MOTIVATING STUDENTS MATHEMATICALLY IN A STEM WORLD WITH PICTURE BOOKS, PHOTOGRAPHY, AND GEOGEBRA

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Abstract
Mathematics teachers can best reach their students and show them how math surrounds us by using children's literature picture books, photography, and GeoGebra while teaching math. In today's high-tech world, students need to be proficient in Science, Technology, Engineering, and Mathematics (STEM) fields. Today teachers also need to use strategies to motivate students and be cognizant and checking for attitudes and dispositions toward learning mathematics, as math anxiety is an issue in today's classrooms. This paper will demonstrate why using children's picture books, photography, and GeoGebra can help teachers create mathematically confident young people who are motivated and excited about learning math. Research and examples of books, photos, and GeoGebra files will be shared.

Keywords:
GeoGebra, Picture Books, Photography, Motivation, Math Anxiety, Real-world Connections, STEM

Introduction

Today motivating student to learn math is critical, we also as educators need to take into consideration that math anxiety is a real phenomenon, and many young people are confronted with this when learning math at many grade levels, Kindergarten through College. Individuals can then often go through such anxiety throughout their entire life and it can often affect many decisions in life as well as the career choices they make. 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. It really is a

school's obligation to see that their students' value and feel confident in their ability to do math and use technology to learn because ultimately, all decisions individuals make, and choices of careers may be determined in part by their attitudes toward mathematics.

Figure 1. Mathematics in Photos

Sabirin et. al (2022) found that it is critical educators motivate students mathematically to achieve success with mathematical literacy. Dahal et. al (2022) found that using GeoGebra was an excellent technology tool to motivate students while learning mathematics. Today children's literature picture books have been a common resource for using for instruction in math class for elementary students for many years now. McGuire et. al (2021) researched and found that using children's literature and picture books and read alouds were extremely effective in teaching for understanding in mathematics instruction. Lubis et. al (2022) found that augmented reality pictorial storybooks used in math greatly influence lessening elementary school mathematics anxiety in students. Wachira & Liu (2022) found that digital-based interventions for learners with mathematics learning difficulties as well. Undheim (2022) also confirmed this in their research as well. Today it is common to use technology to teach with as well as make learning visual, using representation models in picture books through stories and in photographs, and much research has been done by Furner and Marinas (2020) on using photography inserted withing the GeoGebra software to teach a wide variety of mathematical concepts for understanding. Figure 1 shows some photos where learner can identify shapes and math ideas within the photo. Terton et. al (2022) found that through using photography and drawing in teaching mathematics it empowers children to see math in everyday life and feel more comfortable with it. Reyes and Pérez (2022) found using photography for teaching math brought out emotions and was extremely significant in the teaching of mathematics for better understanding and creating connections.

Math anxiety is a real phenomenon that has been researched for many years now (Alday and Panaligan,2013; Beilock and Willingham, 2014; Boaler,2008; Quander, 2013; Richardson and Suinn, 1972; Scieszka and Smith, 1995; Williams, 1988). Mathematics

educators need to take it seriously and use research to address the problem in an age of STEM and work toward building math confidence in all students. By inserting photographs into GeoGebra software and exploring various objectives related to the new Common Core Math Standards, the presenters will motivate students to learn math and minimize math anxiety.

This paper focuses on motivating young learnings in the math classroom for our STEM world by sharing current research to address motivation, math anxiety so students are ready for learning math, and feel comfortable with the math they are learning while using technology and visual learning for understanding by incorporating children's picture books and photography. Today schools need to teach using multiple types of technology as well as math manipulatives and children's literature. This paper will give a current overview of the realities of math anxiety in our society and strategies that educators can do to address such anxiety in the STEM world we now live in, addressing both math anxiety reduction and prevention, ultimately building math confidence. The topics will explore the math that surrounds us in the real world thus creating a connection between the abstract math and the real-life experiences. When mathematics has a purpose, young people are willing to spend time exploring and understanding the math concepts presented in today's school curriculum. Using children's literature and even bibliotherapy can help students see math in the real world while also helping them see other students who struggle with or feel anxious about math come to terms with such anxiety.

Photographs can easily be inserted into the GeoGebra software and can provide the basis to observe relationships with different and similar shapes while using the math tools in GeoGebra. Emerging technologies such as GeoGebra can assist in appealing young learners to enjoy learning mathematics while also addressing math anxiety and attitudes towards the subject. This paper shares how to motive students using children's literature, photography, GeoGebra, math teachers can better explain math concepts and make the teaching and learning of math more real-world and relevant to learners, like using picture books to teach math objectives. In a world where STEM education has become so important, it is critical that we motivate and turn young people onto mathematics through technology like GeoGebra.

Building Math Confidence for a STEM World is Critical

Nowadays math anxiety is a common problem in many mathematics classrooms. Richardson and Suinn (1972) originally defined math anxiety as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Mathematics anxiety is the "irrational dread of mathematics that interferes with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations" (Buckley and Ribordy, 1982, p. 1).

A great deal of research has been done on math anxiety since the 1970s (Richardson & Suinn, 1972). Math anxiety still continues to plague our society and affects our young peoples' success and achievement with the subject (Finlayson, 2014; Quander, 2013). Quander feels that elementary teachers need to help prepare students to be lifelong

learners and develop a productive mathematical disposition so that they are prepared for future schooling and eventual careers. Math anxiety can impede not only mathematical performance but also interest and then career choice and many decisions in life (Furner & Berman, 2004). The idea of looking closely at math anxiety levels, motivation to learn mathematics, and using technology like GeoGebra to teach and motivate students is critical today in a world of STEM and also can impact achievement goals of the learners (Gonzalez-DeHass, Furner, Vásquez-Colina, & Morris, 2017; Furner & Marinas, 2016). A larger part of the NCTM Standards (1989) believes that mathematics teachers need to assess students' mathematical disposition regularly.

Research from Jackson and Leffingwell (1999), found that in their study only seven percent of the population reported having positive experiences with studying mathematics from kindergarten through college. The study cited that there are numerous covert (veiled or implied) and overt (apparent and definite) behaviors displayed by the math instructor in creating such given math anxiety in students. Behaviors such as difficulty of material, hostile instructor behavior, gender bias, perceptions of uncaring teachers, angry behavior, unrealistic expectations, embarrassing students in front of their peers, poor communication and language barriers, the quality of instruction, and evaluation methods of the teacher. Math instructors' behaviors and teaching methodologies can be hurtful and negative to students learning math. Students often say: "I like the class because of the teacher" because the teacher knows how to present developmentally the subject matter, creates a learning environment conducive to learning with compassion, has high expectations for all students without regard to gender, race, or language barriers, and uses a variety of assessment methods and teaching styles to better reach all students to address math anxiety (Chernoff & Stone, 2014; Dowker, Sarkar, & Looi, 2016).

Furner (2007) in synthesizing math anxiety treatments, it was found that there are two distinctions to math anxiety: prevention and reduction and there are distinct strategies and methods to address each is different ways. It has been found that there are three ways 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 and State/Common Core Math Standards into the curriculum and/or instruction; and lastly, the importance of discussing feelings, attitudes, and appreciation of mathematics with students. This same research found that there are three methods to reduce math anxiety: 1). Psychological Techniques like anxiety management, desensitization, counseling, support groups, bibliotherapy, and discussions; 2). Once a student feels less fearful about math, he/she may build their confidence by taking more mathematics classes; and 3). Most research on math anxiety reduction has shown that until a person with math anxiety has confronted this math anxiety by some form of discussion/counseling no "best practices" for teaching mathematics will help to overcome this fear of the subject (Furner & Duffy, 2002). Assessing students attitudes early in the school year is beneficial, how they feel about math so to provide students with a math attitude survey at the beginning of each school year or course and also to read the book,

Math Curse (Scieszka & Smith, 1995), to get students to talk about their true feelings toward math, surveys and biblio-therapy are both effective forms of starting the process of opening up and getting inner feelings out young people may have about mathematics or unpleasant past experiences.

Using Picture Books to Teach Math

Pound and Lee (2021) contend we need to teach mathematics creatively using picture books and children's literature. Zhang et. al (2023) in a meta-analysis of using picture books found many positive as well as barriers to teaching with books, schools today are encouraging it as a best practice, teachers sometimes do not have time, but it is highly emphasized today. Fellus et. al (2022) found many barriers to teach using children's books in math, but saw the benefits and messages it sends students, many hidden ideas and messages through stories and pictures that can help students to understand and visualize math in the context of stories and pictures. Livy et. al (2023) found while there are barriers to using picture books to teach math, the benefits outweigh the difficulties and the children glean a richer meaning to the math ideas through stories and pictures. Most research today supports using children's picture books in the teaching of mathematics today and it is considered a best practice in the math classroom which offers motivating factors.

Making learning connections are critical and can be made when we teach math using such things as technology like GeoGebra and photography. Munakata and Vaidya (2012) based on their research found that students do not consider mathematics and science to be creative endeavors, although the traditional artistic disciplines rank high in this regard. To address this problem in perception, the authors used photography as a means to encourage students to find the deep-rooted connections between science and mathematics and the arts. The photography project had been used in a formal classroom setting as well as an outside activity, i.e. in a more informal setting. The project found student interest and motivation were peaked when photography was part of the instructional strategies to teach new material while making meaningful connections to the math using the photography. Jones (2012) also in her book, *Visualizing Mathematics*, discusses how teachers need to help students visualize and create representations of their math understanding so to turn them on to the subject. Beilock & Willingham (2014) in their research have found that math teachers can help to address and reduce math anxiety. The author believes by using technology like GeoGebra along with the photography teachers can make better connections and students are going to be more highly motivated to learn math (Furner & Marinas, 2016; Marinas, Furner, & Escuder, 2016).

Common Core State Standards (CCSS) as They Relate to using GeoGebra

Many schools and states have to adhere to the new Common Core Math Standards (National Governors Association Center for Best Practices (NGA Center) or variations of them by state and the Council of Chief State School Officers (CCSSO), 2010) which can be found at: http://www.corestandards.org/ GeoGebra is an ideal piece of math software to use to teach many of the Common Core or State Standards today. Furner and Marinas (2016) offer many premade GeoGebra activities that math up with the Common Core

Math Standards and with many more at www.matharoundus.com. Below is a list of common core math standards that can be covered with GeoGebra, see Figure 2. Figures 3-11 Show varies math concepts taught with a book, GeoGebra, and photos.

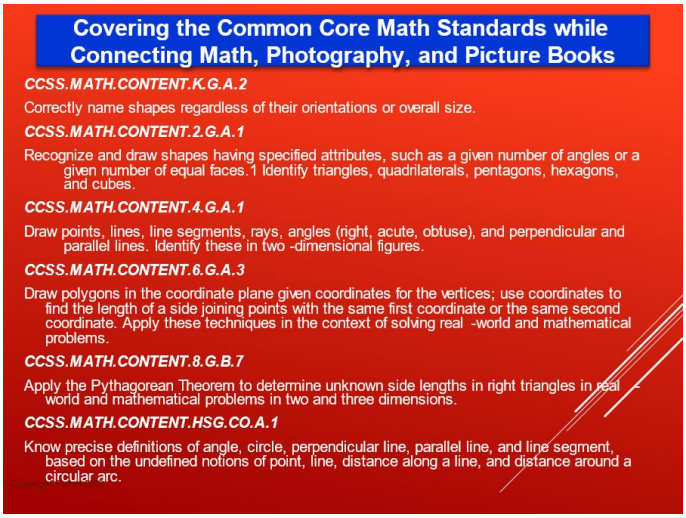

Figure 2. Common Core Math Standards Cover with GeoGebra

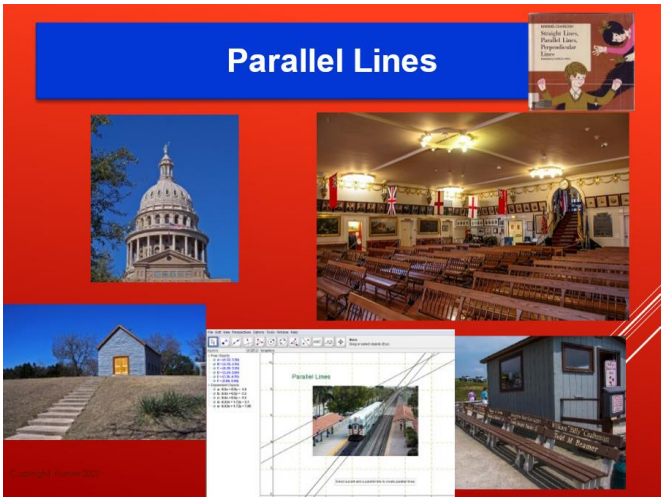

Figure 3. Parallel Lines with Book, Photos, and GeoGebra

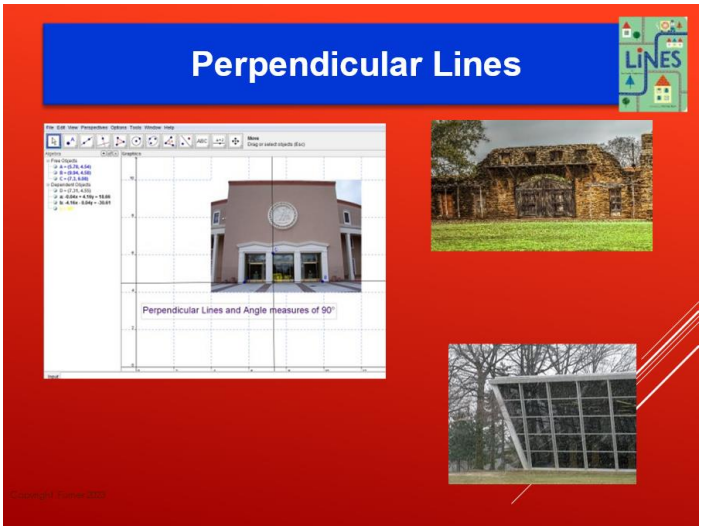

Figure 4. Perpendicular Lines with Book, Photos, and GeoGebra

Figure 5. Circles with Photos, Book, and GeoGebra

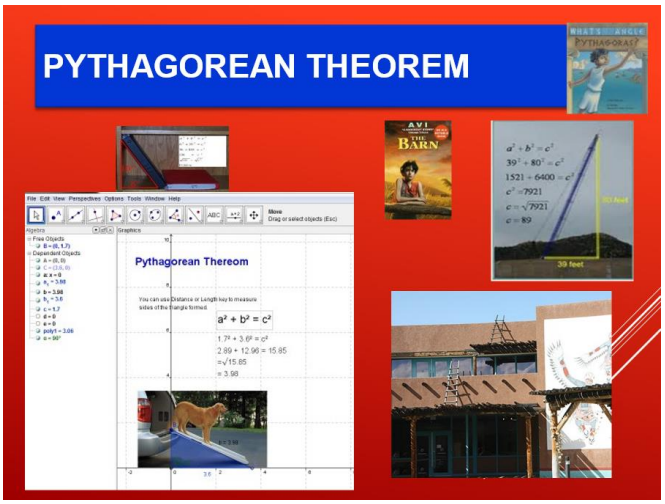

Figure 6. Phythaorean Theoren with Photos, Book, and GeoGebra

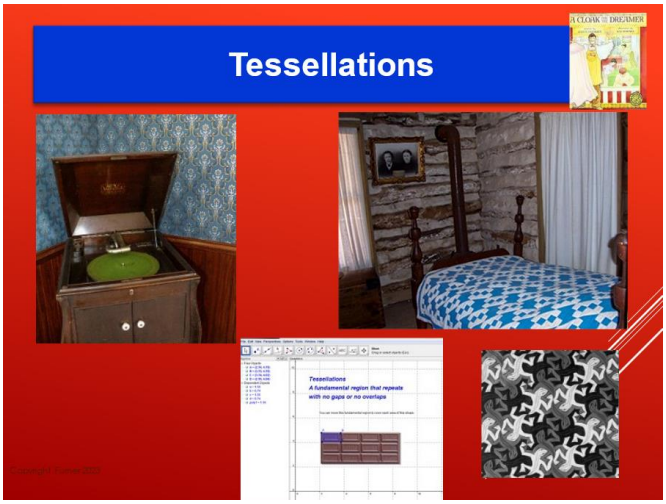

Figure 7. Tessellations with Photos, Book, and GeoGebra

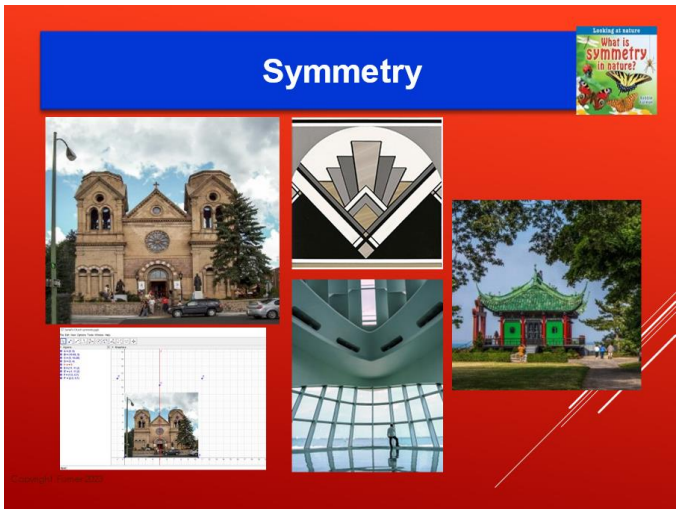

Figure 8, Symmetry with a Book, Photos, and GeoGebra

Figure 9. Reflections with a Book, Photos, and GeoGebra

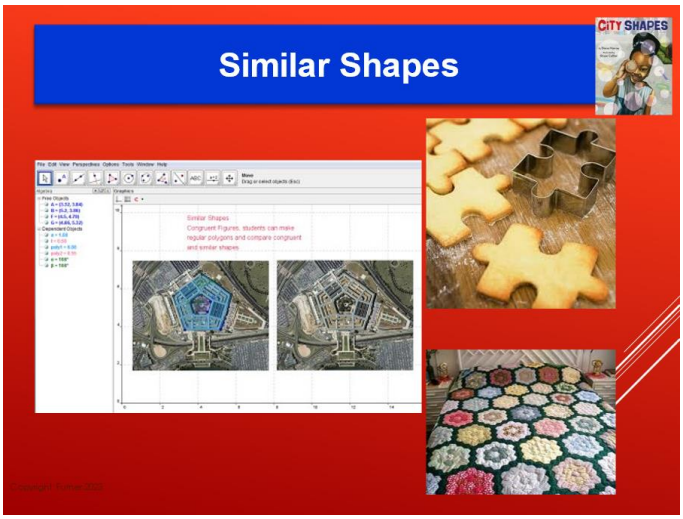

Figure 10. Similar Shapes with a Book, Photos, and GeoGebra

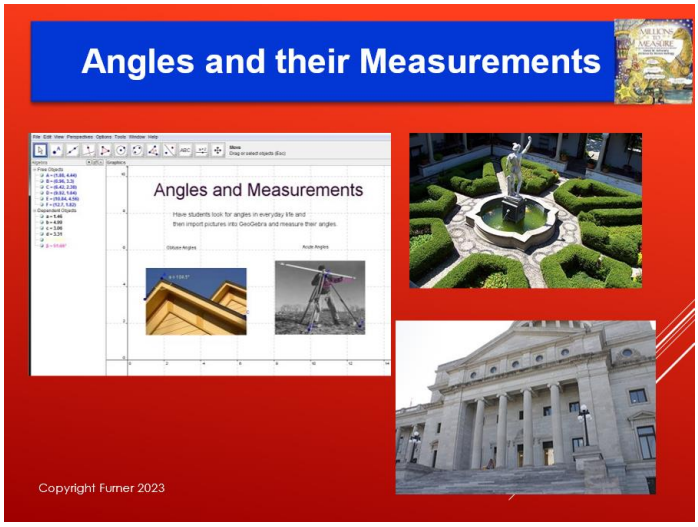

Figure 11. Angles and Measurements with a Book, Photos, and GeoGebra

Technology like GeoGebra is Motivating and Prepares Students for STEM

Using technological tools is critical in today's world for the STEM world we now live in. GeoGebra is one that has gained great grounds in recent years. Our students need to learn to excel at higher levels of generalization, model and solve complex problems, and focus on decision-making and reasoning (National Council of Teachers of Mathematics (NCTM) 1989, 2000, 2006). NCTM believes that mathematical power can arise from technology, which includes increased opportunity for learning, increased opportunities for real-life social contexts, and orientation to the future. The President's Council of Advisors on Science and Technology (PCAST) (Holdren, Lander, & Varmus, 2010) published an executive report with specific recommendations to government leaders given to ensure that the United States is a leader in Science, Technology, Engineering, and Mathematics (STEM) education in the coming decades. One major recommendation

is to recruit and train upwards of 100,000 new STEM middle and high school mathematics teachers over the next decade that are able to prepare and inspire students to have strong majors in STEM fields and strong STEM content-specific pedagogical preparation for such fields. PCAST believes that teachers are the most important factor to address in ensuring excellence in STEM education of future young people for our nation. Despite the ongoing efforts to promote the use of technology in education (e.g., National Council of Teachers of Mathematics [NCTM], 2000; National Educational Technology Standards for Teachers [NETS*T], 2008), teachers' ineffective use of technology has been reported in the literature. Hwang, Su, Huang, & Dong, (2009) found that by combining virtual manipulatives and software like GeoGebra along with whiteboard, educators can better model problems, help students understand and solve the problems while reaching higher levels in the teaching of many mathematical ideas in the math curriculum. Benning (2023) cites that using GeoGebra is motivating in the learning of mathematics for students. GeoGebra provides a hands-on milieu where students used the software to explore mathematics in meaningful ways.

Using GeoGebra to Better Prepare STEM Students

GeoGebra software is a multi-platform dynamic mathematics software for all levels of education from elementary through university that joins dynamically geometry, algebra, tables, graphing, spreadsheets, statistics and calculus in one easy-to-use package (Hewson, 2009; Hohenwarter, Hohenwarter, & Lavicza, 2009). This open-source dynamic mathematics software that can be downloaded free and accessed immediately at: http://www.geogebra.org/cms/en/info. There are no licensing issues associated with using GeoGebra, this then allows students and teachers the freedom to use it both within the classroom and while at home or on the go. GeoGebra has a large international user and developer community with users from 190+ countries it has currently been translated into 55 different languages.

Fahlberg-Stojanovska, & Stojanovski (2009) found that using GeoGebra is motivating for students and helps them learn at a higher level while exploring and conjecturing as they draw and measure. Rosen & Hoffman (2009) established the importance to integrate both concrete and virtual manipulatives into the math classroom, such as representational models like GeoGebra. Furner & Marinas (2007) found that young people could easily transition from the concrete when using manipulatives like geoboards to the abstract when using geometry sketching software like GeoGebra. GeoGebra may have been primarily intended for mathematics instruction at the secondary and college levels; today it is even now introduced at the elementary math levels as well. The Appendix A provides online websites on resources related to GeoGebra.

GeoGebra can model how mathematical equations can be applied to everyday objects. Aydin & Monaghan (2011) in their research feel that math teachers need to explore the potential for students to "see" mathematics in the real world through "marking" mathematical features of digital images using a dynamic geometry system like GeoGebra. Mathematics teachers may find the following videos (Mathematics and Multimedia, n.d.) of basic training for GeoGebra at: http://mathandmultimedia.com/2011/01/01/geogebra-

essentials-series/ useful as they provide great resources for how to quickly use GeoGebra in their classrooms.

GeoGebra research has been described as raising the enthusiasm for the effective and thoughtful application of technology to the mathematics teaching/learning enterprise (Fahlberg-Stojanovska and Stojanovski, 2009; Hewson, 2009). Observations of participants in schools and during the summer workshops are also cited as evidence for providing such motivation for learning. GeoGebra was also credited with changing math teacher instructional habits. Two specific features were referenced as creating this change: 1) that it is an award-winning software system, and therefore has admirable features, and 2) that it provides an effective pedagogical model for math teachers.

Research from Mishra and Koehler (2006) found that math teachers need to know how to represent math content while using technology in the teaching of mathematics. Research from Scandrett (2008) found that math teachers need to always start by using concrete models in geometry using manipulatives like geoboards, which provide a concrete model of understanding. Rosen & Hoffman (2009) have found that teachers need to connect students understanding from the concrete to abstract and using virtual manipulatives and software like GeoGebra better help make those connections to representational models connecting the concrete using geoboards to something oven more abstract in understanding. With the availability of GeoGebra, teachers are able to make graphical representations of math concepts. As the concepts are introduced with pictorial representations, teachers and their students are able to make the connections between the pictures, the math concepts, and the symbolic representation.

GeoGebra is Great for STEM and Fostering Creativity

Research on teaching using GeoGebra indicates many reasons to use GeoGebra some of which are: that it is free to download and use from GeoGebra.org; it is an up and coming dynamic teaching tool in our schools today, dynamic for learners; it is user-friendly for students and teachers; it lends itself well to connection from the hands-on Geoboards to virtual Geoboards to something even more abstract; it is a software that provides many resources and teaching tools at its wiki for educators at: http://www.GeoGebra.org/en/wiki/index.php/Main_Page; GeoGebra may be used for primary-aged students through college: and lastly it is fun, easy to use, and students learn a lot about geometry, algebra, measurement and beyond by using this dynamic learning tool.

Mathematics teachers may ask why it is important to make connections and excite students about learning math while using GeoGebra? To answer this educators will find that when using GeoGebra, educators will be able to: show a purpose for math; develop relationships between math concepts and shapes and ideas; the software will show practical applications to math in life; it employs innovative teaching in the classroom; it stimulates through photography/modeling; it employs emerging technologies in math with the real world application; and it can address math anxiety so students feel confident for any STEM field when they graduate from school.

Figure 12. Using GeoGebra to Foster Creativity

The motivation factor is one critical component to using GeoGebra, but also teachers need to use the technology to also foster creativity. We want students who are confident in their ability to do mathematics. When we turn them on with children's picture books, photographs, and encouraging them to use GeoGebra we can make better connections for their learning and exciting them about mathematics as then take it a step further and foster students' creativity to create designs, art, engineering, and programming with the software to create and foster more creativity and ingenuity with the GeoGebra software. Tejera et. al (2023) found using GeoGebra and 3-D printers as a means for modeling and fostering creativity in the learning of mathematics as well. See Figure 12 with some examples of student creations with GeoGebra. A famous quote from W. V. Williams (1988) is a reminder of how critical it is to teach for understanding making things as hands-on and real world as possible: "Tell me mathematics, and I will forget; show me mathematics and I may remember; involve me...and I will understand mathematics. If I understand mathematics, I will be less likely to have math anxiety. And if I become a teacher of mathematics, I can thus begin a cycle that will produce less math-anxious students for generations to come" (p. 101). Today math teachers need to break the cycle of math anxiety and address it, and by using GeoGebra and making connections with photography, teachers can better connect the math they teach to students and their understanding while using emerging technologies like GeoGebra.

Research by Furner (1999) also made these related observations as they relate to the importance of mathematics confidence: "If math teachers do something about helping their students to develop their confidence and ability to do math, we can impact their lives in a positive way forever." In addition, "Our students' careers and ultimately many of their decisions they will make in life could rest upon how we decide to teach math. We must make the difference for the future of our kids in an ever growing, high-tech, competitive, global world which depends so heavily on mathematics."

Summary

Math teachers today need to employ many of the best practices for teaching mathematics to motivate young learners for a STEM World. Using math manipulatives, photography, and GeoGebra can all help better make connections for learning math and making it more meaningful while also developing confidence while learning mathematics, such best practices help:

- To show a purpose for math
- To develop relationships
- To show practical applications to math in life
- To make connections
- To incorporate literature and reading in the math class
- To employ innovative teaching
- To stimulate through photography/Modeling
- To employ emerging technologies in math with the real world like GeoGebra
- Address math anxiety so students feel confident for any STEM field when they graduate from school

Today young math learners are intrigued by technology and can construct and investigate geometric shapes and many math ideas with GeoGebra and will start enjoying math and have less math anxiety in our STEM World that we now live in. By using emerging technology like GeoGebra and photographs, our young learners who are often intrigued by technology will construct and investigate geometric shapes with GeoGebra and start liking and enjoying math more and will optimistically be less math anxious in the years to come so to pursue any STEM field of their liking. There are many free resources for math teachers Grades K-12 to download which are in Appendix A.

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Appendix A: GeoGebra and Math Confidence Websites and Resources for the Math Classroom

Geoboard Resources	http://msteacher.org/epubs/math/QuickTakes/geoBoard.aspx
GeoGebra	http://GeoGebra.org
GeoGebra Wiki Forum	http://www.GeoGebra.org/en/wiki/index.php/Main_Page
GeoGebra Data Files	http://matharoundus.com
Math Academy	http://www.mathacademy.com/pr/minitext/anxiety/
Mathitudes Online	http://www.fau.edu/education/centersandprograms/mathitudes/

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