

Function Battleship

Use your math skills to sink the battleships!

This activity lets students manipulate functions in order to explore and better understand translating, stretching, compressing and other transformations of functions. Through the Desmos platform the students can graph functions and see the effects of changing coefficients and exponents, adding and subtracting integers, and changing anything else they want to. With the added twist of similarity to the board game Battleship, students can be more engaged in learning some important concepts about functions.

This activity can be done with graph paper and a pencil or with a graphing calculator, but it works best with the Desmos calculator. If you have not tried Desmos yet, then you are missing out! Founded by MATHCOUNTS alum Eli Luberoff, Desmos gives you the opportunity to do more with a calculator than you ever thought possible—all for free. At www.desmos.com/recent, see amazing graphs people have made with Desmos.

MATERIALS NEEDED

- Computer with Internet access
- Battleship scatter plots (available at www.mathcounts.org/resources/function-battleship)
- Scatter plots handouts (if you do not have a computer with Internet access)

GETTING STARTED WITH DESMOS

Desmos is designed to be intuitive and easy to use, so you'll feel comfortable with it after just a few minutes. Here are some tips for getting started before you meet with your club.

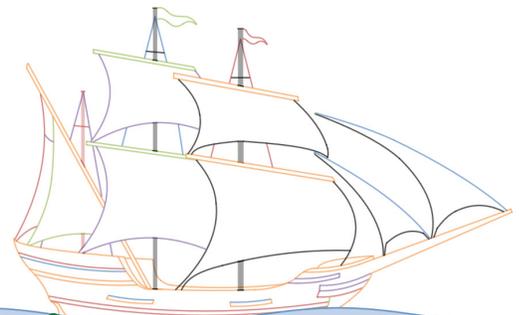
- **Create a Desmos Account:** Creating an account is completely free and will enable you to save your graphs and come back to them later. To create an account, first go to www.desmos.com. Next, click Start Graphing to get to the calculator page. In the upper righthand corner, click on the green Create Account icon. Finally, enter your name and e-mail address and create a password for your account.
- **Review Common Features and Get the Desmos User Guide:** The best way to become familiar with the Desmos calculator is to try it out yourself! Walk through the common features discussed in Part 1 of this activity so that you can show your students how to use them. You also can look through the Desmos User Guide, which has even more information. You can access this at www.mathcounts.org/desmos.

PART 1: USING COMMON FEATURES ON DESMOS

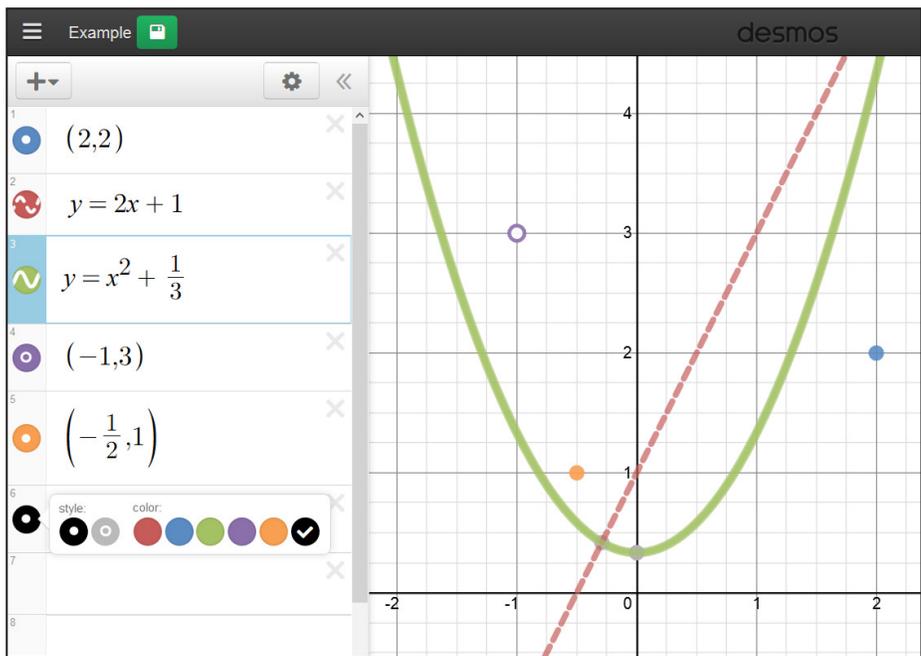
Walking through the following common features with your club will help ensure your students get the full Desmos experience. Chances are, your students will catch on quickly, so it may not be necessary to go through all of the features highlighted here. For information about how to save graphs, please refer to the Desmos User Guide.

Graphing Coordinate Points: To graph coordinate points, simply type an opening parenthesis followed by the numbers representing the x - and y -coordinates, separated by a comma. For example, if you wanted to plot the blue coordinate point shown on the following page, you would type "(2, 2)" and the point would show up immediately on your graph. Desmos will automatically type the closing parenthesis for you, but you must type the opening parenthesis; otherwise it will be unable to graph the point.

Graphing Functions: To graph a function, you will need to type its equation. Desmos automatically graphs what you're typing, so

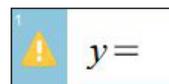


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it's possible that you see a different function from what you were intending until you've typed your equation completely. For example, if you were typing the equation $y = 2x + 1$, you would see an error symbol after typing "y=" (shown below) since nothing can be graphed yet. Then, when you continued and got to "y=2," you would see a horizontal line being graphed, but this would change to the diagonal line you intended to graph, once you finished typing "y = 2x + 1" into the calculator.

In general, an error symbol (yellow triangle with an exclamation mark) can be ignored if you're in the middle of typing an equation,



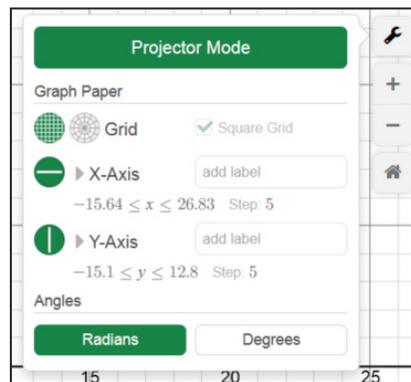
but if it is still showing next to your complete equation, then it means there is a problem with the way the equation was typed (often a small and easy-to-fix typo) that is preventing Desmos from graphing it.

Editing and Deleting Expressions: You can click on any entry you've graphed and (1) change its style or color, (2) make a copy of it or (3) delete it.

1. To change the color or style, click and hold down on the colored circle to the left of the entry. Then click on the color (from six options) or style you would prefer. Any line can be changed to a dashed line, as shown above with the red line $y = 2x + 1$, and any coordinate point can be changed to an outline, as shown above with the purple coordinate point $(-1, 3)$.
2. You can make a copy of any graphed entry by clicking on it and following typical select, copy and paste shortcuts. For example, to duplicate the red line $y = 2x + 1$, you would click on the entry and use the $\text{ctrl} + \text{A}$ (or $\text{cmd} + \text{A}$) shortcut to select the entire entry, use the $\text{ctrl} + \text{C}$ (or $\text{cmd} + \text{C}$) shortcut to copy the entry, then click on the next empty entry field in the expressions menu and use the $\text{ctrl} + \text{V}$ (or $\text{cmd} + \text{V}$) shortcut to paste the entry.
3. You can delete any graphed entry at any time by clicking the Delete (X) icon to the right of it. If you accidentally delete something, just use the $\text{ctrl} + \text{Z}$ (or $\text{cmd} + \text{Z}$) shortcut to undo your action.

Zooming and Using Projector Mode: Zooming in or out of your graph can be done easily with your mouse if you have a scrolling wheel. You can also click on the Zoom (+ and -) icons at the right side of the screen to zoom manually.

Projector mode is useful when projecting your graphs for the entire club, because it makes all of the lines you graph thicker. To switch to Projector Mode, click on the Settings (wrench) icon at the right side of the screen and click the Projector Mode icon, which will turn green once you have clicked it.

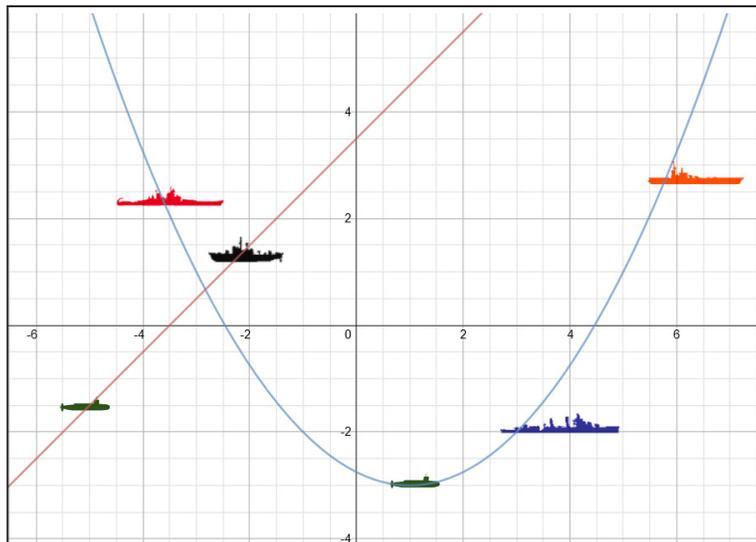


PART 2: FUNCTION BATTLESHIP

When you are ready to start, go to www.mathcounts.org/desmos and open one of the battleship scatter plots. There are three scatter plots, labeled easy, medium and hard. Have the students open whichever one you want them to work on. Students can work in groups or individually, depending on your club size and the number of computers available.

Once you have the scatter plots open, you will see multiple images of boats of different shapes and sizes in the coordinate plane. The object of the game is to “sink” all of the battleships by hitting them with your functions. As in the Battleship board game, you want to sink the ships with the least number of tries. Tell your students that the group or person that sinks the battleships with the fewest functions wins.

Solutions are provided for each of the three given scatter plots; however, it is important to note that each given solution is only one possibility and there are in fact many more possible solutions. Blank scatter plots and solutions are included in this document. If you do not have access to computers for your club, you can have the students use these blank scatter plots to graph by hand.



Have your students explore some of the following function transformations:

Shifts and Translations: Explore adding integers to a function or grouping them with the variable to see the effects. For instance, shift the equation $y = x$ by adding or subtracting: $y = x + a$ or $y = x - a$. Also look at moving functions left and right. For instance, translate the equation $y = x^2$ by adding or subtracting from x : $y = (x + a)^2$ or $y = (x - a)^2$. Shifts up and down occur because you are adding a value to the entire equation and changing y by exactly that amount. Left and right translations occur because you are changing the variable: all the same y values will be obtained, but the x values they correspond to will be different.

Compressions and Stretches: Look at how coefficients affect functions by compressing them toward or stretching them away from the x -axis. For example, look at what happens when you add a coefficient to $y = x^2$: $y = ax^2$ or $y = (1/a)x^2$. If you multiply a function by a coefficient greater than one, it will compress the function toward the y -axis because you are increasing the y -value for each x -value. If you multiply the function by a coefficient with a value between zero and one, it will stretch the function away from the y -axis because you are decreasing the y -value for each x -value.

Reflections: Look at what happens when you change the coefficient to be negative instead of positive: $y = x^3$ to $y = -x^3$. By changing the overall value of the function, you will reflect it over the x -axis. If you group the negative sign with the x -variable, then you can reflect the function over the y -axis: for example, change $y = x^3$ to $y = (-x)^3$.

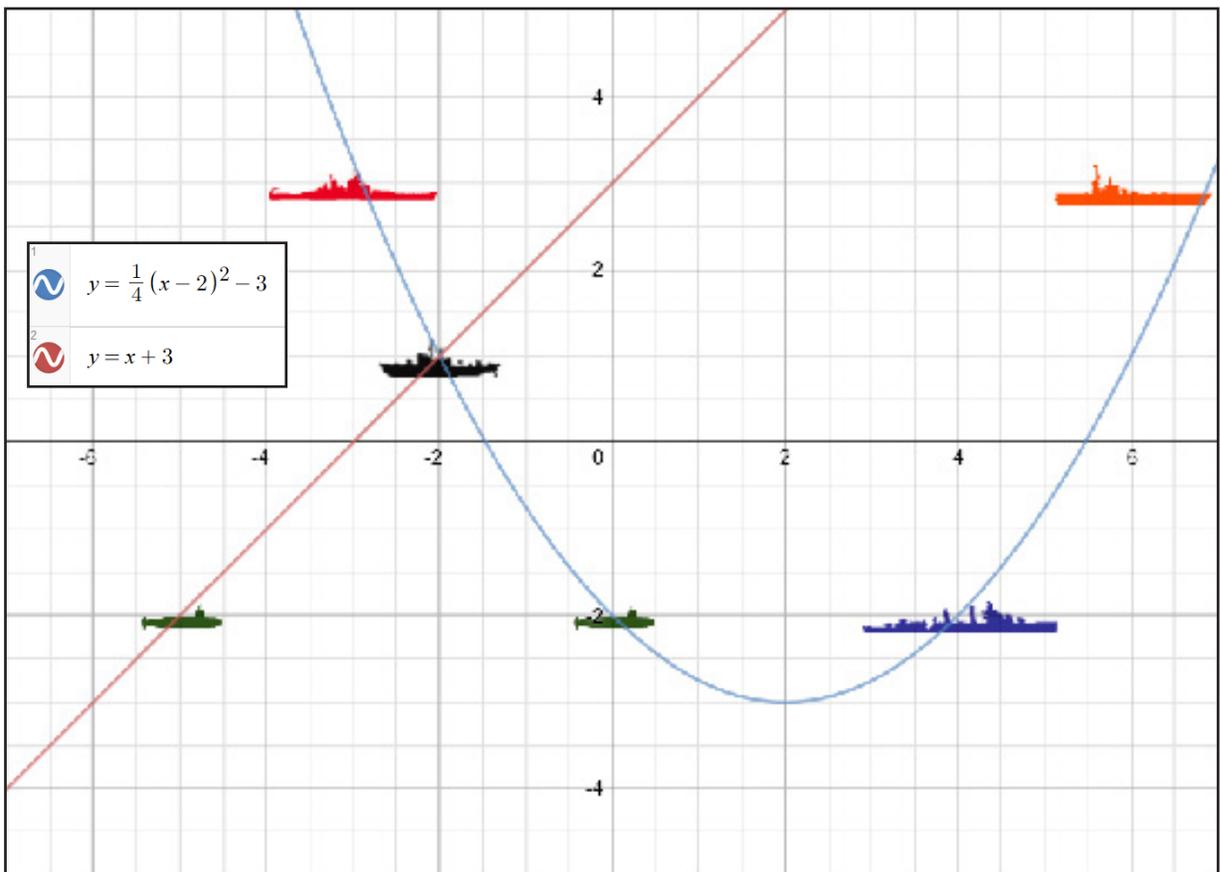
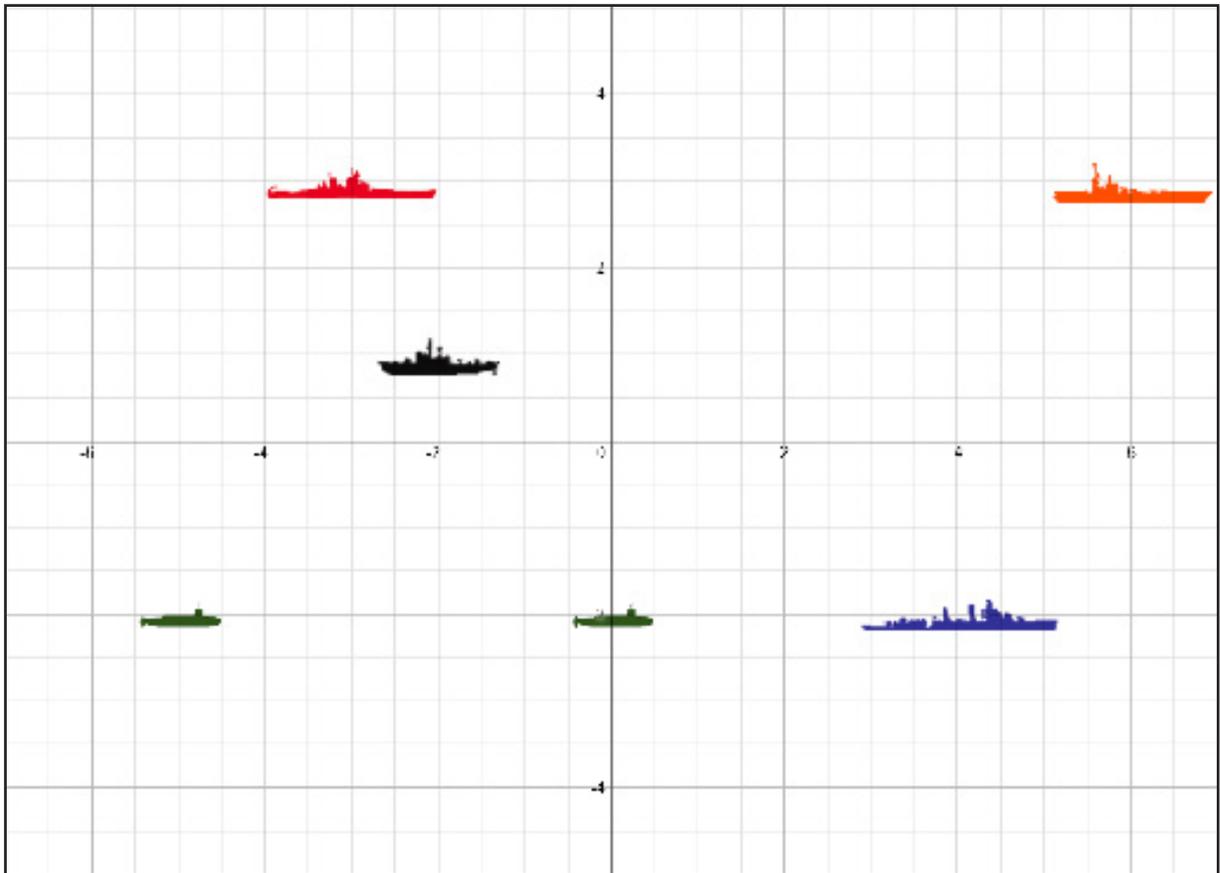
Other function topics: You can have students explore exponents: compare $y = x^2$ to $y = x^3$. Have them graph quadratic equations: $y = ax^2 + bx + c$. Look at absolute value functions or square root functions. Encourage students to be creative! If there is anything you want to work on specifically, encourage your students to explore it here!

DO MORE WITH THIS ACTIVITY

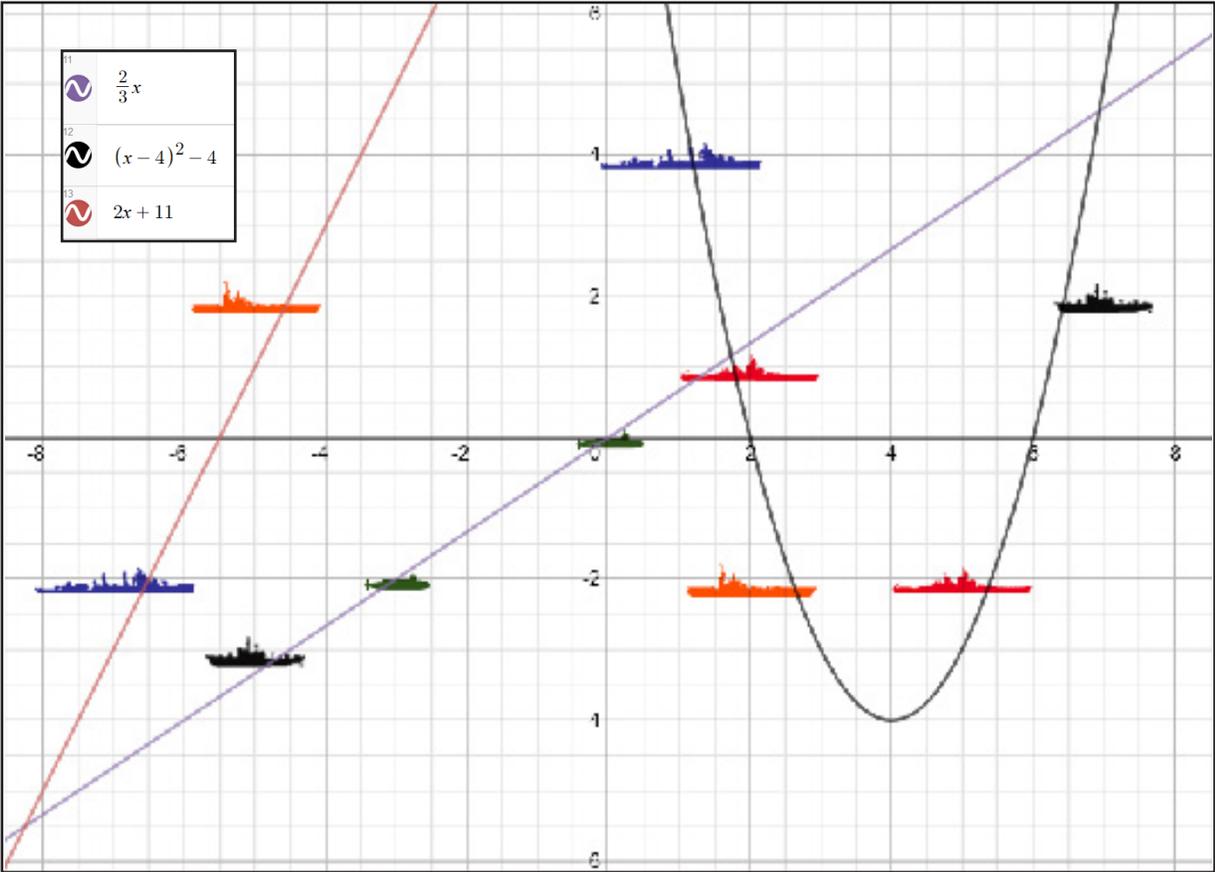
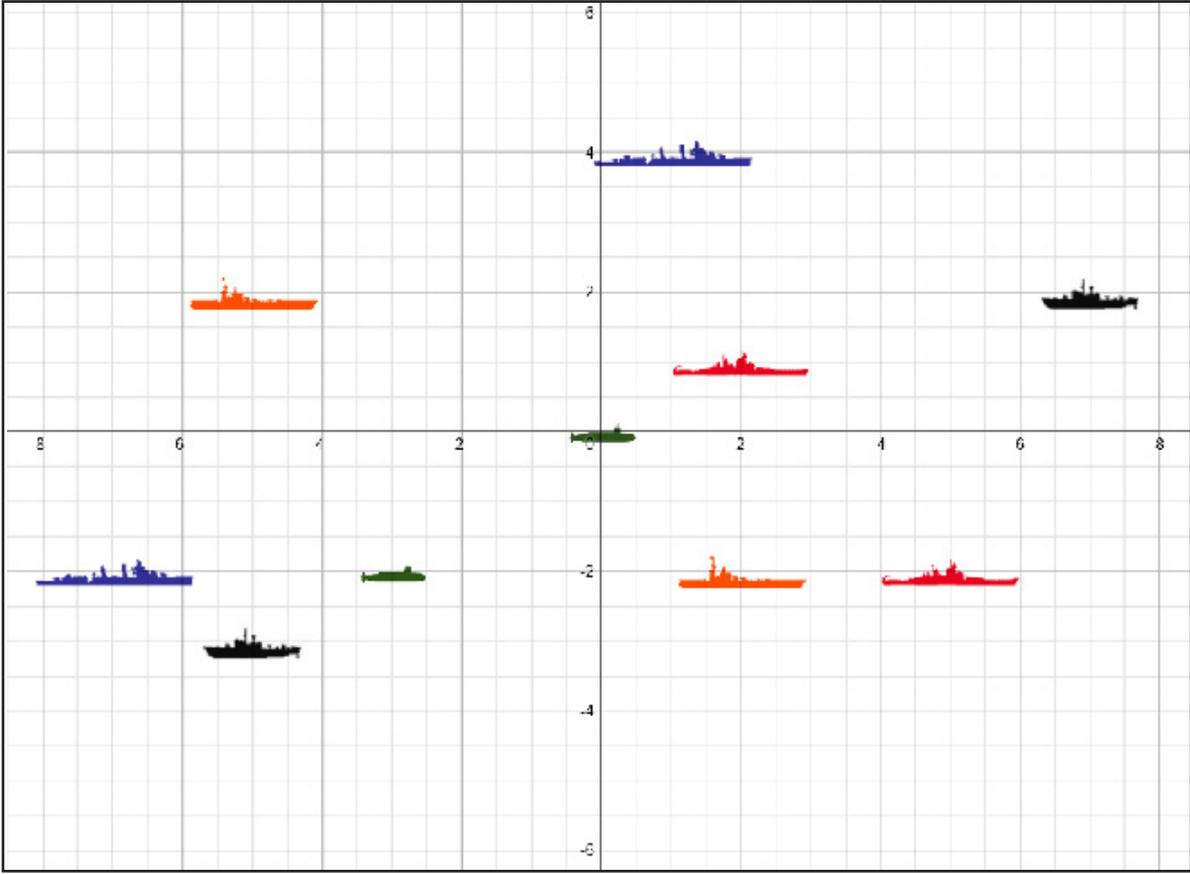
Here are some ideas:

- Create your own scatter plots on the Desmos site so that the students can practice more.
- Have students create scatter plots for each other.

Function Battleship Scatterplot 1



Function Battleship Scatterplot 2



Function Battleship Scatterplot 3

