. (1993) Playing Together Beats Playing Apart, Especially for Girls. Department of Computer Science, University of British Columbia.

Johnson, David W. & Johnson, Roger, T & Holubec, Edith J. (1994) *Cooperative Learning in the Classroom,* Alexandria, Virginia: Association for Supervision and Curriculum Development.

Johnson, David W. & Johnson, Roger, T. (1991) *Learning Mathematics and Cooperative Learning Lesson Plans for Teachers*, Edina, Minnesota: Interactive Book Company.

Kadijevich, D., TIMMS 2003: Relating Dimensions of Mathematics Attitude to Mathematics Achievement. Mathematical Institute of the Serbian Academy of Sciences and Arts, and Megatrend University, Belgrade, Serbia.

Klawe, M. & Phillips, E. (1995) A Classroom Study: Electronic Games Engage Children As Researchers. Department of Computer Science, University of British Columbia.

Kysh, J. & Sallee, T. & Hoey B. (2002) *College Preparatory Mathematics (CPM) Foundations for Algebra,* Sacramento, California: CPM Educational Program.

McGraw Hill &Wright Group. *Teacher's Guide to Games, An Everyday Mathematics Games.* (2003). Chicago, Illinois.

Resek, D., & Rupley, W. (1980). Combating 'Math-phobia' with a Conceptual Approach towards Mathematics. *Education Studies in Mathematics,* 11 (4) 423-441.

Stodolsky, S., Salk, S., & Glaessner, B. (1991). Student Views about Learning Math and Social Studies. *American Educational Research Journal. 28 (1),* 89-116.

Shaftel, J., Pass, L., & Schnabel. (2005). Math Games for Adolescents. *Teaching Exceptional Children.* 37 (3), 25-30.

Boston College, TIMMS & PIRLS International Study Center, Lynch School of Education. (2004). *TIMMS 2003 International Mathematics Report*. Retrieved May 10, 2009, from timss.bc.edu

Wenglingsky, H. (1998). Does it Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics. Educational Testing Service Policy Information Center. Princeton, New Jersey.

Appendix: 1 September's Pre Game Math Survey

Name_____
Date_____
Block _____

Math Survey

1. How would you describe yourself as a math student?
2. What are your strengths as a mathematician?
3. How do you feel about math?

1	2	3	4
Anxious or scared	Math is boring for me	I often like math	Excited, give me a problem and let me solve it!

4. What types of learning activities do you prefer? Circle all that apply.

* group work * independent work * projects *playing games
* taking notes *teaching another student *drawing *solving puzzles
*using hands-on materials *listening to the teacher talk * I don't know

5. Rank your favorite math concepts to explore. (1 being your favorite, 9 being your least)

___fractions ___decimals/money ___Geometry ___measurement
___word problems ___algebra
___addition/subtraction ___multiplication ___division ___ OTHER _____

6. How successful do you feel when learning math?

1	2	3	4
I never get it	I often struggle, but ask for tutoring	With practice, I usually understand	Math is easy for me

7. Why do you think we learn math?

8. What advice would you give another student who is struggling in math?

9. Please write anything else you would like me to know about you. I am so excited to get to know you this year!

Appendix 2: Post Game December Math Survey

1. How would you describe yourself as a math student?

_____
_____
_____
_____

2. What are your strengths as a mathematician?

_____

_____

_____

3. What types of learning activities do you learn best with? Circle all that apply.

* group work * independent work * projects *playing games

* taking notes *teaching another student

*using manipulatives *listening to teacher talk

4. What do you like about Mrs. Allen's math class this year so far? BE SPECIFIC!

_____

_____

_____

_____

5. What is something you might change about our math class? Be honest and specific._____

_____

_____

6. The year is almost halfway through. How have your feelings about Math changed from the beginning of the year? Why do you think this is so?

_____

_____

_____

7. How do you now feel about math?

1	2	3	4
Anxious or scared	Math is boring for me	I often like math	Excited, give me a problem and let me solve it!

8. How successful do you feel when learning math?

1	2	3	4
I never get it	I often struggle, but ask for tutoring	With practice, I usually understand	math is easy for me

9. What advice would you give other students in this room to help them be successful in math class? _____

_____

_____

10. How do you feel about the math games we play in class? Which ones are your favorites? Why? _____

_____

_____
_____

11. What do you think makes a math game fun?

_____
_____
_____

13. Please write anything else you would like me to know. Remember, I love to get your feedback!

_____
_____

Appendix 3: Post Math Game Questions/ Exit Slips

1. Rank the following math games from 1-5 (1 being your favorite, and 5 being your least favorite)
2. What makes a math game fun?
3. How effective was today's game _____ in learning _____?

1	2	3	4
Not effective, I don't understand	Somewhat effective I sort of understand	Effective, I understand	So effective, I could teach another student

4. Use as much detail as you can to describe the math that you were doing in this game?

5. Create a math problem, solve it, and write an explanation of your solution as if you were writing to another student that has not yet learned this concept.

Appendix 4: Student Interview Questions

Student Interview Questions

1. Describe a positive experience you have had in math class?
2. Share a time when you have felt frustrated in math class before?
3. Describe your favorite teacher. How did she/he help you learn?
4. What are the characteristics of your least favorite teacher?
5. How did you feel about math before you came to KLA?
6. How do feel about math class this year?
7. What do you enjoy most about math class this year so far?
8. What has been your favorite activity we have done in class and why?
9. What has been your least favorite activity?
10. How do you feel about the math games we have played in class so far? Which one is your favorite and why?
11. How do you learn best?
12. How can I help you be successful in math class this year?
13. Why do you think it is important for people to understand math?

Appendix 5: Parent/ Guardian Permission Letter

PARENT/ GUARDIAN'S CONSENT FOR MINOR TO PARTICIPATE IN AN ACTION RESEARCH STUDY

HIGH TECH HIGH GRADUATE SCHOOL OF EDUCATION

Title of Study: **"How do math games effect student engagement and achievement?"**
Researcher: Jacqui Allen, Graduate Student, High Tech High Graduate School of Education and KLA 6th grade math teacher
Office: **619-263-9266** *Email:* jallen@keillerleaders.org
Purpose: Your child is being invited to participate in the above research study. The purpose of this study is to develop ways to increase student engagement and achievement in math through playing math games. This project will involve my sixth grade math classes at KLA and will not be used in any way to evaluate them, nor will it interfere with your family life or your child's schooling.
Procedures: If you are agreeable to having your child participate in this study, I will plan to interview your child a couple of times this year in order to find out ways they learn best in math class as well as how they feel about math class.
Risks: There are no known risks to your child for participating in this study.
Benefits: It is possible that your child will not benefit directly by participating in this study. However, this study should provide your child with a valuable opportunity to think and talk about their experiences learning math. In addition, I will get to know how your child learns best and plan math experiences that will help them become more successful in learning math. The information gathered from this study will be presented to other math teachers and will be vital to their efforts to continually improve our math program to meet students' needs and help students reach their goals.
Confidentiality: Absolute confidentiality cannot be guaranteed, since research documents are not protected from subpoena. However, the confidentiality of project records will be maintained to the fullest extent possible. Responses by your child to interview questions will be coded in such a way that her or his identity will be concealed. Your child will never be identified with any particular response, comment or materials that he/she might share with me.
Costs: There is no cost to your child beyond the time and effort required to participate in the activities described above. I will schedule interviews at times that are agreeable to you and your child.
Right to refuse or withdraw: Your child may refuse to participate in this study. If you allow your child to participate, your child has the right to not answer any questions I might ask. Even if you agree, you and your child may change your mind and quit at any point.
Questions: If you have any questions, please contact me at the phone extension or e-mail address above.
Your child's rights: The rights below are the rights of every person who is asked to be in a research study. As a research subject, your child has the following rights:

To be told what area, subject, or issue is being studied.
To be told what will happen to them and what the procedures are.
To be told about the potential risks or discomforts, if any, of the research.
To be told if they can expect any benefit from participating and, if so, what the benefit might be.
To be allowed to ask any questions concerning the study, both before agreeing to be involved and during the course of the study.
To refuse to participate in the study or to stop participating after the study starts.
To be free of pressure when considering whether they wish to be in the study.

CONSENT: Your signature below will indicate that you have agreed to allow your child to volunteer as a research participant and that you have read and understand the information provided above:
Signature of Legal Guardian _____ Date _____
Signature of Investigator _____ Date _____
Jacqui Allen, Graduate Student, High Tech High Graduate School of Education and 6th grade math teacher at KLA

Appendix 6: Student Permission Letter

(9/9/09)
Dear students,

In addition to being a teacher at Keiller Leadership Academy, I am also a student in High Tech High's Teacher Leadership Master's Program. As part of this program, I will be conducting a research study to learn more about how math games help students become more engaged and learn more. I'll be working with many students in this study and would like to invite you to be a part of it. Below is some information to help you make an informed decision:

Why I'm doing this study: I am really interested in how sixth graders learn math best. I would like to know ways that you feel you learn math best as well as your previous experience learning math. I would like to find out ways to make math more fun for you this year. I will be sharing my findings with other KLA math teachers in order to help make learning math more fun and engaging for all our students.

What will happen to you if you are in the study? If you participate in this study I might ask you to meet with me a couple of times this year to talk about your experiences learning math and playing math games. I would love to hear your feedback on which math games you have enjoyed and ones that you did not enjoy.

Will any part of the study hurt you or help you? This study won't hurt you in any way, and it may not help you either. However, this study will provide a chance for you to think and talk about your experiences in math class and ways you learn best. Your opinions will be useful to me and other math teachers who are trying to make their math class more fun and engaging. By sharing your experiences, you could help us better understand how students learn and experience math.

Who will know that you are in the study? I'm going to keep whatever I hear from you separate from what I hear from other people -- other students or other teachers. I won't tell them what you tell me, and I won't tell you what they tell me. However, I will write an article or report based on the interesting things I will learn in this study. I will also present what I've learned at conferences so that it can be useful to other teachers. In either case, I will hide your name so that no one will know who you are, or that you did or said a particular thing.

Do you have to be in the study? No, you don't. No one will get angry or upset with you if you don't want to do this. Just tell me if you don't want to be in the study. And remember, you can change your mind later if you ever decide you don't want to be in the study anymore.

Questions? You can ask questions at any time. You can ask now. You can ask later. You can talk to me or you can talk to your parents about this study at any time. My e-mail is:

E-mail: jallen@keillerleaders.org

If you have concerns about this research, you can also contact my advisor, Professor Stacey Caillier, who will be supervising this research:

E-mail: scaillier@hightechhigh.org

To go ahead with this study, I need to know that you are willing to participate and that your choice to do so is entirely voluntary. Please review your rights at the bottom of this page and sign below if you agree to participate.

Sincerely,
Mrs. Allen

IF YOU AGREE TO BE IN THE STUDY, PLEASE SIGN YOUR NAME BELOW.

Signature of the Participant _____ Date _____

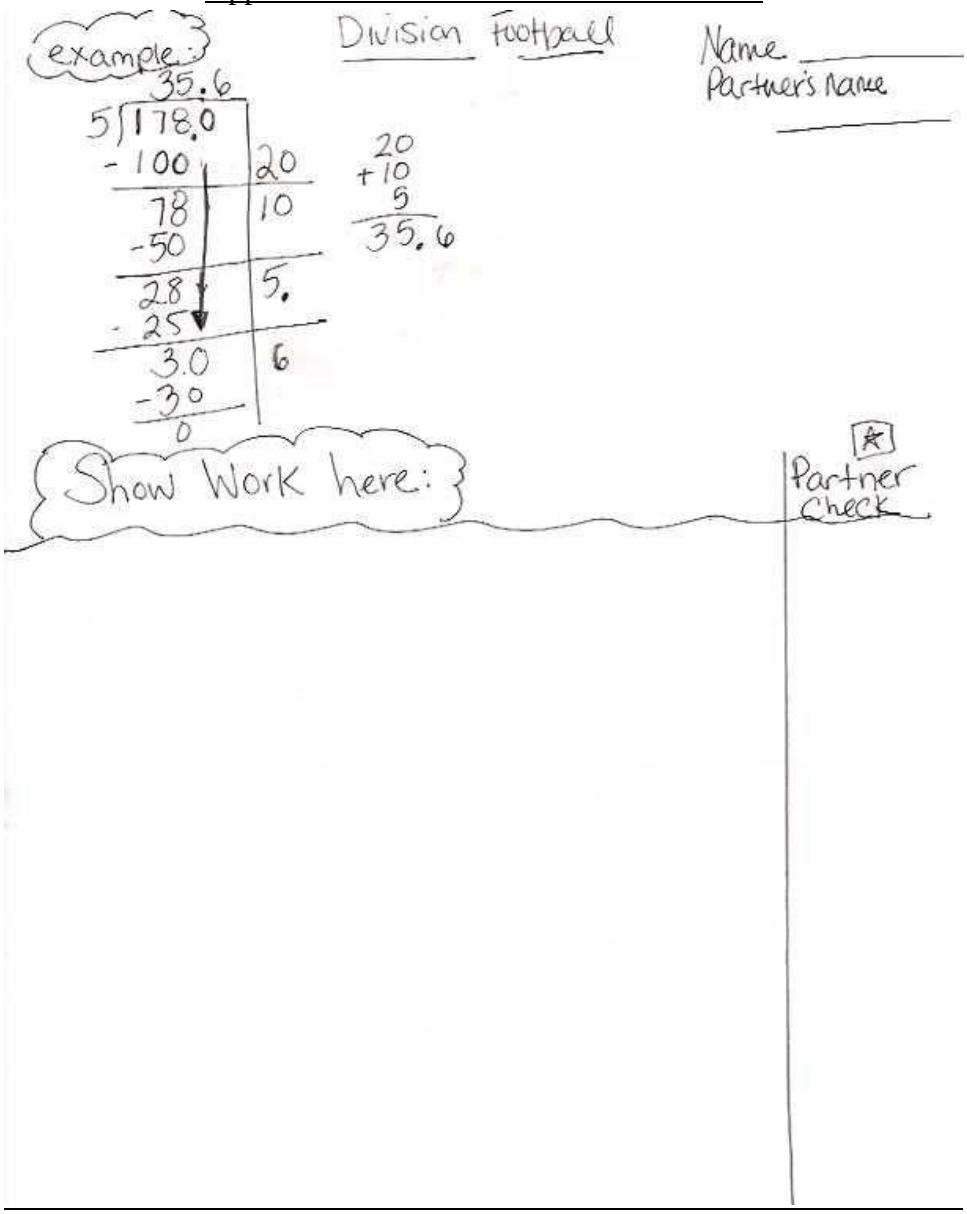
Signature of the Teacher Researcher _____ Date_____

The rights below are the rights of every person who is asked to be in a research study. As a research subject, you have the following rights:

1.) To be told what area, subject, or issue is being studied.

2.) To be told what will happen to you and what the procedures are.
3.) To be told about the potential risks or discomforts, if any, of the research.
4.) To be told if you can expect any benefit from participating and, if so, what the benefit might be.
5.) To be allowed to ask any questions concerning the study, both before agreeing to be involved and during the course of the study.
6.) To refuse to participate in the study or to stop participating after the study starts.
7.) To be free of pressure when considering whether you wish to be in the study.

Appendix 7: Division Football Game board



Appendix 8: Dart Booth chart

Insert pic of dart booth chart

Appendix 9: Win-a-Row Game board

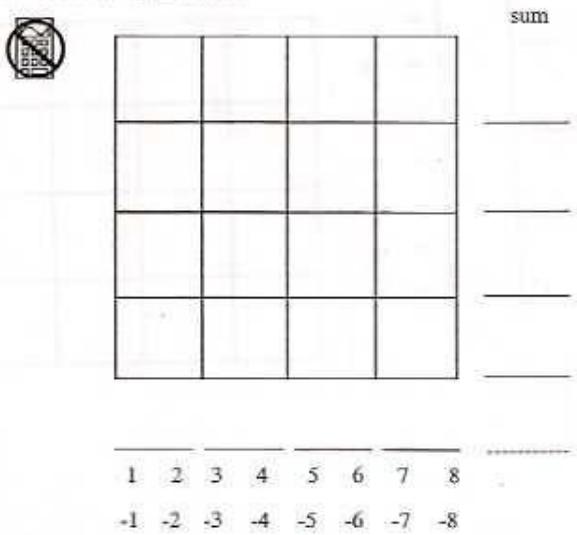
Win A Row

a game for two players

Mathematical Purpose: Adding positive and negative integers.

Object: Strategically place your numbers on the game board so that you can win the largest number of rows.

Materials: One Win A Row game board.



Scoring: Once all the boxes in the table have been filled in, calculate the sum of each row and column. Every positive sum means one point for player 1. Every negative sum means a point for player 2.

How to Play the Game:

1. Play one round of Rock, Paper, Scissors to determine who plays first.
2. Player 1 places one of the numbers 1, 2, 3, 4, 5, 6, 7, and 8 in the square of his/her choice then crosses that number from the list.
3. Player 2 places one of the numbers -1, -2, -3, -4, -5, -6, -7, and -8 in another square then crosses that number from the list.
4. Alternate the play until all the squares are full and all your numbers are used up.
5. Add the numbers in each row and write the sum on the appropriate blank. Give the winner of each row one point.
6. Add the numbers in each column and write the sum on the appropriate blank. Give the winner of each column one point.
7. If the two players tie after adding the rows and columns, find the sum of the downward (from left to right) diagonal to decide the final winner.
8. If the two players are still tied, find the sum of the other diagonal (up from left to right) to decide the final winner.
9. If the game is still tied, you are both winners!

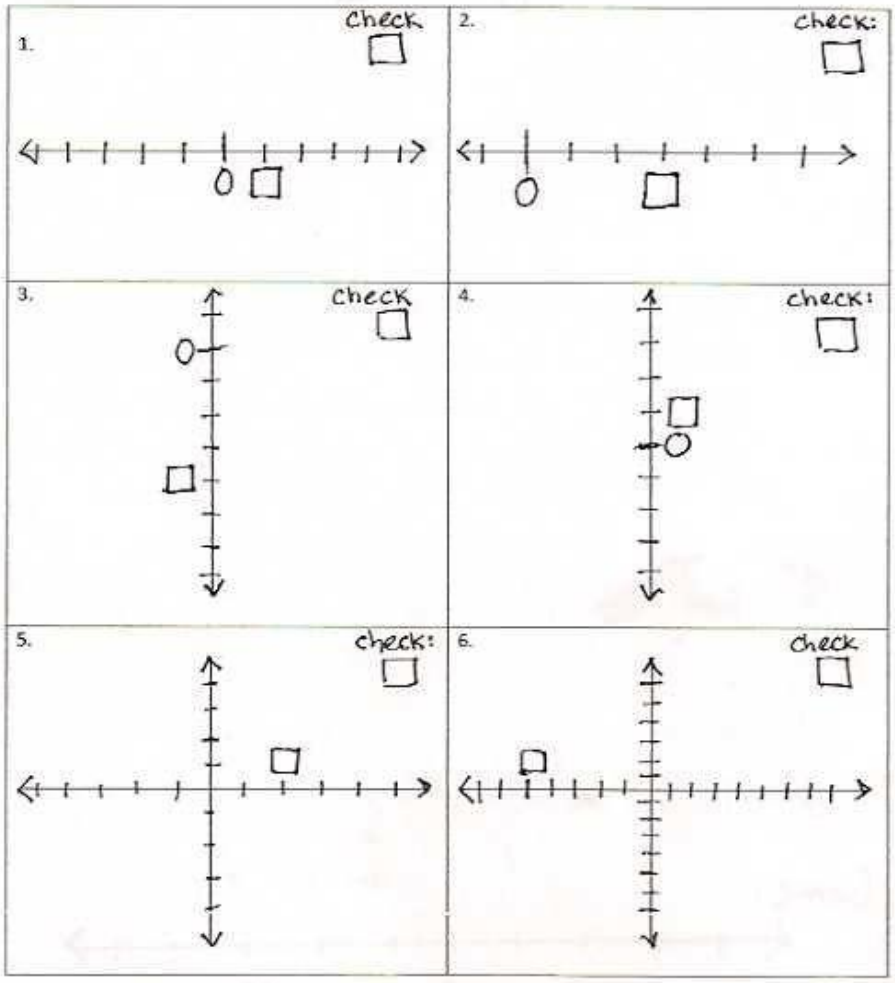
Ending the Game: The game ends when all the squares are full and you have found all the sums.

Appendix 10: Scaling Adventure Game board

Name:
Date:
Block:

Scaling Adventure

Directions: Fill in the following scale with one number from the spinner to give your partner a clue. Then, pass your paper to your partner to solve. Be sure to keep your number SECRET! Don't forget to check their work!



Appendix 11: Game Show Rules Chart

(Insert pic of game show chart)

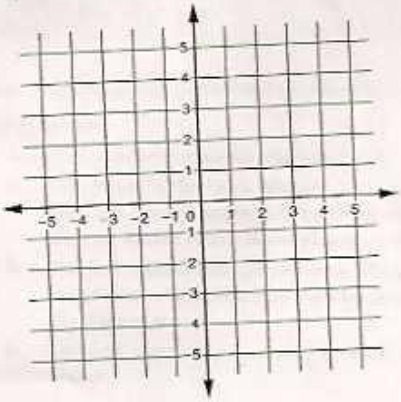
Appendix 12: Battleship/ Hidden Treasure Game board

Name Date Time

Hidden Treasure (Advanced) Gameboards Game Master 91

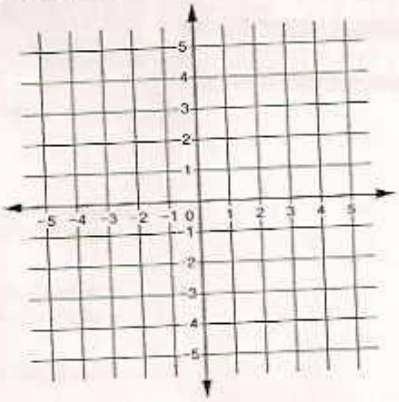
Each player uses Grids 1 and 2.

Grid 1: Hide your point here.



Grid 1

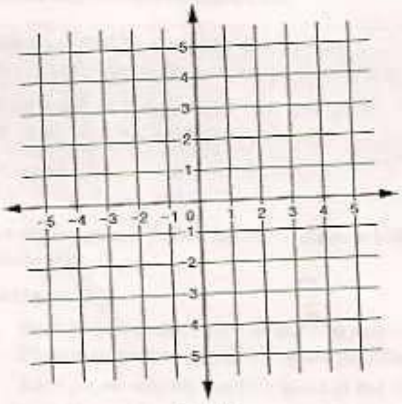
Grid 2: Guess other player's point here.



Grid 2

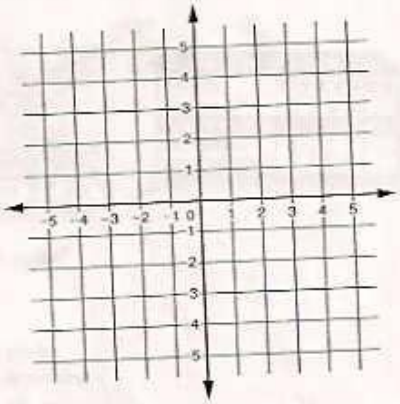
Use Grids 1 and 2 to play another game.

Grid 1: Hide your point here.



Grid 1

Grid 2: Guess other player's point here.



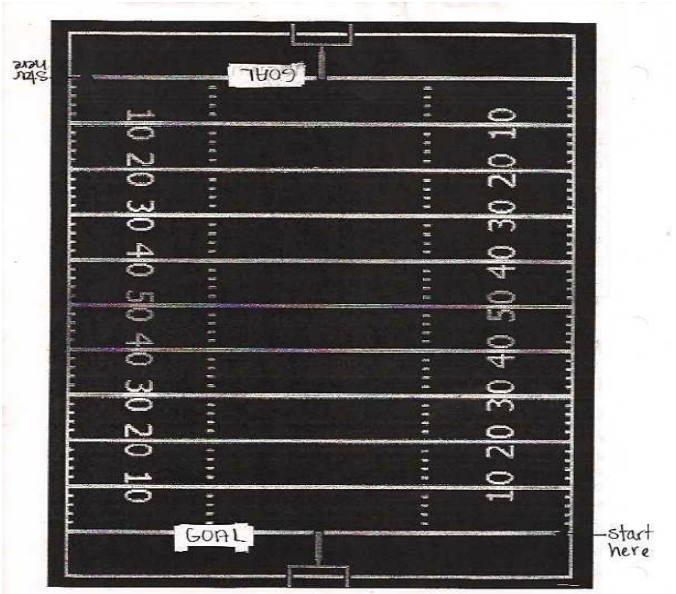
Grid 2

Appendix 13: Subtraction Football Game board and Football Field

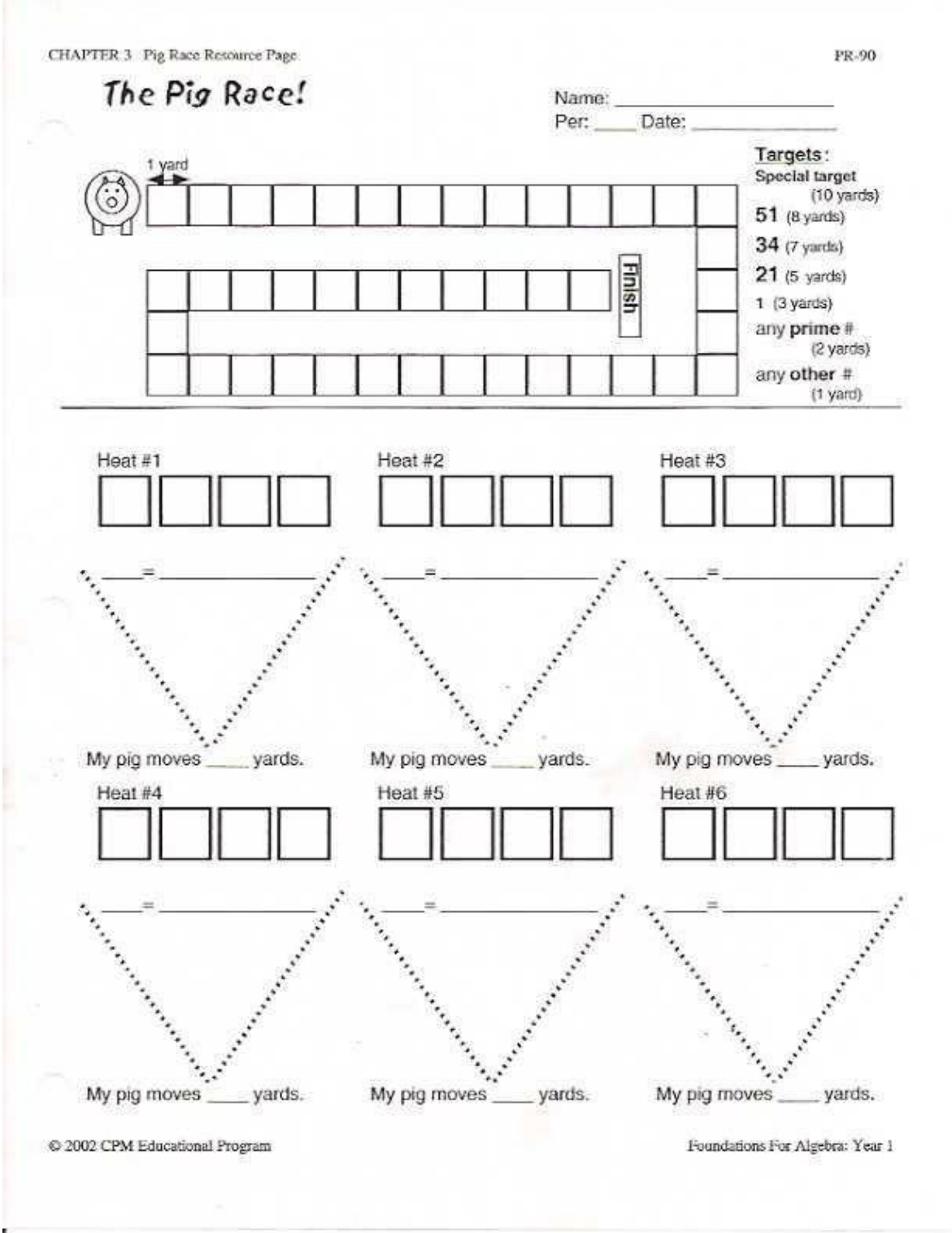
Subtraction Touchdown

Name _____
Partner _____
Date _____
Block _____

	Subtraction Equation	Solution: Picture/ Model using tile integers	Partner check ★	Student with largest difference
1.)				
2.)				
3.)				
4.)				
5.)				
6.)				
7.)				



Appendix 14: The Pig Race Game board



CHAPTER 3 Pig Race Resource Page PR-90

The Pig Race!

Name: _____
Per: ____ Date: _____

1 yard

Finish

Targets:
Special target (10 yards)
51 (8 yards)
34 (7 yards)
21 (5 yards)
1 (3 yards)
any prime # (2 yards)
any other # (1 yard)

Heat #1 ____ = _____ My pig moves ____ yards.

Heat #2 ____ = _____ My pig moves ____ yards.

Heat #3 ____ = _____ My pig moves ____ yards.

Heat #4 ____ = _____ My pig moves ____ yards.

Heat #5 ____ = _____ My pig moves ____ yards.

Heat #6 ____ = _____ My pig moves ____ yards.

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Appendix 15: Rock-Paper-Scissors Game board

Lesson 2.2.4B Resource Page

Rock-Paper-Scissors

A game for two people.

Mathematical Purpose: To practice adding integers.

Object: To have the most points at the end of five rounds.

Materials: Integer tiles, paper and pencil.

Scoring: The winner of each round takes plus tiles and the opponent takes minus tiles in the amounts shown in the table below.

Rock wins + + +	Rock loses – – –
Paper wins + +	Paper loses – –
Scissors win +	Scissors lose –

How to Play the Game:

- At the same time as your partner, shake your fist three times and then display either a closed fist for "rock," a flat hand for "paper," or a partly closed fist with two extended fingers for "scissors."
- Rock beats Scissors (because rock blunts scissors), Scissors beat Paper (because scissors cut paper), and Paper beats Rock (because paper can wrap up a rock). If you both show the same symbol, repeat the round.
- Record your points on a table like the one below.
- Play a total of ten rounds.

Round	(Your Name)	(Your Partner's Name)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Total		

Ending the Game: When you have completed ten rounds, the person highest total is the winner.

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Appendix 16: Family Math Game Night Invitation

Please Join Us For
Family Math Game Night!!!

WHO: ALL STUDENTS AND FAMILIES ARE WELCOME.

WHAT: COME AND PLAY MATH GAMES WITH YOUR CHILDREN. IT WILL BE FUN! THEY WILL SHOW YOU ALL THE FUN THINGS THEY HAVE BEEN EXPLORING IN MATH.

WHERE: ROOM 3 OR THE AUDITORIUM (TO BE DECIDED).

WHEN: THURSDAY, DECEMBER 10TH 5:00 TO 6:00PM

*****PLEASE FILL OUT THE FORM BELOW, CUT AND SEND BACK TO SCHOOL**

STUDENT'S NAME_____

PLEASE CHECK ONE.

YES, I WILL ATTEND _____ OR

NO, I CANNOT ATTEND _____

ABOUT HOW MANY FAMILY MEMBERS WILL BE ATTENDING IN TOTAL, *INCLUDING* STUDENTS? _____