Bounce Wiggle Cross

Polynomial Graphs

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Grade Level	11th – 12th Grade	**Time Frame**	2 class period(s)
Subject	Mathematics	**Duration**	90 minutes
Course	Algebra 2, Precalculus		

Essential Question

In what ways does identifying patterns help determine connections and expand mathematical understanding between functions and their graphs?

Summary

Students will discover the three different types of x-intercepts that happen on polynomial functions.

Snapshot

Engage

Students watch a short video of a roller coaster, prompting them to visualize the graph of the roller coaster's height over time. They will describe the various characteristics of that graph and how they are connected to the roller coaster.

Explore

Students will be divided into small groups and given a card sort with pictures of polynomial graphs zoomed in to see the x-intercepts. They will group the cards into three categories of their choosing.

Explain

Students will come together as a whole group and the teacher will use the "I Notice, I Wonder" instructional strategy to gather students' mathematical knowledge of polynomial graphs and then to incorporate the concepts of the way the x-intercepts bounce, wiggle, or cross.

Extend

Students will use a "bounce, wiggle, cross" handout to further explore and solidify the connection between the way the graph crosses the x-axis and the degree of each factor in the polynomial equation.

Evaluate

Students will create their own sketch of a polynomial and trade with their elbow partner to come up with the best equation to match it. Students will then summarize their sketch and equation, and discuss further the misconceptions, if any.

Standards

Oklahoma Academic Standards Mathematics (Precalculus)

PC.F.1.2: Sketch the graph of a function that models a relationship between two quantities, identifying key features.

Attachments

- Card Sort—Bounce Wiggle Cross.docx
- Card Sort—Bounce Wiggle Cross.pdf
- Guided Notes and Extension—Bounce Wiggle Cross - Spanish.docx
- Guided Notes and Extension—Bounce Wiggle Cross - Spanish.pdf
- Guided Notes and Extension—Bounce Wiggle Cross.docx
- Guided Notes and Extension—Bounce Wiggle Cross.pdf
- Polynomial Behavior—Bounce Wiggle Cross - Spanish.docx
- Polynomial Behavior—Bounce Wiggle Cross - Spanish.pdf
- Polynomial Behavior—Bounce Wiggle Cross.docx
- Polynomial Behavior—Bounce Wiggle Cross.pdf

Materials

- Guided Notes and Extension (attached; for teacher's use)
- Card Sort cards of graphs of polynomials (attached; one per group)
- Polynomial Behavior handout (attached; one per group)
- Graphing calculators (one per group)
- Paper and pencils

10 minutes

Engage

Show the roller coaster video on YouTube and then ask students what mathematical way they could graph the roller coaster's position over time. As the students are discussing, you can model by drawing a polynomial on a sample polynomial graph on the whiteboard/screen. Then ask students to describe what is happening to the roller coaster as you move along the graph from left to right.

Teacher's Note: Sample Probing Questions

- What does the x-axis represent in the scenario?
- What is the x-axis labeled?
- What is the y-axis labeled?

Embedded video

https://youtube.com/watch?v=60zrnOyBo3U

20 minutes

Explore

After the roller coaster discussion, briefly introduce that students will be digging deeper into the polynomial function to find out some more interesting tricks the equation can tell them about the graph.

Teacher's Note: Be Vague

You will be tempted to start some direct instruction right now. Resist that urge, though.

Divide students into groups of 3 or 4. Distribute the **Card Sort handout** to the student groups and introduce the Card Sort instructional strategy. The handout has pictures of polynomial graphs zoomed in to see the x-intercepts. Ask students to sort the cards into three categories. The students choose the categories. There is no right or wrong, students just need to be able to justify their choices.

Teacher's Note: Stay Involved

Listen in for what types of conversations the students are having about the graphs. Make mental notes of characteristics they are pointing out to each other. You may need to lead the students into talking about the x-intercepts instead of the end behavior of the graph. It might be helpful to think of each graph as a roller coaster and what is happening to the position of the roller coaster over time.

After about 5 minutes, prompt student groups to label their categories and come up with a brief explanation of why they chose those categories.

20 minutes

Explain

Ask each group to share out their categories and why they chose them. Facilitate the discussion as they do so.

Teacher's Note: Facilitate Means...

...being a part of the sharing, and helping the rest of the class stay engaged in the conversation as well. That could look like having the other groups compare what is being shared with what they wrote down, or simply documenting (aka taking notes, on the board/screen for everyone to see) what each group is saying.

Once all groups have shared, use the I Notice, I Wonder strategy. Based upon what the groups shared, have students think of at least one thing they noticed about the responses and one thing they are still wondering about.

On the white board/screen, write what the students "noticed" about the different graphs. After the students begin to repeat or run low on observations, prompt them to share their "I wonder" statements about the graphs. These statements will hopefully lead you to incorporating the mathematical discussion of what causes the graph to bounce, wiggle or cross.

Teacher's Note: Keep It Academic and Take It Deeper

Use this time to discuss with students what mathematical concepts are connected to the root behavior, such as the bounce (touches but does not cross the x-axis), cross (intersects with or passes through the x-axis), and wiggle (flattens when it crosses the x-axis).

Deepen the conversation by bringing up the graphs of linear, quadratic, and cubic functions. The root of a linear function is an example of "cross," because the graph of a linear function will only have one x-intercept. A quadratic function with a root that has a multiplicity of two is an example of a "bounce" because the parabola touches the x-axis and changes direction. Prompt students to think about the "wiggle" as how the graph flattens around the x-intercept, like it does in a cubic function.

Remember that you are not giving the students equations to look at, only the graphs.

Remind students that "bounce, wiggle, and cross" are a fun and easy way to remember the way the graph goes through the x-axis, but not the real terminology. Use both the phrase “root behavior” as well as the fun words to ensure that students are connecting x-intercepts to roots to zeros, along with the bounce, wiggle, and cross behaviors.

20 minutes

Extend

Ask students return to their small groups and further explore polynomial functions and their roots, given the equations. Distribute the **Polynomial Behavior handout** to each group. Give a graphing calculator to one student in each group, in order to get a visual of the graph and confirm the group's discoveries.

Tell the students to scan through the document with their groups and find out how to fill in the missing spots on the table. This is the time for students to solidify the connection between the degree between each factor of the polynomial and how it correlates to the root behavior; whether the graph bounces, wiggles or crosses at that given root.

Teacher's Note: Differentiate Instruction

Use the Guided Notes for students that need assistance with the graphing calculator and the steps to follow.

Roam the room to observe the conversations and check for understanding about the connections between the equation, the graph, and the root behavior (bounce/wiggle/cross).

20 minutes

Evaluate

Once groups have completed the handout, get the attention of the whole class to give them their assignment.

Each student will take out a blank sheet of paper and sketch their own polynomial equation with various types of x-intercepts, as they choose. Ask them to be sure to label the roots.

When complete, the students will then trade with their Elbow Partner and then that student will create the equation that best fits the sketch. When finished, have the students trade back and check each others' equations with technology.

Questions/prompts for students:

- Discuss and summarize on the paper where the equation was correct/incorrect and why.
- What there enough information, or is more needed?
- What needs to be done to fix the equation if incorrect?
- If correct, is there another equation that can be used to produce a similar graph?

Have the students then write down a summary about their graph, equation and any connections on the same sheet of paper. Each student turns in the sketch, equation, and summary at the bell as their exit ticket.

Teacher's Note: Extension For Advanced Groups

Give advanced groups the extension question at the end of the Polynomial Behavior handout.

Resources

- K20 Center. (n.d.). Card sort. Strategies. https://learn.k20center.ou.edu/strategy/147
- K20 Center. (n.d.). Elbow partners. Strategies. https://learn.k20center.ou.edu/strategy/116
- K20 Center. (n.d.). I notice, I wonder. Strategies. https://learn.k20center.ou.edu/strategy/180
- Theme Park Review. (2011, May 19). Green Lantern POV Roller Coaster Front Seat Six Flags Great Adventure New Jersey SFGadv [Video]. YouTube. https://www.youtube.com/watch?v=60zrnOyBo3U