TRANSFORMATIONS

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Transformations:
A Journal of the Florida Association of Mathematics Teacher Educators

SUBMISSION OF MANUSCRIPTS

Manuscripts for the journal should be double-spaced for 8.5 x 11" paper. Send manuscripts as attachments from Microsoft Word via e-mail. Illustrations should be camera ready and saved in .gif or .jpg format. Please include a short biographic statement about you and any co-authors. Include your e-mail address and a telephone number. Articles should be no longer than 10 pages double-spaced. Send submissions to:

Angie Su, shuifang@nova.edu

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Joan O'Brien
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From the President's Desk…

Dear Mathematics Educators:

I am excited that the Winter issue of the Transformation Journal is ready for your use. This Journal is made available online through NSUWorks. I encourage you to submit your research articles so that we can share with the mathematics educators around the country. I also invite you to nominate a colleague or self-nominate to serve on our Board so that we can help make a difference in the K-22 mathematics education community in the State of Florida and throughout the country.

As an affiliate of the Florida Council of Teachers of Mathematics (FCTM), I am looking forward to achieving the following goals over the next two years:

1. Annual FAMTE Conference to promote the improvement of Florida's mathematics instructional programs and to promote cooperation and communication among the teachers of mathematics and mathematics teacher educators in Florida.
2. FAMTE Board represented by at least one K-12 Mathematics Teacher educators.
3. Promote scholarly publications.

With Warm Regards,

Hui Fang Huang "Angie" Su,
FAMTE President and Editor of
Transformation

NSU Florida
NOVA SOUTHEASTERN UNIVERSITY

Transformations

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Article 1

November 2023

Creating Mandalas for World Peace While Incorporating Mathematics, Art, Literature, Writing, and Technology

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Creating Mandalas for World Peace While Incorporating Mathematics, Art, Literature, Writing, and Technology

Abstract

Across the USA there are more and more students whose parents are from around the world. It is important teachers can effectively teach mathematics to reach all students, particularly those with limited English proficiency, while establishing interdisciplinary and cultural connections and even working toward world peace. The purpose of this paper is to share how a class of students from an elementary school in South Florida with their teacher created mandalas to teach mathematics, art, writing, and even world peace to their students. Math teachers should strive to bridge the cultural gap among all students by incorporating innovative ideas as well as art, historical and cultural connections into their teaching so to foster understanding, appreciation, and tolerance for the richness inherent in diversity and a sound understanding of mathematics and art appreciation for other cultures which may even promote world peace as well as lowering math anxiety in a creative and meaningful ways. This paper shares a lesson plan activity using mandalas to teach mathematics while also incorporating writing, technology, art, and having students think about world peace.

Keywords: Mandalas, Mathematics, Geometry, Algebra, Art, Writing, Technology, Literature, Peace

Creating Mandalas for World Peace While Incorporating Mathematics, Art, Literature, Writing, and Technology

Introduction

The purpose of education is to awaken joy in creative expression and knowledge.
-Albert Einstein

The mandala is a microcosm within itself, a tiny representation of the universe where myriads points unite and oppose each other to achieve a harmony of peaceful unity.

-Peter Patrick Barreda

Lake Worth, Florida, just south of West Palm Beach boasts one of the largest populations of Mayans outside of Mexico and Guatemala it also has a very high Haitian population. Schools like Indian Pines Elementary School in Lake Worth have very high populations of English Language Learners (ELL), many whose parents are from Mexico, Guatemala, Central America, South America, and Haiti originally, but with their children born here in Florida. This paper shares a project with one of the Second Grade Teachers here, Mrs. G and how she worked with the author and professor at a local university to create a project that integrated mathematics, art, writing, and with efforts to work toward world peace.

Effectively teaching mathematics to all students, and particularly those with limited English proficiency (LEP), means making interdisciplinary and cultural connections while integrating subject areas like math, language arts, and visual arts. Mathematical notations may not share cultural uniformity and for children from diverse backgrounds these differences may present obstacles to learning (Crandall, 1987; Dale & Cuevas, 1987; Moore, 1994; Diaz-Rico & Weed, 1995). Exploring the historical and cultural variants in mathematics can help all students develop experiences and background knowledge. Standards for teaching mathematics developed by NCTM (1989) and best practices suggested by Zemelman, Daniels, and Hyde (2012) emphasize the importance of relating mathematics to prior knowledge, background, real life situations, manipulatives, and technologies. Also, Salazar (2019) found that working with and coloring mandalas had an impact on students' math anxiety level and making students feel more comfortable with the math they are learning when exploring with mandalas.

The study of the cultural and historical contexts of ancient civilizations can be an intriguing way to introduce students to the evolution and logic of today's mathematics (Bidwell, 1993). This paper brings up an issue of ethnomathematics which is beneficial for students to be exposed to as they learn important mathematics concepts, while learning about the mandalas students can explore different cultural ways of using mathematics in diverse cultures. This also helps to highlight such connections where educators can further emphasize that students learn most effectively when taught in ways that resonate with their various ancestral cultural backgrounds. The purpose of this article is to: 1) to explore the

mandalas; 2) to provide suggestions for infusing TESOL (1991) strategies into planning and teaching; 3) to make recommendations to infuse more historical and cultural connections into the math curriculum; and 4) to suggest the use of math, art, writing and even infusing technology as part of math instruction. This lesson plan offers students to learn many math concepts as can be see in the lesson plan (See Appendix A) and cover state math objectives required for the learner (Florida Department of Education, 2020).

What are Mandalas?

A mandala is also known in Sanskrit meaning "circle" and is usually an artistic representation of higher thought and deeper meaning given as a geometric symbol used in spiritual, emotional, or psychological work to focus one's attention. The images of mandalas showed up first in India around c. 1500 - c. 500 BCE however they have been used by many cultures around the globe in many different times up to our present time period (Mark, 2020). Policar (2009) shares how important it is as students learn about geometry and shapes, they can use them as they create mandalas and then there is a better connection to the mathematics and the actual mandalas. Creating the mandalas can become the entire geometry curriculum as you can cover so many math topics as you create the mandalas (See sample mandalas in Appendices A and B).

The meaning of a created mandala often depends on the individual person creating or observing such an image, often mandalas in most culture serve, more or less, the same purposes of centering an individual or community on a given narrative in order to encourage introspection and, ultimately, an awareness of one's place and purpose in the world; this awareness then allows for peace of mind which is a beautiful thing for all of us to consider creating and exploring. What the mandala may represent to one person it essentially often reflects order and peace and it is understood as an almost self-created image of such order. Most mandalas are round or circular, but they can also be square and always enclosed (Mark, 2020). Such activities like suggested in this paper relate to Eco art where you tie in art and the environment/world into you lesson as cited in Geffen et, al (2022). This activity ties math with world peace and various cultures.

A Mathematics Lesson Using Best Practices While Creating Mandalas

As part of this project on mandalas, please see Appendix A and B for sample mandalas created by students and suggested lesson plan ideas. Possible Math Lesson Scenario (See Lesson Plan in Appendix A and Sample Mandalas in Appendix B created by students from this lesson plan activity)

Mrs. G., the classroom teacher, explained to the students about mandalas and showed many examples from books, videos, and even some stories from some children's books related to them. The resources can be found in the sample lesson plan below. After the students learned about mandalas and saw some samples in books, online, in videos, and children's literature, they were given the opportunity to create their own mandalas. The teacher created many shapes and cut outs for students to use to paste and create their own design for a mandala with the shapes, they were allowed to glue on the shapes on to paper plates, using the round plates since mandalas use circles and centers, the design is focused around the circle from the center out or from the border to the center. Students were allowed to draw and explore, creating designs and also using patterns, shapes, colors, and transformations like symmetry, rotations, reflections, transformations and tessellations on

the mandalas. Students were taught that the mandalas help to center people and also bring peace. They were also asked to write a short story/statement of how their mandala design can contribute to peace or bring peace to others and the world and why peace today is so important in our world. Stang (2006) shares about the circle and dividing it in to various parts as you create the mandala, looking at all the math, art, design, and even fractional parts that can be covered by teaching using mandalas.

Following the whole class sharing session with books, videos, and stories, the students worked in pairs at computer stations where they visited websites and took an "Internet field trip." The students saw many types of mandalas, with various designs, colors, shapes used, colors, and allowed them to discuss feelings as they explored with classmates. Johnson and Stemple (2005) discuss how math, art, and technology are at a cross roads and we as educators need to make better connections to using more technology in the classroom and how important it is too that students see the math in art and vice a versa as they learn important concepts. Zhou (2018) advocates using arts and technology in the teaching of mathematics and connections help in the learning of the content area one is focusing on. (See the Lesson Plan in Appendix A for the Technology connections).

After the computer session, the students worked in groups of four where they used paper plates, white round large paper plates and cut out shapes from the pattern block manipulatives, where they could also trace the shapes, create their own designs, and explore making many designs. They were also offered crayons and other resources in their mandala designs. The students had already learned from their website experiences that what a mandala looked like and many examples. The connection between the larger white paper plate and the smaller colored shapes and designs were emphasized and the students were encouraged to create designs so to include geometric patterns, designs, symmetry, transformations, etc. using a variety of colors to make their own personalized mandalas (See Photos in Appendix B for Student Samples). Carpenter and Gandara (2018) advocate from their research that teachers incorporate art ideas within the content areas like mathematics and such activities like the mandalas help make better connections in a collaborative way for our learners today.

This math lesson is interdisciplinary in that it incorporates literature, technology, manipulatives, multicultural experiences with mathematical concepts, and then students were asked to write a story to go along with their mandala to talk about peace and how their mandala can bring peace and center someone by using it. It is critical today that students incorporate writing into their math learning. Also, making connections to the world, the mandalas connect to math by the geometric designs that are created, and use shapes, colors, designs, and geometric transformations to develop the mandala. Students can see the connections to math, and also try to feel centered and stretch to have them focus on how these designs can help student image peace, centering, and bring some cultural connections to mathematics. Such interdisciplinary connections are advocated with research by Zhou (2021).

Mathematics Concepts and Integration Involved for this Lesson

This lesson on mandalas can be very powerful for our young people. While it is not only teaching young people about peace, meditation, and being centered. It is also covering many mathematics concepts that have to be covered in today's math curriculum such as: geometry, algebra and patterns, shapes, geometric transformations like rotations,

reflection, and transformations, symmetry, tessellations, colors, design, etc. Students can also use the math manipulatives like pattern blocks and tangrams to trace and use as part of their own individualized created mandalas. While learning the mathematics students are also able to make connections to the art as well and see how shapes, geometry, and math are found in art and in mathematics and make the connections as they learn while also employing creativity in the process (Jarvis and Naested,2012).

Apart from the math that is being learned and applied, students can read books and literature about mandalas, explore websites, maybe even use sketching software like GeoGebra, and others to make designs and transformations for their created mandala. Students can also be encouraged from their books and literature and information on mandalas to write stories about peace and how their created mandalas can bring peace to others and the world and how their mandalas can bring such centering, meditation, and peace. It is critical today when teaching that interdisciplinary connections are made for our young learner for their lives (Zhou, 2021). Gorkin and Kilmer (2015) advocate for teaching math using mandalas and emphasizing the math when creating them covering many mathematical ideas. Zhou (2021) advocates that it is important as educators to connect art, culture, science, and technology and describing nature through visual data like seeing the math and geometry in a mandala as well as seeing mandalas from various cultures.

All students, particularly those who are reluctant mathematicians or who are limited in their language proficiency, can benefit from the high interest and risk-free nature of the learning experiences in creating mandalas. Groman (2021) also emphasizes that when teaching mathematics, we need to incorporate creativity in the teaching of our subjects and what better way to do this then to have students create mandalas as they learn mathematics and employ their own creativity in the process. Various resources can be used to modify and enhance the lesson to meet diverse populations of students while incorporating math, writing, art, and technology (See Appendix A-The Lesson Plan and Photos by Students of their Mandalas).

Summary

Teachers in today's mathematics classroom are confronted with the challenge of meeting the needs of students with diverse needs and backgrounds. The NCTM *Standards* and the literature on diverse learners suggest that all students may benefit from strategies which promote cultural and historical connections and the use of technologies like GeoGebra and manipulatives which focus upon the active engagement of students through exploration and communications. Incorporating mandalas while using technology, math, writing, and creativity today are critical for our STEM students in this advancing technological era.

In a passionate plea for bridging the culture gap in our classrooms, Moore (1994) proposes that "Mathematics is definitely not culture-free...no mathematics teacher could even contemplate seriously taking only the values of his culture and a textbook which is a product of his culture and imposing both himself and the textbook upon individuals possessed by a culture that diverges from his in any significant area." (p. 13).

Teachers who use a variety of resources and who incorporate innovative ideas like creating mandalas into their teaching in order to make learning more meaningful will find students more interested in mathematics. Salazar (2019) found that coloring mandalas had an impact on students' math anxiety level too and making students feel more comfortable

with the math they are learning. Bridging the cultural gap in mathematics instruction will profit all students as they becoming more understanding, appreciative, and tolerant of one another and each other's cultures while teaching mathematical ideas.

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Appendix A

Sample Lesson Plan on Creating Mandalas in Math Class

Developing a Math Lesson on Mandalas

The following are suggestions for incorporating the mandala into a teaching unit in math class. The lessons might be taught from an interdisciplinary, integrated curriculum perspective, and modified to meet age-appropriate needs of the students. This lesson too can serve in reinforcing concepts related to geometry, patterns, shapes, and spatial sense. The strategies specifically include effective learning techniques for ESOL students (English for Speakers of Other Languages).

Learning Objective(s) [Florida BEST Math Standards]:

MA.2.GR.1 Identify and analyze two-dimensional figures and identify lines of symmetry.
MA.2.GR.1.1
Identify and draw two-dimensional figures based on their defining attributes. Figures are limited to triangles, rectangles, squares, pentagons, hexagons and octagons.
MA.2.GR.1.2
Categorize two-dimensional figures based on the number and length of sides, number of vertices, whether they are closed or not and whether the edges are curved or straight.
MA.3.GR.1 Describe and identify relationships between lines and classify quadrilaterals.
MA.3.GR.1.1
Describe and draw points, lines, line segments, rays, intersecting lines, perpendicular lines and parallel lines. Identify these in two-dimensional figures.
MA.3.GR.1.2
Identify and draw quadrilaterals based on their defining attributes. Quadrilaterals include parallelograms, rhombi, rectangles, squares and trapezoids.
MA.3.GR.1.3 Draw line(s) of symmetry in a two-dimensional figure and identify line symmetric two-dimensional figures (Florida Department of Education, 2020).

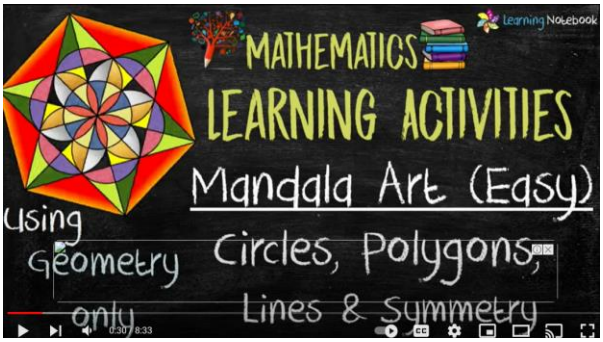
Menu of Suggested Activities:

Menu of Motivation (Initiating) Activities

1) Pairs of students (one of which is an ESOL student) will take and Internet Field Trip and visit websites to read about mandalas
2) Students view some videos on YouTube about Mandalas like:

https://youtu.be/WbZsG0pkYtQ

and



https://youtu.be/wH0QOLqNJM8

3) Students meet in discussion groups. Possible topics for discussion might be:
   a) defining terms such shapes, symbols, geometric transformations
   b) describe similarities and differences between shapes, colors, designs

Explore research on the psychology of shapes, according to Looka.com, they provide some useful information about the psychology of shapes which gives learners the upper hand when designing a logo. By working with the subconscious meaning behind each shape, you'll better communicate your brand and set the right foundation for your logo.

According to Looka.com, the attributes associated with basic shapes:
Circular shapes: Unity, community, friendship, stability, feminine
Triangular shapes: Masculine, power, law, science
Square shapes: Strength, efficiency, professionalism, practicality
Vertical lines: Aggression, masculinity, strength, progress
Horizontal lines: Calm, tranquility, community, speed

Menu of Core Activities

1) Create a mandala
2) Decide on shapes, design, symbols, colors, patterns to us
3) Create mandala with a theme and connect it with writing
4) Read literature which relates to cultural differences in mathematics (particularly Mandalas).
5) Develop and refine discussion groups and paired activities as students each create their own mandala and write a story about it. Possible questions for discussion group:
   - Can you create a mandala?
   - Why do you think Mandalas show up in cultures?
   - How do mandalas compare in different cultures?
   - Why do you think mandalas are appealing to humans?
6) Practice learning about and seeing many different mandalas.
7) Write reflective essays or story about your mandala and peace.
8) Create a mandala with some geometric characteristics and share.
9) Keep a journal of math activities and ideas.
10) Illustrate Mandalas with a selected artistic medium such a magazine photo collage, penciled sketch, etc.
11) Locate additional books and websites about Mandalas and art.
12) Have students explore, create mandalas and write how it can help with world peace.
13) Invite parents and selected community guest speakers who are knowledgeable about the mandalas and art in the world.

Bibliography of Sources for Lessons in Teaching Units on Mandalas

Books for the Lesson with Students

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Cunningham, B. (2003). *Mandala: Journey to the center.* DK ADULT Publishing: NY, NY.

Dahlke, R. (1992). *Mandalas of the world: A meditating & painting guide.* Sterling Publishing: NY, NY.

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Videos/Films

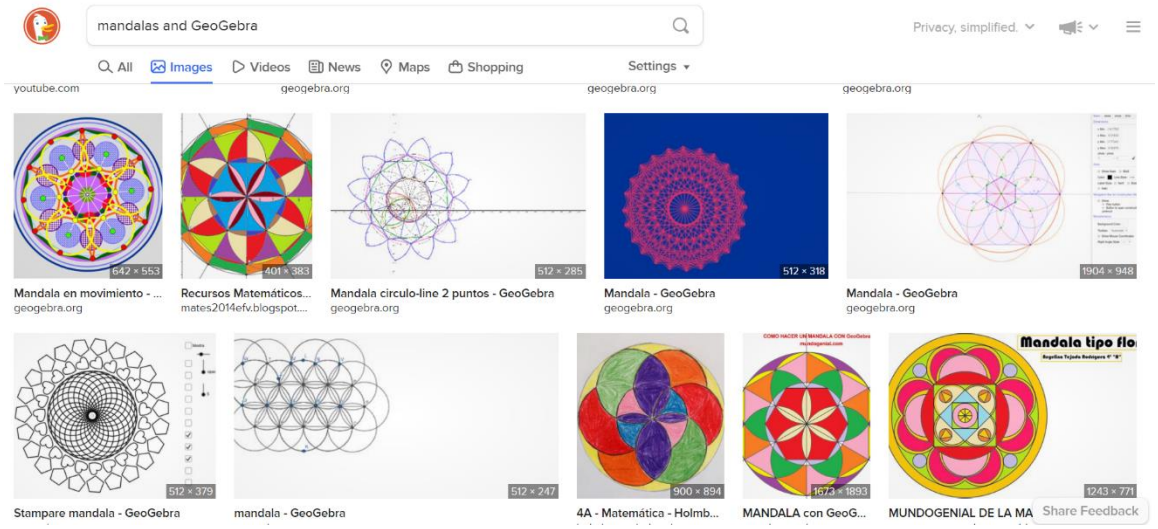
Watch the YouTube Video about How to Create Mandalas with GeoGebra at: How I make mandalas with Geogebra - YouTube at: https://www.youtube.com/watch?v=dhgDoLHq5Y4

Internet Websites

Mandala – GeoGebra at: https://www.geogebra.org/m/jjkabrzw
And https://www.geogebra.org/m/vzBncpYw
https://www.slideshare.net/eam9/mandalas3-31999608

https://www.pinterest.com/pin/circle-mandala-geogebra--393853929887319565/

Mandala Examples Online



Other Children's Books Related to Mandalas and Center

All I See is Part of Me - Chara M. Curtis
In this international bestseller, a child finds the light within his heart and his common link with all of life.

Fun is a Feeling - Chara M. Curtis
"Fun isn't something or somewhere or who. It's a feeling of joy that lives inside of you." A world of fun and fantasy unfolds as a child finds that the joy of life begins from within.

How Far to Heaven? - Chara M. Curtis
Exploring the wonders of nature, Nanna and her granddaughter discover that heaven is all around them. An excellent book to help children who are dealing with the death of a loved one.

No One Walks on My Father's Moon - Chara M. Curtis
". . .a beautiful story, beautifully told. Indeed, there are many moons. And there are many truths. To see them clearly it's essential that we learn to see the universe through the eyes of others. If we could teach our sons and daughters nothing else, this would be enough." - Ron Atchison, Director of JustCause

Beautfiful Warrior-Legend of the Nun's King Fu - Emily Arnold McCully
A wonderful book with two heroines that use their inner strength to overcome great obstacles. I use this book in some of my workshops and both boys and girls enjoy it.

The Dot and the Line - Norton Juster
A great little book for both children and adults showing the splendors of mathematics, not to mention the value in using one's brain and creativity.

The Phantom Tollbooth - Norton Juster
Milo is a bored little boy who learns to use his brain to get involved in his own life when a special gift magically appears in his bedroom. My introduction to the book was in third grade andI still enjoy reading it to my own kids, as it's full of metaphors to which adults can also relate.
All Children's book can be found on the *Mandala Project Website* at:
https://www.mandalaproject.org/Links/Books.html

Diversity and Interdisciplinary Connections Within the Lesson Plan

The lesson suggestions include provisions which are appropriate for all students and specially ESOL students. Realia and demonstrations develop vocabulary through web site field trips, literature, and study of artifacts of the culture. Prior knowledge and background are enriched through the study of the historical context of the evolution of number systems while developmentally appropriate activities using manipulatives provide concrete examples which reinforce concept development and use math manipulatives to trace and make their own mandalas. Exploring learning through various media such as drawing, painting, sketching, and creating collages addresses learning styles and promote creativity. Discussion about readings, field trips (actual or Internet), activities, and possible guest speakers prompt analytical and critical thinking as well as metacognition by encouraging students to verbalize their perceptions of learning. Interdisciplinary and cultural connections are established through historical and literature readings, discussions of economic and marketplace functions, and explorations of artistic and scientific contributions from learning about mandalas.

Mandala Websites /Graphics to Allow Students to Explore for Ideas and Samples at:

http://www.asounddesign.com/

http://www.mandalapeacearts.org/

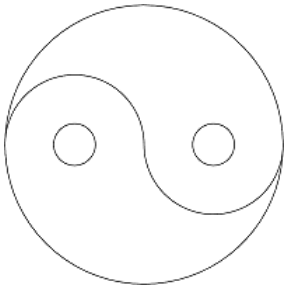
http://www.mandalas.com

http://www.graphics.cornell.edu/online/mandala/

http://www.earthmandalas.com/

http://www.mandalabooks.com/

Example of a Mandala with defined Geometric/Symmetrical Characteristics:

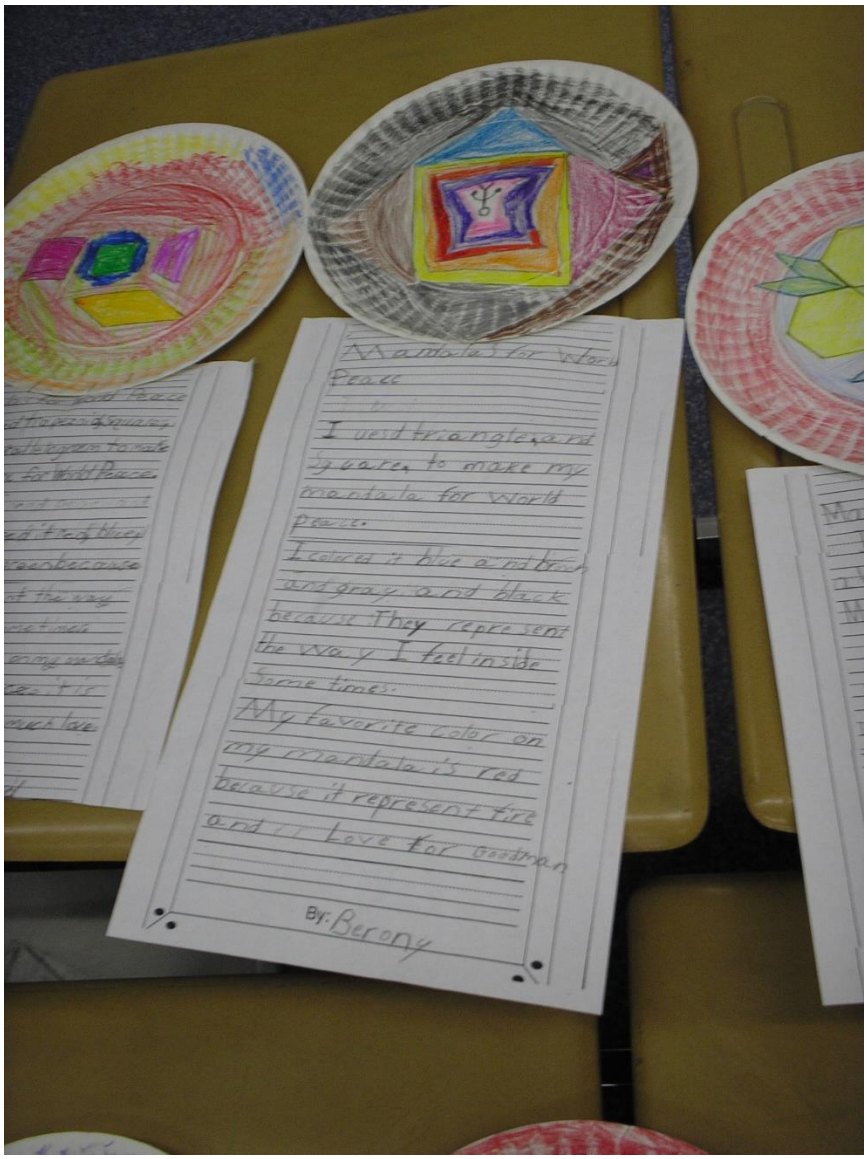


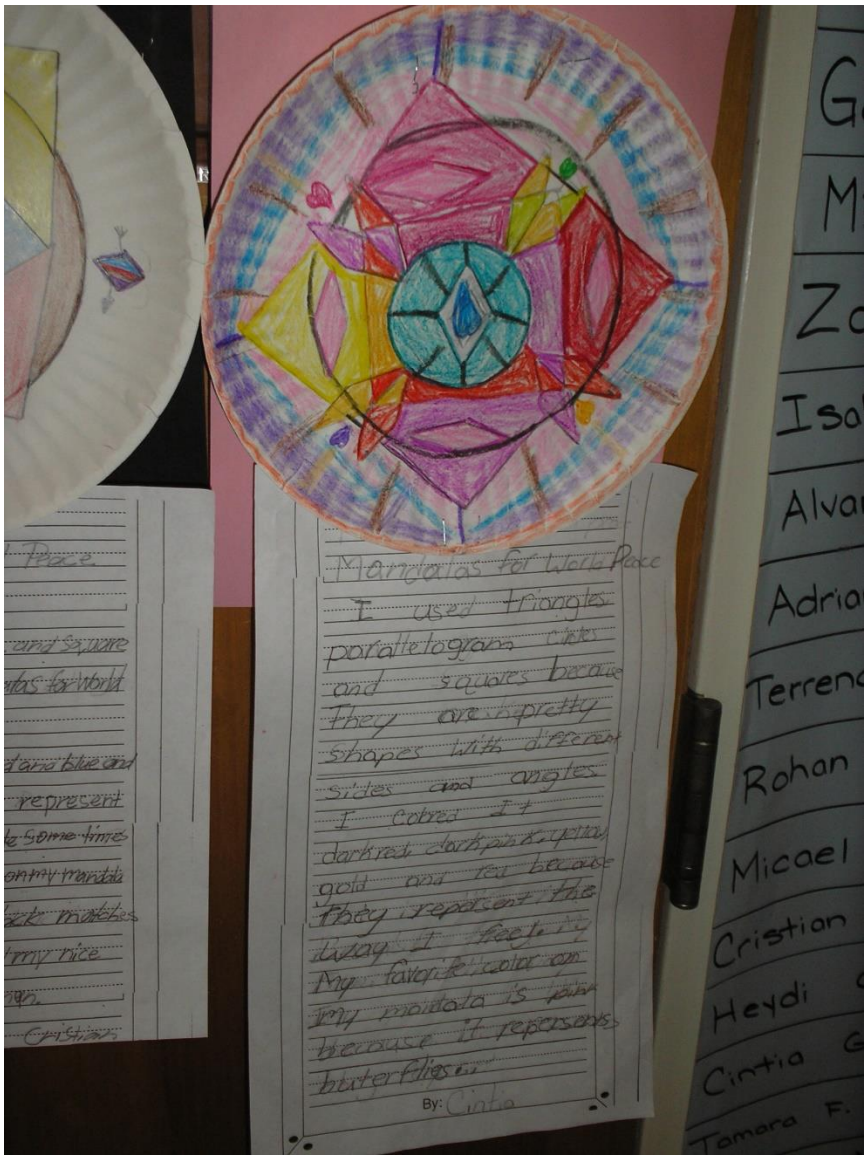
Mandala Peace Arts is dedicated to creating peace through the art of writing Mandala's. A Mandala is an ancient art form. It is a sacred circle that has been used in many traditions around the world. A Mandala can be created in many different ways. The technique we offer is through writing positive words. Thousands of people worldwide have been creating the Mandalas of gratitude and the Mandalas of Bright Words to send forth the written energy of love and harmony. Mandalas can be created regardless of faith, culture, or religion. (Retrieved on February 14, 2023 at: http://www.mandalapeacearts.org/)

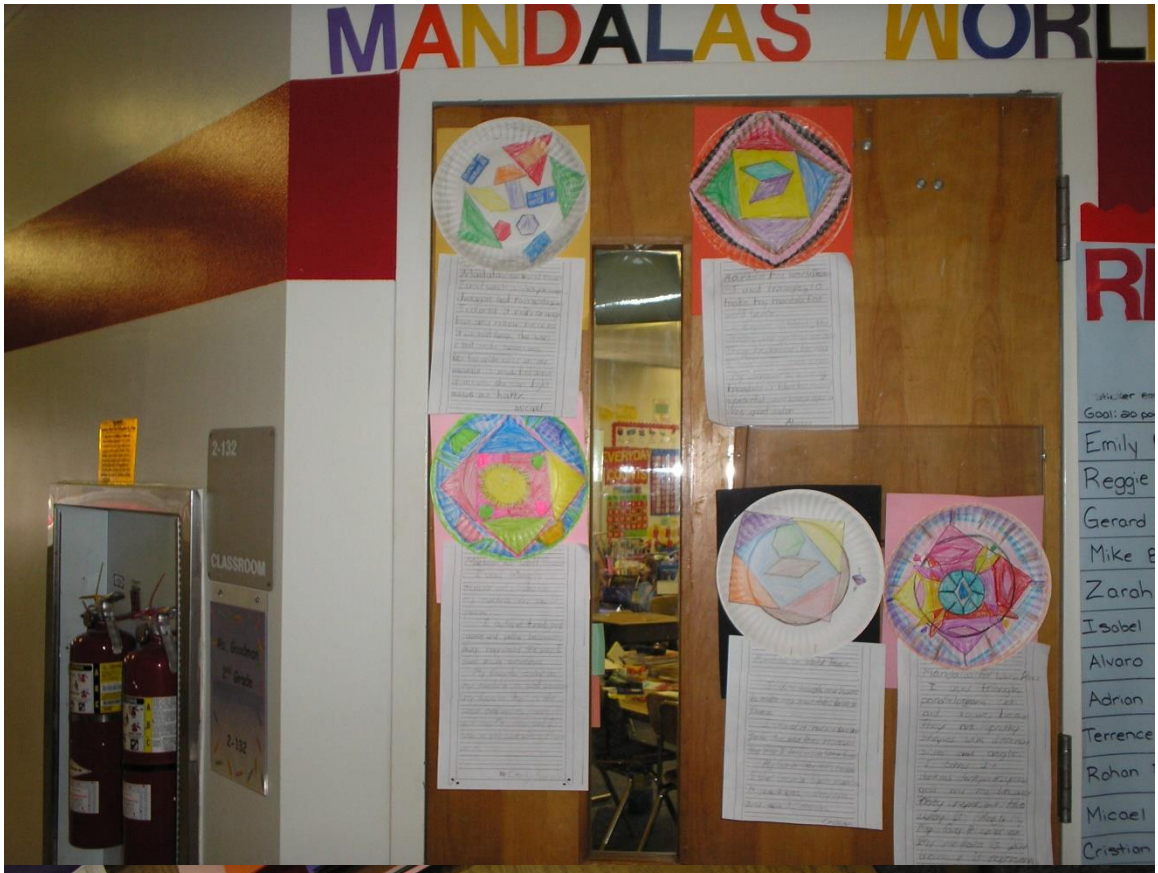
"Mandala (mun'dl-uh), [Skt., circular, round] a concentric diagram having spiritual and ritual significance in Hindu and Buddhist Tantrism. The mandala may have derived from the circular stupa and the ritual of walking around the stupa in a circle. The mandala is seen as a microcosm embodying the various divine powers at work in the universe, and it serves as a collection point for the gods and universal forces. Numbers of deities have specific positions in the diagram, and the symbolism and structure of the mandala are highly elaborated. The mandala symbolizes the totality of existence, inner or outer. Mandalas are used in meditation, particularly in Tibetan Buddhism and Japanese tantric Buddhism. Similar ritual drawings have been found in the sand paintings of Native North Americans and in other traditions." Retrieved on May 6, 2007 at : http://www.mandalabooks.com/) Also, See G. Tucci, *Theory of Practice of the Mandala* (1969); M. Arguelles, *Mandala* (1972); D. F. Bischoff, *Mandala* (1983). For an analytical psychology perspective, see C. Jung, *Mandala Symbolism* (tr. 1972)
~The Columbia Encyclopedia, Sixth Edition

Appendix B

Photos of the Math Art Mandalas by Young Learners


Peace
I used triangle, and
squares to make my
mandala for world
peace.
I colored it blue and brown
and gray and black
because they represent
the way I feel inside
some times.
My favorite color on
my mandala is red
because it represent fire
and the love for Godman
By: Berony


Mandalas for World Peace
I used triangles
parallelograms circles
and squares because
they are so pretty
shapes with different
sides and angles.
I colored it
darkred, darkpink, pink,
gold and red because
they represent the
way I feel.
My favorite color on
my mandala is pink
because it represents
butterflies.
By: Cintia
Heydi
Cintia
Cristian
Micael
Rohan
Terren
Adria
Alva
Isa
Z
M
G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Gerard
Zarah
Isabel
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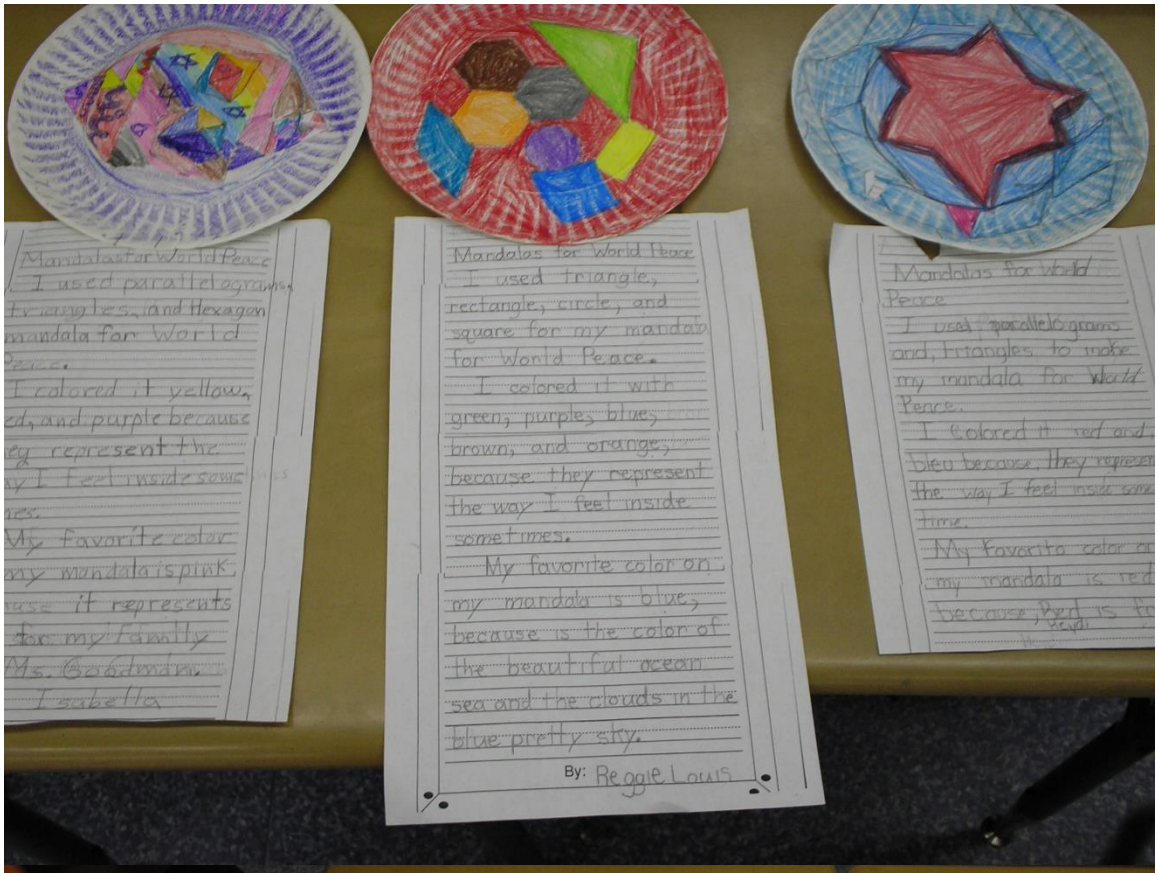
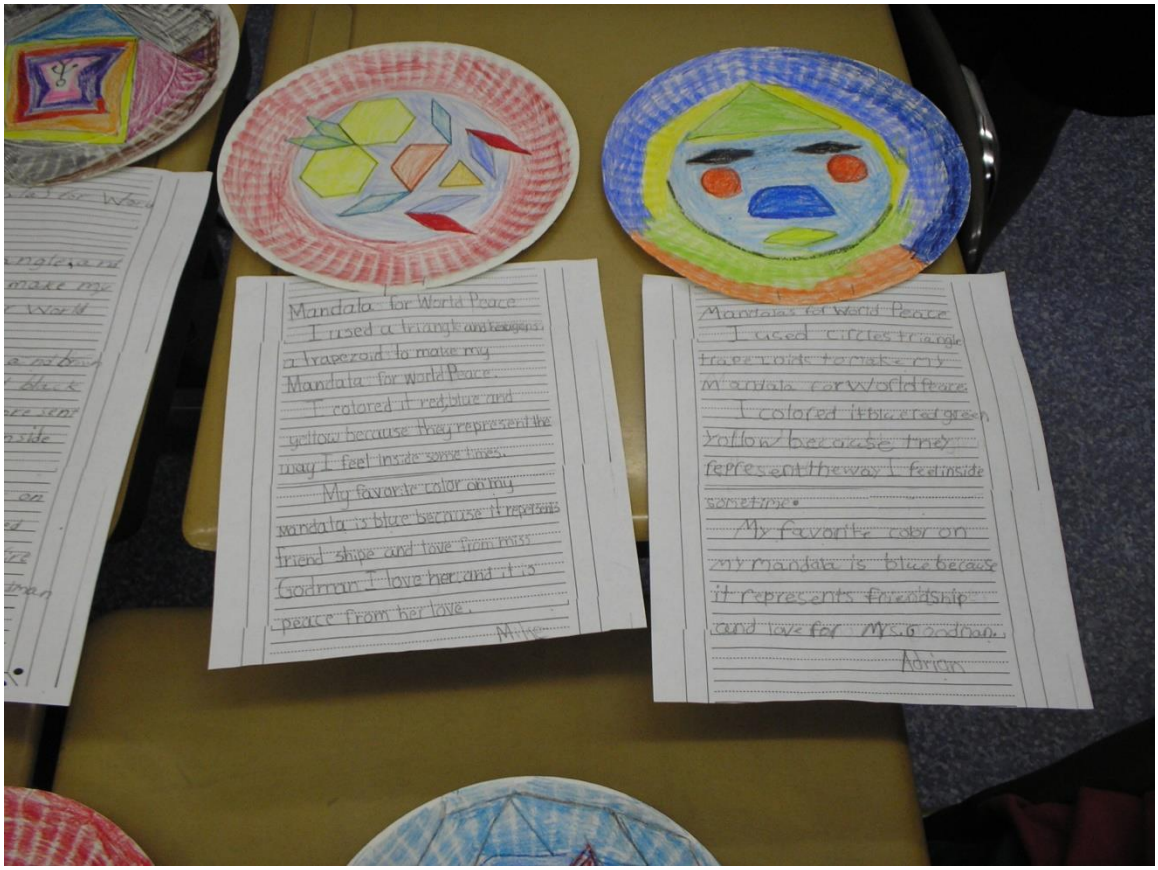
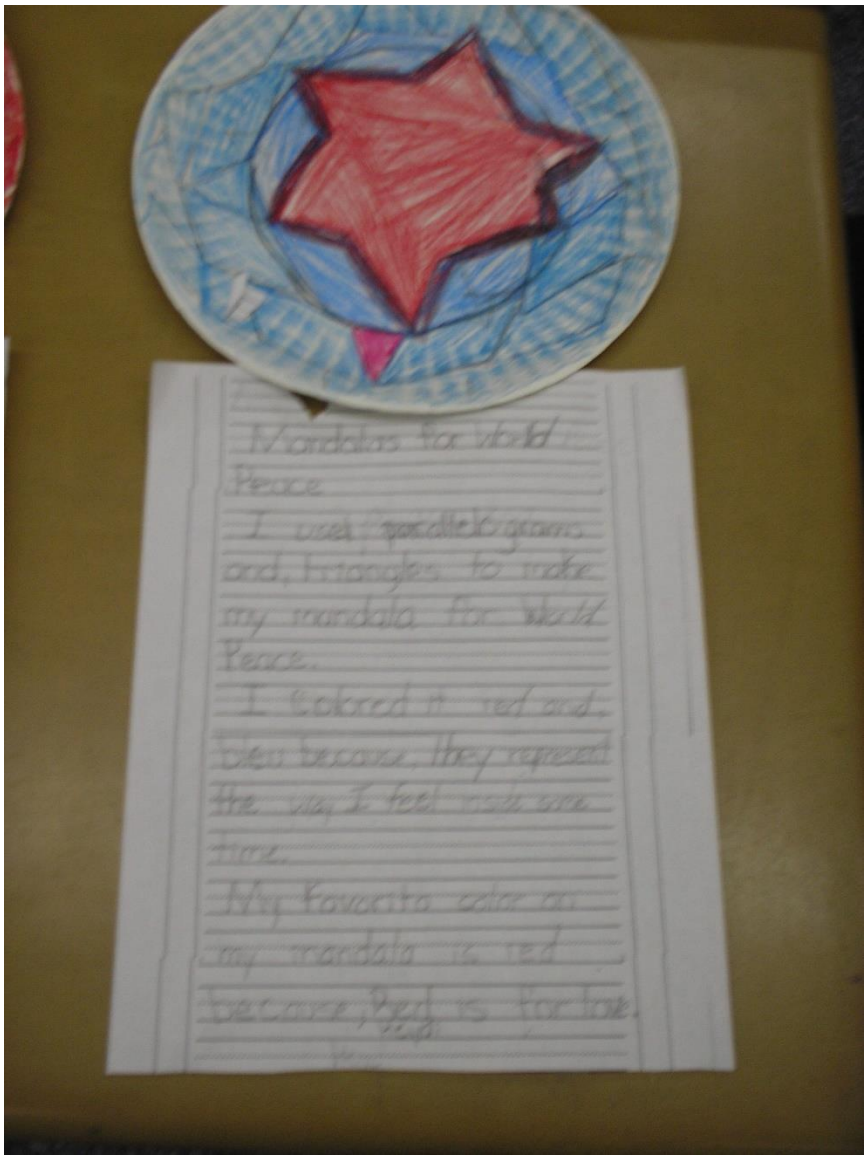
Rohan
Micael


Mandalas for World Peace
I used triangle, rectangle, circle, and square for my mandala for World Peace.
I colored it with green, purples, blue, brown, and orange, because they represent the way I feel inside sometimes.
My favorite color on my mandala is blue, because is the color of the beautiful ocean sea and the clouds in the blue pretty sky.
By: Reggie Louis


By: Berony


Mandala for World Peace
I used a triangle and hexagon, a trapezoid to make my Mandala for world Peace.
I colored it red, blue and yellow because they represent the way I feel inside some times.
My favorite color on my mandala is blue because it represents friend ship and love from miss Godman I love her and it is peace from her love.
Mandala for World Peace
I used circles triangle trapezoids to make my Mandala for world peace.
I colored it blue red green yellow because they represent the way I feel inside sometime.
My favorite color on my mandala is blue because it represents friendship and love for Mrs. Godman.
Adrian



A Special Thank You:

I would like to thank Mrs. Goodman, 2nd Grade Teacher, from Indian Pines Elementary Schools for incorporating the mandalas into her math lessons and being so innovative and creative with her students in her math teaching, and working with me for so many years when I worked with her school and did professional development there. She always had a welcoming classroom and loved to cook and did a lot with math and cooking as well. I really appreciate her inviting classroom to work with as she turned students on to mathematics.

Author Bio

Joseph M. Furner, Ph.D., is a Professor of Mathematics Education in the Department of Curriculum and Instruction at Florida Atlantic University in Jupiter, Florida. His scholarly research relates to math anxiety, the implementation of the national and state standards, English language issues as they relate to math instruction, the use of technology in mathematics instruction, math manipulatives, family math, and children's literature in the teaching of mathematics. Dr. Furner is the Founding Editor of *Mathitudes Online* at: http://www.coe.fau.edu/centersandprograms/mathitudes/ He is the author of more than 100+ peer-reviewed papers and has been cited more than 2,500 times on *Google Scholar*. He is the author of the book, *Living Well: Caring Enough to Do What's Right*. Dr. Furner currently lives with his family in Florida. Please feel free to email him.

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Article 2

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Use of Technology in Mathematics Lessons

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Use of Technology in Mathematics Lessons

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Dr. Joseph M. Furner

Use of Technology in Mathematics Lessons

Abstract

The influence of new technology is one of the most powerful forces driving today's development and evolution of mathematics and math education. The use of technology in the classroom is believed to enhance students' academic performance and attitudes toward learning in today's environment. Technology-integrated math lessons encourage student participation in the learning process, making learning more enjoyable and appealing for the students. As Smaldino et al. (2005) noted, the use of technology in instruction enhances not only the learning capabilities of students but also their motivation, thus, students are more engaged in the learning process. Furthermore, it is thought that when technology is employed effectively in classroom education, it can have significant beneficial effects on the performance or accomplishment of students.

Introduction

Technology provides dynamic opportunities for math instruction in classrooms. Through interesting and interactive media, the learning process can be improved by bringing concepts to life. Using technology excites children, so they become much more interested in the lessons being taught. Since technology permeates every aspect of our lives, adopting digital tools in the classroom can help teachers to grab their students' attention, customize instruction to meet their requirements, and thereby enabling them to understand the mathematical concepts they are learning. Technology has given us new methods to represent and manipulate mathematical data, giving us options for content and pedagogy that we have never had before.

When I first started teaching which was almost fifteen years ago, not much technological resources were able as today. I did not have access to much technology in my classroom. When

I was first hired and was assigned to teach a second grade class, my classroom was right next door to the computer lab. The computer lab was our only source of innovative technology. I remember asking the principal of my school if there were any computers available that can be placed in my classroom for my students to use. She reluctantly told me that she would try to get at least one for my classroom. She mentioned that the school was on a tight budget. She really wanted teachers and students to be able to have access to and utilize various technological tools in class, but there just was not even funds available to provide for all of the classes. It should be noted that this school was a small religious private school in South Florida. I had recently graduated with my bachelors in elementary education and had just completed my student teaching at a school that was really trying to incorporate technology into their lessons in an effort to make the lessons more fun and engaging for students. So at the time I was really eager to incorporate the use of technology in my lessons. I had thirty-four second graders in my class the very first year I began teaching, and I wanted incorporate a variety of strategies such as using technological tools to meet the needs of my students. Since I was fresh out of college, I wanted to utilize the strategies that I had learn in my classes at university and from the student teaching I had just completed so that I can actively engage my students. The principal was able to get me not one, but two desktop computers for my classroom a few weeks after school had started, and I was very thankful. At first, I used the computers for students to play math games on and for reading after they had completed their work, and they were always eager to finish their work to get on the computer. But then, not only did I get two computers, about a month later, I got a Smartboard in my classroom as well. I was ecstatic. This was opening up a whole new world in the classroom. My math lessons and activities had become lot more vibrant and engaging.

Smartboards

The interactivity of the Smartboard is of great benefit to students as it addresses a variety of learning styles. It meets the needs of children who are more tactile and kinesthetic by allowing them to interact with the board. For those who learn visually, presenting math problems in a colorful visual manner is very effective. Students and teachers can write directly on the screen using special pens. They can edit text and images, browse websites, copy and paste research data, watch videos, create graphs and charts, and create engaging presentations. Visually engaging graphics can be manipulated by students and help them better understand the lessons. This technology's foundation is based entirely on active interaction. I really enjoy the interactive features of the Smartboard.

Online Learning

As we know global school closures due to the COVID -19 pandemic forced a sudden switch to online learning. Teachers' competencies were challenged as they had to teach out of their comfort zone. Curriculum, pedagogy, and student results have been impacted across a range of disciplines as a result of teachers and students switching from face-to-face interaction to online settings. Technology was unquestionably an essential instrument for distance learning. As a teacher that taught during the pandemic, I understand how important it is to use the right technological tools to properly engage students and to ensure that learning is taking place. Remote learning really pushed me as an educator to explore math apps and other online resources that would help students visualize and practice what was being taught. I found it a little more challenging to engage students in the math lessons online, but one of the math teachers at my school introduced me to an app called Notability that he was using for his online class.

iPad/Notability

Once I started using the Notability app on the iPad, my students were a lot more engaged, and they were eager to participate in the math lessons because it was a lot more appealing, and it was easy for them to follow along with me while I was teaching them. It made teaching and projecting my lessons online much easier. I used Notability in conjunction with Google Meet to present my lessons synchronously for my students. I was able to share my screen with my students, and they were able to follow along with me, and better understand the concepts I was teaching. I was even able to create notes and audio of my lessons for students to refer to if they needed additional help. Notability definitely enhanced my math lessons and promote student understanding of the lessons.

Kahoot

Game-based learning is designed to balance theoretical content and learning through the use of games. It allows students to explore rigorous learning environments and concepts and targeted learning outcomes (Chen et al., 2018). Utilizing game-based learning is one technological advancement that helps students find learning more engaging. Morten Versvik, Jamie Brooker, and Johan Brand created the educational platform known as Kahoot. I used Kahoot in my online classroom and my students really enjoyed it, in fact, they wanted to play every day. I used Kahoot almost every day to review my math lessons and as a form of assessment for my students. My students were always excited to compete against each other. It definitely made learning math a lot more fun.

Geogebra

The Geogebra software is one example of a computer application used in classrooms as a tool for math instruction. It is designed to aid in the teaching and learning of mathematics,

particularly in the areas of geometry, algebra, and statistics. There are several advantages to using Geogebra software as a supplement to math instruction. For example: Instead of using a pencil, ruler, or compass, geometry drawings may be done quickly and precisely, by employing the animation capabilities and virtual displays in the Geogebra program, students can quickly grasp geometry and get real-world visual experience. The many features offered by Geogebra software helps students in rapidly, precisely, and effectively visualizing abstract geometric shapes. I really enjoy teaching using Geogebra and my students love it as well. It is fun and engaging.

Student Performance

The article, Impact of Use of Technology in Mathematics Lessons on Student Achievement and Attitudes, highlights the findings on a study where it was investigated whether or not the use of appropriate forms of educational technology had a positive effect on attitudes and enhanced the achievement of students in math. The study employed a quasiexperimental research design with three experimental groups. A pretest and a posttest were completed by all groups. Lessons for the control groups were taught using conventional teaching techniques, whereas lessons for the experimental groups were created utilizing a variety of technological tools.

At the conclusion of the study, the experimental groups filled out a scale to look at the preferences and attitudes of the students about technology-based instruction. The findings also indicated that students' attitudes on using technology were favorable. The results showed that many of the students preferred to be in a class where educational technology was used. Also, when the pretest and posttests results were compared at end of the study, the results showed that students who received technology-enhanced instruction in mathematics performed much better

on the posttests than students in groups who received traditional instruction. Bitter and Pierson (2005) stated: “A recent meta-analysis demonstrated that students using technology had positive gains in learning outcomes over those students who used no technology” (p. 107). This article emphasizes that scholars have opined that incorporating technology into the classroom improves learning by bringing the outside world into the classroom, enhancing instruction, and assisting students in developing a broader perspective.

Conclusion

In conclusion, technology use in the classroom is steadily growing and developing, and it is crucial to integrate it into the curriculum to better prepare students for the future. Technology is widely employed in schools in the majority of industrialized nations. It helps students to create a positive mindset when it comes to learning mathematics. The use of technological tools can enhance student learning and result in greater math performance. It is evident that it aids students in their appreciation of mathematics and it enhances their mathematical thinking and understanding. In order to help students with problem solving, it is important to combine various digital tools and resources to build an integrated digital learning environment. When technology is used appropriately in classroom instruction, it has a very positive impact on student achievement, which will result in more learning for students, and that is our ultimate goal as educators.

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Article 3

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How Math Anxiety Affects Educational Trajectories

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Introduction

I excelled in math and really enjoyed it until the 6th grade; that's when I had a very stern teacher named Mrs. Kucs who yelled at me because I just couldn't understand fractions. She would take me out into the hall and reprimand me because she couldn't figure out why I wasn't getting it. She made me feel really, really stupid. That was the year my math anxiety began, and it never fully stopped. I chose to do the bare minimum in high school for math classes, which affected my college applications. I scored high on the verbal portion of my SATs, but I only took the test twice because I hated the math part and scored fairly low on that section. I also avoided any majors in college that would require too many math classes. Like me, many people suffer from math anxiety, especially females. Unfortunately, also like me, many of these individuals make educational and career decisions that avoid this anxiety. Since it's so prevalent, hopefully educators can make a positive impact through different teaching strategies.

What is Math Anxiety

According to the American Psychological Association, "math anxiety is defined as apprehensiveness and tension associated with the performance of arithmetic and other mathematical tasks. It frequently causes distress, disrupts the use of working memory for maintaining task focus, negatively affects achievement scores, and potentially results in dislike and avoidance of all math-related tasks." Unfortunately, math anxiety negatively affects many people throughout the world, with the majority of those being females. According to the National Library of Medicine, a staggering 93% of surveyed adults in the United States say they have suffered from math anxiety, with 17% having high levels of anxiety. Math anxiety has been shown to have emotional, physiological, and cognitive effects on individuals, even affecting working memory. Physiologically, people experience increased heart rates, upset stomachs, clammy hands, and lightheadedness.

How Math Anxiety Affects Primary Education

Mathematical anxiety has been widely studied and documented over the past 70 years since it was first discussed in the 1950s by an educator who published a paper on her student's "emotional difficulties" with math. Since then, several published studies have shown a link between math anxiety and working memory with primary school children. One such study that was documented in the The Impact of Mathematics Anxiety on Primary School Children's Working Memory (2012), determined through the researchers' findings that just the presence of

numerical data caused a decline in working memory for the 9 to 10-year-olds studied and correlated to the reported instances of math anxiety. In another study, researchers Ashcraft and Kirk (2001) found that their study subjects with high math anxiety were more negatively impacted when tasked with the assignment of math involving carrying while concurrently completing a task that involved working memory. “The findings suggested that attention to their mathematical anxiety was competing for participants’ cognitive resources.” Many researchers have theorized that the central executive system, which is responsible for working memory, plays an important role in mathematical tasks. “Even a relatively small disruption in central executive functioning could be sufficient to make a considerable difference to mathematical performance.” The same research suggested that there is a cyclical nature to math anxiety because when it causes decreases in math performance, then that in turn, causes more math anxiety.

How Math Anxiety Affects College Education

Several studies discuss how math anxiety leads students to avoid math classes, including STEM courses. One such study, found evidence that the association between math anxiety and lower STEM grades was strongest among students performing well in non-STEM courses. “This result supports the notion that math anxiety can prevent otherwise high-achieving students from realizing their potential in STEM, suggesting that math anxiety may be a particularly pernicious contributor to the ‘leaky pipeline’ in STEM, possibly preventing talented students from succeeding in STEM courses.” Having math anxiety is especially stressful for the students who are otherwise accomplished, high-performing students. When I was attending college, I took only what math courses were required to graduate. I purposefully chose not to pursue careers that would require too many math courses, such as marine biology and business, two of the careers I had wanted to pursue when I was younger. “Many students who suffer from mathematics anxiety have little confidence in their ability to do mathematics and tend to take the minimum number of required mathematics courses, which greatly limits their career” (Eispino et al. 2017).

Gender Roles & Math Anxiety

According to a study published by Behavioral and Brain Functions (2012), more than 400 secondary school children, ages 7-10, were evaluated for math anxiety, revealing that females were affected by math anxiety much more than their male counterparts. The study found that although females have more anxiety, their performance scores were still comparable to that of the boys. So, while academic performance wasn’t affected, the anxiety still exists in greater numbers for

females and may result in mathematical avoidance. A recent study, published in PLOS One Journal (2016), looked at survey results from approximately 5,000 college students who were on a STEM career path through college. The researchers asked students who switched out of STEM after Calculus I why they chose to change their path. Thirty-five percent of women, as compared to just 14 percent of men, said they did not feel confident in their abilities to decipher Calculus I material well enough to pursue the required Calculus II. Historically, females have been socialized to view themselves as inferior to males in the fields of math and science, a belief which is hopefully changing.

How Can Teachers Help?

"I've come to a frightening conclusion, that I am the decisive element in the classroom. It is my personal approach that creates the climate. It's my daily mood that makes the weather. As a teacher, I possess a tremendous power to make a child's life miserable or joyous. I can be a tool of torture or an instrument of inspiration. I can humiliate or humor, hurt or heal. In all situations, it is my response that decides whether a crisis will be escalated or de-escalated, and a child humanized or de-humanized," Hiam Ginott. There are many things educators can do to alleviate math anxiety with the main one being, to be aware of which students are experiencing the anxiety. The following are just a few of the recommendations from the National Council of Teachers of Mathematics (NCTM) to address these anxiety issues. Teachers can create a variety of assessments, with some open-ended questions, that aren't always timed. Teachers can assure the students that their math grades do not measure their self-worth. In addition, teachers should emphasize that mistakes are common and the best way to learn is through making these mistakes. Furthermore, teachers can provide different learning approaches through direct instruction, student-directed problem solving, group work and individual work. According to Furner and Duffy (2022), "The way we fix math anxiety in our schools. To put it simply: better teaching." Finlayson (2014) suggests the constructivist style of teaching which emphasizes more student involvement, including soliciting more student questions, building on what they already know, initiating more group activities, and developing more teacher with student interactions. Furner et al. (2005) compiled evidence-based practices for teaching math in ways that reduce anxiety "which include: (a) use of manipulatives (make learning math concrete); (b) use cooperative group work; (c) use discussion when teaching math; (d) make questioning and making conjectures a part of math; (e) use justification of thinking; (f) use writing in math for: thinking, feelings, and prob. solving; (g) use problem-solving approach to instruction; make content integration a part of instruction; (h) use of calculators, computers, and all technology; (i) being a

facilitator of learning; and (j) assess learning as a part of instruction." In addition, Furner suggests that journaling is an excellent way to reduce math anxiety. He also suggests that teachers gauge at the beginning of the school year which students may be experiencing this anxiety through a "Mathitude Survey," which prompts students to answer five questions about their math experiences and feelings. "Students are rarely asked how they feel about learning about different concepts and branches of mathematics. Teachers can really get a better understanding and feel for any frustration students are feeling and can be a corrective strategy for helping students develop math confidence and deal with any previous math anxiety." Furner also suggests that teachers work with school counselors and special education specialists to build a supportive team around the children experiencing these anxiety issues. In addition to all these suggestions, I feel being patient and kind is important, and not chastising a student because they don't know the answer goes a long way.

Conclusion

"We predict that math anxiety is learned in the classroom—for example, when a student is called to the board to work on a problem, does poorly, and is embarrassed in front of the teacher and his or her peers. In short, lower-than-average math abilities and/or working memory capacity, susceptibility to public embarrassment, and a nonsupportive teacher all may be risk factors for developing math anxiety" (Ashcraft et al., 2007). Unfortunately, math anxiety plagues many people, but with some positive teacher interventions and teaching strategies, maybe some of the anxiety can be lessened. Becoming more aware of this anxiety is the first step for teachers. According to Furner (2022), "It is the teacher's obligation to see that all students are prepared for a high-tech society where one cannot afford to not feel confident in their ability to do math. Math teachers need to use corrective strategies to support students' math anxiety and help them work toward becoming more confident in doing mathematics." If some of this mathematical anxiety is alleviated or reduced, then the hope is that more students, especially women, will pursue careers in STEM fields.

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Breaking the Math Anxiety Code: Fostering Einstein Intelligence for the Ability to Change and Adapt

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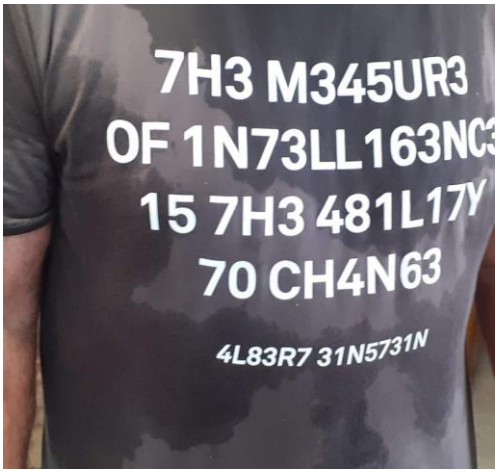
Breaking the Math Anxiety Code: Fostering Einstein Intelligence for the Ability to Change and Adapt

Abstract

Math anxiety impacts the future of people. It is critical that students in school before graduating, come to terms with such anxiety and gain confidence in mathematics. Einstein speaks of his own issues with math and talks about how important it is for us to be able to change and adapt and how this is a true measure of our intelligence. The author believes that as students feel less anxious about, and more confident in their abilities to do math their performance will improve. As math test scores are often a concern for principals, teachers, and society at large, success and confidence with mathematics is critical in our high-tech globally competitive world. Math anxiety has become a growing concern in the United States as well as in many other countries around the globe. Educators need to address this alarming problem and work toward developing mathematically confident young people for a world where Science, Technology, Engineering, and Mathematics (STEM) fields dominate the globe. It is critical educators break the math anxiety code so to reach all learners. Many strategies and recommendations are included for addressing how to improve attitudes toward mathematics so that all students can be Einstein's too.

Keywords: Math Anxiety, STEM, Einstein, Children's Literature, Journaling, Change

Introduction



The measure of intelligence is the ability to change.

-Albert Einstein 1879-1955

How do you feel about math?

“I really don’t like math, but I do okay.”--Julie, 14

"I just don’t like math, it’s the same thing and big numbers, and I don’t like big numbers.”--Brian, 13

"I have lots of math anxiety, for me math is very confusing." --Samantha, 19

"Frustration, sweaty palms, and fear are words I would use to describe what math does to me." --Heather, 34

"When I hear the word math I get goose bumps." --Starry, 9

"Math makes me shake." --Seth, 10

"When I think of math I don't get nervous I get bored." --Chad, 11

Comments from students above about their feelings toward math are just a sampling of how some young people feel about mathematics in the U.S and perhaps

around the world today. Albert Einstein even was known for sharing his difficulties with math. He is quoted saying, “Do not worry about your difficulties in mathematics, I assure you that mine are greater.” Many people today feel overwhelmed and have deep negative feelings toward mathematics and their learning experiences with it. In Marilyn Burns' book, *Math: Facing an American Phobia*, Burns (1998) confronts an interesting subject and has found that two-thirds of American adults fear and loathe math. Mathematics anxiety in students has become a concern for our society for many years now. Evidence of students’ poor attitudes and high levels of anxiety toward math is abundant (Warwick & Howard, 2016; Beilock & Willingham, 2014; Warwick, 2008; Geist, 2010; Furner, 1996 and 2022; Furner and Higgins, 2022, Furner and Duffy, 2022). In the midst of a technological era, declining mathematics (math) scores on the Scholastic Aptitude Test (SAT) have been widely publicized. Some reports have shown that American students rank last when compared with students from all other industrialized countries on 19 different assessments. The Third International Mathematics and Science Study (TIMSS) 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). What is happening to our students that so many of them lose interest in math and lack the confidence to do and take more math classes? Math teachers today need to crack and break the math anxiety code so to reach all students and build math confidence for STEM success.

Research from Geist (2010) states that negative attitudes toward mathematics and what has come to be known as "math anxiety" are serious obstacles for young people in all levels of schooling today, and he feels that an anti-anxiety curriculum is critical in building students’ confidence when working with mathematics especially in the light of a great push for more people going into the fields of Science, Technology, Engineering, and Mathematics (STEM). Helping students identify and address their math anxiety is critical in helping them cope with and overcome such anxiety that otherwise may negatively impact future choices in their academic and professional careers. Boaler (2008) points out, it is critical to ensure students are confident and well prepared in mathematics if they are going to compete for such high-tech jobs today and in the future. Today, the United States is working to lead more young people into the STEM fields so we as a country can compete globally. Zollman (2012) believes that we need to evolve from learning for STEM literacy to using STEM literacy for learning to satisfy our societal, economic, and personal needs. If we are to build math confidence in our students, math teachers need to address head on the issue of math anxiety which often manifests itself as hesitancy or learned helplessness in observed math achievement. This paper will look at the issue of math anxiety and provide research-based suggestions for preventing and reducing such anxiety in today’s classrooms. Hu et. al (2020) contend that not all scientists are equal and it is critical to use role aspirants to influence role modeling outcomes in STEM fields, like Albert Einstein and Thomas Edison. They found relationships to math anxiety, math attitudes, and math achievement and how the increasing role aspirants’ motivation at both a belief and behavioral level suggest promising methods to increase young people’s involvement in STEM to meet the growing need of STEM professionals globally.

Research from Steen (1999) found in her research many 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) believes we have to understand ourselves as MINT-professionals, where MINT is M=mathematics, I=informatics, N=natural sciences, T=technology. Neunzert (2000) feels that mathematics is critical for people living in the 21st Century for them to be successful. Neunzert believes we need to encourage our students in all countries to study more mathematics and to see it as a tool for success in life. Today we live with the more common coined term STEM.

Math educators today must be equipped to reach all children and develop their confidence and ability to do mathematics. All students really can be Einstein's if teachers really take the time to reach each one of them in their unique way. Teachers must check to see that all children have positive attitudes and dispositions toward math while helping them to adapt, change, and cope as they learn. A great deal of literature like Arem (2003), Curtain-Phillips (2004), Lai (2005), Rossan (2006), Sheffield & Hunt (2006), Furner (2016), Furner (2022), Furner and Higgins (2022), and Furner and Duffy (2022) all show that many people do not like mathematics and there are strategies one can use to develop more math confidence in our young people. This paper will explore such strategies.

Today it is critical that our teachers are well versed on how to effectively teach mathematics so as to address math anxiety in students, develop student confidence in math, and help encourage our young people into careers in the STEM fields. Beilock and Willingham (2014) contend that, "A course on how to teach math concepts seems to be more effective in addressing math anxiety among pre-service teachers than a course on math concepts themselves" (p. 31). Teachers instructing courses with mathematical content at primary, secondary and university level should take into account the negative impact of affective factors on teaching/learning processes in mathematics and should incorporate intervention programs in order to mitigate this effect and optimize students' performance (Núñez-Peña, et al., 2013). Putwain & Wood (2023) found that it is critical that intervention take place for students if they do have math anxiety, they found reciprocal relations with control and value, and relations with subsequent achievement as it relates to the math anxious learners. They suggest interventions which may be instructional or psychological in nature as outlined in some of the examples in this paper.

Unfortunately, even teachers who are afraid of math may then pass on math anxiety to the next generation by modeling behaviors of their own discomfort with the subject (Furner & DeHass, 2011; Geist, 2010; Reys et al., 2015). How representative are the above comments from young people about math anxieties? A study in 2004 by Perry indicated that 85% of students in an introductory college level math class claimed to have experienced anxiety when presented math problems. Jackson and Leffingwell (1999) showed another perspective in this study, with only 7% of the college students (N= 157) in their study not expressing math anxiousness. The prevalence of math anxiety in empirical studies is confounding; however, the effect of math anxiety is well documented. Even in populations of students where math is a foundational skill (e.g.

engineering majors in college), researchers have found math anxiety to be present (Hembree, 1990; Ruffins, 2007). Sparks (2011) feels that as the STEM fields become more important for our students to study, our schools and teachers need to do more to address math anxiety so that our students are confident to study areas related to STEM. If math anxiety occurs frequently, then attention to the methods that are effective at overcoming math anxiety are important for teacher preparation as well as for in-service math teachers. Albert Einstein believed that a key to intelligence is the ability to change as stated above in his quote. Since he was a scientist in theoretical physics, Einstein was intensely cognizant of the influence of the intellect. Reading, study, thinking, debate, and investigation provide a path for the intellect. Nevertheless, still Einstein's intelligence is beyond calculation today, he thought that key to aptitude is the ability to be able to change. This is what we need to emphasize and teach our young people today, to be able to change their thinking, to adapt, to make due, and improve their situations to overcome deficiencies and build to make them stronger. Math anxiety can be corrected with this such attitude.

Defining Math Anxiety

Mathematics anxiety may be defined as an *"…inconceivable dread of mathematics that can interfere with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations*" (Buckley & Ribordy, 1982, p. 1). Hill et. al (2016) defines math anxiety as "a debilitating negative emotional reaction towards mathematics" p. 45. NCTM (1989 & 1995) recognized math anxiety as a problem and specifically included in its assessment practices. Standard #10 (NCTM, 1989) prompts teachers to assess their students' mathematical dispositions; such as: confidence in using math to solve problems, communicate ideas, and reason.

Math teachers need to know what causes this dread of mathematics so that it can be prevented, corrected, and/or reduced. Causes of math anxiety may vary from socioeconomic status and parental background to the influence of teachers and the school system. Some educators believe that teachers and parents who are afraid of math can pass on math anxiety to the next generation, not genetically, but by modeling behaviors of their own discomfort with the subject. Research by Oberlin (1982) found that some teaching techniques actually cause math anxiety; (a) assigning the same work for everyone, (b) covering the book problem by problem, (c) giving written work every day, (d) insisting on only one correct way to complete a problem, and (e) assigning math problems as punishment for misbehavior.

Educators need to know what causes this dread of mathematics so that it can be prevented and/or reduced. Causes of math anxiety may vary from socioeconomic status and parental background to the influence of teachers and the school system. Ahmed et. al (2012) examined the reciprocal relationships between self-concept and anxiety in mathematics. A sample of 495 grade 7 students (51% girls) completed self-report measures assessing self-concept and anxiety three times in a school year. The analysis showed a reciprocal relationship between self-concept and anxiety in math (i.e., higher

self-concept leads to lower anxiety, which in turn, leads to higher self-concept). Concluding that math self-concept and math anxiety are reciprocally related. Some educators believe that teachers and parents who are afraid of math can pass on math anxiety to the next generation, not genetically, but by modeling behaviors of their own discomfort with the subject. Lugosi and Uribe (2022) attribute their work to Einstein and the ability to adapt and change as students learn mathematics, they emphasize using active learning and involving students in mathematical explorations, experiments, and projects with continuous motivation and engagement for students as they learn math to prevent and reduce math anxiety.

Poor and ineffective teaching practices are not the only cause of math anxiety. A student's lack of success with math may also be a cause of math anxiety and be heightened by any one of several factors; poor math instruction, an insufficient number of math courses in high school, unintelligible textbooks, or misinformation about what math is and what it is not. Many people often blame their failures on their lack of a mathematical mind, the notion that men are better than women at math, or that they have poor memories or learning disabilities. Sheila Tobias, a guru on the topic of math anxiety since the 1980's, contends that there are two myths about mathematics that need to be eliminated. One is that higher level math is too difficult for otherwise intelligent students to master, and another is that without mathematics you can live a productive intellectual and professional life (Tobias, 1993). Math anxiety is also prevalent in the population of students with disabilities. Some students in special education have specific math related disabilities; this number is estimated to be between 4 and 7% for school aged students (Lewis et. al, 1994). There are other students in special education who claim a math disability as a way to cover up anxiety about school in general. Regardless of the student description, engineering students and students in special education alike need a teacher's help to overcome their fears of mathematics and be challenged to take higher-level math courses. Willis (2010), a math teacher and neurologist, in her book, *Learning to Love Mathematics,* gives over 50 strategies you can use right away in any grade level to: (1) Rehabilitate negative attitudes about math; (2) Reduce mistake anxiety; and (3) Relate math to students' interests and goals. Find out how a better understanding of your students' brains can help you build foundational skills in math and other subjects and develop your students' long-term memory of academic concepts. Explore classroom interventions that help you: (1) Change your students' math intelligences by incorporating relaxation techniques, humor, visuals, and stories into your teaching; (2) Eliminate stress and increase motivation to learn math by using errorless math, estimation, and achievable challenges; and (3) Differentiate your strategies to students' skill levels by using scaffolds, flexible grouping, and multisensory input. Find out how a better understanding of your students' brains can help you build foundational skills in math and other subjects and develop your students' long-term memory of mathematical understanding.

Schools and teachers can do a lot to help prevent math anxiety from occurring in students. It really is a complicated matter and may involve what happens to kids in and outside of the classroom. Teachers and parents can play a critical role in helping to develop positive dispositions toward math. The NCTM (2000, 1995, 1989) has made

recommendations for preventing math anxiety with recommendations such as:

-accommodate different learning styles
-create a variety of testing environments
-design positive experiences in math classes
-remove the importance of ego from classroom practice
-emphasize that everyone makes mistakes in mathematics
-make math relevant
-let students have some input into their own evaluations
-allow for different social approaches to learning mathematics
-emphasize the importance of original, quality thinking rather than rote manipulation of formulas; and
-characterize math as a human endeavor.

It really comes down to is that teachers must employ "best practices" for teaching mathematics. Zemelman et. al (2012) based on a culmination of research have put together what is considered the "best practices" for teaching math which include: (a) use of manipulatives (make learning math concrete); (b) use cooperative group work; (c) use discussion when teaching math; (d) make questioning and making conjectures a part of math; (e) use justification of thinking; (f) use writing in math for: thinking, feelings, and prob. Solving; (g) use problem-solving approach to instruction; make content integration a part of instruction; (h) use of calculators, computers, and all technology; (i) being a facilitator of learning; and (j) assess learning as a part of instruction.

Removing or correcting math anxiety is much different from preventing math anxiety. Teachers almost have to take on the role of a counselor to help lower or overcome such anxiety toward math. Recommendations for reducing math anxiety according to Hembree (1990), treatments effective in alleviating math anxiety include systematic desensitization and relaxation training. Davidson and Levitov (1993) advocate the use of relaxation in conjunction with repeated positive messages and visualizations. dos Santos Carmo and Crescenti (2022) contend that mathematics anxiety can be successfully reversed with such strategies mentioned in their paper and here in this paper. Stress and academic anxiety like math anxiety can be addressed and reversed, and corrected using psychological processes and interventions with students by their teachers a lot of it also has to do with teaching young people how to adapt and change as they are confronted with such anxiety to come to terms with it, much self-regulation has to take place during the reduction/reversal process.

How is math anxiety corrected or lowered? Teachers must help students understand how their math anxiety was created. According to Hackworth (1992), the following activities will assist in reducing math anxiety: (a)discuss and write about math feelings; (b) become acquainted with good math instruction as well as study techniques; (c) quality studying; recognize type of information learning; (d) be an active learner and create problem solving techniques; (e) evaluate your own learning; (f) develop calming/positive ways to deal with fear of math and doing math: visualization, positive messages, relaxation techniques, and frustration breaks; and lastly (g) gradual repeated success in math builds confidence. Tobias (1993) suggests that one way for students to

reduce math anxiety is to recognize when panic starts, to identify the inactiveness in their analytic and retrieval systems, and to clear up the static without ceasing to work on the problem.

Some Top Instructional Practices to Prevent and Reduce Math Anxiety

Research by Ooten (2003) in her book, *Managing the Mean Math Blues*, outlines a four-step method for managing a persons' math anxiety. Ooten believes that a person who suffers from math anxiety needs to first lay the groundwork by coming to terms with their feelings and challenge their current beliefs and realize they are not alone; second, one must change their thoughts and negative thinking and use intervention strategies to improve one's thinking that they can be successful at math; third, one needs to know thyself, it is important that one knows his/her learning style/mode and that he/she apply approaches to doing math by successful people; and lastly fourth, once one has gained some confidence and strategies for doing mathematics they then must apply what they learned and actually do the math. All of Ooten's techniques require the teacher to first be aware and second to support the student in turning around their anxiety. When a student essentially acknowledges that "I'm not good at math and so I never will be", it has dangerous implications for students' motivation (Dickerson, 2013). In a study of over 3,000 students from elementary to high school, researchers found that where a student's motivation came from made a difference. Students who wanted to get better at math to learn more about the subject (mastery-approach goal) ended up improving more than those who were focused on just getting a good grade (Dickerson, 2013). Recommendations for motivational strategies that may be useful in preventing and reducing math anxiety and improving attitudes toward learning mathematics include: making mathematics relevant, highlighting that everyone can make mathematical mistakes while still having the capacity to improve, engaging students in their own self-evaluations, and reducing the importance of ego from classroom practice (Finlayson, 2014; NCTM, 1995).

Real-world Examples of What Teachers can do in their Math Classrooms to address Math Anxiety: Tried and True/Research-based

#1. Journal writing in math classrooms has become an everyday event for many students. Students use journals to express their understanding of mathematical concepts. Journals can also be used to allow students to share feelings and experiences with math. Students are rarely asked how they feel about learning about different concepts and branches of mathematics. Teachers can get really get a better understanding and feel for any frustration student are feeling. The following sample list of journal/discussion question may be used for students to write about alone or to discuss and share together as a class. Teachers must realize that for students to overcome or have their math anxiety reduced, they must first initiate this form of therapy by allowing students to express their true feeling about math and how they arrived at such a disposition:

Journal/Discussion Questions for Students

1. Pretend that you have to describe mathematics to someone. List all the words or phrases you can think of that you could use.
2. Describe how you feel in a math class.

#2. Another practical idea for teachers and students is for teachers to assess their students' dispositions toward math at the beginning of a school year by having them complete the following *Mathitude Survey* (Furner, 2007):

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.....

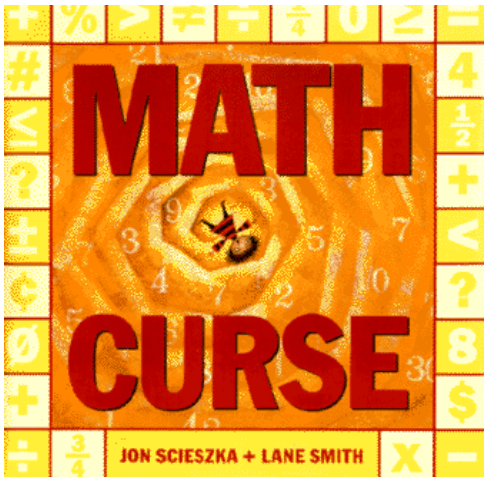
7. If math were an animal it would be.....

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.

(This survey is great to use toward the beginning of the school year to assess students' feelings toward math and level of anxiety.)



#3. We can use bibliotherapy using books. The picture book, *Math Curse* (Scieszka & Smith,1995), addresses the issue of math anxiety. It is an excellent example of how educators have come to terms with the fact that not all people feel confident in their ability to do math. When Mrs. Fibonacci, an elementary school teacher, tells her class that they can think of almost everything as a math problem, one student becomes overwhelmed by the scope of math. This math anxiety becomes a real curse. However, the student eventually realizes that math is everywhere and there is no way of escaping it in daily life; therefore, the math anxious youngster recognizes math as a means of making one's life easier. This book may be used as a form of bibliotherapy to prompt discussion on the topic of math anxiety and allow other students to discuss their feelings on the topic to compare to the character in the book. Hebert & Furner (1997) have found bibliotherapy effective in reaching the math anxious and provide lessons and activities in their work.

#4. Use Famous People and their Biographies. Read and discuss the following statements from Famous People/Build Confidence/Believe that your students can succeed at Math**.** Furner and Grace (2016, p. 1) discuss in their paper how it is important to share stories with both students and parents alike so that they realize that all things are possible, they state and share:
"SOMETHING TO THINK ABOUT:
***Beethoven's music teacher once told him that as a composer, he was hopeless!
***Walt Disney was fired by a newspaper editor because he had "no good ideas."
***Winston Churchill failed sixth grade.
***Louisa May Alcott was told by an editor that she'd never write anything with popular appeal.
***As a boy, Thomas Edison was told by his teachers that he was too stupid to learn anything.
***Einstein was four before he could speak and seven before he could read.

YOUR ASSIGNMENT:
****Read the previous statements every time you think your child is a little different or not being quite what "we" WANT THEM TO BE. Maybe their goals are a bit higher. Maybe, just maybe, they have a different way of reaching their own standard of excellence."

Furner and Grace (2016) in their paper talk about how important it is to makes sure that your students and their parents know that in your class all students will succeed. Grace believes that there are five powers children need. The need to: perceive, interpret, want, feel, and express. Grace feels that this can happen when children's basic needs are met which include: security, self-worth, self-value, strokes, stimulation, and structure. Grace repeats constantly, "You know what ever I'm going to teach, you are going to learn." Grace says, "They believe that I can teach them math." (Page 1.) When teachers believe all children can learn and the children know that the teachers believe this truly, then students really can succeed beyond most expectations. This is a real key component to effective teaching and learning.

#5. Use games to teach math and lower math anxiety. As a math teacher with middle school students, I had my students plan many games, Math Bingo, Relay races on the track in front of my classroom, each week, many classes we were playing math games, it helped too with team building and exciting students, building confidence, and motivating students as they learn and practice math. According to Dondio et. al (2023) in their meta-analysis, they found that math games had a greater effect on math anxiety reduction when they promoted collaborative and social interactions among the learners. The findings showed collaborative game play among the students to be most effective to reduce math anxiety. The math teacher can set up teams where students have to run up and do a math problem, then return to tag their teammate to then go and do the next one, they can make some competition while also getting exercise and it creates a motivating activity for the learners. Games like math BINGO are also exciting for students, but not as collaborative. Cooperative learning activities where students work in groups of four to accomplish a task or study for a test can also be motivating and help students build confidence together while helping each other. Games in math are a useful tool to address math anxiety.

#6. Use movies and the cinema to show students about others discomfort with math or how they have overcome their lack of success or math anxiety. Peker and Naci Küçükgençay (2021) advocate using movies and cinema to help build confidence in mathematics. You can show movies on the life of Albert Einstein, to show how he struggles with math prior to developing his famous theory. Or show the Movie, *Stand and Deliver* which is the story about a math teacher, Jaime Escalante, who is a math teacher in a school in a Hispanic neighborhood. He is convinced that his students have potential and adopts unconventional teaching methods help gang members and no-hopers pass the rigorous Advanced Placement exam in calculus, building confidence and teaching test taking skills. There are a lot of movies out there today that math teachers

can use in their classrooms to reach students and use a a form of therapy to build confidence and help them see they are not alone in their pursuit in learning mathematics. Peker and Naci Küçükgençay (2021) found that watching math-themed movies as a promising, novel and, practical way to introduce and increase positive beliefs, emotions, and attitudes toward learning mathematics and decreasing such math anxiety.

A Brief Synopsis of Resources for Math Anxiety

What NCTM says about Mathematics Anxiety and Dispositions Toward Mathematics

Standard 10: Mathematical Disposition

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 idea 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.

Visit the Mathitudes Website at:
http://www.coe.fau.edu/centersandprograms/mathitudes/

How to Reduce Math Anxiety in a Nutshell

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. Encourage students to adapt and change.

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.

How to Prevent Math Anxiety in a Nutshell

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 *Common Core* and *NCTM Standards* and other State Standards into the curriculum and instruction.

3. Discussing feelings, attitudes, and appreciations for mathematics with students regularly. Encourage students to adapt and change as they learn without stopping.

Recommendations from the National Council of Teachers of Mathematics are words to the wise. The key to all of the NCTM recommendations is to plan wisely and make the instruction welcoming for students. A lesson that engages students with all types of learning styles and learning needs sends a message to everyone in the class that the expectation is for all to be successful. The same is true for a teacher who includes in his lesson plan time to talk about different ways to solve a problem. This underscores, as NCTM advises, that there are different social approaches to learning math, not just the one in the text. Prevention of math anxiety is all about teacher planning and using the best possible practices in math instruction. As mentioned, Geist (2010) feels that negative attitudes toward mathematics and what has come to be known as "math anxiety" are serious obstacles for young people in all levels of schooling today. In his paper, the literature is reviewed and critically assessed in regards to the roots of math anxiety and its especially detrimental effect on children in "at-risk" populations such as, special education, low socioeconomic status, and females, he feels that an anti-anxiety curriculum is critical in building students' confidence when working with mathematics teaching them to adapt and change and come to terms with their math anxiety.

From an academic perspective, Zemelman et. al (2012); Furner et. al (2005); Furner (2022); Furner and Higgins (2022); and Furner and Duffy (2022) have compiled evidence based practices for teaching math which include: (a) use of manipulatives (make learning math concrete); (b) use cooperative group work; (c) use discussion when teaching math; (d) make questioning and making conjectures a part of math; (e) use justification of thinking; (f) use writing in math for: thinking, feelings, and prob. Solving; (g) use problem-solving approach to instruction; make content integration a part of instruction; (h) use of calculators, computers, and all technology; (i) being a facilitator of learning; and (j) assess learning as a part of instruction. Each of these best practices make math more "accessible" to students who enter the math instruction situation with trepidation. The first step in such an important educational goal is to understand effective ways to reduce math anxiety and encourage more positive attitudes for learning mathematical concepts. If the goals students adopt have some relationship to beneficial achievement behaviors and a healthy outlook for learning math concepts, we can then consider how the research literature outlining suggestions for creating mastery-oriented classrooms may also help to reduce the anxiety students experience during mathematics

instruction (Furner & Gonzalez-DeHass, 2011). As the STEM fields become more important for our students to study, our schools and teachers need to do more to address math anxiety so that our students are confident to study areas related to STEM (Sparks, 2011). In this effort, educators can encourage students to develop productive mathematical dispositions, be more willing to take risks and share their ideas, and come to see they can improve through effort and good study habits, so that they are prepared for future schooling and eventual careers (Dickerson, 2013; Quander, 2013).

In Conclusion

Albert Einstein believed that a key to intelligence is the ability to change as stated above in his quote. Since he was a scientist in theoretical physics, Einstein was intensely cognizant of the influence of the intellect. Reading, study, thinking, debate, and investigation provide a path for the intellect. Nevertheless, still Einstein's intelligence is beyond calculation today, he thought that key to aptitude is the ability to be able to change. This is what we need to emphasize and teach our young people today, to be able to change their thinking, to adapt, to make due, and improve their situations to overcome deficiencies and build to make them stronger. To develop confidence. Math anxiety can be corrected with this such attitude, having the ability to change and adapt as you are confronted with learning mathematics. Math teachers can do many things mentioned in this article in their classrooms to help prevent and reduce math anxiety helping their students gain confidence and become mathematical Einstein's. Teachers can also work with school 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 this discomfort our students have toward mathematics. It is important that our students in the U.S. 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 teacher's obligation to see that their students value and feel confident in their ability to do math, because ultimately a child's life: all decisions they will make and careers choices may be determined based on their disposition toward math. As teachers we must make the difference in our students' attitudes toward math! We need to make sure all our students have the capability to become an Einstein and feel confident in their ability to pursue fields like science, technology, engineering, and/or mathematics so to better compete and be successful in this high-tech world we live in. It is our job as math teachers to make sure all our students see success with mathematics and like it too. All students can be Einstein's if math teachers take the time to implement best practices outlined in this paper. If Albert Einstein found his challenges with math were great and was able to overcome them to become one of the most famous scientists of our time, then our young people today can overcome their negative feelings toward math, develop confidence, and become some of the great thinkers of today as well! It is all about our ability to change and adapt. We must break the math anxiety code so to reach all students.

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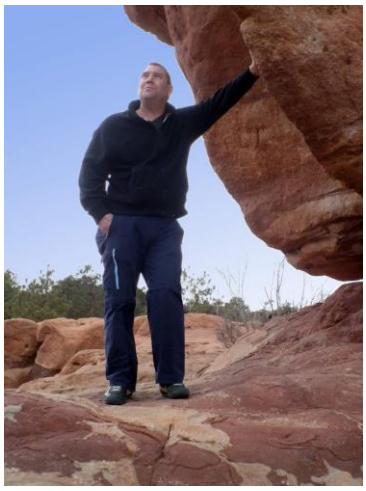
Author Bio



Joseph M. Furner, Ph.D. is a Professor of Mathematics Education at Florida Atlantic University in Jupiter, Florida. He is originally from Sauquoit, New York where he went to elementary, junior high, and high school. He received his Bachelor's Degree in Math Education from the State University of New York at Oneonta and his Masters and Ph.D. in Math Education from the University of Alabama. His scholarly research interests are related to math anxiety, the implementation of the new national and state standards, English language issues as they relate to math instruction, the use of technology in mathematics instruction, math manipulatives, family math, and using children's literature in the teaching of mathematics. He is the author of 100+ peer-reviewed papers and cited on *Google Scholar* over 2,500 times. Dr. Furner has worked as an educator in New York, Florida, Massachusetts, Alabama, Mexico, and Colombia. He has now branched out into more mainstream writing with *Living Well: Caring Enough to Do What's Right* and his new book, *A Light for Others: An Instrument of Peace* will be coming out soon. He is concerned with peace on earth and humans doing more to unite, live in Spirit, and to care for our Mother Earth and each other. Dr. Furner feels that we all have the opportunity to be lights for others and instruments of peace each day we live. Dr. Furner currently calls in Florida where he lives with his family. He enjoys his family and friends, job, civic and church involvement, his beach, and little town by the sea.

Quote

"If we all speak life and
use our words to inspire,
being lights for others,
we can be instruments
of peace in this world."
-Joseph M. Furner

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Identity Transformation through Transformative Learning: Nepali Mathematics Educators' Perspectives

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Cover Page Footnote

This paper highlights Tara’s journey through her doctoral research, focusing on her transformation as a mathematics educator. We would like to express our gratitude to everyone who contributed to the refinement and enhancement of this piece. Special thanks go to the Kathmandu University School of Education in Nepal for fostering a research-oriented environment and providing unwavering support.

Identity Transformation through Transformative Learning: Nepali Mathematics Educators' Perspectives

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This paper reflects the perspective of identity transformation of mathematics educators through the lens of transformative learning, foregrounded on Tara's doctoral research journey. The process of identity transformation seeks to foster reformative skills at various levels by altering individuals and their identities. This is achieved by posing questions about the past that challenge deeply ingrained assumptions, beliefs, values, and perspectives. Therefore, this paper's focus is on how transformative learning facilitates a shift in identity. This issue signifies a theoretical void that warrants further investigation. Consequently, this paper examines identity transformations through the theories and lens of transformative learning. In doing so, Tara has reflected on her own experiences and those of others, integrating them with our collective venture. We have also spotlighted Drikx and Illeris's theory of "transformative learning and identity" and its scope. The key message to be taken from this paper is that transformative learning and identity change come from personal-level transformation and expansion of consciousness at an individual level. Lastly, this paper suggests that transformative learning and a person's sense of who they are—are linked to how they change a person.

Keywords: identity transformation, transformative learning, assumptions, identity change, consciousness

Introduction

One day I was surfing the internet, and my eyes rolled toward a paper on identity and transformative learning. I was eager to know about the topic and planned to read it. I downloaded the paper and carefully read it. The paper touched my heart and struck my mind as I researched identity construction in my MPhil; it made me think about my identity and its history. I began to be curious to search how transformative learning inspires identity shifts. The transformative learning term made me want to know about it. Then, I started collecting stories of my identity that included the aspects of identity change and searching more about areas where I witnessed

transformative learning. This story of mine made me want to think about and make a connection between transformative learning and identity change.

Tara's methods for understanding transformative learning during her MPhil research were highlighted in the above vignette. This paper examines Tara's doctoral research journey regarding identity transformation as mathematics educators through the lens of transformative learning. The paper describes how Tara, a mathematics teacher and doctoral student, encountered and observed identity transformation as a path to transformation as a paradigm shift in transformative learning and research. Regarding the authors' roles, Tara drafted the paper, and Bal commented, suggested, and refashioned the texts here and there. Niroj, as a Ph.D. scholar, was also invited to lend the perspective of a mathematics educator to make the paper more authentic. As the primary author, Tara valued the co-authors' assistance in structuring and re-structuring this reflective paper.

As a doctoral student, Tara worked hard to show how a transformative learning pathway can help people change their identities. A teacher's identity changes over time based on their experiences and stories, which they use when talking to their students and other teachers at work. The narration discusses the relationship between teachers' personal and practical knowledge and the current and historical environment in which they live, work, and groom themselves in terms of teacher identity. When combined with the professional networks where they survive, develop, and shape, the transient meaning of people's experiences and stories reveals who they were, who they are, and who they are becoming (Schaefer & Clandinin, 2019). Similarly, Tara’s life as a university mathematics teacher is a mix of historical and autobiographical stories of struggles and uprisings. These uprisings associated with identity transformation stories align with professional teaching experience. In this situation, Illeris (2014) says that transformative learning includes all learning and means that the identity of the learner changes. In this way, how does transformative learning change? To fill this theoretical gap, we use Tara’s experience as a researcher, a teacher, and a teacher educator, along with the help of the literature, to look at transformative learning and identity change through a single lens. To fill this theoretical gap, we use Tara’s experience as a researcher, a teacher, and a teacher educator, along with the help of the literature, to look at transformative learning and identity change through a single lens.

Transformation is a process of change or alteration in a qualitatively different way (Illeris, 2017), through which individuals critique their values, beliefs, and assumptions and shift in thinking, perception, and behavior. In addition, at a deeper level, the capacity to shift deep-rooted traditional mindsets that any individual self can transform is sensed as transformative learning (Buchanan & Greig, 2021; Dahal, 2022; Luitel & Taylor, 2019; Rajbanshi & Luitel, 2020). This

change has shown that a person's mind is made up of their whole self, identity, person, or personality (Illeris, 2014) and transformative learning (Cinoğlu, & Arıkan, 2012). Cinolu and Arkan (2012) define the self as a mental instance, a primary actor, from which the process of identity evolution starts and is related to transformative learning. From transformative learning, a person's identity is transformed, directly reflected in their personality.

Transformative learning, as a reflective learning process, results in changes in our personal perspectives, such as feelings, thoughts, and emotions, transforming our daily lives in terms of how we see and perceive ourselves, our context, and the world around us as well as thoughts, emotions, and beliefs that arise from their life happenings and alterations (Dahal et al., 2023; Paudel et al., 2023). This identity change relating to transformation in an individual is strengthened through transformative learning that acts as a catalyst for the transformation processes and identity change. In this respect, this paper covers reflections on transformative learning as consciousness changes and how identity change occurs through self-transformation. The paper also discusses Tara's goal to demonstrate how an author like Tara can work with transformative learning in mathematics education. This paper was written from Tara's perspective, emphasizing her thoughts, feelings, and experiences. The role of Bal and Niroj was to nurture Tara as a mentor and critical friend in this field by interrogating her narratives of engagement with researchers, educators, and teachers and capturing her identity transformation process. Furthermore, the paper highlights some of the theoretical perspectives that shed light on transformative learning and identity, and finally, the paper shows the interconnection between transformative learning and identity transformation.

Reflections on Transformative Learning

Learning is a phenomenon that brings about a change of perspective in any learner. In this regard, “Learning is understood as the process of forwarding a prior interpretation to construe a new or revised interpretation of the value of one’s experience in order to escort future actions” (Mezirow, 1996, p. 162). When learners take a different path, they get an opportunity to see and understand different things and start seeing the same things from a different perspective and lens. This phenomenon makes them see more dimensions and begin to understand more deeply what something actually is. Learning guides to make explanations starting from the person’s beliefs, feelings, and judgments that consciously re-define the sense of the experience (Mezirow, 1997). An individual's values and beliefs may experience a transformational process while learning, which guides them toward transformation leading to identity construction. Transformative learning is a change to bring in ourselves, our emotions, thoughts, our worldviews, and our relationship with others (Mezirow & Taylor, 2009). It is argued that

transformative learning critiques and questions the integrity of deeply held assumptions and beliefs based on experience prior to association with the life world and educational practices (Taylor, 2009). In support of the above-mentioned views, Cranton (2006) supports that it is a process of questioning the previously uncritically assimilated perception, assumptions, values, beliefs, and values. This shows that those questions and critiques bring changes in action and new perspectives that greatly differ from their previous views and behaviors as adults.

Mezirow (1991, 2000) says that transformative learning is a way to organize how we think about ourselves and the world around us. Mezirow (1991, 2000) frequently emphasizes the central target of open discourse and critical reflection (Luitel et al., 2022), in this context, as well as the significance of putting new understandings into practice. But this sharpness has been criticized (Carton, 2005; Drix, 2006; Kegan, 2000) for being too narrow and focused on the mind. From our point of view, when people change their point of view and understanding, it usually involves a lot more than just intellectual insight. Instead, all mental abilities, emotional paths, and social situations are taken into account, and these things are always important for change.

Boyd (1991) has depicted transformation as individuation with a change in one's personality. It takes resolving personal conflicts and disputes and expanding consciousness for personality integration. It believes that conflicts hamper a person's mindset and psyche. The findings of the research are not critical self-reflection, but discernment focuses on relational completeness. Boyd (1991) has investigated that two good values, seasoned guidance and compassionate criticism, arouse spiritual energy. This view of transformative learning enlightens psychology with the role of conscience. But Tara's research on transformative learning does not fit well with this idea by Boyd (1991). Here, Tara's research focuses on transformative learning and identity, whereas Boyd's (1991) research focuses on the psychology of consciousness. This research has not included society or culture with coordination with self and identity but focused only on self-conflict, consciousness, and personality.

Freire (1970) has advocated the concept of emancipatory transformation. This idea is about a practical and theoretical approach to emancipation through education (Dahal & Luitel, 2023). Research is based on extensive work and collaboration with participants involved in teaching after the Third World War. The core concept here is that education is an 'ontological vocation' where people should be observed merely as subjects but not as objects. They are continuously walking on the path of changing their world. Transformation is an enduring, never-ending, and energetic procedure (Luitel et al., 2022). The agenda of this research is more of a social transformation and educational transformation with the work in education and knowledge. However, this research does not solely satisfy uplift the purpose of research as here we can sense the seed of transformative learning, but it

is not clear. It works on people as a whole and is much more inclined to social research, whereas our research coordinates society, culture, and more of the personal self.

Also, transformative learning is the expansion of consciousness, which can change a person's basic view of the world. It is based on a constant deliberate attempt to raise our consciousness toward an inclusive knowing of human experience and an open approach to the exploration of different aspects of understanding (O'Sullivan, 1999; Richmond-Bravo, 2011). In addition to what O'Sullivan (1999) and Berry (1999) say, it's about changing our minds to become more aware of how we're all connected. This emerges as self-realization within an individual, born from our experience of the past according to the individual we are. It is a process of expanding consciousness through the transformation of basic worldview and specific capacities of self-transformation. It has been facilitated through a consciously directed process that includes appreciatively accessing, receiving, and critically analyzing all underlying premises (Goharimehr & Bysouth, 2017). This nature of transformation erupting from a deeper unconscious level and touching the conscious level propagates any individual's identity whose seed lies in a person's core.

Transformative learning also travels outward, touching its different internal forms (e.g., thoughts, feelings, emotions, images, memories, and sensations). These different forms transform individually. In this reference, Illeris (2014) elaborates on progressive, regressive, and restoring transformations. Progressive transformation is forward-looking and expansive, which tends to move forward for a new possibility. So, the transformation has to be progressive in nature. However, sometimes, being progressive does not seem to be sensible as it is essential to maintain a pace between forward and backward. Moving ahead can become challenging for a learner, resulting in withdrawal. So, to bring about balance, we can look towards another term of transformation, regressive, which is defensive in nature. In addition, the next form of transformation is restoring transformation, which links the idea of setting a more realistic goal with the concept of balancing transformation.

> After completing my master's degree, I started my professional career as a mathematics teacher at one of the private campuses under Tribhuvan University Nepal. I had to face different startup challenges, like adjusting to the new environment, getting familiar with the teaching-learning pedagogy, and communicating with the teachers, students, and the campus management team. Despite these facts, I slowly started adapting and building up my position in the previous so-called new environment. This shows the progressive aspect of identity construction. But, after a few years, due to unavoidable circumstances, I had to leave my current workplace,

> where I was constructing my identity, to move to the capital city for a new challenge. I had to leave my position back there to search for a new job which shows the regressive part of the identity construction. In the capital city, even though I instantly got a new job, fear started building upon me whether I would be able to survive the new challenge and re-establish my identity. In this view, Gautam (2017) explains that leaving one established place to move to a new place is the transition period of people making their careers. But still, I didn't give up. I started observing new kinds of teaching, learning, and training sessions and tried to adapt to the fresh surroundings. My identity, as well as the emotional aspect of me, took a new turn. I felt as if I had a pedagogy regarding reforming my status.

Thus, the above vignette of Tara marks the restoring aspect of transformative learning. This nature of transformation, springing from a deeper unconscious level and touching the conscious level, proliferates any individual's identity whose seed lies from a person's core. We have experienced progressive, regressive, and restoring transformations in different phases. We ventilated through different literature, sharing thoughts and perspectives on transformative learning. Meziro's (1978) transformative learning is cognitively oriented; however, in 2000, he revamped it, which led to the investigation of the importance of the critical, social, and emotional aspects that influence transformational learning. On the other hand, Kegan (2000) has questioned, "What forms transform?" which means what is the area of any learner that can be enhanced to bring about transformation? This question and issue are now irrelevant. Likewise, Illeris (2014) views about focus area of transformative learning, which addresses the change of a person's identity. The parallel views of Drix and Illeris conceptualize that transformative learning is deeply associated with the personal change in consciousness. As we reviewed related literature, the views varied among those authors. We could sense some uniqueness in each view, but the perspective varied. This paper travels in the direction of Drix and Illeris, where there is a focus on transformative learning connected to identity change, which goes on mutually.

Transformative Learning as Consciousness Change

Individual awareness of thoughts, memories, feelings, and sensations that change a person's perception, feeling, and thinking from the inner level to the outer physical level defines consciousness (Rosenthal, 2009). The world might change through the change in consciousness of each individual. People become aware that an infinite creative power lies hidden within their consciousness. Continuing and transformative change needs to bulge out from the inside out through emotional engagement with meaningful experiences, helping individuals make interpretations

of change by considering new possibilities (Pisters et al., 2019). "When you change not at a superficial level, but fundamentally, you affect consciousness because you are the world and the world is you" (Krishnamurti in Madras 1974/75, Talk). From this view, you are transformed when you are conscious of yourself. It manifests itself from the inner level through transforming consciousness in our interpretation of self and residing in the world (Dirkx, 2012). First and foremost, it is pertinent to ponder profound and meaningful comprehension of who we are as an individual with acknowledging and invigorating voice for more natural qualities. Over time in our life, we gather our experiences from different aspects of living so we can gradually recognize and then establish understanding and clear conscious relationships with the various realms of us as selves. Through transformative learning, individuals can differentiate aspects of themselves forthwith, fostering integrated connections among different parts and areas of their conscious mind. All the influential feelings, emotions, and effects that emerge within our learning experiences grab our attention and energize conscious issues or concerns, seeking to gain a voice (Dirkx, 2000). In this sense, transformative learning as consciousness change portrays learning through which individuals recognize and attach to their senses.

Tara’s journey of professional life was going on at a pace to solve root problems in algorithm procedures as it was the tradition because the teacher would focus on the rightness of every step, which led to procedural knowledge (Rittle-Johnson & Schneider, 2015). The students were manipulated, such as they tended to memorize the information and demonstrate their limited skills in a discrete setting. These traditional teaching techniques are usually teacher-directed, conducive to sitting and listening, where students adapt to it (Tularam, 2018). Teacher-directed is the way students learn through memorization and recitation techniques which hamper their critical thinking, problem-solving, and decision-making skills. At the beginning of Tara’s professional career, Tara followed the approaches led by the behaviorism theory of learning by using the stimulus-response ideology of knowledge reproduction. It was a drill and practice method that emphasized a behavioral teaching pedagogy with control of the learning environment via correct utilization of behavioral reinforcing methodology involving teaching the lesson's specific content (Kasonde et al., 2013). The learning environment was controlled where students were deprived of opportunities to explore, discuss, communicate, share, and question the world beyond the boundary of the classroom, and all the teachers resembled that they followed technical rationalities (Habermas, 1986). That was an example of controlling the environment of teaching-learning through rule-following. In that scenario, students were devoted to memorizing the facts rather than going for meaningful understanding. After experiencing this pedagogy, we realized there is a need to design an empowering educational practice for a pedagogical transformation. Even

more, Tara set up to grow her status, playing different roles in the same way as a teacher, teacher educator, educational leader, and researcher. Pant (2015) said that Tara started fundamental transposition in her former habit of mind, values, and belief systems. We began to see a change in Tara with novelty in her vision. We attempted to critically reflect on Tara's past from contrasting lenses of transformative and student-oriented pedagogy to motivate the students. Tara smoothened her teaching-learning behaviors, furnished the pedagogical practices in order to examine the prevalent conventional teacher-paramount pedagogical practices, and explored transformative pedagogy as student-centric. In this way, transformative learning has not only been helping her practice but also has brought about a change in consciousness, guiding her to critically reflect on her beliefs and practices to brush up her pedagogical practices.

Furthermore, consciousness can also be considered as an act of improvising our internal work, which manipulates self-perception and social relations (Van et al., 2015). It can possibly be seen as self-research and self-exploration. When we traverse within ourselves, we come to know our past and present, the inner light within us, and what our soul is really seeking. Then we derive a change in thinking from our inner level about the change in what we know and the change in how we know (Kegan, 2000). This internal travel itself can lead to various types of changes. This can be correlated with the theme of daily learning in our life, self-research. The understanding level is brought up from the inner level starting from the soul, mind, and physical body levels. All levels of mind, body, and soul transform a person. This internal travel leads to changes in consciousness.

Identity as Self-transformation

We always had a curiosity to understand who Tara was, how Tara came here, and who Tara wanted to become. When we look back on Tara's life journey, starting from student life, during the journey of her research, she perceives identity as who she is now, who she was, and who she will become (Erikson, 1968). This, who she will become, is more critical and transformative. However, any notion of cultural, social, traditional, and historical context is positioning in which exists the individual identity. It is shaped by individual characteristics, family dynamics, historical factors, social and political background, and contexts. Likewise, in Tara personal and professional life, we have understood identity construction as a form of a story of struggle as it takes a long period of time and has been a multi-dimensional construction (Paudel, 2018). As it makes sense, this process transforms different societies, cultures, and politics. Now, as a doctoral student, Tara started searching for her transformative journey and shifting her identity as a teacher and educator; also, to some extent, she has started seeing it from the glass of

transformative learning for the evolution of identity, which depends upon self-transformation.

Self-transformation is the manifestation of forming an individual from every aspect of human existence. In this context, Albert (2017) advocated that the psychology of self-transformation is linked with concepts of human existence, including aspects that give meaning to an individual's life. The common meaning-generating aspect of human existence includes the expression of mind, behavior, personality, attitude, and emotions. During every living moment of an individual's life, the human mind is incorporated with different kinds and vague levels of mental states. These mental states include all the emotions, feelings, thoughts, attitudes, cognitions, perceptions, behavior, personality, and many more (Oosterwijk et al., 2012) that are reflected in the day-to-day interaction of individuals with their environment. A person is affected by the environment and society in which they grow up. This influence can be seen in their way of forming and changing their identity. In this context, Stets and Burke (2014) added that self-transformation involves a critique of the self-confined within a particular socio-cultural context, and nurturing the self from critiques innate to normal human psychology. This human psychology changes an individual internally and externally that relates to interaction with other people in society as well as a component that a person has from within. It is created and recreated during a person's life span for self-transformation.

Likewise, identity deals with the definition from our own perspective and other fellow's perspectives. The world around us has various approaches to describing the multi-dimensional phenomenon of identity. Usually, identity can be illustrated from a subjective and objective perspective (Fadjukoff, 2007). So, identity is also contextual as a person can be identified according to the different contexts that are around. It is a continuous process of individual experiences, interpretation of these experiences, and construction of our meaning of the experiences (Dickinson, 2012). The identity of a person is formed on the basis of their dignity, honor, and self-respect (Fearon, 1999). They have different thoughts and feelings about their identity time and again. The fact is that a person's identity is never constant as it changes as time progresses (Oyserman et al., 2012). Erikson (1968) commented that identity includes self-perception in an equally integrated way, both internally related to the individual and externally related to the individual's interaction with the surrounding world. In this scenario, the concept of the self brought about priority to the inner dimension that takes into consideration the external interaction as a function. Regarding an individual's personality, emphasis is given to external connections and interactions. Hence, identity includes the external as well as learning dimensions as a coherent whole.

Correspondingly, an additional view of Drikx (1998) underpins that identity is also linked with self-understanding, self-confidence, and self-realization. It

includes who Tara really was, what Tara really did, and who Tara really had to become. Identity also builds up self-confidence as a person with identity has the confidence to perform activities better. Furthermore, self-realization comes with identity traveling deeper, touching the area of existence followed by the *Dharma* and *Karma* (Dahal & Luitel, 2022) of human life. It is a concept that is solely dependent on the personal self, and it is also a combinational perspective of personal experiences wrapped up with happenings of any individual life history on physical, emotional, and social grounds. On the contrary, from a cognitive-developmental perspective, it is generally understood how adult learning fits into self-formation and re-formation.

Transformative Learning and Identity Change: A Theoretical Lens

In terms of identity transformation, Tisdell (2012) added when acquiring experience related to transformative learning, a person's primary core identity or worldview changes. The transformational learning experience helps people change their major identities or worldviews (Mezirow, 1991). Illeris (2014) also argued that the learner's identity changes due to the learning process. Similarly, Dirkx (2007) found that transformative learning revealed a fundamental change in our perception of who we are and how we live in the world, including a move toward the truth about our story. Merriam et al. (2007) argue that transformative learning involves a radical, fundamental shift in the way we view ourselves and the environment in which we live. In this regard, Tennant (2005) remarked that studies on transformative learning are supported by implicit and explicit presumptions about our individual selves and identities and the importance of society, which are correlated with the personal formation of any change. Out of all the theories, Illeris and Drikx's theories about transformative learning and identity offer a great theoretical lens through which to view our goal and comprehend the direction of my research into the relationship between transformative learning and identity. Illeris and Drikx have put in a lot of effort to deeply analyze transformative learning and identity change.

When we try to understand identity from the perspective of transformative learning, we can see the direct linkage between identity and transformative learning. In this context, Jordan (2020) proposed transformative learning as all learning processes linked with change in the identity of the learner. Similarly, Dirkx (2007) defined transformative learning as a fundamental shift, a shift in our sense of our identity, ways of being in the world, and a movement toward the story to search for its truth. Baldwin (2019) further visualized transformative learning as a deep learning perspective marked by a transfer in consciousness and self-understanding domain. Self-understanding is merely a way of understanding or knowledge creation of a person’s feelings, capabilities, and motivations

themselves. Here, self-knowledge as a human self-understanding includes gaining a greater sense of analysis and understanding. Transformative learning is nurtured by organizing interactions in daily life from the contexts of learning where emotions, images, and conflicts also emerge. When learners gauge in depth the meaning of all these emotions, images, or disruptions, they experience a conspicuous shift in consciousness, which fosters an intensely personal understanding of which one is a path to becoming something. When transformative learning flourishes, it brings about change and the development of identity.

Relating to the view above further, Illeris (2014) has elaborated on identity connected with the self, which is associated with qualities of understanding, confidence, and realization. It is linked with how much an individual understands the environment and all situations, and happenings around him/her, how much confidence a person has and how much an individual understands and experiences themselves. Illeris (2014) further extended that it is multifaceted, with three layers: core identity, personality, and preference. Core identity is the innermost layer that gives light to the deep qualities that make a person a distinct individual and gives realization of who they are as an individual. Another layer is the personality layer which deals with how one links themselves with the outer world, including society, communities, groups, important issues, happenings, instances, significant events, and incidents. It also embraces one's principles, behavior patterns, values, meanings, and social conventions, including communication habits, collaboration patterns, empathy, social distance, and belonging. The outermost layer is the preference layer in which we encounter things and issues that we encounter in daily life that is meaningful to us. It is not merely about what we feel and think, it is linked with what we are actually able to do and are willing to mobilize our energy for a change. So, we can say that people can only change their sense of self-identity if they have a strong desire to start transformative learning.

Identity Change within the Context of Transformative Learning

When it comes to transformative learning, the self is the target area, and a person who learns is the moonstone of transformation (Jarvis, 2009, 2012). Transformation starts with the self; a similar word that refers to the self is identity. Oyserman et al. (2012) added that self and identity are used synonymously, with identities buried within self-consciousness and self-concepts embedded within the self. Dirkx (2006) remarks transformative learning includes the learner's deeper and unconscious mental layers in addition to their conscious understanding. Making unconscious factors a component of consciousness is regarded as a significant accomplishment of transformative learning. In this passage, Dirkx et al. (2006) offer an alternative transformative learning approach described as "soul work" or "inner work." This perspective suggests a more comprehensive and integrated

understanding of subjectivity that takes into account the emotional, intellectual, moral, and spiritual aspects of how we exist in the world. Deep learning that challenges prevalent, taken-for-granted assumptions, meanings, and notions of what learning is about is the focus of those who take the 'transformative' in transformative learning seriously. As a result, the idea of transformative learning includes learning components that suggest changes in the learner's identity (Illeris, 2014), since the terms "self" and "identity" are typically used in conjunction to depict any personal mental totality. We used the word "identity" to define transformative learning in the sections above because it is a combination of individuality and sociality.

Emerging into professional life and getting close to ideal personalities begins from the time when any individual enters their professional life. In the time span, he/she refines their cultural value, beliefs, and assumptions in the run of finding alternatives for their life. This is reflected in their personal life as well as their professional life. When Tara was in a race in her professional career, she participated in different conferences and webinars and got an opportunity to observe paper presentations and listen to discussions. She started learning about new ideas and ways to bring novelty to her professional tasks. This way, she furnished her presentation and professional development skills. This form of professional transfiguration has also been slowly imparted to her students. Now, we have realized that Tara's perception of teaching mathematics gradually changed. In this process, she constantly started questioning herself, her work, and my situatedness. This habit of questioning has revolved around a personal change in performance and action. In such a way, transformation is based on "before changing others at first try to change yourself" (Mezirow, 1991, p. 12). This has strengthened her consciousness and ability to practice by teaching transformative learning to become a change agent (Shrestha, 2019). This professional incorporation at a slow pace tunes the identity along with personal change as the process of modifying identity.

Transformation can be visualized in terms of psychology dealing with the psychological changes of the individual (Welwood, 2002). A personal transformation as a fundamental change in one's personality involves conjointly resolving a personal change and expanding consciousness, resulting in higher personality amalgamation. Analytical psychology elaborates on the relationships among the known and unknown self-components with how individuals get insights into their inner and outer realities (Boyd, 1989). Personal transformation is also defined in between the framework, including analytical psychology. Through transformative learning traditionally has an exclusive focus on the rational process of learning with an assumption that ways of knowing and constructing knowledge both are related to the human mind and body, we envision transformative learning in a holistic way of knowing and constructing knowledge both should be related to

not only mind and body but touch the spirit too. At this point, transformative learning is an asset to help learners actively participate and engage with the concepts that are attended to within the surface area of their own lives (Schnepfleitner & Ferreira, 2021). This includes, both independently and within others, critically examining the justification of new knowledge content because it has the potential to aid further transformations in the human consciousness.

Identity sprouts within an individual beginning from a sketch and is made attractive through caressing with multiple colors of reality. It depends upon the way an individual sketches the blank pages of their life. A person has a mind, value, and belief and also establishes a level of realization, whereas transformative learning is solely about bringing change in an individual and/or learner's perspective through reflections (Rahman, 2022). Hence, it can be viewed as 'self' and 'identity', which are mostly used to specify any person's mental wholeness. Furthermore, the self includes a diversity of more determined connections, such as self-consciousness, self-awareness, self-perception, self-direction, and self-reflection (Illeris, 2018). Also, when a person undergoes transformative learning, they develop self-understanding, self-confidence, and self-realization (Illeris, 2014), which creates a chain of transformative learning and identity. This chain includes transforming any individual through a change in identity.

Final Remarks

This reflective paper concludes that transformative learning can be defined as the expansion of human consciousness through which they view and tour their self-life world. It is directly related to identity, as identity transformation occurs at a more conscious level. Transformative learning and identity change come from an individual's personal level of transformation and consciousness. In education, a "transformation" is a refinement of the thinking of educational personnel, curriculum developers, teachers, teacher educators, and policymakers that is transferred to the next generation through practitioners. It is a process that involves a shift from one mental image set to another, resulting in an identity shift in both educational and psychological terms.

In teaching-learning, it is a change of assumptions about education and socio-cultural strategies prevalent in societies and individual mindsets. When this form of learning is brought about, it critiques and then redesigns perceptions and values, followed by changing the expectations and aspirations of learners. For transformation, not only cognitive change but there is a need for change in emotional and social dimensions. We have come to realize when there is self-transformation, there is a transformation of inner and outer individual existence. After that, transformation carries about identity change as a whole in general and individuals in particular. We feel that the essence of transformation, a possibility in

the mind of every individual with the awakening of consciousness, gives meaning to life for people. Near the end, we found transformative learning to be the mirror of an identity change for reflecting transformation.

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Math Anxiety Research Paper

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A Strategic Remedy for Math Anxiety

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MAE 6151 -001: Math: Elementary/Middle School

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Abstract

Math anxiety can be characterized as feelings of apprehension or distress that individuals experience when faced with tasks or activities associated with mathematics. Due to its prevalence, math anxiety is a growing issue for teachers who seek to uplift and prioritize the comfort, well-being and success of their students. Failure to address math anxiety can significantly hinder a student's learning, lower their academic performance, and negatively cloud their overall attitude towards mathematics. In gathering and sorting resources associated with prevailing positions regarding math apprehension, this paper aims to explore math anxiety's impact on students' learning, and the benefit of collaborative efforts between parents and teachers to curtail math anxiety. In doing so, this paper details a purposeful approach to teaching mathematics that is conducive for those students who experience math anxiety. It discusses the importance of a supportive classroom environment and implementing unique instructional strategies while identifying various measures that can be used to assess the progress of students who are trying to overcome math anxiety. As an elementary school, third-grade teacher, this paper—and the approach it depicts—is also a reflection of the lessons I learned while teaching two students with math anxiety this past year. It should be noted, moreover, that any general statements that are made about beneficial, strategic instruction are rooted in my own experiences.

I. Introduction

While the term "math anxiety" may be interpreted as an emotional response to a poor performance on a mathematics assessment, or an indicator of an student who is unpropitious in his or her academic endeavors, these are facile generalizations; rather, a student may perform poorly on a mathematics assignments because they feel anxious before they even began the exercise. Author Zarina Geatry's "Math Anxiety is Real; How Teachers Can Help Calm the

Nerves" notes that even accomplished mathematicians, such as Laurent Schwartz and Maryam Mirzakhani, have reported experiencing math anxiety. In studying math anxiety and its consequences for students, researchers have aligned their estimations of the portion of the general population that suffers from the disorder—approximately one-fifth or 20%—with one another, and thus have not only corroborated the prevalence of the academic apprehension, but highlighted the importance of finding an effective remedy (Geatry). By amalgamating the essential takeaways from both the abundance of research centered around math anxiety with my recent observations of two students who suffered from such academic distress, this paper aims to carefully curate an innovative approach—one strictly based on the existing, prevailing positions on the topic— designed to alleviate anxiety among math students.

II. Understanding Math Anxiety

Devising an efficacious solution to curtail the ubiquitous experience of math anxiety requires first delving into the intricacies of such apprehension. As a third grade teacher, I taught and observed two students who suffered from math anxiety in the same classroom last year. Though they both suffer from the same kind of disorder, their behavior starkly differed when confronted with an activity or exercise associated with mathematics. One of the two students would showcase his vehement apathy towards mathematical instruction by yelling, crying, attempting to move around the classroom and disrupting the learning experience for his peers. The other student, on the other hand, would tend to suppress her emotions, stop talking, and avoid eye contact; it was apparent that though this student may not have been as verbally or physically disturbed by the introduction of mathematical instruction, she was equally detached from the lesson. This experience depicts the range of expression regarding math anxiety; it is

imperative for educators to recognize that individuals react to unpleasant stimuli in different manners.

Given math anxiety's seemingly paradoxical nature, individualistic complexities, and relevance to improving the learning experience for all students, much research has been dedicated to defining and identifying the indicators and effects of the disorder. General academic anxiety refers to a broader kind of anxiety experienced by students in regards to their overall academic performance. Math anxiety, in contrast, specifically pertains to the apprehension that students experience when faced with math-related, mental tasks. According to the Journal of Experimental Psychology, math anxiety can be described by the experience of "panic, tension, and helplessness aroused by doing math or even just thinking about it." Because the brain devotes more energy to coping with the stress than to processing information, students are more likely to lose focus and as a result, struggle to retain and process information (Ashcraft & Kirk, 2001). The added challenges associated with devoting energy to math-related mental tasks—according to "General academic anxiety and math anxiety in primary school. The impact of math anxiety on calculation skills"— tends to also induce students to have low perceptions of their capabilities and as a result, perform poorly in reasoning, processing and evaluating information (Commodari & La Rosa, 2021).

III. Creating a Supportive Classroom Environment

Carrying out a teaching approach that is conducive to the goal of curbing stress and anxiety among students begins with the classroom environment, which, if meticulously maintained, can play a crucial role in relieving anxiety among students and enhancing their academic performance. By carrying out lesson plans in strategic ways designed to make students feel engaged, accepted and valued in the classroom, teachers can foster a positive atmosphere

that encourages risk-taking, engagement, and open communication. For example, research has shown that dedicating the first five minutes of a lesson to short, anxiety-reducing exercises, such as meditation or do-now activities with no "incorrect" answers helps students loosen up, improve focus and concentration. For instance, questions such as "What did we enjoy doing in class yesterday?" or "What is on our agenda today?" allow for multiple correct answers and serve to boost esteem, confidence and camaraderie among the students (Gearty).

Additionally, it is the relationships within a classroom, whether between a teacher and a student or among students themselves, that are vital for creating a positive and empowering learning environment. Though building these relationships ultimately serves to enhance a class of students' overall academic and social growth, however, few classroom teachers have much training or knowledge regarding such social support. Author Jessica Minahan of "Building positive relationships with students struggling with mental health" noted that "few classroom teachers have much training in mental health counseling and support… despite the proven value of interaction strategies, they are almost never written out and shared among colleagues." Some of these mechanisms or interaction strategies include tact regarding tone of voice, proximity, use of humor, de-escalating responses to defiant behavior, and gentle ways of giving constructive feedback (Minahan, 2022).

IV. Implementing Instructional Strategies

For the educational system to truly encapsulate a collective commitment towards ameliorating the content-learning experience and reducing math anxiety among students, then teachers must utilize an engaging and relevant math curriculum with the goal of capturing interest and motivating students to learn. In overseeing and delivering meaningful and relatable

math lessons, teachers can help students visualize the role of mathematics in their daily lives, which can promote a deeper understanding of the pertinent concepts.

Teaching a course in an equitable manner that aims to appeal to each student in the classroom requires an educator to differentiate instruction to accommodate diverse learners; this includes, if possible, teaching students multiple ways to help solve a math problem. For example, a valuable mechanism that is versatile enough to be tailored to each student's personal creativity and comfort, according to "How to Help Kids With Math Anxiety" by Rachel Ehmke, is the mnemonic device. As it pertains to aiding students in retaining information, moreover, clear and effective communication of mathematical concepts is necessary. As opposed to dull, verbal teaching instruction, the use of captivating visual aids and manipulatives are among the best tools for teachers to employ in order to achieve this goal. As conveyed by "Impact of Visual Aids in Enhancing the Learning Process Case," it is due to the meteoric, innovative nature of technological design, visual aids are only growing in their appeal: "practical improvements in the creation of visual aids for classroom use have been remarkable…using visuals aids as a teaching method stimulates thinking and improves learning." Manipulatives, additionally, hold significant value for educators since they provide concrete, hands-on experiences for students to explore mathematical concepts. In having my students tackle hands-on math activities that required them to use—and become comfortable with the concepts illustrated by —tangible examples, such as place value blocks, I can attest to their value in lessening math anxiety; they help students visualize abstract ideas, develop critical thinking skills, and increase their comprehension of mathematical principles.

V. Addressing Math Anxiety

As stated, persistent commitment from teachers towards actively considering ways to mitigate a student's math anxiety during class time is paramount, but as is the potential collaborative relationships these teachers can share with the parents of the students. By establishing open communication and coordinated, collaborative efforts, both parties can work together to provide the necessary support and resources to propel the student past their apprehension and towards success in mathematics. Building and refining my relationship with the parents of my students was indispensable in my pursuit to attenuate the effects of math anxiety in my classroom.

In working together, parents and educators can efficiently cater to the needs of kids to help them become more resilient learners. One strategy that both parties can cooperatively employ, Dr. Pagirsky of the Child Mind Institute notes, is to alter how they praise children and adjust what they think of as a successful learning experience. In other words, praising students for the work that they put in, not necessarily for the grade that they get, can be beneficial. Moreover, though trying to help children with their math homework may be anxiety-provoking for some parents, it is important for them to recognize that they use math reasoning in their daily lives more than they realize. Thus, parents of math students can expand on the momentum that teachers—with their use of in-class instructional strategies, such as manipulatives—have generated in class by using real-world examples to explore math concepts with their children (Ehmke, 2023).

VI. Evaluating the Effectiveness of Strategies

The effectiveness of a holistic teaching approach that is aimed at reducing apprehension can be evaluated through various lenses, considering factors such as student engagement, anxiety indicators, academic performance along with measuring progress based on class-oriented goals

made at the beginning of the school year. When measuring the success of such strategic instruction, teachers must be cognizant of the cues that their students make when faced with math related tasks; students with math anxiety display it in different manners, so identifying a disgruntled student's tendencies and measuring his or her departure from, or gravitation towards, that behavior over the course of the year. Examples of indicators of math anxiety include, but are not limited to: a student "shutting down" avoiding eye contact, having closed body language, or making self-critical comments such as "I'm bad at math" (Gearty).

In addition to identifying and monitoring indicators among their students, teachers have access to tangible results such as math quizzes, exams, homework, and student performance during math lessons. However, it is important to remember that these have limitations, given that some students with math anxiety nevertheless perform strongly in the subject and vice versa.

Finally, teachers can evaluate the success of their students relative to if they are on track to meet the math learning goals and or expectations that were set forth at the beginning of the school year. If a select student doesn't appear to be gravitating towards such desired results, then the primary educator can try to identify the basis for such academic shortcomings, and whether math anxiety had a role in producing them.

VII. Conclusion

The most effective remedy for mitigating and assuaging the effects of math anxiety is a multilayered approach that aims to empower students to overcome their distress and develop a positive relationship with mathematics. Such a calculated practice requires patience, empathy, and consistent support on behalf of the student's learning environment. Moreover, a thoroughgoing commitment towards alleviating a student's math anxiety entails active,

cooperative action by teachers and parents who seek to deepen their understanding of the disorder and as a result, can accommodate the student on a daily basis. Since tangible results associated with academic performance have their limitations, educators can assess and monitor their progress in reducing math anxiety among students by focusing on indicators such as increased participation in class, improved self-confidence, and enhanced academic performance in math-related assessments and assignments. This methodical process for teachers, aimed at limiting the effects of apprehension among students, is based on the prevailing positions and research that has been assembled regarding math anxiety. By implementing these approaches, teachers can create a nurturing learning environment that empowers students to overcome their math anxiety and develop a positive relationship with mathematics.

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Math Anxiety

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MAE 6151-001: Math: Elementary/Middle School

Summer 2023 - 2 First Half Term

Dr. Furner

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Abstract

This paper examines the concept of mathematic anxiety, which has become so prevalent in students ranging from early elementary grades up to middle school and on into adulthood. Math anxiety can develop from many experiences and can easily proliferate over time.

Do you ever look at a math equation… maybe one including numbers, different signs, or even letters and think to yourself what am I looking at? This is mathematic anxiety. Mathematic anxiety is when you associate fear and worry with math. It sounds like a made up "disorder", but it is actually very common and there is evidence to prove it.

Back in 1950s Dreger and Aiken coined the term mathematic anxiety, but some people or only believe that Mary Fides Gough was the one who is invented it. Math anxiety is a real. There are many layers to mathematic anxiety. Math anxiety has negative effects immediately for people, but also overtime on the human brain.

Many people have anxiety due to math because of a whole multitude of reasons. Ashcraft and Kirk (2001) discovered that " people with high maths anxiety demonstrated smaller working memory spans than people with less maths anxiety, especially in tasks that required calculation. In particular, they were much slower and made many more errors than others in tasks where they had to do mental addition at the same time as keeping numbers in memory." These notable scholars are essentially saying having math anxiety is an issue not just because of worry and fear of numerical equations, but also because it can decrease someone's ability to store important data in their mind, therefore their memory is on the decline. Also, researchers suggest that mathematics anxiety has to do with the negative connation people associate with math… like test taking, word problems, and the complexity of equations. According to Psychology Research and Behavior Management section of the National Library of Psychology, "Attitudes to mathematics also involve conceptualization of what mathematics is, and it is possible that this is relevant to mathematics anxiety. Many people seem to regard mathematics only as school-taught arithmetic and may not consider other cultural practices involving numbers as mathematics," this can relate to people fearing math due to them not using or envisioning math to be someone exciting that

surrounds us. Associating a negative connation with math anxiety is one of the main reasons why students dread walking into math class.

So how can someone prove that mathematical anxiety is not just something people say to get out of math or fearing if they are going to do their family finances correctly. Well, math anxiety can relate to people who despise math, but it also is a real issue for the neurodiverse population. People actually have math disabilities, I included. Although there is an assumption that some people believe that people cannot have math anxiety and it just something that they don't enjoy doing or are lazy. People try and prove that the only portion of our population that is justified to have math anxiety is those who have special needs. This is not factual information because all people can have math anxiety, but math anxiety cannot be because of someone's view of math…that is not a sufficient enough answer or reason.

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Transformations

Manuscript 1051

Which Modality Best Promotes Student Achievement in College Algebra

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Introduction

Palm Beach Atlantic University (PBA) is a small, private university located in West Palm Beach, Florida. 2,137 traditional, undergraduate students attended PBA during the 2020 fall semester (PBA Facts & Data, 2020). Due to the COVID-19 pandemic, during the 2020 fall semester, PBA gave the traditional undergraduate students, who would normally attend class in person, the option of either attending classes in person or logging in remotely to the learning management system (LMS), which is Canvas, and attending via Zoom. Students could choose to attend in-person classes remotely for the entire semester, if desired. However, if a student was quarantined or tested positive for Covid-19 at any point in the semester, they were also able to attend the in-person class remotely during the quarantine period via Zoom. At PBA, this new instructional modality was called “HyFlex”.

To accommodate these HyFlex students, each classroom was equipped with a computer that included a webcam and speaker. Our eLearning and campus technology departments spent many hours configuring this technology so all students were able to actively participate in class discussion remotely while the class was being conducted face-to-face. In the two weeks prior to the start of the fall semester, faculty were trained in the use of the new HyFlex classroom technology and provided with suggestions on best practices in teaching in person students and remote students at the same time. During this semester, professors teaching a face to face class had students in the classroom, as well as other students who were viewing and participating in class, by choice or by being quarantined by the Health Alert Term., via Zoom. Additionally, the students who joined remotely changed throughout the semester as students moved in and out of quarantine.

Although professors were able to teach in person classes remotely if they were quarantined, they were not afforded the same opportunity to teach remotely for the entire semester if they had health issues and were uncomfortable coming to campus due to the pandemic. For example, a week or two before the semester was to begin, an adjunct professor informed the Chair of the Mathematics Department at PBA that she would feel uncomfortable teaching a face-to-face class at this time. She was scheduled to teach a section of Intermediate Algebra and a section of College Algebra. This adjunct faculty member had a respiratory problem and felt unsafe coming to campus with the possibility of contracting the virus. The courses were not able to be converted to completely online courses since both courses had students who were registered to attend these courses in person Therefore these classes were scheduled as face-to-face modality. The College Algebra class is included in this study. As a result, the Department Chair taught 5 different sections of College Algebra during the 2020 fall semester – 3 online, 1 hybrid, and 1 face-to-face. Both the hybrid and face-to-face sections included different HyFlex students at various times throughout the semester.

The purpose of this study is to determine if there is a significant difference in student achievement in totally online, hybrid, or totally face-to-face instruction modalities using Trigsted's College Algebra, 3rd ed., implementing MyMathLab software in all three.

Background

The text and software that is used in my College Algebra classes is a Pearson product. The title is College Algebra and the author is Kirk Trigsted from the University of Idaho. The first edition was developed in 2012 and was intended to be used as an entirely online experience. As is mentioned on its website:

> "*Everything your students need to be successful in your course is located in one convenient place. Built entirely within MyMathLab, the Trigsted MyMathLab Series delivers a completely clickable, totally integrated learning experience.*" (Trigsted MyMathLab Series, 2021)

In the year 2020, the third edition of the text was used. All of the homework, quizzes, and tests are the same for all types of delivery.

The homework problems can be done an unlimited number of times, but an 80% achievement score must be achieved before the quiz for that section will be available to the students. Even though they can do the homework problems an infinite amount of times, if the correct answer is not obtained after three tries, the software will ask if you want another problem similar to that one or if you want to move on to the next problem.

All quizzes are timed, but may be taken twice. However, if the student wants to take the quiz a second time, he/she must get a 90% on the Customized Practice (CP). This CP only needs to be completed if the student wants to take the quiz a second time and is "customized" to the individual student and the type of problems which were not correct the first time taking the quiz will appear on the CP. If a quiz is taken for a second time, the software takes the higher score between the first and second attempts at the quiz as the grade recorded for the quiz and synced to the Canvas gradebook..

There are three tests and the final exam and they are all timed. Each test can only be taken only once and has three parts. The first part is the Review Check-up and is timed and is to be taken like a quiz in one sitting. The result is not counted in the student's gradebook, but

has the purpose of finding out what material the student remembers and understands. Any score will suffice to move to the next step on the Review Check-up, but the better the score on the Review Check-up, the less work needed for the Customized Practice for the test. Unlike the CP for the quiz, the CP for the test has to be done and counts toward the student's grade. Each CP is different for each student and is made-up of problems missed on the Review Check-up and a 80% needs to be obtained on the CP for the test before the test itself will be available. The CP for a test is like homework and has unlimited chances to get a problem correct. The objective is for the students to learn the material and to be successful in ~~m~~athematics and to have a positive experience, which will be defined as the student having a better feeling toward mathematics and having an attitude that they can achieve an A, B, or C in College Algebra.

Method

As noted in the Introduction, the study was conducted in the Fall semester 2020 at Palm Beach Atlantic University. Due to the COVID-19 pandemic, during the 2020 Fall semester, PBA provided traditional, undergraduate students three different modalities for completing College Algebra: attending classes in person for live lectures during each scheduled class session, a hybrid class that met for 75 minutes each week as compared to Face-to-Face instruction which meets 150 minutes per week., or taking the class entirely online with no live face-to-face lectures. A choice was offered for students to participate in a live class remotely for the entire semester, if desired, by logging into the live class using Zoom. The number of students using this option was very small and the authors considered attending a

live lecture presented on Zoom to be the equivalent of attending a class in person since the Hyflex system was used to present these lectures. The Hyflex system allowed students to see lectures by using a classroom mounted camera, to hear lectures by using a classroom mounted microphone, and to ask questions that could be heard by the instructor and other students through classroom speakers. Additionally, if PowerPoint or other electronic media were used, screen-sharing within Zoom would allow students to see these resources as well. Students were not randomly selected for each class instruction modality, as students self-selected the modality they preferred when registering for the class, if at all possible. The classes were listed in the college course catalog for the Fall 2020 semester with identifiers indicating the modality of the instruction that would be used within the course.

The method of the study was to collect Final Course averages from each modality of instruction, totally face-to-face instruction, hybrid, or totally online and compare levels of achievement by Final Course averages. Achievement was not a subjective judgment of performance, but merely a comparison of Final Course averages (means or medians) attained based on each modality of instruction.

Table 1: Group A Face-to-Face Instruction (n=23)

Student	Gender	FR,SO,JR, or SR	Letter Final Average	Numerical Final Average
1	M	FR	W	NA

2	M	FR	B	84.03
3	M	FR	B-	80.10
4	F	FR	B	85.86
5	M	FR	C+	76.62
6	F	FR	A	92.77
7	M	FR	W	NA
8	F	FR	C-	70.26
9	F	FR	C-	70.85
10	F	FR	C-	70.96
11	F	FR	A	93.97
12	F	FR	F	28.44
13	F	FR	D	63.05
14	F	FR	B	86.27
15	F	FR	B-	81.82
16	F	FR	D-	60.81
17	F	FR	A-	89.52
18	F	FR	B-	80.38
19	M	FR	A	92.87

20	F	FR	B	84.24
21	M	FR	B	85.79
22	M	FR	C-	71.14
23	F	FR	A	95.14

1. 0 SR (0.0%), 0 JR (0.0), 0 SO (0.0). 23 FR (100.0%)
2. 8 Males (34.8%), 15 Females (65.2%)
3. 5 A's (21.7%), 8 B's (34.8%), 5 C's (21.8%), 2 D's (8.7%), 1 F (4.3%, 2 W's (8.7%)
4. The two W's were not included in the statistical calculations

Table 2: Group B Hybrid Instruction (n=35)

Student	Gender	FR,SO,JR, or SR	Letter Final Average	Numerical Final Average
1	M	FR	F	18.12
2	M	SO	B-	81.99
3	F	FR	F	23.23
4	M	FR	D-	61.57
5	M	FR	F	0.00
6	M	FR	F	48.97
7	F	FR	C	75.74
8	F	FR	A	96.16
9	M	FR	C+	76.78
10	F	FR	B-	81.80

11	F	SO	F	0.84
12	F	FR	D+	67.97
13	F	FR	D	66.30
14	F	FR	F	48.48
15	M	FR	F	8.43
16	F	FR	F	56.26
17	F	SO	W	NA
18	M	FR	B-	82.27
19	F	JR	B-	79.40
20	F	FR	F	25.89
21	M	FR	A	93.59
22	M	FR	C	75.63
23	M	FR	F	0.84
24	F	FR	A	93.84
25	M	Non-Degree	W	NA
26	F	SO	W	NA
27	M	FR	C	72.51
28	F	FR	C-	71.01

29	F	FR	A	96.25
30	F	FR	A-	90.30
31	M	FR	F	38.21
32	F	FR	B-	81.15
33	F	FR	A	95.13
34	M	SO	F	6.31
35	F	Non-Degree	D	67.74

1. 0 SR (0%), 1 JR (2.9%), 5 SO (14.3%). 27 FR (77.1%), 2 Other (5.7%)
2. 15 Males (42.9%), 20 Females (57.1%)
3. 6 A's (17.1%), 5 B's (14.3%), 5 C's (14.3%), 4 D's (11.4%), 12 F (34.3%, 3 W's (8.6%)
4. The three W's were not included in the statistical calculations

Table 3: Group C* Totally Online Instruction (n=71)

Student	Gender	FR,SO,JR, or SR	Letter Final Average	Numerical Final Average
1	F	FR	B	83.31
2	F	FR	B-	80.77

3	F	FR	F	4.40
4	M	FR	A-	89.3
5	F	FR	D+	67.91
6	F	FR	B-	81.59
7	F	FR	B-	79.34
8	F	FR	D-	61.69
9	F	FR	F	1.51
10	F	FR	B-	81.27
11	M	FR	F	4.46
12	F	FR	B	84.93
13	M	FR	C	76.34
14	M	FR	B	82.12
15	F	FR	B-	80.39
16	M	FR	C-	68.27
17	M	SR	B-	82.29
18	F	SO	A	94.73
19	F	FR	A	93.14
20	F	FR	B-	81.26

21	F	FR	C	73.17
22	F	SO	A-	91.77
23	F	FR	B	85.52
24	M	JR	B	83.74
25	M	FR	B	85.70
26	M	FR	B	86.37
27	M	FR	A	97.06
28	F	SR	F	7.25
29	F	SO	W	NA
30	M	FR	B-	81.52
31	F	FR	C+	78.44
32	M	FR	C	76.10
33	M	FR	B-	80.87
34	F	FR	A-	89.30
35	F	FR	B	82.41
36	M	FR	W	NA
37	F	FR	B	83.33
38	F	FR	F	20.77

39	F	SR	C+	79.01
40	F	SO	A	95.10
41	M	SO	B+	86.54
42	F	FR	W	NA
43	F	FR	B+	78.90
44	F	SR	F	0.00
45	M	FR	F	25.33
46	M	FR	B	85.45
47	F	FR	W	NA
48	F	FR	A	95.80
49	M	FR	F	16.89
50	F	FR	F	11.11
51	F	FR	B+	87.16
52	F	FR	F	27.64
53	M	FR	D+	66.85
54	F	FR	A-	88.51
55	F	FR	C	72.12
56	F	FR	B	85.50

57	F	JR	A	92.62
58	M	FR	C+	78.58
59	F	SO	B	85.95
60	M	FR	B-	80.38
61	F	FR	B-	80.15
62	M	FR	D-	59.04
63	F	FR	C-	69.52
64	M	FR	B+	88.43
65	F	FR	C+	78.24
66	M	FR	F	21.13
67	F	SO	C-	71.48
68	M	FR	F	15.85
69	M	FR	F	24.47
70	F	FR	B-	82.30
71	F	FR	W	NA

1. 4 SR (5.6%), 1 JR (1.4%), 6 SO (8.5%). 60 FR (84.5%)
2. 26 Males (36.6%), 45 Females (63.4%)
3. 10 A's (14.0%), 28 B's (39.5%), 11 C's (15.5%), 4 D's (5.7%), 13 F's (18.3%), 5 W's (7.0%)
4. The five W's were not included in the statistical calculations

* Group C is the result of combining three online sections.

Results

The three students in the three different class modalities were not randomly selected, however, no known systematic process was used to encourage students to opt for one type of teaching modality over another. The feeling of the authors is that students tend to choose classes based on two conditions: 1) what class fits their schedule and 2) what instructor is teaching the class. In this study, the same instructor taught all three classes using three different modalities so the second part of the decision-making process was not an issue. Therefore, if we consider that the priority for students choosing a class is how it fits their schedule, then the choice of each class is left to each student thereby inducing a sense of randomness to the instructor since each student in each class is not selected by the instructor. The results for each instructional modality of College Algebra are shown below in Table 4.

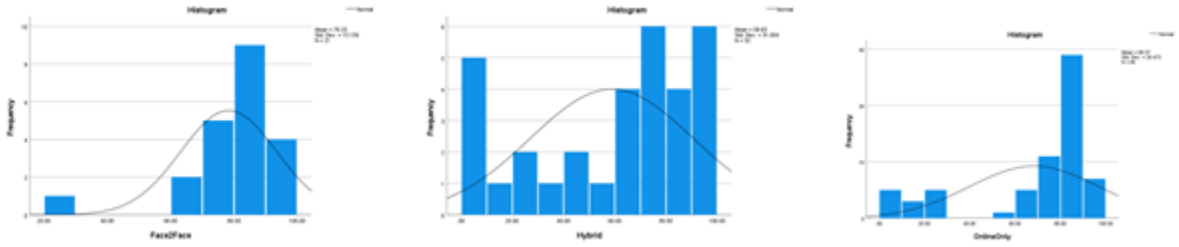
Table 4

	Face-to-Face	Hybrid	Online Only
Mean	78.328	58.835	68.370
Median	81.820	69.490	80.580
Standard Deviation	15.156	31.954	28.473
Variance	229.704	1021.086	810.717
Skewness	-1.857	-0.716	-1.396
Kurtosis	4.956	-0.850	0.452
N	21	32	66

The means for each instructional modality of College Algebra can be seen to vary substantially with about a 20 point difference between Face-to-Face and Hybrid modalities. The medians are close for Face-to-Face and Online Only modalities while the Hybrid median appears to differ.

The distributions of the modalities can be seen in the following Chart 1.

Chart 1



It is pretty easy to observe that the second (Hybrid) and third (Online Only) distributions are not normally distributed. A stronger argument for the normality of the first distribution (Face-to-Face) could be made if the extreme left data points were accounted for. However, using the results from an SPSS Shapiro-Wilk test of normality on each distribution (H_o: The distribution is normally distributed, $\alpha = 0.05$), it can be seen that none of the distributions are normally distributed (Table 5). In each case the Sig. (Significance level) was less than the established alpha value of 0.05 leading to a rejection of the null hypothesis in each test..

Table 5

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Face2Face	.166	21	.137	.838	21	.003
Hybrid	.186	32	.006	.878	32	.002
OnlineOnly	.274	66	.000	.741	66	.000

a. Lilliefors Significance Correction

The original intent for the analysis of the results was to compare the mean final scores for each modality using a one-factor analysis of variance (ANOVA). However, in general, ANOVA requires that the distributions used in the analysis are normally distributed. This is not the case, so the non-parametric Kruskall-Wallis test was used to compare the median final scores for each modality.

The hypothesis for the Kruskal-Wallis test assumes that the samples come from populations with the same median, whereas the alternative hypothesis is that the medians that are not all equal. Output from SPSS is shown in Table 6 below.

Table 6

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The medians of FinAvg are the same across categories of CollAlg.	Independent-Samples Median Test	.044	Reject the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

The test statistic is $H = 6.228$. The basis of the Kruskal-Wallis test is the Chi-square distribution. In this case there are two degrees of freedom and the Chi-square critical value using an alpha value of 0.05 is 5.991. Even though the test statistic 6.228 > 5.991, there is not convincing evidence to confidently reject the null hypothesis. This notion is supported when considering the

p-value (p = 0.044). Again, it can be seen that while the test shows significance, the significance is fleeting.

To further compound the uncertainty of drawing a strong conclusion regarding the differences between the medians of the distribution of the different instructional modalities, pairwise comparisons between the groups, when corrected, using the Bonferroni correction factor, show no difference in medians for any of the comparisons. Table 7

Table 7

Pairwise Comparisons of CollAlg

Sample 1-Sample 2	Test Statistic	Sig.	Adj. Sig.[a]
Hybrid-OnlineOnly	4.640	.031	.094
Hybrid-Face2Face	4.316	.038	.113
OnlineOnly-Face2Face	.097	.756	1.000

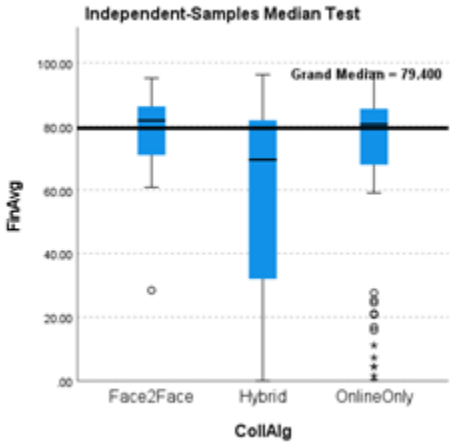
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Based on the above discussion, it would be difficult to state that instructional modality was a key factor in determining students' final averages in the courses examined in this study.

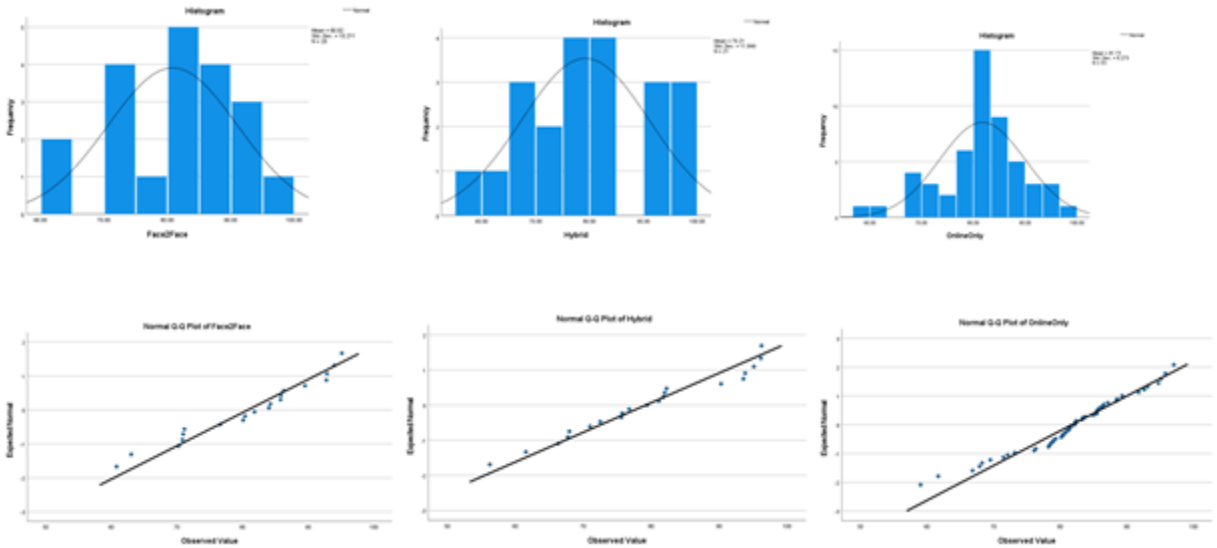
However, before abandoning the idea that instructional modality is not a factor, it may be worth considering students who, for whatever reason, failed to participate in the course in which they were enrolled. As can be seen in Chart 2 below, there appear to be several outliers which may represent students who are affecting the distribution's instructional modalities.

Chart 2



With that in mind, the data was modified to exclude students in each of the three groups who were not engaged (inactivity with assignments) for at least one month of the class. As shown below in Chart 3 the resulting distributions tend far more toward normality than their previously investigated counterparts. Also included are the Quantile Plots for each distribution.

Chart 3



Again, using the results from an SPSS Shapiro-Wilk test of normality on each distribution (H_o: The distribution is normally distributed, $\alpha = 0.05$), it can be seen that all of the distributions are normally distributed (Table 8). In each case the Sig. (Significance level) exceeded the established alpha value of 0.05 leading to a failure to reject the null hypothesis in each test.

Table 8

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Face2Face	.129	20	.200*	.944	20	.281
Hybrid	.126	21	.200*	.951	21	.353
OnlineOnly	.129	53	.028	.965	53	.117

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

As mentioned earlier, the original intent for the analysis of the results was to compare the mean final scores for each modality using a one-factor analysis of variance (ANOVA). Since the normality requirement for the ANOVA was met, an ANOVA was run using the Final Scores as the dependent variable and the modality of instruction as the factor. Table 9. Since another condition of ANOVA is the general equality of variances between distributions, Levine's test for equal variances was also included. Table 9. (The results of the Levine test showed no substantial difference between variances and $\alpha = 0.05$.)

Table 9.

ANOVA

FinAvg

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	96.000	2	48.000	.523	.594
Within Groups	8348.058	91	91.737		
Total	8444.058	93			

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
FinAvg	Based on Mean	3.057	2	91	.052
	Based on Median	2.873	2	91	.062
	Based on Median and with adjusted df	2.873	2	88.790	.062
	Based on trimmed mean	3.022	2	91	.054

Observing the results of the ANOVA on the three modified distributions of instructional modalities, it can be seen that the mean Final Score (FinAvg) does not appear to differ based on instructional modality at $\alpha = 0.05$. ($F = 0.523$ and $p = 0.594$)

At this point, the analysis of results based on instructional modality show:

1) Using unmodified data including all students completing each course (with its accompanying instructional modality) results in a very weak rejection of the null hypothesis of equal medians.

2) Using modified data excluding students in each of the three groups who were not engaged (inactivity with assignments) for at least one month of the class, the null hypothesis of equal means was not rejected.

Discussion

Whether students considered the modality of the class is an unknown factor in the study. Also unknown is whether students chose a modality they thought would best fit their own learning style or chose a modality based on some perceived probability of successfully completing the course. Future research is needed to determine the degree of confidence students have at the start of the semester and why they chose the type of modality that they did or why the scheduling counselor chose to add them to a class with a certain modality. Was it due to class space or some other issue? These are questions that could generate additional study on this subject. Additionally, why in the hybrid course did students spend a period of time in inactivity, while in face-to-face and totally online classes this did not appear to happen as frequently. The answers to these questions would be very interesting and could help mathematical educators better understand which mode of instruction would be best for certain students.

References

PBA Facts & Data. Retrieved from https://www.pba.edu/about/facts/index.html on May 18, 2021.

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[1] https://www.pearsonhighered.com/trigstedinfo/