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Christina J. Peterman
Stephen F. Austin State University, petermanchristy@gmail.com

Jim Ewing
Stephen F Austin State University, ewingjs@sfasu.edu

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Effects of Movement, Growth Mindset and Math Talks on Math Anxiety

Christy Peterman and Jim Ewing, Stephen F. Austin State University

Recently, the nation has focused tremendous attention on the need for our children to be prepared to take on the more challenging endeavors of a more technological world (Boaler, 2016). The skills of the future are steeped in having deep knowledge of the fields of Science, Technology, Engineering and Mathematics (STEM) (Boaler, 2016). One major problem our children are facing in this endeavor is the fact many of them, even at a very young age, are developing an intense anxiety when faced with mathematic situations (Clyatt, 2017). Research has uncovered several factors leading to the mathematic anxiety, such as environment, peer opinion, parental self-concept, and teacher influence (Arens, Marsh, Craven, Yeung, Randhawa & Hassselhorn, 2016). The effects connected to math anxiety are detrimental to a child's academic achievement and are far reaching (Arens, Marsh, Craven, Yeung, Randhawa & Hasselhorn, 2016).

According to Adding it Up (2001) there are five strands of learning mathematics effectively. These five strands consist of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. When students have deep understanding of how mathematics can build from one concept to the next, it enables them to reinforce what they have already learned and begin to form connections as they ask themselves questions of how a new concept may fit with a concept prior to the new. This enhances deep conceptual development. Having procedural fluency will help support conceptual understanding by students understanding which procedure to apply in which mathematical situation. When students have procedural fluency it also helps them develop strategies to solve real world mathematical problems and decide which mathematical tool to use in which situation. As students develop the tools and strategies, it allows them to better formulate, represent, and solve mathematical problems. It is also imperative students can form adaptive reasoning when working through real world mathematical situations. Students need to be able to visualize the situation and find mathematical relationships to find reasonable solutions to the problems they encounter. Finally, students will need a productive disposition which allows them to see value in mathematical concepts and how mathematics evolves over time and how, with steady effort, mathematics is useful in many daily circumstances.

All five strands must work and evolve together as a whole, although separate, entities. Using the five strands has the potential to greatly reduce poor mathematics performance, which plagues schools today. Teachers need to be aware of how to implement all five strands as a strategy for learning, especially if they have students struggling with math anxiety. If students have low productive dispositions (math self-concepts), it may affect their ability to make gains in mathematics. This is why focusing on the student's learning as a whole and using all five strands woven together is key to mathematical growth.

The fifth strand, productive disposition, is similar to math mindset. Children who have a fixed mindset about a subject, such as math, are developing a negative concept of self, which is difficult to overcome (Clyatt, 2017). When educators believe a child's, mindset is fixed and cannot grow, the child begins to believe it as well, which can happen in a relatively short amount of time (Boaler, 2016). There are many ways an educator can help a child change their mindset about mathematics, thereby alleviating the child's math anxiety, but first the educator must develop a growth mindset themselves (Boaler, 2016). When an educator believes in a child's potential, adds appropriate math materials to increase excitement and interest, along with creating a positive connection between math and the child's world the brain can be "rewired" to change their mindset (Boaler, 2016).

As an educator who has struggled with math anxiety and fixed mindset my entire life, I could identify with the students in my second-grade classroom who had already developed intense anxiety and fixed mindset regarding math. Math is an integral part of the world and students need to be able to find a way to develop the concepts needed to not only solve mathematical problems but be able to solve problems in fun and meaningful ways which speak to their learning styles. Children do not learn best by sitting and performing "drill and kill" concepts; rather, they need to be engaged in worthwhile activities requiring them to move and activate their brain more (Tate, 2009). Children also need to be exposed to the notion of growth mindset and the power they possess in developing their thinking to overcome math anxiety (Boaler, 2016). The following research focused on the effects of adding movement, growth mindset, and number talks into mathematic lessons on second graders mathematical mindsets when learning mathematical concepts. This research attempted to answer the question, what is the effect of implementing growth mindset activities, math talks, and mathematical movement on second grade student's mathematical anxiety? This research could be of value in reducing the overwhelming amount of mathematical anxiety which prevails in K-12 students. This anxiety hinders their ability to pursue technological professions and even avenues of higher education (Boaler, 2016). The combination of the three interventions showed a triple-threat in reducing mathematical anxiety, improving math self-concept, and empowering students for greater mathematical confidence. This strategy will ignite a brighter, more positive and successful future for students of all ages.

Literature Review: Math Anxiety

Math anxiety is a huge problem in our educational system and affects children and adults of all ages and genders. Math anxiety can lead to a low perception of self and can affect a child's future and their success in academics after high school. The research below will outline and define what math anxiety is and how it can affect a child's math self-concept. Finally, the paper will suggest methods in which teachers can help alleviate math anxiety in their classrooms and build a safe and nurturing environment for group math discussions and learning.

According to Hartwright et al. (2017), math anxiety is defined as negative emotional response when faced with mathematical situations. Math anxiety can impact anyone regardless of gender and can begin at a very early age (Hartwright et al., 2017). People who have math anxiety can struggle with academics which can be far reaching affecting several aspects of their lives (Hartwright et al., 2017). Our country is full of adults who struggle with math phobias and math anxiety, and it is affecting the future of the many STEM fields our country needs to thrive (Casad, Hale, & Wachs, 2015). The way mathematics is being taught must be explored and the teaching techniques need to be greatly improved because it is influencing our children's success in their academic endeavors (Casad, Hale, & Wachs, 2015). There have been studies on the way math anxiety looks when neuroimaging the brain, and it has shown how working memory and attention factors are affected (Hartwright et al., 2017). Those with math anxiety show varying levels of lower working memory capacity, reduced attentional control, inhibitory control, and deficit in low-level mathematical problems (Hartwright et al., 2017).

Boaler (2016) acknowledges the importance of students having a deep understanding of how numbers work, rather than students memorizing mathematical facts. Working memory is the portion of the brain responsible for memorizing math facts, and when anxiety and stress are applied the students working memory can become blocked. The students who do not have a deep knowledge of how numbers work may not perform well in high stakes mathematical situations. Boaler (2016) suggests rather than focusing on memorization, students should focus on developing strategies and having group discussions about real world problems where they are allowed to reason out a problem with no fear of making mistakes in front of their peers.

It is imperative children learn how to solve problems to function in their lives (Lai, Zhu, Chen, & Li, 2015). When students have math anxiety it greatly affects their ability to solve mathematical word problems (Lai, Zhu, Chen, & Li, 2015). Research has shown cognition (process of acquiring knowledge through mental actions) and metacognition (the awareness of one's own thought processes) develop together as the learner acquires new information and can be a great indication of a child's mathematic success (Lai, Zhu, Chen, & Li, 2015).

Math Self-Concept

Metacognition plays a key role in a child's mathematic success because it helps a child develop a self-image about how they feel they perform on mathematic concepts. Children who are taught to believe their intelligence is malleable are more likely to persevere when they make mistakes and have a better self-image (Hatcher, 2018). When a child's self-image is low it can affect the way they tackle more challenging math obstacles. Improving a child's math self-image can help them improve upon their problem-solving strategies and help them improve on their belief about their math solving abilities (Lai, Zhu, Chen, & Li, 2015). When a child can improve their metacognition in regard to math ability, it can help alleviate their math anxiety because they have better strategies and the higher belief in their ability will help them overcome greater obstacles (Lai, Zhu, Chen, & Li, 2015). Although there are other factors which can play a part of a student's math outcomes, like test anxiety and reading comprehension in processing word problems, a child's metacognitive self-image is a great indicator of mathematical success (Lai, Zhu, Chen, & Li, 2015).

A student's self-concept is one of the greatest indicators of their future academic success and it affects their determination when faced with problems and the effort they put into learning (Erdogan & Sengul, 2014). Self-concept is how people view and perceive their learning progress and the outcome of past events (Erdogan & Sengul, 2014). How people view their self-concept can greatly influence the view they have of what they will be able to achieve in the future (Erdogan & Sengul, 2014). Research shows people can have different self-concepts, such as their academic self-concept which consists of math and verbal (Erdogan & Sengul, 2014).

Self-concept is how a person thinks, feels, acts, and evaluates themselves in regard to mathematical concepts and skills (Erdogan & Sengul, 2014). Studies done by Erdogan & Sengul (2014) reported finding there is a decrease in math self-concept as children progress through grade levels, and they also found a significant difference in male and female outcomes, showing males having a higher mathematic self-concept over girls. There are many factors which can help improve a student's mathematical self-concept and it needs to begin early, such as a positive school environment, parental involvement, and cooperative learning groups (Erdogan & Sengul, 2014).

It is important to create a strong math self-concept in early years as well, as research has shown math self-concept begins even in pre-school (Arens et al., 2015). Math self-concept, as well as academic motivation, begins to develop in preschool, and it can differ from how we see school aged children (Arens et al., 2015). In school aged children there is more focus on the math and verbal academics, whereas in preschool it is more about allowing children to become more acquainted with motivating skills through playful and informal situations with other children (Arens et al., 2015). Schools should focus on building academic readiness in preschool children and nurturing their belief in their math and verbal skills (Arens et al., 2015).

Possible Causes of Math Anxiety

Math anxiety can be influenced by many personal factors such as parents, teachers and other peers (Casad, Hale, & Wachs, 2015). Parents who also suffer from math anxiety model poor mathematic behavior by the way their children see them react to mathematical situations (Casad, Hale, & Wachs, 2015). There is research showing how parents can affect their child's mathematical beliefs and behavior, especially mothers (Casad, Hale, & Wachs, 2015).

How much impact a parent has on their children depends heavily on the parents' beliefs in their own sets of mathematical skills. Other studies show how the role of parental views on growth mindset can also influence their child's perception of mathematics growth mindset (Hatcher, 2018). If they exhibit high math anxiety their children may also take on these same beliefs as their own (Casad, Hale, & Wachs, 2015). When a parent has a fixed mindset, it can result in their children exhibiting poor academic views verses a parent who displays a more advanced growth mindset (Hatcher, 2018). It is important for educators to communicate the importance of having a positive outlook on mathematical concepts to parents (Van, 2015). Van (2015) suggests one way of building strong mathematical support at home is having schools provide family math nights, where parents and children come to play engaging math games and enjoy math concepts together.

Often there is encouragement for parents to help their children with their homework because it builds a strong academic knowledge bond between parent and child (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). However, when it comes to parents who also have math anxiety, helping their children with math homework could have long lasting negative effects on the child's math anxiety or lead to the development of math anxiety (Maloney, et al., 201). When parents with math anxiety help their children, they are often faced with the inability to guide their children's mathematical thinking because they lack the foundational skills to explain the reasoning behind the concepts.

There is another underlying factor which may add to math anxiety, and that is gender bias. Despite some growth in gender gap closure, there is still an understanding among many which believes men to be superior to women in mathematical fields (Casad, Hale, & Wachs, 2015). When a female teacher displays math anxiety it has been shown to greatly affect the other female student in the class, though it does not seem to affect the males in the classroom (Casad, Hale, & Wachs, 2015). When a female student experiences their teacher's math anxiety it solidifies the gender stereotype that boys are better than girls at math (Casad, Hale, & Wachs, 2015). This type of formed understanding of their abilities is slow to change and overcome (Casad, Hale, & Wachs, 2015).

Another aspect to math anxiety could be based in the socio-economic status of students. Studies have shown children from wage earners verses salaried earners may have a lower self-image of their academic self, because it is not as highly valued in their social class (Parker et al., 2018). Some of these studies even suggest many working-class families do not place a high expectation on academic learning, and therefore, children may not have positive role model at home to aspire to (Parker et al., 2018). The authors also found working class children have less access to resources and opportunities which could build their prior knowledge and expertise; therefore they may not have high self-concept in regard to math or verbal (Parker et al., 2018). The above research suggests that working-class families do not value their children's education, but Gorski (2018) challenges this idea. He points out that many economically disadvantaged families often work multiple jobs to afford their cost of living, thus lacking time to spend valuable moments with their children helping with homework and reading to them. Another issue Gorski identifies is the children's families may not speak English. This language barrier may impact their literacy skills and ability to read to their emergent bilingual children.

It is important for all students to have a healthy belief in their academic abilities regardless of their family's income status or educational background. Evans and Schamberg (2009) state the longer a child is subjected to poverty, the higher the potential for the academic achievement gap to expand. Furthermore, this gap in achievement has the potential to impact a child's self-esteem and inhibit the child's working memory (Giofre, Borella, & Mammarella, 2017). Self-belief is key to predicting future outcomes of many aspects of a student's life (Parker et al., 2013). When looking at self-belief there are two aspects which are rarely considered together. Self-efficacy is one's belief in his ability to succeed in specific situations or tasks. Self-concept is the belief someone has about himself and the responses of others (Parker et al., 2013). When students have high self-efficacy, they believe they can accomplish a certain goal or task, and this is directly related to their academic self-concept (Parker et al.). Another key to a student's self-belief is the role social and relational aspects play into a student's self-concept (Parker et al., 2013). As mentioned above the social aspect played a significant role in the children of wage earners. Their social structures did not support them being high achievers in academics, so their self-efficacy would be greatly affected by this social aspect. School achievement plays a large role in the choice to continue education past high-school and can affect all areas of a student's future goals (Parker et al., 2013). Therefore, it is imperative teachers and education systems delve deeper into creating in children the understanding of the role their beliefs in their self-concept can play in their future (Parker et al., 2013).

Culturally Responsive Mathematical Pedagogy

Culturally responsive teaching requires teachers to understand children do not learn by sitting in a classroom for long amounts of time listening to a teacher drone on about what they are supposed to know with proper body alertness and eyes focused on the teacher (Gay, 2018). Teachers must ensure they are taking into account the individual child and attend to the ways they learn best (Gay, 2018). When a teacher can take the strangeness of a subject away and make the subject more familiar, the children will be more engaged (Gay, 2018). Gay (2018) also discusses the fact that if children believe they are capable of learning they will be able to learn more effectively--a major part of the growth-mindset movement. Tate (2009) notes that children need to move and be engaged in their own learning and involved in meaningful lessons, which will add to their first-hand experiences. Teachers are often caught up in the pressures of their students performing well on standardized tests, so their focus is on teaching the students basic and monotonous math facts and strategies and it becomes meaningless and boring to the students (Tate, 2009).

Another aspect to look at when discussing culturally responsive teaching is how culture affects the way children learn. William Tate addresses the issue of social aspect of learning math when looking at the African American community. Often when students show an interest in a subject, such as math, they can be made fun of or bullied by their peers (Tate, 1995). Tate (1995) also mentions how the way many teachers are teaching is foreign to many African American students. The teaching is often teacher directed, and then students are then made to work worksheet problems similar to the teacher's instruction independently. This is not familiar to students (Tate, 1995). Tate (1995) recommends a more project-based learning (PBL) approach to learning mathematics because the problems used in PBL can be more meaningful and hands on. PBL is a way of creating interest and engagement in students who typically would have no interest in subjects such as math or other STEM related fields (Capraro, Capraro, & Lewis, 2013).

Often, there is so much focus on teaching the strategies to the students; educators fail to see learning mathematics must also be a social in nature as well (Willey, 2013). When students can have discourse in mathematical language, it helps them become more comfortable in discussing mathematic concepts. This is beneficial for everyone and can be a key component for emergent bilinguals mathematical learning process (Willey, 2013). Ewing (2018) states that emergent bilinguals thrive in classroom settings where they are comfortable making mistakes and able to safely rehearse the mathematical language they are learning. Depending on their proficiency, emergent bilinguals should be able to answer questions and begin to defend their answers as they explain the thinking used to work through a mathematical problem (Ewing, 2018).

When children are not engaged in what they are learning it can often turn to misbehavior in the classroom, which distracts from learning (Tate, 2009). There are several ways Tate (2009) recommends teachers attempt to make learning more meaningful and productive for the students. Some strategies Tate (2009) mentions are manipulatives, labs and models, movement, music, project-based and problem-based instruction, role-play, games, and discussions. Tate's use of these strategies directly ties into Gardner's (2006) theory on multiple intelligences. Children learn in different ways and teachers need to take this into account when teaching all subjects (Gardner, 2006). Adding movement, music and discussion aspects to math lessons will help reach those children who learn in those ways. Gardner (2006) suggest teachers observe the way children relate to a content area to figure out what a child's working style is. This will give the teacher insight on how the child learns best (Gardner, 2006).

There are several ways in which teachers can increase the math self-concept and self-efficacy of their students by increasing their mindsets (Boaler, 2016). The first thing teachers need to know are the signs to look for in a child struggling with math (Picha, 2018). Some of the signs to look for are avoidance, lack of response, tears or anger, negative self-talk, and low achievement (Picha, 2018). Picha (2018) suggests helping build a child's math identity by giving them time to understand why math concepts work the way they do, and when asking mathematical questions, the teacher should allow for extra think time for the student to process the problem. She also mentions having group conversations about how negative self-talk can impact the student's work (Picha, 2018). Finally, she mentions using mixed ability groups to allow students different perspectives and access to different math abilities (Picha, 2018).

Boaler (2016) states how babies and young children love to do mathematics; they naturally find patterns, sort colored blocks, and notice many shapes within nature. However, when the children enter school their love of mathematics declines when they are shown boring methods of calculating numbers (Boaler, 2016). Teachers need to fight against the child developing a fixed mindset, which will lead to lower math self-concept. Rather they need to inspire flexibility by modeling and informing how mistakes help the brain get stronger and learn (Boaler, 2016). By creating a safe environment where children are taught, they can discuss and explore different mathematical thinking and strategies which will help them to develop a stronger sense of self-efficacy and they will find value in their math abilities (Boaler, 2016).

Teachers must also allow students the opportunity to develop their math skills by working on real life and rich mathematical tasks to give meaning to what they are learning (Boaler, 2016). Roth (2016) suggests providing activities which students can make and create the objects they will be using in a concrete way to learn mathematical concepts. When children can use real-life, everyday objects to manipulate and represent data it helps the mathematical concept become and absorb into their souls (Roth, 2016). Teachers need to enable students to have opportunities to construct and build ideas in a concrete way with objects which are familiar to them (Roth, 2016).

Discussion of mathematical related learning is also highly beneficial for students developing a deep understanding of the concepts being taught (Banes, 2017). When students can discuss and even write their strategies out on paper it will help them gain a greater comprehension of new mathematical skills (Banes, 2017). The process of writing their thinking out on paper has shown to greatly increase their ability to retain and explain the new concept to others (Banes, 2017). This form of writing to explain mathematical reasoning is new to most learners; however, it shows tremendous potential as a tool for helping students, especially emergent bilinguals, deepen their understanding of mathematics (Banes, 2017).

There has also been research into the concept of allowing peers to help other peers with low math self-concept with their math works (Cropp, 2017). When some students who may shut down at the mere mention of math are left to work on a certain concept, they may become frustrated and want to quit when math anxiety sets in (Cropp, 2017). There are studies done where students with math anxiety are paired with older peers who are not currently working on the same math concepts (Cropp, 2017). The idea was this would make the struggling student less nervous and both students would find value in the shared ideas and learning (Cropp, 2017). The peers are able to offer support, discussion of mathematical concepts and collaborations (Cropp, 2017).

When students can study math in a meaningful way and are able to feel safe, they will have more Aha! Moments, and when this happens it increases a student's self-concept (Clyatt, 2017). Along the same lines, teaching children to evaluate their abilities will help with student-initiated metacognition (Clyatt, 2017). When students can initiate their own meta-cognition, they become more motivated in their learning endeavors (Clyatt, 2017). Teachers need to help students' mindsets of math change by helping them see making mistakes is not an embarrassing thing, it is a way for their minds to grow (Clyatt, 2017). Children also need to understand math concepts and skills are not just something a person can do right away. It takes patience and persistence (Clyatt, 2017).

Instructional Strategies

Students need to be able to build experiences, as Roth (2016) mentions, with hands-on ways, but also through bodily movement and kinesthetic ways. Movement is so important to learning and as studies show, is tied to assisting the brain in remembering through muscle memory of the mind and body (De Freitas & Ferrara, 2014). The De Freitas & Ferrara study (2014) shows children acting out horizontal, vertical and diagonal lines with their hands, which is showing their ability to show mathematical concepts through mind and body movement. They have ingrained the line placement into their brains through their bodily movement showing the great mind and body connection (De Freitas & Ferrara, 2014). Tate (2009) also mentions the use of students' acting out the different line angles to further increase the muscle memory in the brain. As stated previously, when children have great math anxiety it can affect their ability to work through mathematical word problems as well (Lai, Zhu, Chen, & Li, 2015). Adding movement to a student's mathematical lesson through movement, story-telling, music, and drama helps children see the importance of mathematical concepts in other subjects as well. Mathematics through stories helps a child develop a better understanding of word problems by having the ability to work through the problems in a real-life situational way (Tate, 2009).

Movement and physical activity in the classroom are important for getting the blood pumping to the brain and have been shown to improve mood (Tate, 2009). Teachers can be reluctant to include movement in their classrooms for fear it may interfere with learning; however, the opposite is true. Movement built into academic lessons have been shown to increase the level of enjoyment and engagement in the lesson (Miller & Lindt, 2018). When movement is added to the classroom student and teacher's moods, excitement, engagement and overall experience with learning mathematical concepts improved as shown in studies by Miller and Lindt (2018).

A discouraging situation is happening to many students in schools with high poverty levels. Many of these schools have less experienced teachers, mostly due to lower salaries in economically disadvantaged school districts, who may not realize the importance of physical movement (Harrison & Clark, 2016). These teachers do not allow the time for proper physical movement and may not understand best practices for open play and movement which help fortify a student's academic abilities (Harrison &

Clark, 2016). Students living in these communities usually do not have time to play or move outside of school to and frequently lead more sedentary lives compared to more affluent communities (Milteer, Ginsburg, & Mulligan, 2011). Students in poverty do not have access to safe playgrounds, and multi-job families do not have the luxury of taking time to play and have movement time with their children (Milteer, Ginsburg, & Mulligan, 2011). The lack of culturally diverse and knowledgeable teachers greatly hinders proper physical movement for these students of poverty (Harrison & Clark, 2016).

Movement also improves students spatial thinking and reasoning, which is the base for mathematical understanding. Incorporating movement with math concepts opens the classroom up for more math discussions about students' understanding of their bodies' place in space, which will help with spatial reasoning (Rosenfeld, 2017). Incorporating math movements and dance to develop math reasoning ability will also help children gain rhythmic understanding which ties into patterns of numbers and number reasoning (Rosenfeld, 2017). Movement and dance in the classroom can also begin to integrate other subjects such as language, literacy, and science. It allows the child to make meaningful connections of math to other areas of real-life (Kaufmann & Dehline, 2014).

Children are born to move and explore their world, as Miller and Lindt (2018) discuss, and when teachers add movement to the classroom it helps increase enjoyment and excitement about what they are learning and plays into their natural need for movement (Kaufmann & Dehline, 2014). Research shows over 85 percent of young learners are considered kinesthetic learners, meaning children need to move and learn by doing (Kaugmann & Dehline, 2014) In adding movement to math and increasing the amount of enjoyment using meaningful activities should decrease the level of math anxiety and fear children have developed. When dance and movement are added to a child's mathematical lessons it has shown to increase their social-emotional well-being as well as improving their ability to process new vocabulary related to math skills (Anderson, 2015).

Montessori (1995) also expressed the key importance for movement in a child's general development. The need for movement has been vastly misunderstood and completely neglected, only to be implemented at times of recess (Montessori, 1995). Montessori (1995) explains there are main components to movement and they involve the brain, nervous system, senses, and muscles. She reasons for the relationship to develop properly between these facets are children need to experience proper amounts of movement in their day, not just during a focused "recess" period. Montessori (YEAR) disagrees with the vegetative state of students in the classroom, sitting all day long without the ability to move and develop their muscle memory, brain, and nervous system relationship with the environment around them (Montessori, 1995). Montessori (1995) discusses how intellectual and mental development hinges on the ability for the body to move and experience the world around them.

The inclusion of math talks during instruction have become more popular due to the discovery of how it allows children to use their metacognitive skills and schema to develop mathematical strategies to discuss, work through, and solve more complex mathematical problems (Parish, 2014). Children need to experience the discussion portion of math concepts and hear the mathematical terms used (Susperreguy & Davis-Kean, 2016). The earlier a child can begin to hear and discuss mathematical concepts, especially early learning taking place in the home, the better the mathematical success and achievement in the future (Susperreguy & Davis-Kean, 2016). Implementation of math talks can help facilitate the ability of deeper knowledge development, as well as increase their ability to articulate their mathematical thinking to others (Murata, Siker, Kang, Baldinger, Kim, Scott, & Lanouette, 2017). Teachers must understand and be aware, however, that math talks must account for the diversity of the classroom and cannot be scripted completely (Murata, et al., 2017). Teachers have to be able to maintain flexibility and guide the math talks where their children lead them (Murata, et al., 2017).

When teaching in a diverse and multicultural classroom it is important to incorporate real-world problems in meaningful ways. Studies show adding literature with multicultural stories will help children make connections to mathematics through their cultural background (Leonard, Moore, & Brooks, 2013). There are many mathematically rich texts which are also culturally diverse to choose from and using these texts will help all children connect with the vivid pictures which are painted about mathematics (Leonard, Moore, & Brooks, 2013). Having the ability to create a mathematical picture in a student's mind is crucial for all children but can be particularly important for students who are learning a new language (Leonard, Moore, & Brooks, 2013). When students can make connections to mathematics on a cultural level it helps them improve and be proud of their cultural identity and mathematical abilities as well (Leonard, Moore, & Brooks, 2013). When using math talks it will be essential for teachers to keep in mind the diversity in their classroom and apply culturally relevant and meaningful word problems and discussion to their classroom.

Additionally, it is important that children understand the way their brain works and how their metacognition plays a part in that. This will help children adjust their thinking to have more positive outlooks on their math skills (Brock & Hundley, 2016). When children have a fixed mindset, it impairs their thinking to believe they cannot change their intelligence level (Brock & Hundley, 2016). They feel lost and hopeless; however, when they are taught, they do have power over their learning abilities and they can discover strategies to grow their brain it allows them to boost their confidence and take on new concepts more easily (Brock & Hundley, 2017). Teachers can have a huge impact on their students by implementing more activities which allow children to learn how to think about their thinking or metacognition (Brock & Hundley, 2017).

Students who have a deep understanding of growth mindset and how their thinking impacts their learning, will have a greater capability to strive and grow to their full potential in a world which requires more self-motivation, determination and self-regulated skillsets (Ng, 2018). Students need to develop the correct mindset for intrinsic motivation and to not be discouraged if they meet a road block (Ng, 2018). A key part of growth mindset is students learning what they can do if they come across a frustrating obstacle. They need to expand in their understanding of how to think in a more metacognitive way about the problems which arise (Ng, 2018). When students begin to understand their thinking, they will have a greater ability to reflect on the process and plan a new and innovative way to accomplish a goal (Ng, 2018).

Studies have shown when students do not develop a growth mindset, especially in mathematics, it can lead to lack of success in college and higher learning (Hoang, 2018). Students who do not have a high self-efficacy are less likely to succeed than those who have high self-esteem and outlook on their abilities (Hoang, 2018). The behavior of students with low self-efficacy exhibit shows they do not attempt to take on challenging tasks and will avoid difficult learning situations (Hoang, 2018). Many students who have fixed mindsets have been shown to see themselves as lacking intelligence, and they do not thrive in academic settings because of their low self-efficacy (Yeager & Dweck, 2012). It is important to establish a deep understanding of growth mindset early in childhood to help ensure the success in the future. (Yeager & Dweck, 2012).

Method

The purpose of this study was to discover if the integration of growth mindset, math talks, and movement during math lessons would help alleviate children's math anxiety. This study attempted to show how these three strategies used together would help bolster and increase children's interest and motivation about learning math. This study used mixed methods to measure the effectiveness of these interventions. Using the mixture of qualitative and quantitative data collection showed a more well-rounded picture of how the interventions were working. While the Math I-station reports and individual math self-concept surveys provided formalized data, the anecdotal notes and observations from teachers participating in the dependent group classrooms provided a clearer picture of how the students were feeling about the interventions.

Population and Sample

The population studied in this research consisted of five second grade classrooms in an elementary school located in rural Texas. This school was considered low socio-economic status with over half the population receiving free or reduced lunches.

Classroom A

Gender	White/European American	Black/African American	Latinx/Chicanx/Hispanic American	Native Americans	Asian Americans/Native Pacific Islander	Two or more races	Low Socio-Economic Status
Male	9	0	0	0	1	2	6
Female	6	0	0	0	0	1	4
Total	15	0	0	0	1	3	10

Classroom B

Gender	White/European American	Black/African American	Latinx/Chicanx/Hispanic American	Native Americans	Asian Americans/Native Pacific Islander	Two or more races	Low Socio-Economic Status
Male	8	0	1	0	0	2	2
Female	7	0	0	0	0	1	4
Total	15	0	0	0	0	3	6

Classroom C

Gender	White/European American	Black/African American	Latinx/Chicanx/Hispanic American	Native Americans	Asian Americans/Native Pacific Islander	Two or more races	Low Socio-Economic Status
Male	11	0	0	0	0	2	5
Female	5	0	0	0	0	1	1
Total	16	0	0	0	0	3	6

Classroom D

Gender	White/European American	Black/African American	Latinx/Chicanx/Hispanic American	Native Americans	Asian Americans/Native Pacific Islander	Two or more races	Low Socio-Economic Status
Male	5	0	0	0	1	2	2
Female	9	0	0	0	0	1	4
Total	14	0	0	0	1	3	10

Classroom E

Gender	White/European American	Black/African American	Latinx/Chicanx/Hispanic American	Native Americans	Asian Americans/Native Pacific Islander	Two or more races	Low Socio-Economic Status
Male	10	0	0	0	0	1	4
Female	8	0	0	0	0	0	6
Total	18	0	0	0	0	1	10

The participants in this study were second graders located in a small rural Title I school where over half of the students were considered economically disadvantaged and received free or reduced lunch. The second-grade class consisted of 96 students, which has 54 males and 42 females. The school was composed of students representing the following race/ethnicities: 84.4% white/European American, 0% Black/African American, 2.05% Latinx/Chicanx/Hispanic American, 0% Native American, 2.05% Asian Americans/Native Pacific Islander, 11.5% two or more races. The column titled Socio-Economic Status (SES) refers to the number of low SES students in each classroom.

In this study classrooms A-C used the interventions and classrooms D and E were used as a control in the study and did not participate in the interventions. All five classroom layouts were identical and only differ by each teacher's decoration preferences. Four of the five classrooms were set up with desks in groups of four or five for collaborative work between students, the fifth classroom had the desks set up in horseshoe form. All rooms contained large white boards, smart boards and two laptops per room. All classrooms contained cubbies for each student and enough room in the front of each room for circle time together.

Data Collection Strategies/Instruments

As mentioned previously, this study used a mixed method data collection. The researcher collected pre-intervention I-station math data, which was collected monthly, and compared it to post I-station data when interventions were complete. The students completed math I-station data once a month with the computer teacher in the computer lab. The students then completed a math self-concept Likert-scale survey to gauge their thinking on their math self-concept prior to the interventions and then again after the interventions. The data was collected on all students in the second grade; however, interventions will only be done with classrooms A-C, with classrooms D and E as the control group. Pre-tests and post-tests were compared to show the results and effectiveness of the interventions.

Throughout the interventions the participating classrooms collected anecdotal notes and recorded any observations they found notable during the five weeks of interventions. The concurrent triangulation strategy was applied to all pre and post quantitative data as well as the qualitative data of anecdotal notes and observations throughout the study.

Procedure

The following interventions were implemented to help alleviate the math anxiety seen in the students. The teachers in the participating classrooms provided three days of interventions a week. Mondays consisted of mathematical growth mindset group discussions and journal time. Students thought deeply about the thinking they had about math and then journaled their thoughts over the span of four weeks. After the journal they had discussions about their journal entries and had a safe and open dialogue about their journal entries. On Tuesdays the students participated in math talks where they were taught in-depth mathematical strategies and learned to have mathematical discussions about their strategic thinking. The students learned how to appreciate their mistakes while working through mathematical concepts and learned to encourage each other in their mistakes. Wednesdays the classroom participated in some form of mathematical movement. The teacher guided the students in movement, which correlated to whatever math concept being taught. The movement included song, dance, or whole-body movement. These interventions lasted for five weeks in the participating classrooms. The control classrooms did not participate in any of the interventions mentioned above but provided all I-station data and pre and post intervention surveys which were compared to the participating classrooms data. The control group classroom teachers were not required to provide any anecdotal notes or observations.

Results

Several students in second grade classrooms displayed anxious behavior or made fixed-mindset comments when working on math concepts. Most of the math lessons given in the second-grade classrooms consisted of direct teaching of a new concept each week and then independent worksheet time and small group pullouts. Often there was little movement or collaborative discussion between teacher and students during instruction. Many students made statements of how they were unable to learn math, how they could not do math or made blanket statements of how they were bad at math.

After interventions of movement, mathematical growth mindset discussion and journaling and number talks were performed for four weeks a post-test mathematical self-concept survey was completed. The following results were based on a five-point Likert Scale of a Math Self-Concept survey. The survey was given as a Pre-Test before interventions and a Post-Test after interventions were complete. The survey was given to all five second grade classes. Classrooms A and B had 19 students consistently for both pre and post-tests. Classroom C had 17 students for the pre-test and 19 students for the post-test. Classroom D had 18 students consistently. Classroom E had 18 students for the pre-test and 20 students for the post-test. Classrooms A-C were participating in the interventions and classrooms D and E were used as a control group and did not participate in the interventions.

There were also observation notes taken in the three intervention classrooms by the three teachers. The teachers all noted how responsive the students were to having growth mindset discussions as a class. The students would at times make comments about how they sometimes struggle with a concept, but when they have a plan and strategies to help them, it makes it easier. The students also reflected in their growth mindset journals about the growth mindset vocabulary they learned each week. They drew pictures and discussed as partners about what the vocabulary meant to them.

The teachers noted how positive the discussions were and how the conversations they heard were not just limited to the math block. They heard the students encouraging each other with the vocabulary words in all areas of learning. Teachers also provided positive stories of discussions with their student's parents about the growth mindset vocabulary being used at home during math homework. The students were observed becoming more comfortable sharing math ideas during math talks and helping each other when they finally caught on to a math concept, which reinforces the concept in their brain (Cropp, 2017).

Table 1. Math Self-Concept Survey Questions

Questions
1. Math is my favorite subject.
2. I like working in groups on math activities.
3. I have someone at home who helps me with my math homework.
4. I feel more comfortable using math manipulatives to solve problems.
5. It bothers me when I make mistakes on math problems.
6. I am not good at math and there is nothing I can do about it.
7. I like when my teacher calls on me to work math questions.
8. I like to play math games.
9. I am good at math.
10. I enjoy learning new math strategies.
11. How many answers I get correct on a math test tells me my math ability.
12. Explaining math ideas and concepts to others, helps me to understand it better.
13. I enjoy sharing my math strategies with my peers.
14. Drawing pictures helps me understand math better.
15. You have the power to change how intelligent you are.

The survey questions can be grouped together and broken down into three main categories. Questions one, five, six, nine, 11 and 15 were grouped together to score and are questions, which provide insight to the math self-concept of the students. Questions two, four, eight, 10 and 14 deals with the student's comfort level using math strategies. Questions seven, 12, and 13 shows how students felt sharing mathematical concepts and strategies with and in front of their peers. Question three was used to show a possible connection to parental involvement and students math self-concept, but there was not enough data to make any connections to the overall mathematical anxiety of students in this study but gives insight to possible research on the impact of parental involvement and children's mathematical anxiety in the future. It is important to mention questions 5, 6 and 11 were worded in such a way that to have a negative response would have been positive. So, for the sake of organizing the data in a more viewable way the answers to these three questions were inverted to make the negative response a positive one.

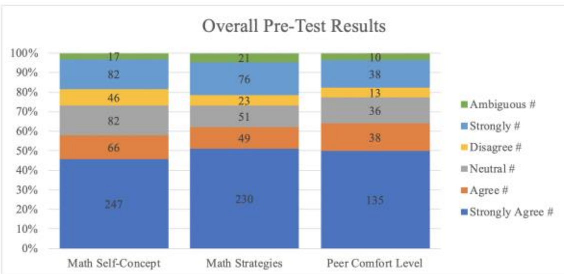

Figure 1. Overall Pre-Test Results

The results from figure 1 show the overall pre-test results for all second grade classrooms with 100% reporting. In the category of math self-concept there were a total of 313 positive responses to the math self-concept questions, a total of 279 positive reactions to math strategies, and a total of 173 positive reactions of showing their comfort level working with math concepts in front of peers.

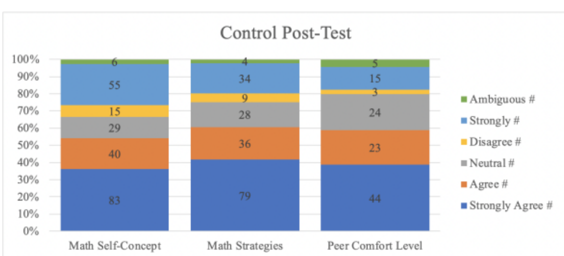

Figure 2. Control Post Test

Figure 2 shows the control post-test and breaks it down into all three catagories. In the category of math self-concept there were 123 positive reactions to the questions in that category. In math strategies there were a total of 115 positive reactions. For the category of the students peer comfort level sharing math concepts there were 67 positive answers.

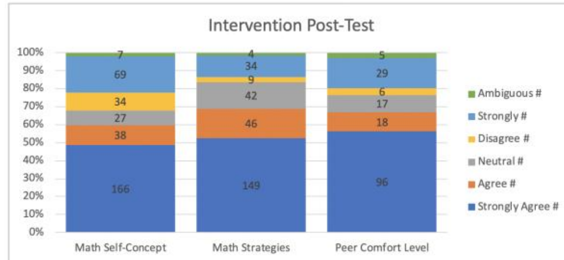

Figure 3. Intervention Post-Test

Figure 3 shows the intervention responses to the different catagories. In the category of math self-concept there were a total of 204 postive results. The category of math strategies shows a total of 195 postive responses. Comfort sharing math concepts with peers showed a total of 114 positive responses.

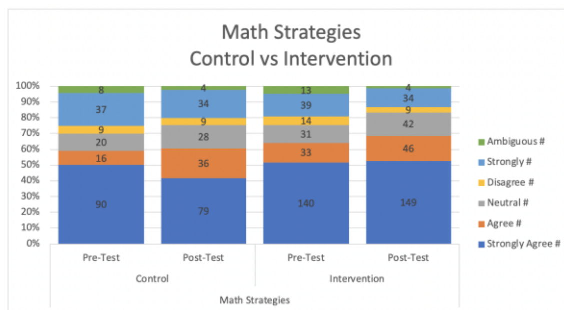

Figure 4. Math Stategies Control vesus Intervention

When comparing the control results versus the intervention pre and post tests results in the category of math strategies you can see in the control group the positive results went from 106 to 115, but the stongly agree went down by 11 positive responses. The intervention group went from 173 positive responses to 195, with 9 responses higher in strongly agree. For the post test the intervention group showed a diffence of 80 postive responses higher than the control group for math strategies.

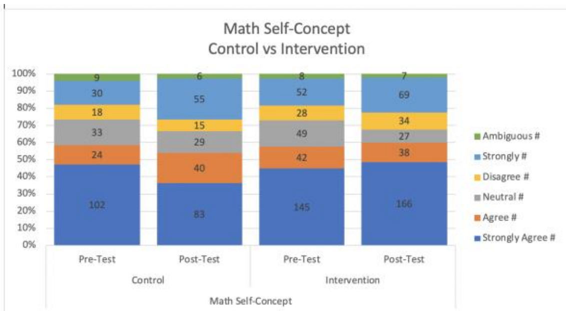

Figure 5. Math Self-Concept Control versus Intervention

Figure 5 shows the results and comparison of the control versus the intervention group in the math self-concept category. The control group went from 126 positive responses to 123 which shows a 3-response negative difference. The intervention group went from 187 positive responses to 204 positive responses, which shows a gain of 17 positive responses. There was a gain of 21 strongly agree responses for the intervention group. When comparing the control group to the intervention group there were 81 more positive results for the intervention group than the control group.

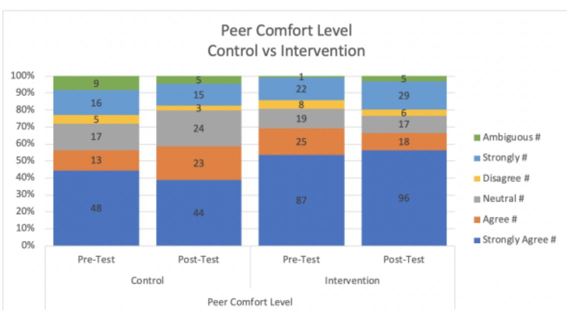

Figure 6. Peer Comfort Level Control versus Intervention

Figure 6 shows the students' comfort level when sharing math ideas and concepts with their peers. The control group starts out with 61 positive responses to peer comfort level questions for the pre-test and 67 positive responses for the post-test. The intervention group shows 112 positive responses on the pre-test and 114 positive responses in the post test. When comparing the control group to the intervention group the intervention group showed 47 positive responses higher than the control group.

The ISTATION math test reports, which were taken monthly, did not show enough information to provide any clear results for this study. When the chart is shown as a whole it shows all of the second grade together but does not allow the researcher to group the intervention group and the control group. The report does break down individual student results, however this study was done anonymously and did not focus on individual students. If this study was replicated in the future, ISTATION would be best used if students were kept track of individually. Another possibility would be to have students take the math self-concept survey and based on individually recorded answers, those who struggle with math anxiety could be followed and tracked more closely using tools such as ISTATION.

The students were observed becoming more comfortable sharing math ideas during math talks and helping each other when they finally caught on to a math concept, which reinforces the concept in their brain (Cropp, 2017). Students also had positive reactions to the math movements they were participating in. In one classroom the teacher noted how they voted to make Mondays math movement days for the rest of the year. The students enjoyed using new mathematical vocabulary while learning their math movements described in the methods section. Adding movement to the mathematical vocabulary has helped it become a part of their bodies as well (Rosenfeld, 2017). Teachers also took note of the level of enjoyment the students felt while participating in the mathematical movements, they heard many children make declarations of how much fun math was, which can help reduce the amount of math anxiety students feel (Kaufmann & Dehline, 2014).

Discussion

The focus of this study was to find out what the effect of implementing growth mindset activities, math talks and mathematical movement on second grade students' mathematical anxiety would be. Overall, the interventions implemented in this study appeared to have a positive effect on the students who received the interventions. According to the data the intervention groups saw a greater amount of positive responses to the three main categories explored in this study. We may have seen a greater divide in the intervention group in comparison to the control group if the study would have been longer than four weeks. I have personally seen a greater positive reaction to students in my classroom over the past four weeks, especially when they struggled productively. Before the interventions they tended to be shy and embarrassed to come up the board and answer problems in front of the class. After interventions, I have experienced more students volunteer to solve problems and if they get stuck while ask their peers to raise their hand and help them. The students in these classes were able to gain confidence in their abilities and comfort level while involved in math talks. While this comfort level is good for all learners, it is particularly important for emergent bilinguals (Ewing, Gresham, & Dickey, 2019). The students felt safe answering questions and discussing the math problems, they also became very encouraging for students who were shy in their explanations. Willey (2013) found language usage to be crucial to an emergent bilingual, which is another aspect of the math talks which is beneficial to emergent bilinguals because it gives them more opportunity to practice their developing language. While this study did not have many emergent bilinguals, more research is needed to see how math talks affect language development and confidence using language in front of peers.

Although the study was geared toward lessening math anxiety in second grade students in general, I began to observe an improvement in my economically disadvantaged (ED) students as the lessons went on. I noticed a change in their attitudes and self-concept when we would begin our math time. I found several of my students, especially my ED students, coming into the classroom in the morning asking if we would be doing math movement or math talks that day, even though they knew math would not be until after lunch. As time went on, I saw my ED students more excited to explain their strategies while doing math talks. They were also able to correct and discuss mistakes they would see others make or mistakes they themselves made. It was promising to see. Likewise, while they were working independently, they were able to work through tougher questions and if they were stuck and asked for help, they were able to verbalize their misconceptions to me. I could hear and see the way their brain processed the problems in front of them.

The way this study was designed was to be anonymous. I did not require the students to record their name on their survey. Perhaps I would have been able to see more specific results and tie them to the ED students we would have been able to see if the strategies used were beneficial to ED students. More research is needed to determine if the strategy of using math talks with ED students has the potential to increase their working memory. Boaler (2016) has already determined math talks can help increase working memory; however, further research on how math talks can specifically impact the working memory of economically disadvantaged students to improve their mathematical understanding. Not only would math talks possibly have the ability to strengthen ED students' mathematical skills, but it would also influence the students' academic self-esteem (Giofre, Borella, & Mammarella, 2017).

Knowledge Gained from Key Aspects of Survey

When looking at the three key aspects the math self-concept survey measured, we see how the interventions used appeared to help lower their overall math anxiety and improve their math self-concept. The first concept to look at is the math self-concept. According to the data the intervention group had a lead over the control group by 81 positive responses. This is important because having a healthy math self-concept will help the students learn they have the power to change their intelligence and grow in their ability to learn mathematical concepts (Hatcher, 2018). It is also important for students to have a positive math self-concept because if they do not it can affect them in other areas, especially STEM subjects which may also rely heavily on math ability (Erdogan & Sengul, 2014). When students believe they are not good at math it can discourage them from trying new experiences and even hinder them from attempting college, because of assured math classes (Casad, Hale, & Wachs, 2015). The intervention which had the most positive improvement appears to be the growth mind-set talks and discussions which the students participated in. When students have open minds, they can learn strategies to help them overcome obstacles or challenges in their lives (Brock & Hundley, 2016). Students who do not have these strategies are said to have a fixed mindset, which can decrease their ability to increase their knowledge (Brock & Hundley, 2016). By providing the opportunities for students to discuss their struggles and then discuss ways they can take control and develop a way to improve their math misunderstandings by learning growth mindset vocabulary, it will help them learn there is always a way to improve their understanding of any challenge which may come about.

The second measure the math self-concept looked into was the student's perspective on learning math strategies. This ties into the math self-concept, because when students are faced with challenges in math, they will be able to have tools and strategies to help them overcome. Students learn to build their knowledge of mathematical concepts by learning new ways to view a math problem (Parish, 2014). The intervention which helped students develop this key concept was the number talks. Students were able to use their schema and knowledge of different strategies and mathematical vocabulary to solve problems presented during the number talks (Murata, Siker, Kang, Baldinger, Kim, Scott, & Lanouette, 2017). This use of mathematical language is why more math talks should be done with emergent bilinguals. Likewise, math talks show to be a great way to improve working memory in economically disadvantaged students by allowing them to be comfortable enough to allow the information to enter from working memory to a more long-term knowledge base (Evans & Schamberg, 2009). Stress greatly impacts working memory, so by reducing the stress of learning math it greatly improves the ability to retain the concepts (Evans & Schamberg). By doing math talks students learn there is more than one way to work or solve a problem and they may all choose to work a problem in a different way based on how they personally view the problem (Susperreguy & Davis-Kean, 2016). The more they can find comfort with these strategies the better the mathematical concept will become permanent in their brain. Based on the data shown above the students in the intervention group scored more positively than the control group by 80 positive responses.

The final key category to help improve math self-concept is the comfort level of students sharing and discussing their math strategies in front of their peers. This is important for improving math self-concept because how students feel they are viewed by peers greatly affects the way they see themselves (Arens et al., 2015). There were two interventions which worked together to help improve the perception the students had on sharing math ideas in front of their peers. First, as discussed above would have been the math talks. Second was the mathematical movement we used. When doing the math movement, the students were able to discuss strategies and use new math vocabulary with each other in small groups in pairs while participating in fun and enjoyable movements (Tate, 2009). This gave them the opportunity to practice the concepts they were learning in non-threatening or high-pressure testing situations (Clyatt, 2017). The movement was also providing them with better blood flow to the brain and creating muscle memory connections from the movement to the concept (De Freitas & Ferrara, 2014).

Impact on K-12 Learning

This research has the potential to impact K-12 classrooms by providing a more enjoyable math environment where they are taught strategies to help them understand their thinking when dealing with math concepts which they struggle with (Miller & Lindt, 2018). Reducing math anxiety will also help students develop their working memory, which will further them further in all areas of study (Casad, Hale, & Wachs, 2015). I recommend more research to examine if there is a correlation between math talks, working memory and economically disadvantaged students. This study will also affect the way students learn to solve problems, which is a key mathematical concept. If they do not become comfortable with their cognition and metacognition abilities it will greatly increase their future success (Lai, Zhu, Chen, & Li, 2015). This study introduced three different ways to increase the enjoyment of learning math which, based on the observational notes and the data provided previously, will have a great impact on students' growth in their math skills.

Impact on K-12 Teaching

The impact this study has on teaching in grades K-12 is in the awareness of how teachers can build and provide a foundation for strong minds which fully understand how important it is to have an open and flexible mind while learning (Boaler, 2016). This study provided several strategies to try if a classroom or students are struggling with math and the signs to look for when students may be dealing with mathematical anxiety (Picha, 2018). This study also helps to further show how students do not learn by sitting in a desk: if a teacher will add movement and number talks and discussion into their math classes it will help students become more engaged and take more personal ownership over their learning (Tate, 1995). When teachers provide opportunities to teach students how their mind operates and what the brain does when it becomes fixed compared to when it is open to mistakes, it will help them have a deeper comprehension for how learning takes place and how without mistakes the brain does not grow and mature (Ng, 2018).

Limitations

Some limitations to this study were in the survey itself. I noticed when scoring the responses several students had eraser marks and it looked as if they may have been confused as to how to answer the questions, which is why there may have been so many ambiguous answers to some of the questions. To solve this problem in the future I would use a scantron or possibly a computer-generated survey they could use a computer to answer questions on. This would also be a time saver and ensure less possibility of confusion when scoring. This would also solve the problem of more than one answer being chosen per question.

Another limitation to this study was the time constraint. I believe to see more realistic results the interventions should have taken place and measured over a longer time. Four weeks may not have been enough time to see the true effects of the interventions. I plan on continuing the interventions used in this study until the end of the year, but results will not be provided in this study.

Reflection

I have learned much through this action research and have seen the impact it has made on the children in my class and heard what the other teachers have expressed through their observations. I am encouraged to continue these interventions through to the end of the year. I plan on giving the students the math self-concept survey at the end of the year and compare to the findings provided in this paper. I also plan on sharing this paper with my administrators and encouraging my second-grade team to continue or start adding these interventions to their own classrooms. I have plans on presenting my research to parents as well as other colleagues in upcoming open houses and training meetings.

Future Plans

Future research on the impact parents have on student's math anxiety and math self-concept would be a natural step to make to build on the research provided in this study. After sending home the consent forms to parents for participation in this study, I have had several parents asking for more information on this topic. I have had inquiries about a parent's own math anxiety, as well as questioning how to help their children at home. Further research on this topic is important to help not just students in the classroom but allow students to have advocates at home to help them overcome possible math anxiety.

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Appendix A

Math Self-Concept Survey

Question	Strongly Agree	Agree	Neutral	Disagree	Disagree Strongly
Math is my favorite subject.					
I like working in groups on math activities.					
I have someone at home who helps me with my math homework.					
I feel more comfortable using math manipulatives to solve problems.					
It bothers me when I make mistakes on math problems.					
I am not good at math and there is nothing I can do to change that.					
I like when my teacher calls on me to work math questions.					
I like to play math games.					
I am good at math.					
I enjoy learning new math strategies.					

How many answers I get correct on a math test tells my math ability.					
Explaining math ideas and concepts to others, helps me understand better.					
I enjoy sharing my math strategies with my peers.					
Drawing pictures helps me understand math better.					
You have the power to change how intelligent you are.					