Using Parent Graph Transformations to Create Art
By Diarra Bousso Gueye

Lesson Plan

Overview

This series of lessons can be used as a weeklong project or in shorter segments in class throughout the unit (eg: the last 20 min of every class, preceded by a formal lesson and worksheet/book exercise of the relevant topics).

This series of lessons/project involves parent graphs and transformations for linear, quadratic, absolute value, square root, circular, exponential and rational functions. This series can be followed by a cumulative task using Desmos to combine several patterns into a culminating final segment with the goal to create an artistic design for pages of a coloring book, textiles or artwork.

See the Appendix & Resources at the end of this document for sample designs, assessment sheet and list of state standards.

Essential Questions/Big Ideas/Enduring Understandings

How can we use parent graph equations to model with mathematics in order to understand and create shapes in the real world. What kind of math is behind the beauty that we see in the world? How can math help me appreciate that beauty? How can art help me appreciate math? How do changes in parameters of functions affect the shape of the graph?

Broad Learning Goals: Students will be able to: (SWBAT…)

- *Students will be able to use algebraic parent graph function families, linear, quadratic, absolute value, square root, exponential and rational that will provide the basis for a graphic design for fabrics.*
- *Students will be able to graph the parent function, apply transformations using a, h and k (with Desmos) and create a design that is aesthetically pleasing for the purpose of a coloring book, textile print or artwork.*
- *Students will be able to create reflection and rotational symmetry in the designs they create by manipulating transformations.*
- *Students will be able to describe using academic language how they arrived to the design and how they transformed parent functions.*

Note: See Appendix & Resources at the end of this document for connections to math content, common core practices and academic language goals

Instructional and Learning Segments

Activity	Notes
Segment 1 - Warm Up - Notice and Wonder (10 min) Students will: ● Look and touch a piece of textile with geometric shapes Teacher will: ● Ask them how they think the patterns were created. By hand? By computer?	The purpose is to have students start considering whether math can be used to create shapes outside of the classroom
Segment 2 - Exploring Linear Patterns (15 - 30 min) Teacher will: ● Show students patterns (on textile or paper) with straight lines such as stripes, that can be represented with equations of the form y=mx+b ● Ask students to create their own equations to graph parallel lines on graph paper Students will: ● Create and graph a set of linear equations ● Color in between to create stripe-inspired patterns	The purpose is to have students see how patterns result from different ways to colors between the lines. This activity is recommended on graph paper to allow students to practice graphing themselves and refresh their memory on the impact of m and b on the lines.
Segment 3 - Designing with Quadratic Function Transformations (20 - 45 min) Teacher will: ● Provide students graph paper and a table to graph the first parent equation ● Walk around and support students as they create their own functions Students will: ● Graph the parent equation $y=x^2$ ● Rewrite the equation of another quadratic from factored form ($y=ax^2+bx+c$) to factored form ($y=a(x-h)^2+k$) ● Transform the parent function in at least 6 different parabolas of their choice by manipulating h, k and a to create patterns ● Color in between the patterns to create a design	The purpose is to balance between giving students the freedom to create their own parabolas while still manipulating ALL parameters (a,h and k) in different ways to show conceptual understanding of how the parameters impact the patterns.
Segment 4 - Designing with Absolute Value Function Transformations (20 - 45 min)	The purpose is to first have students recognize

Teacher will: ● Show students a V shaped or upside down V shaped textile pattern and ask students what equation they think created that pattern ● Provide students graph paper and a table to graph the first parent equation ● Walk around and support students as they create their own functions Students will: ● Graph the parent equation y= |x| ● Rewrite the equation of another absolute value function in graphing form (y=a|x-h|+k) ● Transform the parent function in at least 6 different absolute value graphs of their choice by manipulating h, k and a to create patterns.	absolute value functions from a textile patterns and later to balance between giving students the freedom to create their own V shaped graphs while still manipulating ALL parameters (a,h and k) in different ways to show conceptual understanding of how they impact the patterns.
Segment 5 - Designing with Other Function Families (20 - 45 min) Teacher will: ● Provide students graph paper and a table to graph the first parent equation ● Walk around and support students as they create their own functions Students will: ● Graph the parent equation from any of the other function families such as $y=\sqrt{x}$, $y=x^3$, $y=\frac{1}{x}$, $y=b^x$, $x=y^2$ and $x^2+y^2=r^2$ ● Transform the chosen parent function(s) in at least 6 graphs of their choice by manipulating h, k and a to create patterns ● Color in between the patterns	This segment assumes that students have prior knowledge of all the other function families mentioned. This segment would need to happen after students have taken notes or been given a toolkit and some practice working with the other function families. By now students have even more freedom as they get to choose the third function family to work with. It is important to keep in mind that the goal is to be able to color in between and in that regard, rational equations may be tricky but still interesting for them to explore and discover the limitation on their own in terms of which function families are going to be more challenging to color in between

Segment 6 - Putting it Together on Desmos (20 - 45 min) Teacher will: ● Provide students chromebooks and show them how to enter their equation into Desmos and how to use the platform such as changing colors of lines, etc… ● Ask students to create a final design with reflection symmetry (across the x / y axis) ● Walk around and support students as they work on Desmos and help them organize their work (such as asking them to graph all function families in the same color on Desmos) Students will: ● Gather all their work from previous segments (quadratic, absolute value and other function families) ● Decide which ones they want to keep (at least 4 from each family) to graph on Desmos in order to create a final culminating pattern that can serve as a page of a coloring book, the basis for a textile print or any other creative use of their choice.	This is the final segment in terms of designing and the students by now should have a clear understanding of which functions will 'work' for them and which will not in terms of the overall style or aesthetics of the final pattern they want to create. Students are expected to have a basic knowledge of the Desmos software program. The reflection symmetry element will push students to be more intentional about their graphs and still show skills in transformations besides just copying previously used equations.
Segment 7 - Closure / Wrap Up Activity (10 min) Students will: ● Reflect on 1) How does mathematics connect to Art and Design 2) How will they continue this work on their own. ● Reflect by 1) Writing a personal statement in essay form or 2) dictate their thoughts to an audio platform or (3) create a short video holding their final design while talking about the reflection question? Teacher will: ● Provide the relevant tools for students to reflect based on whether the reflection structure is 1), 2) or 3) from above	This is a crucial part and the purpose is for students to see the applications of math to real life but also to have the desire to continue this exploration further even outside of Art and Design. This can hopefully open doors for them to think of math creatively and applicable to various fields.

Unit Assessment
Designing a coloring book page using Parent Functions and Transformations

The Drawing:

You are going to create a design to be printed as part of a coloring book. The goal is to create something aesthetically pleasing and fun to color (lots of shapes)

Go to www.desmos.com and "Sign In" to desmos so you can save your work

Requirements for Meeting the Standard

1. Pick at least 3 different function families to work with ((lines, parabolas, cubics, square root, absolute value, hyperbola,)

2. Create at least 4 transformations in each function family to create a design / drawing.

3. Your design must have reflection symmetry along the x axis

4. Click "Share Graph" and copy the web link to submit on canvas. **'Print Design Assignment'**

Requirement for Exceeding the Standard

5. Shade the designs in different colors using inequalities and restricting the domain. See example below. Use curly brackets {} to constrain the domain and range. *Click on "Edit List" to change line styles and colors.*

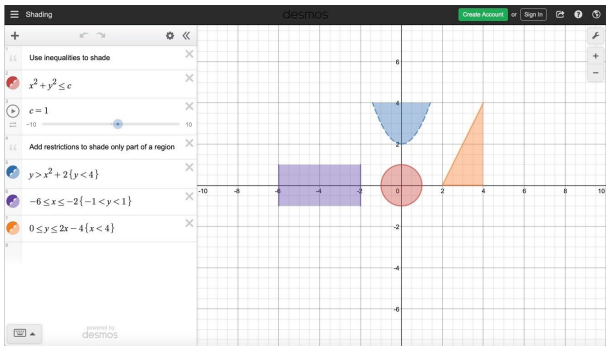
6. Your design must have reflection symmetry along the y axis

7. Click "Share Graph" and copy the web link to submit on canvas. **'Print Design Assignment'**

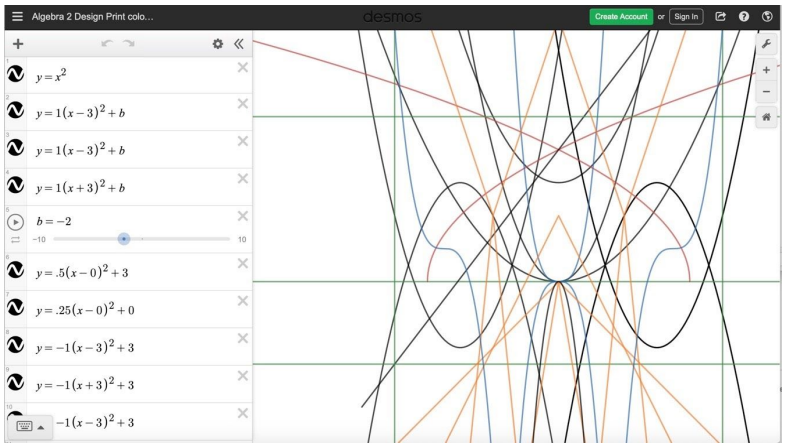
Created by Diarra Bousso Gueye & Nancy Lobell, Stanford Graduate School of Education 2019

Examples:

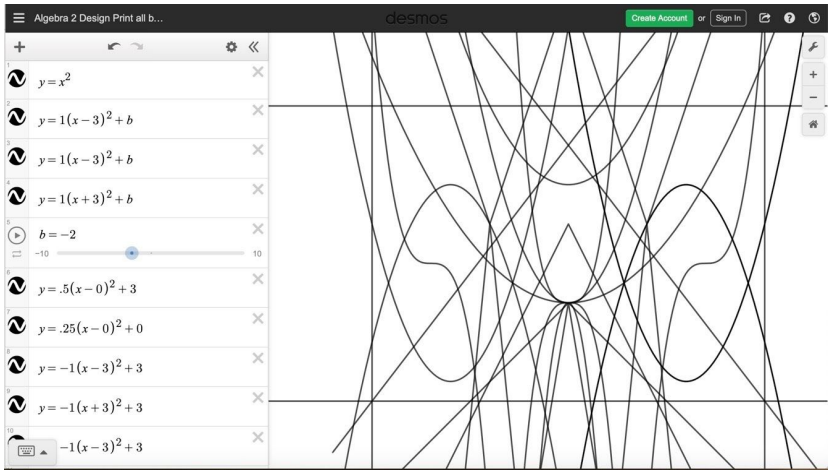
How to shade with colors on Desmos



Ms. Diarra's example colored by function families



Ms. Diarra's Final Example

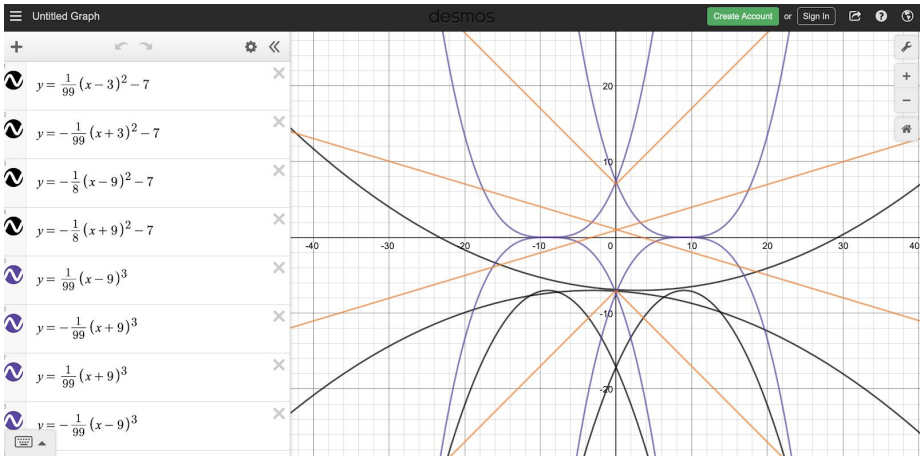


Rubric

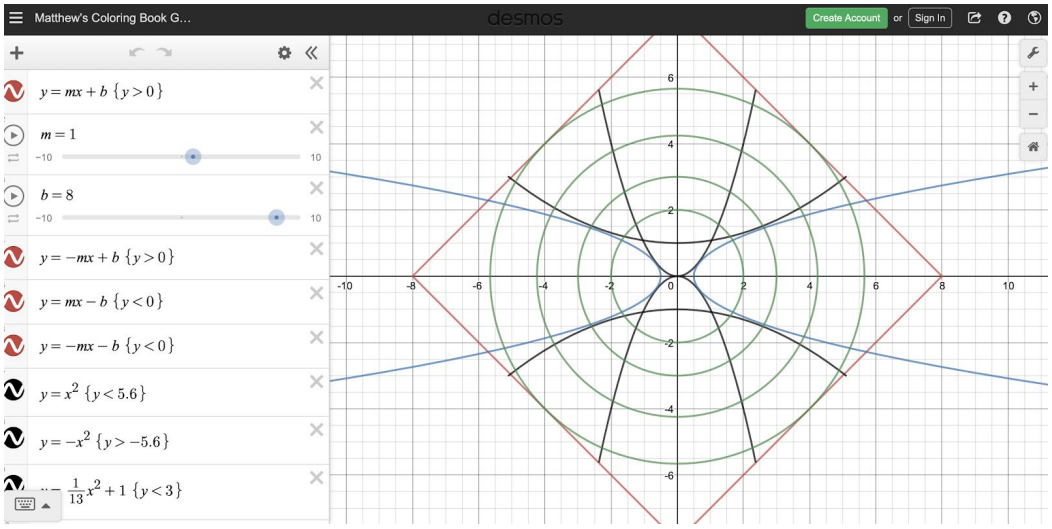
Learning Outcomes	Exceeding	Meeting	Approaching	Initial
Algebraic Transformations The student is able to show connections between multiple transformations of parent graphs and show understanding of the impact of the parameters on the shapes of graphs	Consistently transforms more than 3 function families by changing all parameters (at least one at a time)	Consistently transforms all 3 function families by changing all parameters (at least one at a time)	Is aware of more than one parent function family but not able to graph and/or transform all 3	Is aware of only one parent function
	• Decides what parameter is most useful in creating the transformations they need • Logically change parameters to obtain reflection symmetry across the x axis and y axis • Able to use inequalities for coloring the designs	• Decides what parameter is most useful in creating the transformations they need • Logically change parameters to obtain reflection symmetry across the x axis.	• Decides what parameter is most useful in creating the transformations they need	• Has difficulty graphing equations • Struggles to connect the values of a,h and k to the graphs
Artistic Design The overall design is aesthetically pleasing, authentic and original	• The student accurately creates a design with enough intersections to be shaded with more than 5 colors. • The students is able to color the design and submit a final pattern ready for printing and framing.	• The student accurately creates a design with enough intersections to be shaded with at least 5 colors. • The students submits a final pattern (similar to a coloring book's page) but doesn't use colors to shade it	The student reaches partially complete graphs / patterns with very few intersections to be colored	The student reaches incorrect or incomplete graphs with few intersections to be colored.

Sample Student Work

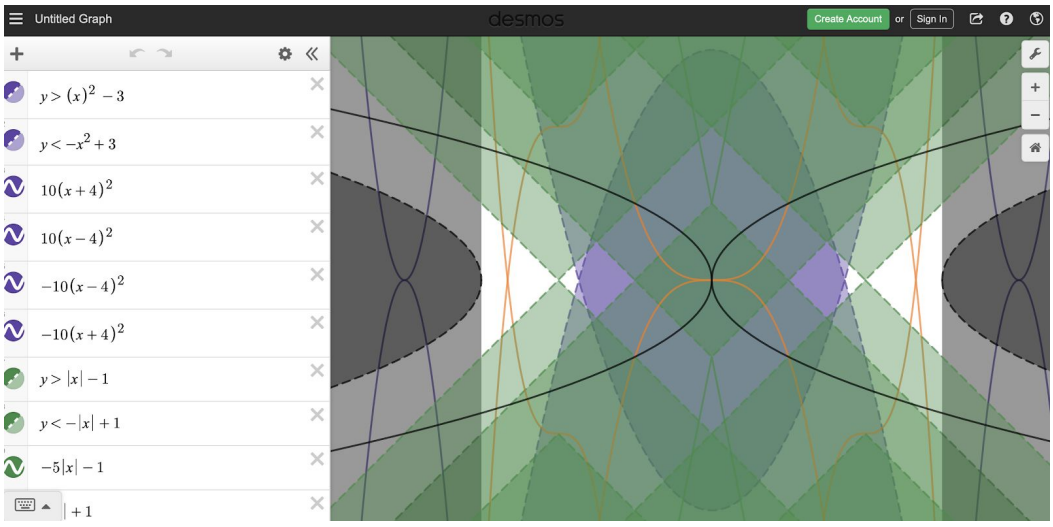
[Example of Student who is approaching the standard]



[Example of Student who is meeting the standard]



[Example of Student who is exceeding the standard]



Extensions

See Segment 7 of the Appendix and Resources at the end of this document: Fashion, Art, Textiles, Interiors

Using Parent Graph Transformation to Create Art
Appendix and Resources

Connections to math content, common core practices and academic language goals

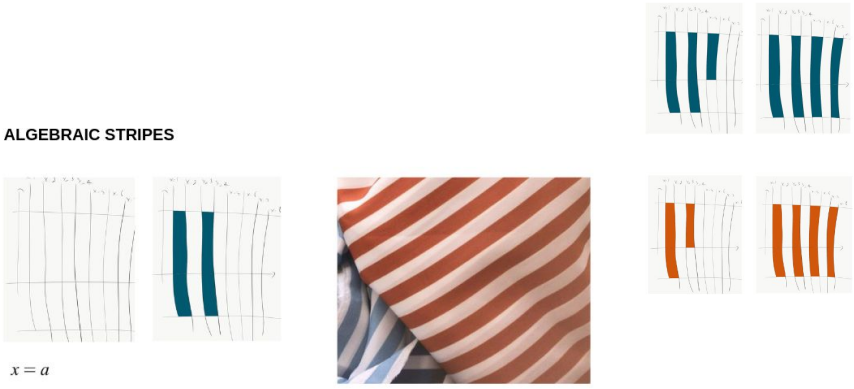
	Math Content Goals	Academic Language Goals	Common Core Mathematical Practices
SWBAT	to shift, stretch, compress, and flip the graph of $f(x)=x^2$, $f(x)=\sqrt{x}$, $f(x)=x^3$, $f(x)=\|x\|$ $f(x)=\frac{1}{x}$ $f(x)=b^x$ $x=y^2$ and $x^2+y^2=r^2$	Vertical compression, horizontal shift.	Model with Mathematics Attend to precision Look for and express regularity in repeated reasoning
SWBAT	Write a general equation of a parent equation using a, h and k	SWBAT explain what a "parameter of an equation" is and be able to describe which parameters they are changing in order to affect which changes they seek to make in their design.	Model with Mathematics Attend to precision
SWBAT	Produce graphs of functions without a calculator using the parent function and applying geometric transformations using their understanding of a, h and k for each family of functions	SWBAT correctly use the following terms when describing their work to peers or teachers: reflection, translation, rotation.	Model with Mathematics Attend to precision Make sense of problems and persevere in solving them Look for and make use of structure
SWBAT	Rewrite equations in graphing forms using techniques such as completing the square or factoring		Model with Mathematics Attend to precision
SWBAT	Model mathematically with parent functions and their transformations		Model with Mathematics Attend to precision Look for and make use of structure

Segment 1 Resource

Textile images or actual fabrics to show during the warmup

Segment 2 Resource

Examples of linear designs

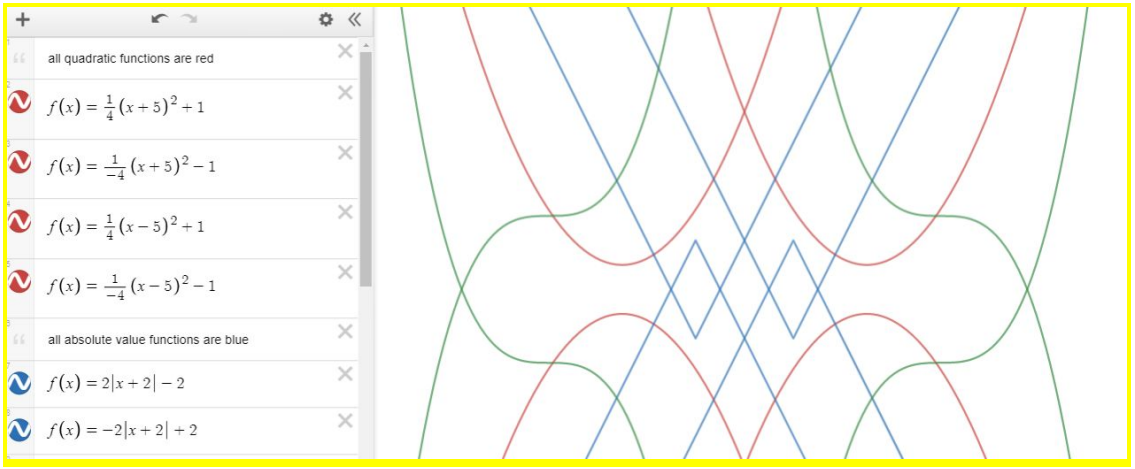


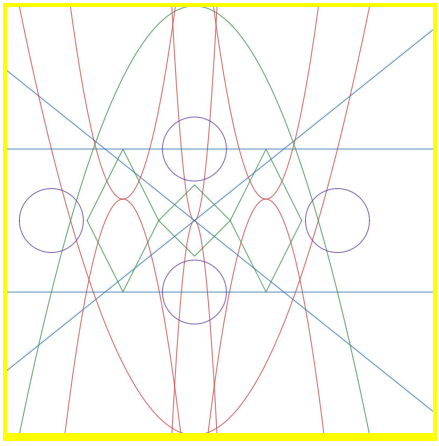
Segment 6 Resource

Examples of final designs and extensions

Segment 3, 4, 5 Appendix

Examples of student work

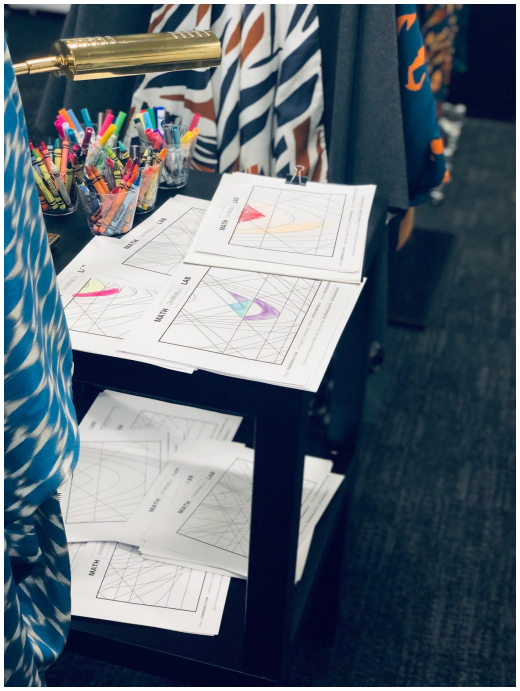




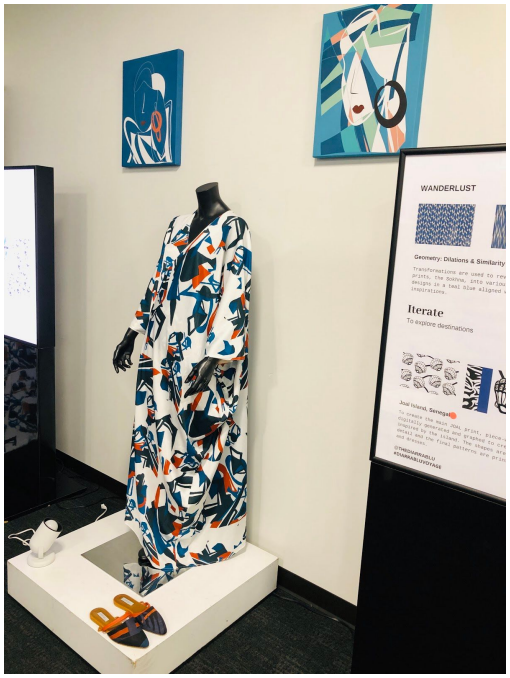
Segment 7 Resource

Extensions / Applications to fashion, art, textiles and interiors

Using Algebraic transformations to create paintings



Using Algebraic transformations to create a coloring book



Using Algebraic transformations to create paintings to design textile, clothing and shoes