Family Ties

Exploring Families of Functions

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Grade Level	10th – 11th Grade	**Time Frame**	3 class periods
Subject	Mathematics	**Duration**	110–130 minutes
Course	Algebra 2		

Essential Question

What is a family of functions? How can we identify the family a function belongs to?

Summary

In this lesson, students will be able to identify the family to which a function belongs using characteristics of graphs. This is a great lesson to use at the beginning of Algebra 2, before students begin to study any of the specific function families (absolute value, quadratic, radical, exponential, logarithmic) or transformations. Alternatively, this lesson can be used later in the year as an introduction to transformations.

Snapshot

Engage

Students decide which graph they believe is not like the others and justify their thinking.

Explore

Students sort cards into sets based on common characteristics they see in the graphs.

Explain

Students share how they grouped their cards and formalize the meaning of *family of functions* and *parent functions*.

Extend

Students sketch a graph for each given story and then identify which family of functions the graph belongs to.

Evaluate

Students demonstrate their understanding by creating Anchor Charts for different families of functions.

Standards

ACT College and Career Readiness Standards - Mathematics (6-12)

AF705: Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$

Oklahoma Academic Standards Mathematics (Algebra 2)

A2.F.1.2: Identify the parent forms of exponential, radical (square root and cube root only), quadratic, and logarithmic functions. Predict the effects of transformations [f(x + c), f(x) + c, f(cx), and cf(x)] algebraically and graphically.

Attachments

- Card Sort Sets—Family Ties.docx
- Card Sort Sets—Family Ties.pdf
- Function Cards—Family Ties.docx
- Function Cards—Family Ties.pdf
- Lesson Slides—Family Ties.pptx
- Modeling the Story—Family Ties.docx
- Modeling the Story—Family Ties.pdf
- Not Like the Others—Family Ties.docx
- Not Like the Others—Family Ties.pdf

Materials

- Lesson Slides (attached)
- Not Like the Others signs (attached; one set; print one-sided)
- Function Cards (attached; one set per group; print two-sided)
- Card Sort Sets handout (attached; one per group; print one-sided)
- Modeling the Story handout (attached; one per student; print two-sided)
- Chart paper (seven sheets)
- Pencils
- Markers
- Paper
- Document camera (to display cards; alternative option provided)

Preparation

Before you begin, print the attached **Function Cards** (one set per small group of 2–3). Print these two-sided while selecting the "flip on long edge" setting, which is typically the default printer setting. This printer setup ensures that each function appears on the back of its corresponding graph. There are 35 unique cards across the 12-page document, resulting in 6 printed pages when printed two-sided.

Consider printing on cardstock, especially if you plan to reuse these cards. Once printed, cut out the cards. All of these cards are the same size for easy cutting.

15 minutes

Engage

Teacher's Note: Activity Preparation

Prior to beginning the lesson, print out the attached **Not Like the Others** signs and hang them in four corners of your classroom.

Introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to share the lesson's essential questions, and then move to **slide 4** to review the lesson's learning objective. Review each of these with your class to the extent you feel necessary.

Display **slide 5** and introduce the Not Like the Others strategy. Ask students to identify which graph does not match the others. Ask them to be ready to explain why. After a minute of wait time, direct students to move to the sign to indicate which graph is not like the others. Invite each group to discuss among themselves why they think this graph is not like the others. Allow 1–2 minutes for this discussion, then have each corner select a spokesperson to share their reasoning.

Sample Responses

Since there is no right or wrong answer for which graph does not belong, students may have a lot of variety in their rationales. For example:

- Graph #1 is the only one completely below the *x*-axis.
- Graph #2 is the only graph without any curves; it could be made with a ruler.
- Graph #3 stops/starts on the *y*-axis; it doesn't go forever to the left.
- Graph #4 is the only one that goes forever up and down.

20 minutes

Explore

Explain to students that they will be examining many different kinds of graphs in class. To be able to describe graphs efficiently, they will need to categorize graphs, just like shapes can be categorized by their dimensions, number of sides, or angle properties. Then show **slide 6**.

Have students get in small groups of 2–3 or assign groups. Give each group a set of the attached **Function Cards**, graph-side up. Introduce the Card Sort strategy and direct students to sort the cards into sets. Students can group cards however they wish, as long as they follow the rules (shown on the slide):

- Each set must have more than one card in it.
- All cards within a set must share a single characteristic. For example, they are all lines; they all contain the point (0, 3); etc.
- No card may belong to more than one set.

Teacher's Note: Guiding the Activity

Letting students sort in any way they wish allows them to explore different properties of graphs. Although most groups will sort by shape of the graph (that is, by function families), some may sort by the number or position of *x*- or *y*-intercepts, etc. Each method of sorting should be considered a conversation starter about that property.

As students near the end of their Card Sort activity, transition to **slide 7** and give each group a copy of the attached **Card Sort Sets** handout.

Teacher's Note: Purpose

The purpose of the Card Sort Sets handout is to help with pacing and engagement. During the next phase of the lesson, students share with the class one of their sets and reasoning. So that other groups can stay engaged and easily follow along—without unsorting their own cards—they can use this handout to keep track of their thinking. If this lesson needs to be paused at this point and resumed the next class period, groups can easily find their sets of cards in preparation for the next activity.

45 minutes

Explain

Taking turns, have each group bring one set of their sorted cards to the front. Have them place their cards under the document camera, graph-side up, and explain what all of their graphs in the set have in common. Ask students to confirm that these cards all have this common characteristic and that no other cards share the characteristic. Use the hidden **slide 8** as a reminder to have students share their card sets. This slide also has the link for a digital option for displaying card sets (see details in the note below).

If the class agrees that the group has found a correct set, have the group flip their cards over to display the equations of the graphs on the back. Ask the class what the equations have in common and what conclusions they can form based on their observations. As a group is sharing, have those at their desks arrange their cards to follow along. Remind them that this is the reason they took notes on their Card Sort Sets handout.

Ask students to write down the conclusion they formed as an if-then conditional statement. Follow classroom norms for this, whether that is having students write in their math notebook or on a piece of notebook paper.

Alternative to Document Camera

The ideal approach to this activity is using a document camera so that the front and back of the cards can both be displayed easily. However, each group has the same set of cards, so if you do not have a document camera, consider using the following Amplify Classroom activity.

Go to *Amplify Classroom: Card Sort Sets*. You do not need to have an account to use this resource as described below. However, if you also intend to share the activity with your students, you will need to have an account to create a session code for students. For more information about getting started with Amplify Classroom, go to k20.ou.edu/StartAmplify.

Under “Screens,” there are three rectangles representing the three screens of the activity. Select **screen 1** and display this to the class. When a group brings a set of their sorted cards to the front, select the numbers on the screen that correspond to the numbers on the graph-side of the Function Cards.

Select the “Next” button in the top-right corner to navigate to **screen 2**, which will show those selected graphs. You can zoom out to show more graphs at a time.

Again select the “Next” button to navigate to **screen 3**. Here the corresponding equations are shown, simulating flipping the cards over.

Teacher's Note: Guiding the Discussion

It may not be possible to form any conclusions for a group's set of cards. Reassure students if their observations do not lead to conclusions. Explain that it is as important to recognize when we cannot make general conclusions as it is to recognize when we can.

Possible conclusions should definitely include (but are not limited to) the following:

- If the graph is U-shaped, then *x* is squared in the equation of the function.
- If it is a V-shaped graph, then the equation of the function contains absolute value symbols.
- If the graph is S-shaped, so that the bend is almost vertical, then there is a cube root in the equation of the function.
- If the graph is S-shaped, so that the bend is almost horizontal, then there is an exponent of three in the equation of the function.
- If the graph has an endpoint (continued in only one direction) and looked like half of a parabola fallen over, then the equation of the function contains a square root.
- If the graph is almost horizontal at one end, then the equation of the function has *x* in the exponent.
- If the graph is almost vertical at one end, then the equation of the function contains "log," which is a "logarithm."

As you discuss student conclusions, introduce or reinforce academic vocabulary, allowing students to state their conclusions more precisely. For example, if students discuss the graphs that "become almost vertical," you can define the concept of a vertical asymptote for them and reword their conclusion to something as follows: "If the graph has a vertical asymptote, then the equation of the function contains a logarithm (or logarithmic function)."

Terms that may need defining include: endpoint, intercepts, and horizontal or vertical asymptotes.

Record conclusions, using academic vocabulary, on the board or on chart paper. Once the conclusions have been written for the seven sets of cards, based on the seven families of functions, display **slide 9**. Ask groups to discuss what they think a *family of functions* is.

After several minutes, ask for volunteers to share their answers. Explain that the class should create one definition for a *family of functions*. Discuss with students what this definition should be, questioning them as necessary until a sufficiently precise definition is formed.

Show **slide 10** and tell students that each family of functions has one parent function. Ask students to look at the equations (not the graphs) in each group and see if they can determine which equation is the parent function. Ask groups to think about how they would define *parent function* as they are looking for the parent function for each set. Give students several minutes to think about this.

Ask different groups to each share examples of parent functions (the cards they selected for each family of functions). Then ask for volunteers to share their definitions of what a *parent function* may be. Again, discuss the definition and question students until a sufficiently precise definition of *parent function* is created.

Display **slide 11** and confirm with students that they have all identified the parent functions for each family of functions. Direct students to set aside those cards to use for the next activity. The rest of the cards can be put away.

15 minutes

Extend

Show **slide 12** and give each student a copy of the attached **Modeling the Story** handout. Here students are asked to sketch graphs based on the information provided in each story and then identify the family of functions each graph belongs to. Display **slide 13** for students to use as a quick reference while they complete their handout. Alternatively, you could have students complete this handout at home.

Once students complete their handout, have them check their results with a partner.

Teacher's Note: Guiding the Activity

If students are struggling, encourage them to match their Function Cards (with the parent graphs) with the given stories.

Sample Responses

- Story 1 would be best represented by the absolute value function because that's the shape it looks most like and the volume increases and decreases at a steady rate.
- Story 2 would be best represented by the quadratic function because the ball starts going up fast, slows down at the top, and gains speed as it falls.
- Story 3 would be best represented by the exponential function because the tree seems to be growing faster and faster every year.

Depending on how students interpret the stories, their graphs may represent the inverse function. For example, for Story 2, if students place time along the *x*-axis and height along the *y*-axis, they should model a quadratic equation. However, if they reverse the axes, then they may consider their graph to be in the family of square root functions. Use student responses to decide if there is a need to facilitate a discussion on independent and dependent variables or the vertical line test with your students.

15 minutes

Evaluate

Divide the class into seven groups, one for each family of functions, and show **slide 14**. Introduce the Anchor Chart strategy and give each group chart paper and markers. Assign each group one of the following families of functions: quadratic, square root, cubic, cube root, exponential, logarithmic, and absolute value. Use the slide to communicate your expectations for the anchor charts.

Each anchor chart should include the following:

- Function name
- Equation of parent function
- Sketch of parent graph with labeled key characteristics, such as intercepts and asymptotes

Digital Option

If you prefer that students create a digital anchor chart, consider having them use a tech tool such as Canva or Google Drawings.

Teacher's Note: Purpose

This activity should act as a formative assessment, allowing you to identify what information students have learned and what information about parent graphs still needs to be learned. Therefore, do not supply students with the information needed on anchor charts.

Resources

- Eike, M., & Matchell, C. (n.d.) *Amplify Classroom: Card Sort Sets* [Interactive activity]. Amplify Classroom. https://classroom.amplify.com/activity/6a75edd076083fe50900e1d0
- K20 Center. (n.d.). Anchor chart. Strategies. https://learn.k20center.ou.edu/strategy/58
- K20 Center. (n.d.). Canva. Tech Tools. https://learn.k20center.ou.edu/tech-tool/612
- K20 Center. (n.d.). Card sort. Strategies. https://learn.k20center.ou.edu/strategy/147
- K20 Center. (n.d.). Google drawing. Tech Tools. https://learn.k20center.ou.edu/tech-tool/629
- K20 Center. (n.d.). Not like the others. Strategies. https://learn.k20center.ou.edu/strategy/77