High School
Algebra II
Quadratic Equations

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Throwing a football, a basketball, even launching a ball from a cannon all have one thing in common: quadratic equations. Quadratic equations can be used to find an equation that will go to the target. Even though students have experienced throwing objects in the air, they have not yet connected mathematics into their activities.

The thirty students in an Algebra II class at a Wahluke High School in Mattawa, Washington will be learning how to graph quadratic equations using function notation to plot points, graphing equations in standard form, and graphing equations in vertex form. The students will focus on how to graph quadratic equations and how they apply in real world settings. The students will be taught using direct instruction, group work, and by scaffold worksheets. The students will also be using the Algebra II book by Holt McDougal as a resource.

The students will learn how to evaluate a function and graph the points through the teacher scaffolding the process. The learning targets for the lesson is: Students will be able to evaluate a quadratic function and graph the points with 85% accuracy. In the next lesson, students will learn how to graph quadratics in standard form. The students will be working towards achieving the learning target: Students will be able to use the vertex, the axis of symmetry, and plotting points on an xy-coordinate axis with 85% accuracy. Then the student will learn how to graph quadratic equations in vertex form. The learning target will be: Students will be able to identify the vertex point, axis of symmetry, and evaluate points in order to graph the quadratic equation in vertex form with 85% accuracy.

The lessons are aligned to the three Common Core Standards that are shown on the right. The first cluster represents the first lesson and the second cluster represents the next lesson and so forth. The students will also demonstrate three of the six Mathematical Practices during the unit. They will be demonstrating MP1, MP4, and MP6.

First Cluster

Understand the concept of a function and use function notation.

Common Core Math Standards

CCSS.MATH.CONTENT.HSF.IF.A.2

Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

Second Cluster

Analyze functions using different representations.

Common Core Math Standards

CCSS.MATH.CONTENT.HSF.IF.C.7.A

Graph linear and quadratic functions and show intercepts, maxima, and minima.

Third cluster:

Build new functions from existing functions.

Common Core Math Standards

CCSS.MATH.CONTENT.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.

Mathematical Practices

MP1: Make sense of problems and persevere in solving them.
MP4: Model with mathematics.
MP6: Attend to precision.

In the unit, the students will be beginning by evaluating linear equations using function notation. The Common Core Math Standard that is aligned to this lesson is HSF.IF.A.2. The students will be practicing how to evaluating x-values on a linear equation because it only contains one variable. In Figure 1-1, shows the students task. Once the students complete the beginning task, the teacher will then start a class discussion asking the students to go to the white board and demonstrate their process of evaluating the linear equation. The students will be demonstrating the Mathematical Practices of MP4 and MP6. Each student will be modeling mathematics through a representation of a table and a graph. The students will also need to attend to precision and accuracy when graphing the quadratic equation. The teacher will then be checking for understanding in the whole class to make sure any confusion has been clarified before moving on. The teacher will then move on to introduce the quadratic equation to the students. The teacher will demonstrate and scaffold each step on how to evaluate the quadratic equation. According to Wass and Golding, "Scaffolding provides assistance for a task so that students learn to do the task independently…" (p. 677). Scaffolding will help the students go through each step and ask questions as they go through the process. The teacher will be showing the students how to square a number as the students may mistake the computation has been finished, degree of 2 as multiplying the number by 2. In Figure 1-2 shows the class work. The teacher will remind the students to graph the equation at the end. After the students will then be working with a partner to complete evaluating a quadratic equations that are given on a worksheet shown in figure 1-3. Their partners allow for peer-tutoring to happen within the classroom. They will be completing a table in the process and the graph the points. The worksheet also allows the students to develop their procedural fluency as they work through each equation. They are also able to ask the teacher for one-on-one help with the assignment. Towards the end of the lesson, an exit slip will be given. The slip will contain questions such as: What did you learn in class? What do you need more time on learning? The students

Figure 1-1

Entry Task:

Use the table below to evaluate the linear equation, $y = 2x + 1$. Then use the points to graph the linear equation.

x	-3	-2	-1	0	1	2	3
y							

Show your work below.

Figure 1-2

Class work:

Use the table below to evaluate the quadratic equation, $y = x^2 + 3$. Then use the points to graph the equation.

x	-3	-2	-1	0	1	2	3
y							

Show your work below.

Figure 1-3

Sample problems:

Instructions: Create a table to evaluate the quadratic equations below. Then use the points to graph the equation.

1. $y = x^2 - 1$
2. $y = 2x^2 + 2$
3. $y = \left(\frac{1}{2}\right)x^2 + 3$

Figure 1-4

Exit Slip:

Please answer the following questions.

1. What did you learn in class?
2. What do you need more time on learning?
3. Evaluate the quadratic equation $y = 3x^2 + \left(\frac{1}{2}\right)$, when $x = 2$.

will also be evaluating one x-value using a specific equation. The problem will provide feedback that will help the teacher determine what still needs to be reviewed a bit more. To accommodate for students, an extension on time will be allowed in order to have the students learn to the best of their capabilities. The worksheet can also be enlarged for students with visual impairments. For students with physical impairments, allowing them not to be able to write, the students will be able to orally communicate the process with their pattern or an aid that is in the classroom.

In the next lesson in the learning progression, the students will be learning about how to graph quadratic equations in standard form. The students will be working towards achieving the learning target: Students will be able to use the vertex, the axis of symmetry, and plotting points on an xy-coordinate axis with 85% accuracy. The Common Core Math Standard that are aligned to the learning target is HSF.IF.C.7. During the lesson, the students will be demonstrating the Mathematical Practices MP1 and MP4. The students will be evaluating quadratic equations. They will need to make sense of what the numbers they find and how they relate to creating a graph. The students will then be modeling the points found using a graph. The teacher will be starting the students off with an entry task. The students will be evaluating x values in a table for the quadratic equation of $y = x^2$. The students will also need to graph equation. The beginning entry task will help the students recall the information they previously learned the day before. The students will be working in pairs in case the student needs help with evaluating x values. The teacher will then going over the entry task with the class and will be clarifying any questions that the students have. The teacher will then move on using direct instruction to present information. The teacher will discuss about the standard form of a quadratic equation. The variables of the equation will be discussed about what they do to the quadratic equation. During the lecture, the vertex and axis of symmetry formula will be stated and there will be an example shown in class. Figure 2-1 is shown on the right. After the lecture is given, students will be working in pairs to

Figure 2-1

Instructions: Evaluate the table using $f(x) = x^2$. Show your work below.

x	-3	-2	-1	0	1	2	3
$f(x)$							

complete a worksheet of three problems. Figure 2-2 shows one problem students will be completing. The students will completing more problems but with different equations. Students will be working in pairs will enable students develop the conceptual and procedural understanding to graph quadratics in standard form. The students will be given time in class to work on each problem. They can ask for help, which will help develop their understanding in graphing quadratics in standard form. The worksheet they will be given will be designed using scaffolding because the students will need support in completing the problems. Then towards the end of the class, the students will be completing an exit slip. This exit slip will help the teacher have feedback to design the next lesson that the students will be learning. Figure 2-3, shows the exit slip the students will be completing. These problems will be used as informal assessment and will be used as participation points. They students will not be able to finish all of the problems on the worksheet. The students will be getting assigned the rest of the worksheet for homework so that they are able to achieve the learning target for the lesson. Allowing for more time for the students will help the students understand what they still need help with and what they know how to do on their own.

The next lesson will then be presented in class the next day. The students will be learning how to graph quadratic equations in vertex form using the vertex point and by evaluating x values of the equation. The lesson is aligned to the Common Core Math Standard of HSF.BF.B.3. During the lesson, the students will be demonstrating two Mathematical Practices of MP1 and MP4. The students will need to make sense of how the vertex point is connect to how they are able to graph it. The students will then be using a graph to model the quadratic equation in vertex form. The teacher will being the class off with an entry task. The students will be working in groups to graph quadratic equations such as $y = x^2 + 2$. In this lesson, the students will be describe the behavior of the equation from its parent function. The students will work in groups to sketch the graph, find the vertex. The students will present a quadratic equation given by to the teacher. The students will be peer

Figure 2-2

1. Given $f(x) = 3x^2 - 5x - 2$ answer the questions below.
    a. What is $a, b, and\ c$?
    $a =$ $b =$
    $c =$
    b. Will $f(x)$ be open upward or downward? **Why?**
    c. What is the a value? Will the $f(x)$ be wide or narrow? **Why?**
    d. Find the vertex coordinate point. Show your work.
    e. Find the axis of symmetry. Make sure to state what the axis of symmetry is below.

Figure 2-3

Exit slip:

1. What was the one main thing you learned in class?
2. Do you need more time on learning more about: (Circle all that apply to you below.)
    a. How to find the vertex
    b. How to plot points
    c. How to find the axis of symmetry
    d. Calculating the values in the table
    e. Other:
3. If you had a test on this tomorrow, how do you feel that you would do on it? Explain.
4. Given the equation
    $f(x) = x\text{^}2 + 5x + 6$
    a. Find the vertex. Show your work.
    b. Find the axis of symmetry.

teaching their groups work. The students in the class will then either agree or disagree with their peers. This small activity will help the students learn from each other and ask questions when they are confused. From this activity, the teacher will lead the students into difficult problems. The teacher will introduce problems that will be difficult and new for the students to understand. The teacher is starting from easy quadratic equations to the vertex form of quadratic equations. This instructional method, enables the students to see how the behavior of the graph relates to the how to graph the vertex form of an equation. The teacher will then balance between direct instructions to small group work. The students need to learn what the vertex form of a quadratic equation is and they need to be able to practice what they learned with others. Then once the students learn the information, they will be handed a worksheet called "*Graphing Quadratic Equations in Vertex Form."* The students will be collaborating with their groups as they complete the worksheet. Figure 3-1 shows an example problem the students will be completing. The students will not have time to complete the worksheet in the class. The students will be assigned the worksheet for homework. The assignment will also be posted on Google Classroom for students who lost the worksheet or were not in class. Google Classroom also helps students will access the instructions and the worksheets. Then to end the lesson, the students will be completing an exit slip worksheet called "*Don't let it slip out of your brain!"* This worksheet will help the teacher gain feedback on how the students felt that they learned from the lesson. The exit slip will also have a small hinge question that the students will be completing in order for the teacher to assess the student's mastery level at the end of the class. The feedback results will help the teacher redirect the next unit.

Furthermore, there will be informal assessment given in each lesson of the learning progression to measure the student's mastery towards the learning targets. There will also be accommodation for students such as an extension of time for assignments, peer-support, peer-teaching, working individually, and working in groups. There will be group work after a small lecture from the

Figure 3-1

1. Write the vertex form of a quadratic equation, $y = x^2$.
2. Given the equation $y = 2(x + 3)^2 + 2$, what is the value of:
3. $a =$ _____ $h =$ ___$k =$ _____
4. Describe the behavior of the equation, $y = 2(x + 3)^2 + 2$ is doing. Use complete sentences.
5. Does the graph open upward or downward? Does it vertical shrink or vertical stretch?
6. What is the vertex of $y = 2(x + 3)^2 + 2$? Write the vertex point in coordinate notation of (h, k).
7. What is the axis of symmetry of $y = 2(x + 3)^2 + 2$?
8. Using the information that you have found in questions 2-5, graph the equation $y = 2(x + 3)^2 + 2$ in the space below. You can use the table to find the points of the graph. **Label** the vertex and the axis of symmetry.

x					
y					

Figure 3-2

"Don't let it slip out of your brain!"

Instructions: Use the information that you learned to help you complete the problems below.

1. What did you learn in class today?
2. What do you still need help on:
3. Finding the vertex, Graphing the equation in vertex form, Finding the points of the equation, Describing the behavior of the graph, Other:
4. What could Ms. Guajardo do to help you learn easier? Circle that apply or write one in: Use more examples, Work in groups, Need more time to understand the information, Nothing, she did great today!, Use simpler problems?, Other:
5. Circle below the level you are at:

2	1	0
I understand how to graph quadratic equations in vertex form. I am ready to move on.	I still need more time to practice how to graph quadratic equations in vertex form.	I do not understand at all how to graph quadratic equations in vertex form.

6. What is the vertex of $y = (x - 3)^2 + 4$? Write the vertex point in coordinate notation of (x, y).
7. What is your attitude towards the math that was done in the class today?
8. For example: *"I liked the math that we did today because I understood it!"* or *"I am confused on what we are doing!"*

teacher. There will be small a discussion that students will be using their peer support to allow them to develop and increase their understanding of the concept. There will be informal assessment in the entry task and exit slips that will be given in class. The students will have formative assessment in the worksheets that will be assigned in class and as for homework. The worksheets will be counted as points for their grade in the class. The formative assessments also help to plan the lesson for the next day. The exit slips must be graded the same day in order to implement a strategy to teach the students the next day.

Overall, the students in the classroom need to be able to demonstrate their learning to peers and be able to communicate their ideas to the class. This will enable the students to gain deeper learning about how to graph quadratics equations by evaluating points, in standard form, and in vertex form.

Works Cited

Wass, Rob, and Clinton Golding. "Sharpening A Tool For Teaching: The Zone Of Proximal Development." *Teaching In Higher Education* 19.6 (2014): 671-684. *Academic Search Complete*. Web. 17 Feb. 2016.