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Propensities by Grade of Math Anxiety Levels K-12: Addressing Mathematics Dispositions and How Manipulatives May Help

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Abstract

Math anxiety remains a critical issue affecting student performance and confidence across grade levels throughout the world today. This paper looks at the impact of math anxiety and how students' dispositions toward math from a leadership perspective and the real hinderance for them as learners in life in a STEM world. The paper shares data from a K-12 school on math anxiety levels and offers insights from a school principal who has served K-12 levels where math anxiety and discomfort levels of math are seen across the spectrum. This paper provides much research and recommendations of best practices for teaching math, leadership responsibility, and the use of math manipulatives to address the reality of math anxiety as we prepare our young people to compete for jobs in a STEM world. Research, best practices for teaching, strategies, and a survey are included.

Keywords: Math Anxiety, K-12, STEM, Propensities, Math Manipulatives, Leadership, Best Practices

Introduction

> *"I could tell the look of fear; it's the reason I gravitated toward her. I bent down next to the 7th grader's desk and asked if she needed help, and we spent the next few minutes converting fractions to decimals, aligning the decimals, and then using subtraction to answer the final question of the math problem. As the principal of an elementary school, math teacher, and previous high school principal, I have watched students struggle with (and master) topics from simple addition and subtraction to unit vectors, the Converse of the Pythagorean Theorem, factorials, and differential equations. That look of fear happens in the 1st grade classroom as well as the 9th grade classroom, and beyond, but it is the sudden expression of understanding on the student's face, or the passing grade on the AP exam, or just the confidence to explain a math problem in front of peers that keep us coming back again and again to the classrooms, offices, and labs".*
>
> -Dr. Christine Higgins

The differences between a 1st grade math classroom and a 9th grade math classroom are, of course, varied, and complex, especially as students move through the three stages of understanding – concrete, representational, and abstract. The focus of Jean Piaget's research started with the younger student's exposure to the concrete and math manipulatives, followed by the representational stage and finally the abstract stage. There must be a strong math foundation in the early years; students need to be able to make sense of their mathematics and see the relevance of math in their daily lives.

This paper will look at the importance of examining math anxiety levels of students K-12 and using math manipulatives and the research surrounding the use of manipulatives in the classroom; the importance and research behind effective teachers and classroom practices that lead to success, and the role of administrators in the implementation of learning communities, peer observations, and teacher leadership to affect the day-to-day practices of teaching mathematics. This paper will address the following questions: How do classroom teachers ensure that students have a strong foundation that will give them success at the next level? What are some of the best practices that teachers are using? What improvements can administrators suggest to teachers to make learning math more effective? Horne (2022) contends that the school leadership needs to play a critical role in the disruption of math anxiety in the classroom.

Best practices for teaching mathematics require teachers to be active. Looking at prior knowledge, transfer of learning, and making connections beyond the classroom into the real world are critical. We need to focus today on teaching for understanding and employing higher-order thinking. Segiovanni (2007) reminds us that administrators, whether elementary or high school level, are responsible for the "collective intelligence of their schools" (pg. 291). Also stating, "The greatest enemy of understanding is coverage. As long as you are determined to cover everything, you actually ensure that most kids are not going to understand. You've got to take enough time to get kids deeply involved in something so they can think about it in lots of different ways and apply it – not just at school but at home and on the street and so on" (p.257). Principals and teachers must develop a system of supervision that is built on shared leadership, a commitment to learning, and a focus on teachers' everyday practices.

Negative attitudes toward mathematics and math anxiety are serious obstacles for students in all levels of schooling today (Furner, 2017; Geist, 2010). Yet only limited attention has been devoted to the antecedents of math anxiety, which may include social factors like exposure to teachers who themselves suffered with math anxiety (Maloney & Beilock, 2012). This study looks at the math anxiety levels among students K-12 and shares a trend in math anxiety as students increase in grade level.

This paper shares data and information from K-12 schools, one who had decided to as part of their Southern Association of Colleges and Schools (SACS) accreditation as a K-12 international school (USA based curriculum) in Latin/South America to survey 25% of their students at each grade level (they have approximately 100 students per grade), Grades 1-12, and administered the Abbreviated Version of the Mathematics Anxiety Rating Scale(MARS) (Alexander and Martray, 1989) to see how their students feel about their math attitudes (See Figures 1 and 2). The results are somewhat inconclusive, but the graph shows primarily that as students increase in grade levels, their level of math anxiety increases for the most part (Furner, 2019) (See Figures 1 and 2). This may not be a complete surprise and seems consistent with the Third International Mathematics and Science Study (TIMSS) math results in the USA, whereas students increase in grade, their level of math achievement drops significantly from elementary to middle, then from middle to high school (Schmidt, 1998). Today, in an age of preparing our young people for fields in the areas of Science, Technology, Engineering, and Mathematics (STEM), it is critical young people have positive dispositions and attitudes toward mathematics.

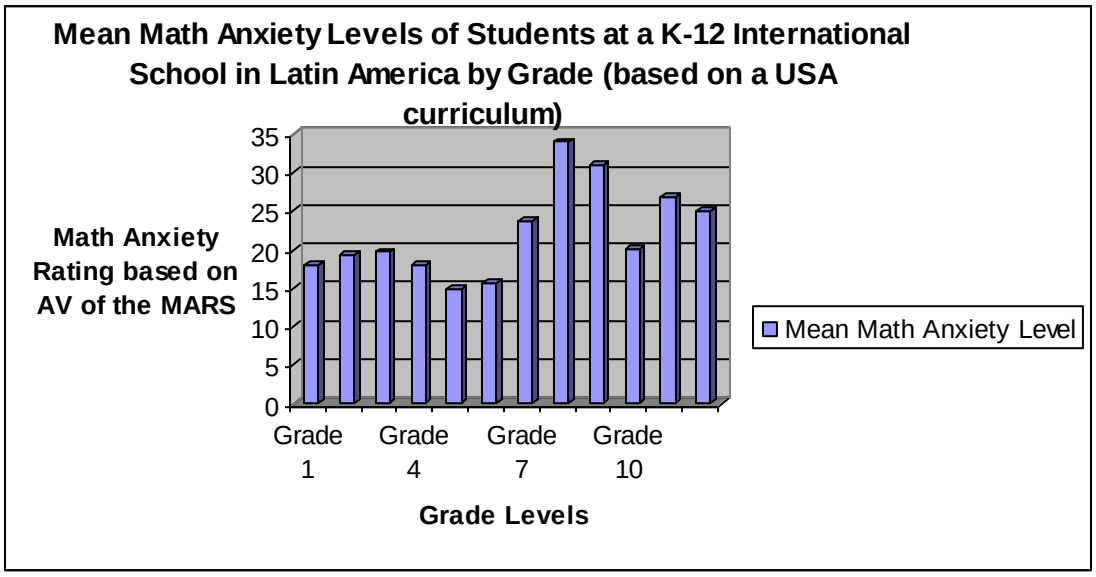

Figure 1. Mean Math Anxiety Levels by Grade

Mean Math Anxiety Levels by Grade

Grade	Average of the MARS
Grade 1	18
Grade 2	19.3
Grade 3	19.7
Grade 4	18
Grade 5	15
Grade 6	15.7
Grade 7	23.8
Grade 8	34
Grade 9	31
Grade 10	20
Grade 11	26.8
Grade 12	25

Figure 2. Raw Data of Math Anxiety Levels by Grade

Math Anxiety Overview

Today, math anxiety and dislike have reached epidemic levels in our schools as so many young people and adults have poor dispositions and bad experiences with learning mathematics (Furner, 2017). Metje et al. (2007) believe that math anxiety is a worldwide phenomenon and that many people are not going into math fields, like engineering, and that more and more math instructors at the university level are not prepared to deal with the increased number of students who have a fear of math. These instructors are not equipped with the tools to reach the students during instruction, resulting in frustration on both sides. Addressing math anxiety and supporting students in overcoming this fear of mathematics has become one of the largest challenges for a classroom teacher and university lecturer.

Anyone can do an informal survey on the street and discover that most people will not report positive experiences, dispositions, or good attitudes toward math. Now in the STEM world we live in, we are all encouraged to be good at

math and problem solving in our lives if we are going to be successful (Furner, 2017 and 2019). Today we are living in a world in which our students will soon be competing with young people from all parts of the globe for jobs. It is imperative that our students develop positive attitudes toward mathematics and the sciences in an informational age which has become so technologically oriented. Young people today need to be well prepared in the areas of math, science, and technology for all career choices. Nurses, engineers, architects, lawyers, teachers, along with many other fields will continue to use more advanced forms of technology that require one to know more mathematics and problem solving to perform their jobs more effectively. Sequencing, ordering, patterning, logic, spatial sense, and problem solving are some of the basic skills that all careers require (NCTM, 2000). By the time our young people reach middle school, they have developed certain dispositions toward mathematics. Students' confidence and ability to do mathematics and apply these skills in many diverse settings is essential for success; therefore, our young people need to be well prepared to do the mathematics of the 21st century.

Steen (1999) found that "national and international studies show that most U.S. students leave high school with far below even minimum expectations for mathematical and quantitative literacy." Neunzert (2000) contends that we must understand ourselves as MINT-professionals, where MINT is M=mathematics, I=informatics, N=natural sciences, T=technology. Neunzert (2000) believes that mathematics is crucial for people living in the 21st Century if they want to be successful. Neunzert feels educators need to encourage students in all countries to study more mathematics and to see it as a tool for success in life.

What is math anxiety? Simply put, it is anxiety when confronted with math, especially about one's own performance in solving math problems. It can range from slight nervousness to all-out panic. This anxiety makes it more difficult for students to focus in class, learn math, and solve math problems. Frequently students would rather give up than face their fears. This means that they never get better at math and can therefore never overcome their anxiety. If this math anxiety is not overcome, the student may suffer from this anxiety for their entire life, even beyond their time in school. Math anxiety is a well-documented phenomenon that has affected our society for over sixty years, and not enough is being done to address it in our classrooms or in the way we teach math (Furner, 2017: Beilock & Willingham, 2014; Boaler, 2008; Dowker et al. 2016; Geist, 2010; Metje et al. 2007). Negative attitudes toward mathematics and math anxiety are serious obstacles for students in all levels of schooling today (Geist, 2010). Beilock and Willingham (2014) state that "Because math anxiety is widespread and tied to poor math skills, we must understand what we can do to alleviate it" (p. 29).

What Causes Math Anxiety? Math anxiety is caused by a combination of external and internal factors; however, we cannot change internal factors within the student, so as teachers it makes more sense to focus on what we can control (Chernoff & Stone, 2014). Studies show that math anxiety is caused primarily by the way the student learns math: the type of authority the teacher uses, an emphasis on right answers and fear of getting wrong answers, requirements that the student respond with an answer sooner than he or she might be ready, and exposure to the rest of the class and their potential condemnation of a student who responds poorly, in short, the traditional way of teaching math (Chernoff & Stone, 2014, Finlayson, 2014). Traditional teaching emphasizes:

- "Basic skills
- Strict adherence to fixed curriculum
- Textbooks and workbooks
- Instructor gives/students receive
- Instructor assumes directive, authoritative role
- Assessment via testing/correct answers
- Knowledge is inert
- Students work individually." (Finlayson, 2014)

Unfortunately, these methods can cause and increase math anxiety in the classroom (Finlayson, 2014).

Math anxiety can also be transmitted and learned from others, usually from parent to child or teacher to student, but occasionally student-to-student. If someone teaching math, whether to their own child or to a class, experiences math anxiety, they are more likely to rush through things to "get it over with." They are not sure of their methods and because of their lack of confidence, they focus more on the correct answer. Like the student with math anxiety, they are also likely to become exasperated and give up rather than continue solving the problem. When this is done, it teaches the student that math is something to be afraid of and that, if they are not good at it, their parent or teacher will become angry with them and potentially leave (Furner, 2017). They also learn in class that, if their peers see that they are bad at math, they will be ridiculed publicly. Embarrassment can be considerable for children, especially in the middle and high school grades.

Another problem for those who suffer from math anxiety is the nature of anxiety itself. According to Rubinstein et al. (2015), anxious individuals tend to focus on negative stimuli more than positive stimuli, making themselves more anxious. The same thing is true of individuals with math anxiety; the only difference is that for people with math anxiety, math is negative stimuli (Rubinstein et al, 2015). This suggests that math anxiety could be handled through therapies designed to lessen anxiety, such as cognitive behavioral therapy and exposure therapy (exposing a person little by little to the thing that they are afraid of) (Rubinstein et al, 2015). While this is not something that a teacher could do with a full class to manage, it is something that tutors could be trained to help with; naturally, a licensed therapist would be the best option, but not all therapists are trained to help students with math. A combination of the two fields would be optimal.

Math anxiety remains a perplexing, persistent, and only partially understood problem from which many people suffer. NCTM (1991, p. 6) says, "Classrooms should be mathematics communities that thrive on conjecturing, inventing, and problem solving, and that build mathematical confidence. Unfortunately, many students and adults do not feel confident in their ability to do math. Mathematics anxiety in students has become a concern for our high-tech, informational world. Is it possible that only about seven percent of Americans have positive experiences with math classes from kindergarten through college (Jackson, C. D. & Leffingwell, 1999)? Burns (1998) in her book, *Math: Facing an American Phobia*, tackles an interesting subject and has found that two-thirds of American adults fear and loathe math. Whether it is 93% or two-thirds of Americans experiencing negative math experiences, there is a problem, and we need to do something about it as educators. If math anxiety is such a problem, one has to wonder why it is not being addressed in our schools today?

Evidence of students' poor attitudes and elevated levels of anxiety toward math is abundant. Amid a technological era, declining mathematics (math) scores on the Scholastic Aptitude Test (SAT) have been widely publicized. Tomasetto et al. (2021) found that mathematics anxiety interferes with learning novel mathematics contents in early elementary school. Some reports have shown that American students rank last when compared with students from all other industrialized countries on 19 different assessments. The TIMSS study has shown a trend in U. S. students' math scores as they decline as students increase in age group from grade four to grade twelve (Schmidt, 1998). Educators need to ask what is happening with today's youth that so many of them lose interest in math and lack the self-assurance to do and take more advanced math classes?

How Do We Repair Math Anxiety Concerns in our Schools?

To put it simply: active teaching. Finlayson suggests the constructivist style of teaching which emphasizes these ideas:

- Begin with the whole – expanding to parts in the learning process
- Pursuit of student questions/interests
- Use primary sources/manipulative materials
- Learning is interaction – building on what students already know, constructivism
- Instructor interacts/negotiates with students
- Assessment via student work, observations, points of view, and tests. Process is as important as product
- Knowledge is dynamic/change with experiences
- Students should work in groups (2014)

This style of teaching is vastly different from the traditional style which can cause and increase math anxiety. The constructivist style is much less intimidating and does not emphasize timed assessments or correct answers; instead, it focuses on the process of doing mathematics. Students are also likely to feel more engaged in class due to the more participatory style of teaching, making them want to work harder, instead of "getting it over with" heedless of how this affects their performance.

However, frequently the problems in the classroom that cause math anxiety are due to a teacher with math anxiety (Chernoff & Stone, 2014). These teachers choose the easiest ways of teaching (rote memorization of formulas, practice using one method to get one right answer, timed tests, etc.) to minimize their own math anxiety, not realizing that they are passing their own anxiety onto their students (Chernoff & Stone, 2014). Therefore, we must first remove math anxiety from teachers, so they may teach their students not to experience math anxiety. Math is not inherently frightening, but that is the message that is modeled and expressed to many children, even from their parents and teachers.

As mentioned previously, math anxiety is a form of anxiety and therefore treatable through the same types of therapy we use to treat general anxiety and phobias (Rubinstein et al, 2015). This may prove especially helpful for adults with math anxiety, especially teachers; by working to handle their own math anxiety,

adults would be able to prevent transmission of their anxiety to their children or students (Chernoff & Stone, 2014).

Discussing the Data from the K-12 School's Math Anxiety Levels Presented in this Study

The major trend from this data shows a notable upward trend in math anxiety in students as students increase in grade level (See Figures 1 and 2). The data set of a K-12 International School in South America with a US-based curriculum shows that as students take more math classes, and are exposed to more math teaching, their level of math anxiety increased. In discussions with the administrators and teachers, little is often done year to year with students as they pass from grade to grade in respect to addressing a students' math anxiety. This math anxiety can fester and continue to pass on and increase as students continue through their studies. The author of this paper worked with this school for two years during this data collection in the school as part of the SACS accreditation. He also worked as the 9th Grade Geometry teacher for the first year prior to the data collection year and has extensive expertise in math anxiety research and implemented extensive math anxiety reduction and prevention techniques. The author employed these techniques with the 9th grade mathematics students the year prior to the data collection. It is visible to see that the 10th grade students had reduced levels of math anxiety, likely due to the preventative and reductive math anxiety techniques used. Preventative strategies: like using "Best Practice" in mathematics include using manipulatives, cooperative groups, discussion of math, questioning and making conjectures, justification of thinking, writing about math in math journals, using a problem-solving approach to instruction, content integration, using technology Geometer's Sketchpad, assessment as an integral part of instruction, such as homework quizzes and math portfolios. Along with math anxiety reductive strategies which include using psychological techniques such as anxiety management, desensitization, counseling, support groups, bibliotherapy, and classroom discussions of how students feel about math and what they are learning. These insights can better help to understand why the 10th grade class had significantly lower math anxiety than the other middle school and high school grades. Students in elementary school often start out with little math anxiety, but this anxiety can increase as students go from grade to grade in their learning process. It is critical in an age of STEM (Science, Technology, Engineering, and Mathematics) that schools and teachers work to correct this trend of increased math anxiety as students move from Grades K-12. More schools need to include affective aspects into their improvement plans, like checking for math anxiety, and then compare such data to their students' achievement levels. Unfortunately, like TIMSS showed for US schools, the trend of math achievement went down as students increased in grade like this study shows with math anxiety and it is likely

correlations exist with how students feel about mathematics and how they perform. School leaders need to start looking at both affective and cognitive aspects of learning to see the relationships and to better address achievement and performance of their students in mathematics and likely all subjects.

Teachers and Leaders Working Together to Improve Math Scores and Dispositions

To address the issue of math apprehension, classroom teachers need to team up with school counselors, ESE teachers, school leaders, and professional development experts in teaching mathematics and make this part of their improvement plan. Teachers need to assess attitudes toward math to then work toward improving math achievement. Teachers should be sensitive to students' needs, feelings, and experiences with mathematics. Brigman & Campbell (2003) and Parker (1997) have found based on their research that when school counselors team up with classroom teachers they can have a profound effect on student achievement scores. A counselors' psychological expertise can serve as a real asset to classroom teachers and students who struggle with a fear of mathematics or poor math instruction experiences. As educators, we need to remember that not all students are alike, yet all students deserve equal opportunities in the mathematics classroom (NCTM, 2000). A math teachers' job is not only to teach the subject matter. One of NCTM's goals for all learners was that as math teachers, we should help students become confident in their ability to do mathematics (NCTM 1989). NCTM (1989, 2000) contends that students should be exposed to numerous and varied interrelated experiences that encourage them to value math and to develop mathematical habits of the mind. They should understand the role of math in human affairs: they should be encouraged to guess, read, write, make conjectures, and make errors so that they can gain confidence to solve complex problems. It is clear that math teachers are not only instructional leaders, but they are also counselors and confidence builders for their clients, their students. Furner and Higgins (2019) contend that we must empower teacher leadership to address math anxiety in today's schools as it is more important than ever for teacher leaders and administrators to work together on creating opportunities for math teachers to learn best practices for handling math anxiety and low dispositions for the STEM courses. Traditional professional development that uses workshop and lecture format to bring "external ideas" in to change the practices of teachers in the classroom is "deeply flawed as a theory of action" (Fullan, 2007). Additionally, Elmore (2004) stated:

> The problem (is that) there is no opportunity for teachers to engage in continuous and sustained learning about their practice in the setting in which they actually work, observing and being observed by their colleagues in

> their own classrooms and classrooms of other teachers in other schools confronting similar problems. (p. 127)

The type of professional learning that is needed involves "deprivatizing teaching," changing the well-rooted norm of teachers working in isolation and privacy (Fullan, 2007). It means that all teachers need to take risks, share ideas, and open classroom doors.

Math anxiety may be defined as an inconceivable dread of mathematics that can interfere in working with numbers and solving word problems within a variety of everyday world and academic situations. NCTM (1989 & 1995) recognizes math anxiety as a problem and has specifically included in its assessment practices as a teacher's job to assess for their students' mathematical dispositions as NCTM Standard #10 (NCTM, 1989) (See Appendix A)

Today, there are strategies that teachers and schools can use to help prevent math anxiety from occurring in our students. However, it becomes more complicated as it may include what happens to students in and outside of the classroom. Both parents and teachers can play vital roles in helping to develop positive dispositions toward math in students. It is important that teachers check for these positive attitudes and dispositions toward mathematics at an early age. Often students can develop such anxieties toward math early on in their math classrooms due to poor teaching, drill and practice, strained testing situations, parental and teacher insecurities about their own math abilities, etc. The elementary and middle school years are critical to developing positive perceptions toward mathematics in children. The NCTM (2000, 1995, & 1989) has made recommendations for preventing and reducing math anxiety (See Appendix A).

Reducing math anxiety is much different from preventing math anxiety. Teachers need to work with school counselors and to act as psychologists or counselors themselves to help lower or overcome such anxiety toward math in their students. It is critical that math teachers team up with school counselors to address reducing math anxiety in their students. Researchers in math anxiety propose systematic desensitization (Arem, 2003; Furner, 1996; Schneider & Nevid, 1993; Hembree, 1990; Trent, 1985; Tobias, 1993; Olson & Gillingham, 1980) as one of the most effective approaches for helping people reduce their math anxiety. Systematic desensitization in the context of math anxiety may be defined as a gradual exposure to the mathematical concepts that are causing students to become distressed and teaching them how to cope with the fear they are experiencing. Each time students are exposed to the math they fear, they should improve their techniques in coping with their anxious feelings. Being able to talk about their history with math and releasing their anger and fear of the subject may be

therapeutic in nature and then eventually students can work toward and come to terms with this anxiety, eventually overcoming it. Through these types of counseling approaches, students will be able to understand that their anxiety was a learned behavior, that they were not born with these feelings toward math, and they can be taught to overcome the feelings by consistently implementing self-monitoring strategies to become less anxious.

How is math anxiety reduced? Teachers must help students understand how their math anxiety was created (See Appendix A) and work toward overcoming this fear while developing confidence. As Reuters (2007) and the American Association for the Advancement of Science in San Francisco reported, a relationship does exist between math anxiety levels and math achievement levels. Teachers can work with school counselors and ESE Teacher and be counselors themselves to ease such anxiety and work toward helping the students gain more confidence in doing math so that math achievement levels improve. In the case of the school mentioned here that is also assess math attitudes using the abbreviated Version of the MARS, they are using this information to work more closely with students to then help them overcome their math anxiety so that the school will hope to see high math achievement levels in the years to come. Higgins et. al (2020) outline an action research project to reduce math anxiety using reductions strategies like bibliotherapy. Higgins et. al (2021) go into depth with the action research protocol employed to help reduce math anxiety in high school students incorporating researched-based practices to reduce math anxiety as effective means to lower and counsel young people with math worry.

Math manipulatives have been around for years as a best practice for teaching mathematics. The Montessori Schools have long advocated teaching using concrete objects along with Piaget's emphasis on teaching from the concrete, to the representational, to lastly the abstract, to help young learners make sense of their mathematics understanding. George Cuisenaire (1891–1975), a Belgian educator, is famed for his development of the Cuisenaire Rods used today to help teach fraction concepts along with other math ideas; these were developed in the 1950's. Later, many other math didactics came out of these ideas and led to the Cuisenaire Math Manipulative Company. Today, there are many commercially made math manipulatives that fill the shelves in most school classrooms.

How Math Manipulatives Play a Role in Building Math Confidence

Ball (1992) references a story from her own teaching of a third-grade mathematics lesson. She explains that she was showing a group of educators a segment from her lesson on odd and even numbers for her third-grade class. The video segment began with a student, Sean, proclaiming that he had been thinking

about how the number six could be both odd and even because it was made of "three two's" and "two three's." Sean illustrated both scenarios on the board for his classmates and teacher to inspect. The other students challenged his conjecture of six being both an odd and even number and much talk was generated about it. In showing this video to educators, Ball hoped to generate a lively discussion on numerous ways this situation could have been handled, such as clarifying the definition of even and odd numbers or asking for other students' opinions. The educators watching the video immediately wanted to know if Ball used manipulatives or any concrete materials to clarify the meaning of odd and even numbers to Sean. When she explained that drawings and illustrations were used, the teachers became fiercely adamant that had Ball used physical counters, she could have more firmly guided her students toward the correct conclusion. Ball points out that, as a teacher, she does not want to prevent this sort of "discovery learning" that her students made in allowing them to grapple with the ideas behind the math concepts of odd and even numbers. Ball also states that she is not convinced that allowing students to use manipulatives would automatically guide them to the correct mathematical conclusions. She claims that there is a common misconception among educators of a tremendous faith in the almost magical power of manipulatives to automatically convey the underlying mathematical knowledge with their mere presence. Ball asserts that it is the context with which the manipulatives are used that creates meaning, such as talk and interaction between teacher and students that evolves during instruction. Ball claims that current education reform implies, in many ways, that manipulatives or physical materials are crucial in improving mathematics learning. This sentiment is reinforced in several ways such as the inclusion of manipulatives in mathematics curricula from school districts and publishers and the inclusion of "manipulative kits" to districts and schools that purchase their curriculum materials. The offering of in-service workshops and professional developments on manipulatives are also popular and sometimes required by school administration or districts. Ball asserts that there is not enough examination as to the validation of the appropriate role in helping students learn mathematics using manipulatives. Little discussion occurs as to possible uses of distinct types of concrete materials or illustrations. It is assumed that students will "magically" learn the math concept and draw the correct conclusion that the teacher intended her students to derive from the activity. Ball claims that one of the reasons adults over emphasize the power of concrete representations to convey accurate mathematical skills is because adults are seeing concepts they already understand. Students who do not already possess this knowledge may not come to the same, correct conclusions about the underlying mathematical knowledge the manipulative is alleged to convey. Ball suggests that there is a need to examine the difficult problem of helping students make correct connections between the manipulative and the knowledge it is meant to convey.

She discusses the need for teachers to develop rules for students as to how to operate with the manipulatives so that they are more likely to arrive at the correct mathematical conclusions. One such rule is when students are using base-ten blocks to subtract two-digit numbers with regrouping, they would have to trade in a ten bar for ten ones, to complete the correct regrouping procedure. A teacher could take that a step further and have the student relate this activity to the subtraction algorithm of regrouping and structure student talk and interaction that requires reflection, around the subtraction activity.

A 21-week qualitative pilot study conducted by Golafshani (2013) examined the practices of four 9th grade applied mathematics teachers concerning their beliefs about the use of manipulatives in teaching mathematics, its effects on learning and enabling and disabling factors. The teachers taught various topics to 9th grade students with diverse learning abilities. The teachers were given support, such as manipulatives, a math literacy tool kit, the opportunity for professional learning, training and dialogue, and resources to plan for five math lessons with manipulatives.

Teachers' beliefs about manipulative usage and comfort level with them play an important role in student access and manipulative usage in instructional lessons. Teachers limited student access by displaying lists on containers, assigning manipulative monitors, and using them as a reward/punishment tool. A limitation of this study was the teachers in the study were selected from a group of teachers attending a math summer institute workshop. They were not selected from a general pool of math educators, so it could be concluded that these teachers were more interested in student learning than the average teacher.

Uribe-Flórez and Wilkins (2010) examined 503 in-service elementary teachers' background characteristics, beliefs about manipulatives, and the frequency with which they used manipulatives as part of their instruction. The teachers were part of a professional development experience in which they were asked to complete a survey related to their beliefs, attitudes, and instructional practices associated with mathematics teaching.

Marley and Carbonneau (2014) assert that rather than determining if instruction with manipulatives is more effective than conventional instruction, more effort should be made to examine the value added by various instructional factors that may accompany instruction with manipulatives.

All of this aligns with Ball (1992), who stated that there is not enough examination as to the validation of the appropriate role in helping students learn

mathematics using manipulatives. It would be more helpful to teachers if more professional development opportunities were made available that specifically focused on teachers learning to help students make the important connections between the mathematics manipulatives and the underlying mathematics concepts they are investigating and how they can be used within instruction. Marilyn Burns (n.d.) has been an advocate for math manipulatives now for over 30 years, leading to her company, *Math Solutions*, which provides resources and training on using math manipulatives to educators around the world. Her role today in the math manipulative movement has been far reaching; she provides videos and demonstrations of the most common manipulatives used today to teach most math concepts in today's math classrooms. As research shows, math manipulatives aid in preventing math anxiety.

Common Mathematics Manipulatives and Their Uses

It is important that math teachers use manipulatives to make math concepts concrete rather than abstract. Teachers can obtain commercial-made manipulatives, make their own, or help the students make their own. Examples of manipulatives are paper money, buttons, blocks, Cuisenaire rods, tangrams, geoboards, pattern blocks, algebra tiles, and base-ten blocks. The use of manipulatives (See Figure 3) provides teachers with an exciting potential to use their creativity to do further work on the math concepts instead of merely relying on worksheets (Furner and Worrell, 2017). Consequently, students learn math in an enjoyable way, making connections between the concrete and the abstract. Piaget and Montessori philosophies are still alive and well received in today's math classroom. The CRA (Concrete-Representational-Abstract) Model for teaching mathematics is the main approach for teaching most math concepts for K-8 learners. When teaching mathematics, teachers always need to start with concrete manipulative materials to first teach for understanding, then transfer to representational models like pictures or diagrams, leading and bridging learning to the abstract level of understanding of symbols and operation signs so that students eventually do not need the manipulatives to do the mathematics. Escarez and Ching (2022) found that math manipulatives and representation models used in teaching mathematics had a powerful impact on math anxiety levels of learners. Hidayah and Prayoga (2021) found in their study that students' attitude towards mathematics in discovery learning using concrete and virtual manipulatives had an impact on their learning and concrete manipulatives were much more impactful in improving attitudes and preventing math anxiety.

Figure 3: Common Math Manipulatives in US Schools

To understand the concept of money, teachers can have students "buy" items tagged for sale in the classroom. Students are given an opportunity to describe purchases they or an adult have made. Students select the proper combinations of coins to purchase the item. As each student participates, the class helps by showing the coins on the classroom display. By handling the coins, students can correct mistakes and verify counting amounts of money. Math manipulatives make learning math concrete, they build confidence and lower math anxiety as students learn important math concepts in a hands-on concrete way. Research from Stoehr and Olson (2021) found that teachers showed math manipulatives were instrumental in helping to lower and prevent math anxiety in students learning.

Summary

Math anxiety is a considerable problem in today's world. As the adage says, "attitude is everything." When students have bad attitudes toward mathematics, it can affect their lives forever. As adults, we need to be aware of our own anxiety to prevent it from being transmitted to our children and students; for those who are unduly impacted by math anxiety or for those who are more likely to transmit this anxiety to children, it may be helpful to receive assistance from a therapist. The data presented in this paper show little math anxiety with the early grades and increasing as students go up in grade. As math teachers, we need to make our classrooms a haven for students with math anxiety by altering our teaching styles; this will help all students, not just those with math anxiety. To fix this problem, we need to go straight to the source, even if that source is in our own anxieties. Only

then can we prevent future generations from becoming part of the pandemic of math anxiety. Today, math teachers can use best practices like math manipulatives to assist in teaching mathematics to build confidence and understanding; while addressing both preventative and math anxiety reduction strategies with their students to improve math attitudes is critical (Furner, 2017). See Appendix A.

Teachers need to put on their educational psychologists' hats in their classrooms to help address the issue of math anxiety. Teachers may also want to work with school principals and counselors as well as encourage their schools to have family math nights where parents come with children and together, they can "do math" and see its importance and value in life. As a society, we must work together to extinguish the discomfort that our youngsters are having toward mathematics, especially as students increase in age. It is important that all students feel confident in their ability to do mathematics in an age that relies so heavily on problem solving, technology, science, and mathematics. Math teachers are facing unprecedented challenges trying to address student achievement levels, changing standards, accountability, and high-stakes testing – on top of the fear and anxiety of math. Administrators and teacher leaders need to understand their responsibility for building professional skill - "ongoing professional learning" is needed to teach mathematics effectively (Ball, 2002). Educators must make the difference in our children's attitudes toward math, math manipulatives have shown to be very effective in the prevention of math anxiety. The data in this study shows an upward trend in higher math anxiety levels as students increase in grade level. It is evident teachers need to do more starting in the early grades and each grade to use best practices for teaching math and use math anxiety reduction strategies to work on reducing math anxiety as students increase go up in grade. It would be nice to hear more young people and adults when asked how they feel about math say, "Math was my favorite subject" or "I am great at math!" not "I hate it" which is more often heard by adults in the 21st Century and the STEM world we now live in. We need to flatline this trend, not allowing it to create an escalating bar graph of increases as students increase in grade level. As math educators, we need to correct these poor attitudes toward mathematics, using math manipulatives can assist in this learning and provide a motivation and sound concrete way to teach math for understanding while building confidence in young learners for a STEM world.

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Appendix A:

Standards and Strategies to Address

Math Anxiety including the *Mathitude Survey*

Name_____

Grade_____

Math Class_____

Age_____

Career or Career Interest_____

Mathitude Survey

1. When I hear the word math I.....

2. My favorite thing in math is.....

3. My least favorite thing in math is.....

4. If I could ask for one thing in math it would be.....

5. My favorite teacher for math is_____because_____

6. If math were a color, it would be.....

7. If math were an animal, it would be.....

8. My favorite subject is_____ because_____

9. Math stresses me out: True or False Explain if you can.

10. I am a good math problem-solver: True or False Explain if you can

Mathematics teachers need to be leaders and counselors too…

What NCTM says about Mathematics Anxiety and Dispositions Toward Mathematics

Standard 10: Mathematical Disposition (NCTM 1989)

As mathematics teachers it is our job to assess students' mathematical disposition regarding:

-confidence in using math to solve problems, communicate ideas, and reason;

-flexibility in exploring mathematical ideas and trying a variety of methods when solving;

-willingness to persevere in mathematical tasks;

-interests, curiosity, and inventiveness in doing math;

-ability to reflect and monitor their own thinking and performance while doing math;

-value and appreciate math for its real-life application, connections to other disciplines and cultures and as a tool and language.

A Synthesis on How to Reduce Math Anxiety

1. Psychological Techniques like anxiety management, desensitization, counseling, support groups, bibliotherapy, and classroom discussions.

2. Once a student feels less fearful about math, he/she may build their confidence by taking more mathematics classes.

3. Most research shows that until a person with math anxiety has confronted this anxiety by some form of discussion/counseling no "best practices" in math will help to overcome this fear. (Furner, 2007)

A Synthesis on How to Prevent Math Anxiety

1. Using "Best Practice" in mathematics such as: manipulatives, cooperative groups, discussion of math, questioning and making conjectures, justification of thinking, writing about math, problem-solving approach to instruction, content integration, technology, assessment as an integral part of instruction, etc.

2. Incorporating the NCTM *Standards* and your State Standards into curriculum and instruction.

3. Discussing feelings, attitudes, and appreciation for mathematics with students regularly (Furner, 2007).

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