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The Parabolic Math Classroom

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Goals and Objectives

Goals

- To revolutionize the way mathematics is perceived by the majority of students.
- To disrupt the way mathematics has been, and for the most part, is still being taught.
- To eradicate the tacit notion that only certain students are capable of being successful at mathematics.
- To establish the fact that “mathematics trauma” is a real “thing” that negatively affects and immobilizes billions of students and adults on a daily basis.
- To use theoretical math concepts, where applicable, to help us to solve classroom and learning related challenges.
- To design a physical classroom space that reflects the theoretical ideas of the Parabola; to design a space that is welcoming and comfortable; and to design one that facilitates learning regardless of the student’s preferred learning style.

Objectives

- To build a sustained level of “mathematics confidence” in every child during every class.
- To provide teachers with a new teaching platform that first considers the social and emotional well being of the student and then uses every opportunity to build and revisit foundational mathematical skills and coherently interleave mathematical concepts.
- To convince teachers, through current research, that all students are equally capable of effectively learning mathematics with the requisite assistance.
- To be aware that “mathematics trauma” is a real and pervasive element in most math classrooms and to imbed strategies in lesson plans to address this reality.

- To use the three basic parts of the Parabola(with their definitional underpinnings) to design a student driven classroom that honors where students currently are (on the Parabola); to design and implement tools to connect them to what they have already learned (the directrix, behind them); and to explicitly point them to where they will be going (focus, in front of them).

- To create four Parabola's in the classroom. Each Parabola will face a wall of the classroom and will be constructed with student desks. The vertex of each Parabola will point to the empty space in the center of the classroom.

Florida Standards

MAFS.912.A-REI.4.11

Explain why the x-coordinates of the points where the graphs of the equations y = f(x) and y = g(x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where f(x) and/or g(x) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.

MAFS.912.A-REI.4.12

Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

MAFS.912.A-CED.1.1a

Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational, absolute, and exponential functions.

MAFS.912.A-REI.2.3

Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

MAFS.912.F-IF.3.9

Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.

MAFS.912.A.CED.1.2

Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

MAFS.912.A.REI.4.10

Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

MAFS.912.A.REI.4.12

Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

MAFS.912.A.SSE.2.4

Derive the formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. *For example, calculate mortgage payments.*

MAFS.912.A.-ID.2.6

Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear, and exponential models.*
b. Informally assess the fit of a function by plotting and analyzing residuals.
c. Fit a linear function for a scatter plot that suggests a linear association.

MAFS.912.A.-APR.1.1

Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

MAFS.912.A.-APR.2.3

Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.

MAFS.912.A.-REI.2.4

Solve quadratic equations in one variable.

a. Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x – p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.
b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.

LAFS.8.RL.2.4

Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.

<u>LAFS.8.L.3.4</u>

Determine or clarify the meaning of unknown and multiple-meaning words or phrases based on *grade 8 reading and content*, choosing flexibly from a range of strategies.

a. Use context (e.g., the overall meaning of a sentence or paragraph; a word's position or function in a sentence) as a clue to the meaning of a word or phrase.
b. Use common, grade-appropriate Greek or Latin affixes and roots as clues to the meaning of a word (e.g., *precede, recede, secede*).
c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning or its part of speech.
d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary).

<u>Course Outline/Overview</u>

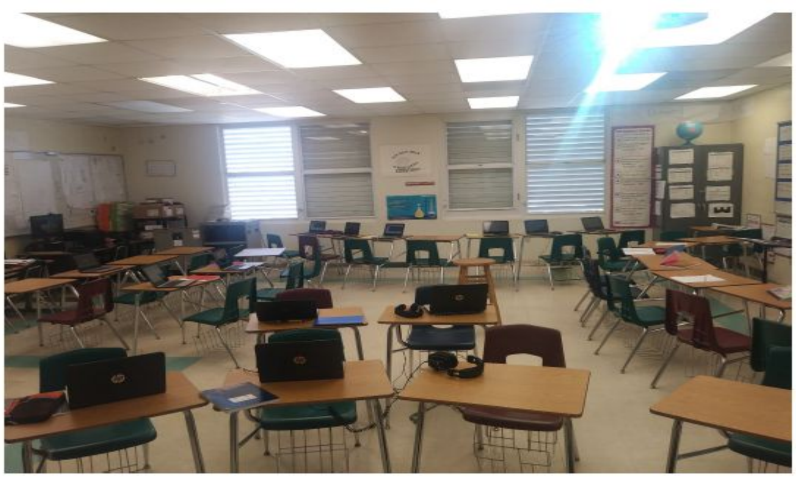
We often hear that U.S. student's academic achievement in mathematics continues to lag their peers in many other countries. Although this is perhaps statistically true, as numbers people, we should desire to know the demographic breakdown of those U.S. students who are performing poorly in mathematics. Further, the question should be asked, "why are certain demographic groups consistently performing at such low levels?"

The goal of this course is to identify and capture these groups of students who have underachieved in mathematics and to build in them a sustained level of "mathematics confidence." This sustained level of confidence can be created and nurtured by first identifying the reality of what I call "mathematics trauma". Social and emotional learning strategies can then be applied to the affected students in an effort to eliminate the trauma and to create a new foundation where acquisition of math concepts and skills are possible. It is critically important to first acknowledge the math trauma, address the issues that caused the trauma, and then nurture that student so that the scars of the trauma no longer impact their life. As math teachers, we are all conscious of the fact that the acquisition of content knowledge is impossible if these traumatic events are not addressed.

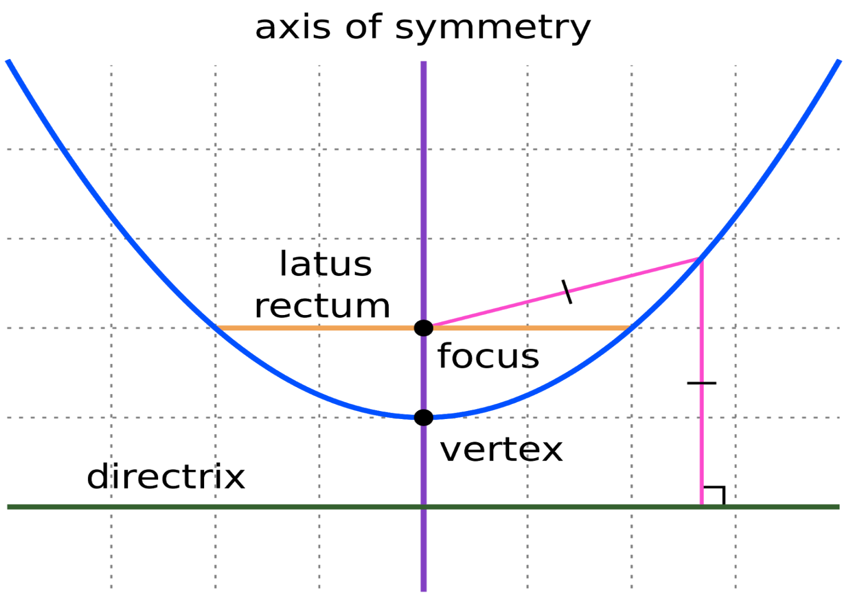
Teachers who are convinced that certain students are incapable of being proficient in math will be incredibly surprised once the issues related to math trauma are addressed. The research clearly indicates that math comprehension is not relegated to one or specific demographic groups. According to Colleen Ganley (Are Boys Better Than Girls at Math, 2018) the disparity in testing results had nothing to do with ability, but more to do with higher levels of math anxiety and lower levels of confidence in math skills. Once these issues have been addressed the teacher in The Parabolic Classroom is now able to engage the students in the present content and is now also listening for gaps in understanding.

The physical layout of the Parabolic Classroom has four parabolas made of student desks with each parabola facing a wall (See picture below). Lecturing occurs, in the front of the classroom, for a small group of students who are facing the whiteboard. The two parabolas to the left and the right of the front are engaged in Khan Academy (videos and practice related to the lecture), and Reflex Mathematics or Gizmos (this is based on where the student is academically). The group in the back of the classroom is working collaboratively on a worksheet that is related to topics from the previous class. The rotations last for 20 minutes and students move in an anti-counterclockwise direction to the next parabola.

The Parabolic Classroom



This course takes the basic parts of a Parabola and superimposes it on the individual math student. The concept works for students who are both struggling and excelling. The Parabola has three significant features: the curve itself; a point on the inside of the curve called the Focus, and a line on the outside of the curve called the directrix.



Each student is represented by some point on the curve. It must be noted that although these points are united they each represent a distinct student with very specific math needs. The points represent where the students are currently (current coursework). The Directrix of the Parabola represents those math skills and math ideas that students have been exposed to in the past (content that has been covered). Notice that the directrix is a line with an infinite amount of points; students have been exposed to more math than they actually are aware of. The Focus, on the inside of the Parabola, represents where students are heading (this is future work). The Focus being a single point indicates that current lessons should always be focused on very specific objectives.

Amazingly, each point on the curve is equidistant from the focus and the directrix (see picture). However, this distance varies based on where a student is theoretically located on the parabola. Students located at or near the vertex have a sound understanding of where they were mathematically(past math lessons), this allows them to be comfortable and more easily absorb current math concepts (current lessons), and then it puts them in position to better understand future lessons. Notice that the vertex of the Parabola is the shortest distance from the Focus and the Directrix. The aim of the Parabolic Classroom is to have all students crowded around the vertex so that the distance from the focus(what they will be learning) and directrix(what they have learnt) to the curve is minimal. More ideally, if the Parabola is compressed then it actually becomes a line. This scenario would represent a situation where all students are functioning at a very high level; one of the objectives is to flatten the parabolic curve.

In the Parabolic Classroom, teachers must align their lesson plans and physical or virtual classroom space with the parabolic theory. At all times teachers must be aware of a student's degree of math trauma, if any, and their relative distance from the Focus and Directrix. This knowledge of a student's current academic situation allows lesson plans to be crafted more effectively and it gives the teacher an opportunity to use the Socratic method to enhance a student's understanding of content.

Parabola #1: The Lecture- 20 mins

The lecture is a concise presentation that quickly zeros in on the content objectives. The theoretical links to previous lessons must be established early in the lecture. Real life applications should be designed with relevance to students in mind, and there must be a strong hint at where the current lesson is leading the students to in the future. The lecture is interactive and the known and discovered deficiencies of students are addressed through a socratic dialogue. Once the objective has been established and students have a firm understanding there should be a brief discussion for the purposes of clarification and then students should be left to collaborate in pairs. At this point there are 5 more minutes left in this rotation and the teacher is now free to answer questions that students may have from the other three Parabolic centers(These are questions that the lead student was unable to answer).

Parabola #2: Khan Academy- 20 Mins

Khan Academy videos and practices are only used if they appropriately compliment the lesson plan and the lecture. Sal Khan has proven to be extremely effective in explaining remedial skills that are needed to comprehend math content and also higher order math skills. So for those students with diagnosed gaps they can be assigned additional targeted videos during the Reflex Math Parabola, if the need arises. The Khan Academy Parabola is designed to expose the students to at least two videos on a current topic (lecture topic), a short article if applicable, and a set of four practice problems. Sal Khan acts as a second teacher inside the classroom so videos must be screened so as to prevent confusion. Headphones must be available for each student. However, the era of Covid-19 compels students to each have a personal earphone.

Parabola #3: Collaboration Center - 20 Mins

The purpose of this center is for the students to practice a concept that was covered in the previous lesson. The teacher must either obtain a worksheet from an outside source, generate practice problems from the digital textbook company, or create them herself. The practice problems must align with the teaching objectives from the previous lesson. So this may require that some questions from a pre-made worksheet may have to be removed or some questions may have to be added. The collaboration center is expected to have a higher volume than the two side Parabolas because the students here are supposed to discuss and debate the efficacy of all the solutions. When the teacher takes the five minutes break from lecturing this is usually where her time is spent. During these important interactions the teacher must listen, redirect, and ask for justification more than provide explanations.

Parabola #4: Gizmos or Reflex Math - 20 Mins

The primary purpose of this parabola is for students to use the Gizmo program to model the actual math concept that is being presented in the lecture. The Gizmo program is graphics heavy, it has moving parts, and its manipulation ability allows students to better visualize what is happening mathematically as they learn a particular concept. Even if a student reaches the Gizmo's Parabola prior to the lecture or the Khan Academy videos she is able to get a visual introduction to the lesson even though it may not be fully understood. If a student is still building her math confidence and there are still significant gaps in her understanding it would be more advantageous to relegate that student to Reflex Math or a similar program that builds the basic math skills. Alternative programs can be used at this Parabola as long as the purpose aligns with objectives of this center.

Adaptability to Distance Learning

Breakout rooms will serve as Parabolas. So during a standard block schedule four breakout rooms should be established prior to the meetings. In the Distance Learning version of The Parabolic Classroom the students rotate back to the main session at the end of each 20 minute segment for further group instructions. These instructions must be standardized:

- If you were in Parabola #1 (Lecture) your group will now go to Parabola #2 Khan Academy Videos.
- If you were in Parabola #2 (Khan Academy) your group will now go to Parabola #3 The Collaboration Center.
- If your group was in Parabola #3 you will now go to Parabola #4 Gizmos/Reflex Math.
- If your group was in Parabola #4 you will now go to Parabola #1 (Lecture).

The adaptability ofThe Parabolic Classroom is seamless in the Digital environment.

Lesson Plan #1

Social Emotional Learning Component (3 minutes)

Teacher: (Once students are quiet and seated) “Each of you have the ability to understand math at a very high level no matter what your past experiences with math were. Every day is a new day and a new opportunity for you to understand math a bit more clearly and deeply. Together we will build your math confidence each and every day.”

Title: Equal Breath

First: begin seated and place your feet flat on the floor, roll your shoulders back and lengthen your spine.

Then: Notice the pattern of your natural breath. Notice the inhalations and the exhalations. Which is longer? Which is deeper?

Next: With your next breath, you make your inhalation and exhalation the same length. Let’s start with the count of 4. Slowly count to 4 as you inhale. (Teacher slowly counts aloud) 1-2-3-4. Now, also count to 4 as you exhale. The exercise is to match the length of your inhalation and exhalation.

Last: Continue breathing this way for several minutes. You may experiment with changing the number you count to, just make sure your inhalation and exhalation stay the same length.

Lesson Plan #1: Understanding Graphical Solutions to Equations

Name of Instructor: Kelsey Major	**Subject Area: Mathematics**	**Course Name: Algebra 1 Honors**
Unit Name: Reasoning with Equations and Inequalities	**Implementation Dates:**	**Period(s): 2,3 and 5**
Standard/Objective: **MAFS.912.A-REI.4.11** Explain why the x-coordinates of the points where the graphs of the equations y = f(x) and y = g(x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where f(x) and/or g(x) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.		
At the end of this lesson, students will		

Know: What a solution means graphically.	**Be Able To: Identify graphical solution to linear, polynomial, rational, absolute value, exponential, and logarithmic functions.**	**Relevance/Think About: Things happen in real life when real world functions are equal to each other: If the amount of calories that I eat is equal to the calories that I burn then I don't gain weight.**

Essential Questions: Why are the x values considered solutions and not the y values?Can a graph of two functions accurately predict real world solutions?

Enabling Activity: A video showing the Parabolic launch of a Navy missile that intersects and destroys an old spy satellite.

Instructional Activities:	**Parabola #1 (Lecture): Link the math of F(x) = G(x) with the graphical explanation. Equate equations and solve them by identifying the coordinate(s) of intersection. The equations should be graphed so students can visualize a solution. Give students a chance to solve and graph equations.** **Parabola #2 (Khan Academy): Watch the following videos** https://www.khanacademy.org/math/cc-eighth-grade-math/cc-8th-systems-topic/cc-8th-systems-graphically/v/solving-systems-graphically-examples https://www.khanacademy.org/math/algebra-home/alg-quadratics/alg-systems-of-quadratic-equations/v/non-linear-systems-of-equations-1 https://www.khanacademy.org/math/algebra-home/alg-quadratics/alg-systems-of-quadratic-equations/v/non-linear-systems-of-equations-3 **Parabola #3 (Collaboration with worksheets):** https://drive.google.com/file/d/1Co5oRY6yBQx5dalHjmOrbx_ngPFvg2fi/view?usp=sharing **Parabola #4 (Gizmos and Reflex Math (if needed)):Gizmos -Solving equations by graphing each side; Solving Linear Systems Slope Intercept Form**
Assessment:	**Formative Assessment: At the begging of the next class students will have a 5 question assessment (10 minutes).**

Home Learning:	Written Summary of the Content of Khan Academy Videos		
Accommodations:			
ESOL	**Differentiated Instruction**		
Instructions will be intentionally slightly above students English proficiency level; students will be paired, as needed, with a proficient peer.	**The various modes of content presentation allows for learning at varying levels and pace. Videos can be stopped and reviewed; students can collaborate with a peer that already understands the content; and the teacher is constantly probing students during the lecture segment to uncover and repair gaps in understanding.**		

Lesson Plan #2

Social Emotional Learning Component (3 minutes)

Teacher: (Once students are quiet and seated) “Each of you have the ability to understand math at a very high level no matter what your past experiences with math were. Every day is a new day and a new opportunity for you to understand math a bit more clearly and deeply. Together we will build your math confidence each and every day.”

Title: Brain Massage
Time: 3 Minutes

Brain Massage: The activity is a positive way to manage our emotions, and is also an easy thing to do if we are at home and need a break.

Brain massage begins with a facial massage! Close your eyes and take a deep breath. Keeping your eyes closed and your breathing deep, tap your fingertips on your forehead (pause for 5 seconds), down your cheekbones (pause for 5 seconds), on the bridge of your nose, (pause for 5 seconds), and on your chin (pause for 5 seconds).

Next, place your fingertips on top of your head and gently squeeze and massage around your head for the count of 10. (teacher counts aloud to 10).

Lastly, let's give ourselves a calming temple massage. Place two fingers on your temples. Move your fingers in circles for the count of 10 deep, relaxing breaths (Teacher counts aloud to 10).

Well done! Brain massage is an important Social-Emotional Learning activity. It helps us remember to take the time to care for both our bodies and our minds, because the two work together to keep us healthy and ready to learn.

Lesson Plan #2: The identification of zeros of polynomials and constructing rough graphs

Name of Instructor: Kelsey Major	Subject Area: Mathematics	Course Name: Algebra 1 Honors
Unit Name: Reasoning with Equations and Inequalities	Implementation Dates:	Period(s): 2,3 and 5

Standard/Objective

MAFS.912.A.-APR.2.3

Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.

At the end of this lesson, students will		
Know: What does an algebraic zero mean graphically.	Be Able To:Find zeros algebraically, plot them graphically,and estimate the rest of the graph.	Relevance/Think About: What does a zero mean? Is there a real life equivalence? How can a zero be a zero and a solution?

Essential Question:Is there a way to know how many possible zeros any polynomial will have?			
Enabling Activity: Study Skills Video. This video is 7 minutes long but it is excellent. https://study.com/academy/lesson/finding-zeroes-of-functions.html			
Instructional Activities:	**Parabola #1 (Lecture): The focus here will be to use the details of the enabling video as a springboard for the lecture. The students will get direct exposure to finding the zeros of linear and quadratic functions. Once the zeros have been identified they will be marked on the coordinate plane and the rest of the graph will be estimated. The teacher will lead with two linear examples and two quadratic examples.** **Parabola #2 (Khan Academy): Watch the following videos** https://www.khanacademy.org/math/algebra-home/alg-polynomials/alg-finding-zeros-of-polynomials/v/finding-roots-or-zeros-of-polynomial-2 https://www.khanacademy.org/math/algebra-home/alg-polynomials/alg-finding-zeros-of-polynomials/v/finding-roots-or-zeros-of-polynomial-example https://www.khanacademy.org/math/algebra-home/alg-polynomials/alg-finding-zeros-of-polynomials/e/find-the-zeros-of-polynomials **Parabola #3 (Collaboration with worksheets):** **https://drive.google.com/file/d/1k87m_zSo7uuFnlZgnimUoYYX6aDiEav6/view?usp=sharing** **Parabola #4 (Gizmos and Reflex Math (if needed)):Gizmos - Quadratics in Factored Form; and Roots of Quadratics.**		
Assessment:	**Formative Assessment: At the begging of the next class students will have a 5 question assessment (10 minutes).**		
Home Learning:	**Khan Academy Practice Questions (See Parabola #2)**		
Accommodations:			
ESOL	**Differentiated Instruction**		

Instructions will be intentionally slightly above students English proficiency level; students will be paired, as needed, with a proficient peer.	**The various modes of content presentation allows for learning at varying levels and pace. Videos can be stopped and reviewed; students can collaborate with a peer that already understands the content; and the teacher is constantly probing students during the lecture segment to uncover and repair gaps in understanding.**		

Resource List

Khanacademy.org
Gizmos (Explorelearning.com)
Reflexmath.com
Desmos.com
District Digital Online Book (great place for worksheets)
Laptops (At least 20 school issued laptops)
Headphones (These must be given to students and not taken back)