Lesson 2: Quadratic Graphing Target Practice

Getting Started with the Basics

Abstract:
This lesson uses a physically active beanbag toss activity to reinforce students' understanding of graphing quadratic functions. Students compete in teams to physically use beanbags to physically mark coordinate points on a floor-based graph, based on quadratic equations provided in factored, standard, or vertex form. By quickly computing y values from x values (or vice versa), students gain fluency in evaluating quadratic functions, connecting symbolic representations to tangible graphs. The movement component of the game enhanced student engagement, encourages teamwork and quick math reasoning, and provides visual feedback as points accumulate on the graph.

Keywords: quadratic function, graphing, math, middle-school, high-school, embodied movement, data visualization, movement-based learning, coordinate plane, vertex form, standard form, factored form.

Goals:
At the end of this lesson, students should be able to:

- Understand the difference between factored, standard, and vertex form
- Understand how to graph quadratic functions
- Identify key features of a quadratic function from plotted points: vertex, axis of symmetry, zeros
- Optional (if time): inter transformations such as vertical and horizontal shifts, stretches and compressions

Learning Objectives:
From Unit 6 of the Algebra 1 textbook, cover lessons 11,16.

- 6.11 Graphing from the Factored Form:
  - Create graphs of quadratic functions that are in factored form.
  - Given a quadratic function in factored form, explain how to determine the vertex and y-intercept of its graph.
- 6.16 Graphing the Vertex Form:
  - Create a graph of a quadratic function written in vertex form, showing a maximum or minimum and the y-intercept.
  - Use an equation in vertex form to identify the maximum or minimum of a quadratic function.
- (Optional: If extra time): 1.5 Calculating Measures of Center and Variability

  - Calculate mean absolute deviation (MAD), interquartile range (IQR), mean, and median.
  - Note: This can be collected as a low-stakes quiz or assigned as a take-home pset.

Assessment:

Intermediate and Informal: After each toss, groups evaluate the correctness (peer checking). After each function round, students are cold-called to report key features of the quadratic function.

If time, students should manipulate the beanbags to reflect transformations (vertical shifts, horizontal shifts, stretches, &/or compressions).

Purpose/Rationale:

This lesson directly supports many lessons in Unit 1 of the Algebra 1 textbook, which addresses the Common Core State Standards (CCSS):

- HSA-SSE.A
- HSF-IF.C
- HSF-IF.C.7.a

Traditionally, statistics is taught with pre-made datasets. This embodied education approach allows students to represent their own data in a game they are playing, which will make the concepts more applicable and concrete, thus memorable.

Using physical activity in math has the benefits of

- Providing mental breaks between critical thinking of calculations and interpretation
- Embedding movement into the classroom to enhance engagement, memory retention, and well-being
- Encourage collaboration and peer interaction through shared data collection
- Makes math and learning feel fun!

Prior Preparation:

Instructor:

- Ensure there's enough floor space for the class to play the game
- Draw multiple coordinate systems on the floor
- Gather materials
- Write quadratic functions on each of the cards, put answer keys in envelopes at each station

Students:

- Wear comfortable clothes and shoes for light physical activity

Location:

- Outside on blacktop, or indoor gym (open space required)

Materials/Resources:

- Beanbags (lower-cost option: balled-up pieces of paper)
    - Needs to distinguish between two teams, so 2 different colors/marking on them
- Chalk (If outside on the blacktop), paper and tape (If inside gym).
- Cards
- Mini whiteboards and markers
- envelopes

Cost:
If all materials need to be acquired, $25, schools typically possess most/all of these items.

Bibliography and Sources for Further Reading:

Algebra 1 Unit 6: *https://im.kendallhunt.com/HS/teachers/1/6/index.html*

National Math Foundation's Article on "The impact of kinesthetic instructional strategies and manipulatives on fourth grader's self-efficacy and self-confidence toward multiplication"
https://www.tandfonline.com/doi/full/10.1080/10986065.2024.2343036

Common Core State Standards Initiative:
https://www.thecorestandards.org/Math/Content/HSF/LE/

6-Step Procedure for Experiential Education

#1 Introduction: "Set Up for Success" (10 min)

- Review factored, standard, and vertex form.
    - Show video in class/as pre-class assignment
- Review the game setup
    - Show how there's multiple coordinate systems on the floor, each has a card near it with a quadratic function on it.
    - Students will use beanbags to plot the function, the more of your team's beanbags graphing the function, the better
- Safety Overview
    - If a student obviously throws a beanbag out of bounds/towards a student, that student you are out will sit out the next game
    - Students must only collect beanbags when the Judge says it's ok (for bad shots or at the end of each round). No one should throw beanbags when students are collecting beanbags
- Review Game Rules:
    - Students get into groups of 3 (or 5 or 7 depending on class size). For each round, groups split into half (different teams each round), and the 1 person left out is the

    "Judge." The judge has an answer key in an envelope with coordinate points and the name for the type of function,
  - The Judge picks up the card and shows the function to both teams. The first team to correctly identify if the function is written in standard, factored, or vertex form gets the opportunity to toss first. The Judge gives the X values that the teams must solve for them to target to graph that coordinate on the graph. The first team presents their answer to the Judge. If correct, that team gets the opportunity to toss. If they are accurate, they get a point. If they miss in the answer or toss, the other team steals. If that team misses, the first team gets to try again, and can move 1 coordinate closer. Repeat until the Judge views that a team has scored.
  - For all future rounds, the first team to determine the correct coordinate point gets the opportunity to toss first.
  - If neither team lands the or accurately lands their toss, move onto the next round.
  - When the teacher calls time, the group analyzes the graph. Then, the group moves to the next station and reshuffles the team (new Judge and 2 teams), and repeats the game.
  - **Challenge modes:** If the class seems to understand the premise of the game well and there is lots of time and you would like to increase the difficulty of the rounds, below are some modifications that may be more fun to try:
    - Students must hop on one foot while throwing the bean bag.
    - Students must throw the bean bag as high as possible before it lands on the target square.
    - Students must spin around 3 times before throwing the bean bag and throw it within 5 seconds.
    - Students must throw the bean bag on their knees.
    - Students must only slide the bean bag.

#2 Exploration: "Do it" (25 min)
- Following the game rules, have the students perform rounds of the beanbag toss game.

#3 Sharing: "What Happened" (10 min)
After each round, analyze the graph by determining x- and y- intercepts, direction of opening, axis of symmetry, and any other notable features.
Students will discuss their experiences in that round. Students from both sides of the game will be called on to discuss the results, their reactions and observations, and anything unexpected about the experience. This discussion period will allow students to connect the concept of quadratic functions with how the games went.

Students will likely comment on the patterns they saw which sped up their arithmetic solving and note challenges with the time-pressure and tossing accuracy.

Some recommended discussion questions (they can discuss in small groups or as a class):
- Which type of graphs were easier to graph?

- Which points were easiest/hardest to graph?
- What shape did you notice the graphs take?
- What did you notice about different terms impacting the function?
- What would have happened to the function if you changed some terms?

#4 Processing: "What's Important?" (5 min)
Transition the knowledge to the academic concept, guide students to understand that:
- The points forms a parabola when connected
- Vertex form easily shows shifting
- Factored form helps predict x-intercepts
- Standard form requires careful computation
- The impacts of different signs on the intercepts and opening direction

#5 Generalizing: "So What?" (5 min)

Ask students to brainstorm real-world examples where quadratic functions are visible (ie ball trajectory in sports).
Discuss with students how graphing and interpreting functions is a foundational skill for future math lessons. Explain to students that the lesson's goal was that embodied education should help students internalize quadratic functions by seeing it themselves.

#6 Application and Wrap-Up: "Now What?" (5 min)

Summarize the key takeaways from the class, that students gained a lot of practice with different quadratic functions. Hopefully students learned that math can be fun, physically active, and social.

<u>PSET:</u>
- Note: Having students reflect on how different terms impact the function will help setup the next lessons (6.10, 6.12, 6.13, 6.14, 6.15 - interpreting the impacts of each term in factored and vertex forms).

Problem 1:
1) Factor the following equation: x^2 + 3x + 4
2) Graph the equation from x = [-3, 3]
3) What is the x-intercept?
4) What is the y-intercept?
5) What is the vertex?
6) What is the vertex form of the equation?
7) What is the maximum of the equation?
8) What is the minimum of the equation?
9) What would happen if the 2 became a ½ ?
10) What would happen if the + 4 became a -2 ?

Solution: (x+3)(x+1)

Problem 2:

1) Factor the following equation: x^2 + x - 2
2) Graph the equation from x = [-3, 3]
3) What is the x-intercept?
4) What is the y-intercept?
5) What is the vertex?
6) What is the vertex form of the equation?
7) What is the maximum of the equation?
8) What is the minimum of the equation?
9) What would happen if the 2 became a ½ ?
10) What would happen if the + 4 became a -2 ?

Solution: (x+2)(x-1)