***Parabolas on the Move!* Lesson plan**

Ideal for Algebra 1 as an introduction to quadratic functions, or review of quadratic functions in Algebra 2.

Prerequisite Skills:

- Identify a parabola on a coordinate plane.
- Graph points on a coordinate plane.
- Understand linear functions.
- Be able to identify x and y intercepts.
- Knowledge of transformations, reflections, dilations, and translations.

Learning Goals:

- Describe and predict how changing the coefficients of a quadratic function changes the graph of the function.
- Identify specific geometric transformations on the coordinate plane (reflection, translation, dilation).

Common core standards:

HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

HSF-IF.c.7a: Graph linear and quadratic functions and show intercepts, maxima, and minima.

HSASSE.1   Interpret expressions that represent a quantity in terms of its context.
HAASSE.1a Interpret parts of an expression, such as terms, factors, and coefficients.

Mathematical Practices:

- Model with mathematics
- Use appropriate tools strategically
- Construct viable arguments and critique the reasoning of others

Materials:

- PhET *Graphing Quadratics* simulation:
  https://phet.colorado.edu/sims/html/graphing-quadratics/latest/graphing-quadratics_en.html?screens=1
- Computers/chromebook/iPad for each student or pair of students
- *Parabolas on the Move!* Activity sheet

Estimated time:

50 - 90 minutes depending on time for extension activities and class discussion.

Timing	Students...	Teacher...
5 min Warm up	Work independently for 2 minutes then discuss with table mates/ classmates.	Display picture of a parabola and ask students to identify key characteristics: vertex, axis of symmetry, zeros, orientation, etc…
5-10 mins	Question 1. Explore the simulation.	Circulates, listening to student conversations and asking questions to help students experiment with the simulation. ● What do you notice? What do you wonder?
8-15 mins	Discuss observations from open play with the simulation.	Allows students to drive the simulation in front of the class, as well as documenting observations on board. Key ideas to look for: ● a value controls compression/stretch and reflection across x-axis ● b value controls horizontal shift, axis of symmetry ● c value controls y-intercept, vertical shift ***This is designed as an exploratory activity, so informal language from students is expected. Teacher can scaffold vocabulary based on previous class experiences or add to key ideas as they occur.
15-25 mins	Question 2. Work through the graphs and try to match the given graph. *Students can work independently, or in small groups.*	Circulate around the room helping students who may be stuck or need additional direction. Listen to student discussions and note who may be willing to share important discoveries with the class. If *students are struggling with comparison to the parent graph, encourage them to snap a picture of the parent graph on the sim before they change the values of a, b and c.* Some guiding questions: ● What would happen if… ● How can you be sure you have correctly matched the graph? What strategies can you use to verify your answers? ○ See if the students find the coordinate identifier tool to match coordinates from the parabola on the activity sheet ● How would you explain your thinking to a classmate? ● I see that you wrote, "The graph moved up." Could you dig a little deeper? Do you know how many units the graph shifted? Can you give me more specific information about how you changed the 'a, b or c' value to make that transformation?

		● Have you seen these types of transformations with other functions? Are there similarities to transformations of linear functions (or other functions students have studied previously)?
5-10 mins	Summarize key ideas from lesson.	Facilitates a whole-class discussion to address learning goals and summarize discoveries. Have students write down other observations from class discussion in a different color on their activity sheet. Have students reflect on how the new information informs their understanding. *This can be done formally or informally.*
Varies	Challenge 1: In pairs, one student creates a graph for the other student to mimic. Can use '20 questions' type prompts to help each other. Ex: Does the 'a' value need to be greater than 1? Challenge 2: Ask students how changing a, b and c specifically impacts the vertex of the parabola. Challenge 3: Why does changing the b term have the 'opposite' effect on the parabola...why does adding b move the parabola left while subtracting moves the parabola right?	Monitor student interactions
5 min	Exit ticket	Optional closing activity