INSTRUCTIONAL STRATEGIES TO PROMOTE ENGAGEMENT
FOR STUDENTS OF POVERTY IN A MATHEMATICS CLASSROOM - PROJECT

by

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A capstone submitted in partial fulfillment of the requirements for the degree of Master of Arts in Education.

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**Description of Project**

The research question for this project is, “What instructional strategies can I employ with my high school students of poverty to better engage them in learning mathematics?” The method of answering this research question was to create a presentation through Power Point. The presentation is designed for high school mathematics teachers who teach students living in poverty. The timing of the presentation is approximately one hour and would be best if given early in the school year. It is possible that the presentation could be given before the school year begins but it would be more beneficial to the participants if they have some experience to build off of for the discussion pieces. The participants should be sitting in groups during the presentation.

The Power Point presentation is modeled after Malcolm Knowles’ Whole-Part-Whole (WPW) Learning Model. WPW has three parts; 1) the “first whole” contains the advance organizer and motivates the participants; 2) the “parts” are the in-between pieces and 3) the “second whole” is the part of the presentation that ties all of the individual parts together. The advance organizer for this presentation is a quote to get the participants thinking about Maslow’s Hierarchy of Needs and Bloom’s Taxonomy and how they each affect a student. The motivation to learn is given through the objectives given at the start of the presentation. The “second whole” for this presentation is at the end when teachers are asked how they are going to take the information given and apply it to the classroom. Teachers are asked to write down specific ideas they can take to the classroom.
The presentation has two main focuses; the background knowledge teachers need for teaching students of poverty and teaching strategies. Along with a printout of the Power Point, participants are also given a handout which is referenced in the second half of the presentation.

The first portion of the Power Point presentation begins by discussing Abraham Maslow’s Hierarchy of Needs. In order for a person to begin to make their way to the top of the pyramid to reach the level of self-actualization, the bottom levels must be met. The bottom levels of the pyramid are a person’s physiological and security needs. Research has shown that oftentimes, students from poverty do not have these bottom levels met. Because these needs are not met, these students have difficulty in the classroom. The Power Point describes each level of the pyramid and discusses ways in which teachers and schools can begin to meet some of these needs in order to allow students to be active participants in the classroom. The Power Point goes on to discuss how students of poverty typically have gaps in their learning and shares possible ways to fill in these gaps. Next, qualities of effective teachers are discussed and what those qualities look like in a mathematics classroom is presented. One of those qualities is culturally-relevant teaching. Culturally-relevant teaching is described and it provides the steps teachers should take to if they want to create more culturally-relevant lessons.

The second portion of the Power Point presentation focuses on six teaching strategies that have been shown to be effective in the classroom. The six strategies are cooperative learning, jigsaw learning, card sorts, walk-arounds, culturally-relevant lessons and intentional vocabulary instruction. Each strategy is described and an explanation for why they are effective is given. This information is included in the
handout along with a sample lesson plan of how the strategy is used in a high school mathematics classroom. Any material referenced in the lesson plan is also included in the handout.
Welcome! My name is Jessica Lind and today I am going to be talking about strategies to engage students from poverty in mathematics. I have taught math for seven years; six of those years were in a high-poverty, high-minority charter school in Minneapolis. I quickly learned that teaching these students was going to be different than my previous year of teaching. This presentation has two main focuses. The first is the background knowledge I believe teachers need to know before they begin to think about lesson planning and teaching. I believe teachers need to know the general characteristics of students from poverty, how these characteristics affect learning and what teachers can do in their classroom to help. The second part of this presentation will discuss some teaching strategies I’ve found to be effective with my students. Let’s begin!
In teaching, “You can’t do the Bloom stuff until you take care of the Maslow stuff.”
Alan E. Beck

“child at the window” by pixbay is licensed under CC0
Objectives

- I will be able to describe how Maslow’s Hierarchy of Needs affects students of poverty.
- I will be able to give examples of how to better meet the basic needs of my students.
- I will be able to describe ways to fill educational gaps in my students’ learning.
- I will be able to describe and implement effective strategies in my classroom to better engage my students in mathematics.
What challenges do students bring to the classroom?

Using the post-its on the table, write one challenge per post-it. Use as many post-its as you would like.
A low-income family is defined as a family whose income level is less than twice the federal poverty level. This means a family who earns less than $44,700 is a low-income family. These statistics represent the children in the state of Minnesota.
Coming from poverty can have detrimental effects on a child’s education. Today, the barriers I will touch on are children’s basic needs and the quality of past teachers.
Psychologist Abraham Maslow created a hierarchy of needs for humans. At the bottom level is physiological needs. These are a persons’ most basic needs and they are food, water, warmth and rest. The second level is safety needs: security and safety. Next are belongingness and love needs; followed by esteem needs. At the top is self-actualization. Starting at the bottom, each level needs to be met before a person can move upward. The goal is for everyone to reach self-actualization. It is at this stage that a person reaches their full potential in life. Oftentimes, children from poverty come to school without the first two levels being met. This creates challenges when teachers want them to be engaged and an active participant in their learning. The first part of my presentation will discuss some of the ways I have attempted to meet these needs for the students in my classes. There will also be time for you to discuss with the people at your table other ways you might help meet each need with your students.

“Maslow’s Hierarchy of Needs” by Tomwsulcer licensed under CC BY-SA 3.0
Basic Needs

- Many students from poverty come to school without the bottom two levels met.
- How can we as teachers help meet these needs in our school and in our classrooms?

(Give participants a few minutes to discuss and write answers on large post-it paper)
Physiological Needs

- Some of the ways I’ve tried to help meet these needs are:
  - Buying granola bars and string cheese from Costco to keep in classroom
  - Buy water cooler and keep in open space
  - Donate clothes, jackets, hats, gloves, etc to school social worker
  - If a student falls asleep in class, leave them be (case by case basis and with a conversation)

Here are a few of the ways I have tried to help meet the physiological needs of my students. Many of my students, for various reasons, do not get enough to eat at home. I’ve used my Costco membership to buy large amounts of granola bars and string cheese to keep on hand in my classroom. I limit students to one a day (otherwise I’d be wiped out daily) and I have them tell me one thing about their day before I give them a food item. This helps build relationships with students in my classes and I usually get students who aren’t in my classes visiting me. This is also beneficial because I may get them as students later on and a relationship is already established. This can be costly but I feel the payoff is worth it. Secondly, a few teachers got together to buy a water cooler and we kept it in the school’s resource room. The school already had a contract with a water supplier so we only needed to buy our own cooler. Students could bring their own water bottles and had access to cold water throughout the day. Another school-wide practice was bringing clothing to be donated to our school social worker. She had a room full of clothes that she organized and our students had full access to it. This was especially important in the winter months; many students received winter coats, gloves, hats and boots from this room. Lastly, and I know some of you may not agree with this, but if a student fell asleep in my class, more often than not I would leave them be. I know that some of them work late or have others in the family who work late and rely on them to help out at home. I always check-in with these students and set-up a time for them to come in during lunch or some other time to get caught up. Sometimes I have no idea what is going on in their lives outside of school, sometimes they tell me but not always, and I believe if they need to sleep then they should. Now, if a student is repeatedly sleeping in class, I do not allow it. At this point I would bring in administrative help and/or assistance from the social worker. I believe all these measures help meet the basic physiological needs of food, water, warmth and rest.
Safety Needs

- Some of the ways I’ve tried to make my classroom a safe space:
  - Call students out on swearing and derogatory language
  - Address bullying
  - Remove students from classroom when necessary

The next level in the basic needs category is safety needs. Children do not always come to school feeling safe and secure. It is our jobs as teachers and as a school community to help students feel safe when they are with us. When it comes to creating a sense of safety in my classroom, I always call students out on their swearing and use of derogatory language. Working with the students I work with, this kind of language is almost second nature to them. When I ask them not to talk that way, they usually say “I talk like this at home” or “everyone else talks like this”. Regardless of their reasoning (and usually they don’t even realize when they swear) I always make sure to say something to them. You never know what may offend or how someone else may react to another person’s choice of words. Additionally, the math classroom is not the place for that type of language anyway. As I’m sure you all do too, I always address bullying and keep an eye and ear out for students interactions with others. Lastly, I have no problem removing a student from my classroom if they are making it an unsafe or unpleasant atmosphere.
Belongingness, Love and Self-Esteem Needs

- How can we as teachers make our classrooms accepting and positive for our students?
- How can we as teachers build the self-esteem of our students in our classrooms?

(Give participants a few minutes to discuss and write answers on large post-it paper)
Love and Belonging

Here are ways I’ve tried to make my classroom positive and accepting:

- Greet students at the door
- Walk the cafeteria during breakfast and lunch
- Five minute check-in at beginning of class
- Encourage students to put their answers on the board
- Insist on every student asking a question every week

The middle level of Maslow’s hierarchy is love and belonging. Sometimes children from poverty do not get enough love and attention from home. In my classroom, I greet my students at the door and take time to walk the cafeteria during breakfast and lunch to talk with students. It is always nice to see students outside of the classroom and away from the pressure of needing to get everything in the lesson plan completed in the hour. In the classroom, I try to take a few minutes at the beginning to simply check-in with students. Every student may not say something but I think it is a chance to let everyone get settled before jumping into the lesson right away. To help build a sense of community in my classroom I encourage students to put their answers on the board. By doing this, I think it builds confidence in the student doing it, and it is good for other students to see how another student solved the problem. It also helps students create academic dialogue. If they disagree with the answer, we can work together to talk about why they disagree or if they answered another way, we can talk about why both ways work. Another tactic I use is insisting on every student asking a question at least once a week. Some students have no problem asking questions but I want every student to know that I expect them to be paying attention and that I notice everyone.
The next level is self-esteem. Children from poverty sometimes have low self-esteem in general. Particularly in math classrooms, many students, regardless of family income, have low self-esteem when it comes to their confidence in their mathematical ability. To help build the self-esteem of my students, I have a quote on the front of my wall that I reference frequently. The quote is “It’s ok to not know, it’s not ok to not try”. I really like this quote because children are in school to learn, if they were expected to know the material already, what would be the point of the classes? I’ve found that students think they should know how to solve the problems I present in class already and when they don’t know it, they feel bad and think they are behind. Or they think if they don’t know it by now they never will or other teachers have tried teaching it to them and they didn’t get it and what is the point of trying. I believe, like with many things, in order to become better at mathematics you need to do mathematics. Listening and observing others doing math is not enough; you need to put pencil to paper. Furthermore, mistakes will happen and that is not only ok but it is to be expected. No one is perfect and it is important for our students to know this. If we make a mistake, point it out. If a student makes a mistake, help them realize the error in their thinking and encourage them to try again. Another way to build their self-esteem is to celebrate small victories. Students will be more willing to try new things and take more risks when they feel good about what they are doing. Lastly, on any assignment or assessment I give back to students I always use a “+” rather than a “−” for their points. I think this is a very small but very powerful tool. I think as teachers we should focus on the positive and what students did well then showing them where they can improve rather than focusing only on where they went wrong.
Self-Actualization

- How can we as teachers foster hope in our classrooms?

(Give participants a few minutes to discuss and write answers on large post-it paper)
Hope is a very powerful feeling. If a student feels there is no hope for them, they probably will not put much effort into their education. We need to find ways to create a feeling of hope for a better future for our students. Whether I’m teaching seniors or ninth graders, I always talk about graduation. Some students do not think about their future. They may not think about graduating high school or what they would do afterwards. They seem to be just going through the motions of the day-to-day life. I want all of my students to know the graduation requirements to earn their diploma, think about what it would feel like to walk across the stage and what they want to do with their lives. They need to think about these things so they make the necessary steps to get there. Another important piece is goal-setting and making sure to follow-up on their goals. Because so many of them do not think too far into the future, we do a lot of short-term goals. It may be goals for a particular class, goals for that week, month, grading period, school goals or personal goals. It is important for them to be working towards something and to know that someone is going to be checking in on them to see their progress in reaching these goals.
Teacher Quality

- It is very likely that students from poverty have had poor teachers in the past.
- Teachers of students from low-income families are more likely to have been not licensed, not licensed in correct field or inexperienced (Haycock & Crawford, 2008).
- Students of these teachers are more likely to have gaps in their learning.

A major barrier for students of poverty is the general quality of teachers they have in their educational career. It is very likely they have had poor teachers. These teachers are poor-quality because they are typically not licensed, not licensed in correct field or are inexperienced. Because of this, it is their students who suffer. They will probably have gaps in their learning that will make school harder for them down the road.
I have a lot of experience with students who have gaps in their mathematical learning. At times, it seems overwhelming at how much knowledge a student may be missing and it can be easy to only teach to the level that they are at. This is wrong; they will never catch up to their peers if they are not taught the grade-level material they need, and deserve, to be taught. This can be very difficult in mathematics because math builds on itself. We need to find ways to fill in the gaps without it consuming our entire day. I have found a few ways to do this. First of all, I use my daily warm-ups to focus on the lower-level skills my students are missing. Every week we work on three skills that I have picked and the warm-up for the day is a quick, computational question for each skill. I also like doing warm-ups this way because it doesn’t rely on a student being present the previous day(s) and it is an easy way to build their confidence right at the start of class. Another tool I’ve found to be incredibly helpful is a website called ALEKS. ALEKS is a subscription that you must buy per student but it is a great tool that meets students where they are at and allows them to work on skills they are ready to learn and it gives them choice in what they choose to work on. Lastly, as a math department we found a way to incorporate support classes into our schedule. These support classes are a way for students who struggle to preview lessons with a teacher and get help with homework.
Research has shown that students from poverty have very likely had poor teachers in their past, what do you think are some of the qualities of an effective teacher? What do they need to do, act like, sound like, etc? (Give participants a few minutes to answer. Write down their responses on large post-it paper)
Here is a list of what I, and research has shown, feel are the important qualities an effective teacher needs to possess.
In our math classrooms we need to allow our students to correct their mistakes. It is during this process that a lot of the true understanding takes place. If you have to make corrections an assignment in order for students to do them, do it. If you have to do it as a class the first few times, do it. We have to believe our students can learn and understand the material and not allow them to move on if they do not get it the first time. As teachers, we can not allow incorrect answers. What I mean by this is, say you have a student who struggles but one day they volunteer an answer or work out a problem for you after class. They make a mistake in their work but you’re so happy they are trying you don’t want to hurt their confidence by pointing out their mistake. I’ve certainly been in this position and have felt this way but we have to keep our expectations high. No-Opt out means if you call on a student in class, they can not say “I don’t know” or not answer. They must say something. In my class, especially in the beginning of the year, I allow students to ask another classmate but then I go back to original student and have them repeat what the classmate said. Again, we need to keep our expectations high. Sometimes students from poverty are not able to work on homework at home. They may not have a quiet place to work or have their own space or they may have other responsibilities at home that take away from homework time. Because I believe in homework, I also give my students time and space to work on it before or after school or during lunch. When I have students who stay after school, I make sure I have extra snacks available. I have found this encourages students to stay and it builds community. Lastly, I try really hard to contact one or two parents every week. This could be a quick phone call, email, text or a note in the mail. It is important for parents to stay connected and updated. Oftentimes parents only receive communication from schools when their child is in trouble. We need to work on creating a positive experience for the parents as well.
Another quality of an effective teacher is using culturally-relevant teaching. There are five elements to culturally-relevant teaching: knowing about the culture, caring environment, relationships with diverse students, incorporating diversity into instruction and responding to diversity of learners.
Learning about your students’ culture is the first element of culturally-relevant teaching. The easiest way to learn about their culture, in my opinion, is to talk to your students, talk to their parents/guardians and listen to their pop culture references. I remember one year I happened to see a well-known comedian’s stand-up routine. I quickly realized that a lot of the comedian’s routine was repeated by my students and I had no idea. Finding out about what music your students listen to, what movies or television shows they watch and what they are reading are all ways to connect with them on a more personal level. Another way to learn about their culture is to find out how and where they encounter mathematical concepts outside of the classroom. This could be done simply through conversation or it might be an easy exit ticket at the end of a lesson.
We have to be aware of the diverse learners in our classroom and the diverse ways in which they learn. Some students need to be active while learning. A couple of ways to accomplish this is to have students come to the board to write their answers or have large poster paper on the walls that students need to walk to in order to get the problem. Some students like competition. To help reach these students, make worksheets into a game. Allow students to roll dice for small prizes or have a small basketball hoop in the room that students can shoot a basketball for every correct answer. I’ve noticed that some students would rather answer problems on a whiteboard than with pencil and paper. Lastly, some students prefer to show their knowledge orally rather than by writing. While this is not always appropriate, at times an oral assessment is feasible.
Once you get to know your students, you can start to incorporate their culture into your lessons. Mathematics is all about the word problems. Word problems are a great way to start adding culture to your teaching. We can rewrite the word problems we give our students to reflect situations they face in their lives. Another way to add culture to our lessons is to use culturally relevant videos to introduce mathematical concepts.
15 Minute Break
The second part of this presentation is going to focus on teaching strategies that I have found to be effective with students from poverty. They are cooperative learning, jigsaw, card sorts, walk-arounds, culturally-relevant teaching and intentional vocabulary instruction. I have a hand-out that gives a description of each strategy and have a sample lesson plan that I have used that contains each strategy. (Pass out handout)
Cooperative learning is a strategy in which teachers place students in mixed-ability groups to work together on a single task. The size of the groups is determined by you and what works for your students. It is effective because it relies on students working together, using their own strengths and perspectives, to complete a task.
The jigsaw is a form of cooperative learning. The jigsaw is a strategy in which each member of the group becomes an “expert” in one area of the topic being taught. Each “expert” meets with the other “experts” in that same topic and discusses how to teach it to the original group members. Each “expert” then teaches that topic to their group. The jigsaw is an effective strategy because each student is responsible for learning one topic. Furthermore, they have the opportunity to discuss with other “experts” in the same area before going back to their group. This gives the chance for those who may not be as confident in their ability to feel confident before teaching it to their group.
Card sorts is an activity in which students work with vocabulary words, phrases, pictures, numbers, etc. that are on individual cards. Students work individually or with a partner to sort the cards into different groups. Card sorts are effective because students are given the opportunity to work together to decide what various items have in common and how they are different. They are also effective because students can work in pairs and as long as they have an explanation for their groupings, there are no “wrong” answers.
Walk-Arounds are an activity that requires students to get out of their seats. To set it up, take a sheet of paper and fold it in half. On the outside is an answer to a problem. On the inside is a problem. Tape the pieces of paper around the room. Students start at one problem, find the answer somewhere in the room, and lift the answer to find their next problem. Walk-Arounds are effective for a few reasons. First, they get students up out of their seats and walking around. Secondly, students choose what problem they want to start with. Lastly, all of the answers are available for students to see. This is helpful because they will know right away whether or not their answer is correct. This knowledge can motivate students to keep working. Furthermore, they will know if they answered all of the questions correctly if each of their answers led them to a different problem (it works like a circle).
Culturally-relevant lessons are lessons that incorporate the culture or everyday life of the students within the class. These lessons are effective because students may be more willing to be engaged in the learning if they feel the knowledge is relevant to them. They may feel more connected to the material if it reflects their life experiences.
Every teaching unit has academic vocabulary words that students need to know in order to learn the material, including mathematics. Teachers need to intentionally teach these vocabulary words to help students learn them. In the handout I will list several activities I have used to teach vocabulary words. Intentionally teaching vocabulary words is effective because students need to understand the academic language in order to show they understand the material. They can not answer a question correctly if they do not know what the question is asking.
Before we go I would like you all to take a few minutes to think about what you can do in your classrooms starting tomorrow in terms of meeting your students’ basic needs. Think about a class as a whole or maybe there is an individual student you are thinking about, what can you do tomorrow to help them? Also, I want you to think of an activity discussed today or a lesson you could modify to actively engage your students. Do you know something about your students’ culture that you could incorporate into a lesson? Do you know of an upcoming lesson that has not been very engaging in the past that you want to improve? Take a few minutes to answer these two questions then discuss with your table. Afterwards, I will ask for any volunteers to share out with the group.
Effective Strategies for Teaching Mathematics to Students from Poverty

Handout

by

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Saint Paul, Minnesota
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TABLE OF CONTENTS

Strategy Descriptions......................................................................................... 3
Cooperative Learning Lesson Plan......................................................................... 5
  Cooperative Learning Classwork....................................................................... 7
Jigsaw Lesson Plan................................................................................................. 8
  Parent Function Reference Sheet..................................................................... 11
  Parent Function Classwork............................................................................... 15
Card Sort Lesson Plan........................................................................................... 17
  Card Sort Activity............................................................................................. 19
  Card Sort Classwork......................................................................................... 20
Walk-Around Lesson Plan........................................................................................ 21
  Walk-Around Answer Sheet.............................................................................. 23
  Walk-Around Problems...................................................................................... 25
Culturally-Relevant Lesson Plan........................................................................... 55
  Scatterplot Classwork....................................................................................... 57
Vocabulary Activities............................................................................................. 60
# Teaching Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
<th>Why it is effective</th>
</tr>
</thead>
<tbody>
<tr>
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<td>A strategy in which teachers place students in mixed-ability groups to work together on a single task.</td>
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Intentional Vocabulary Instruction

Every teaching unit has academic vocabulary words that students need to know in order to learn the material, including mathematics. Teachers need to intentionally teach these vocabulary words to help students learn them. In this handout I will list several activities I have used to teach vocabulary words.

Intentionally teaching vocabulary words is effective because students need to understand the academic language in order to show they understand the material. They can not answer a question correctly if they do not know what the question is asking.

Cooperative Learning Lesson Plan
## Cooperative Learning Lesson Plan

### STAGE 1 – DESIRED RESULTS

**Unit Title: Quadratic Equations**

**Established Goals:**
9.2.2.1: Represent and solve problems in various contexts using linear and quadratic functions.
9.2.4.1: Represent relationships in various contexts using quadratic equations and inequalities. Solve quadratic equations and inequalities by appropriate methods including factoring, completing the square, graphing and the quadratic formula. Find non-real complex roots when they exist. Recognize that a particular solution may not be applicable in the original context. Know how to use calculators, graphing utilities or other technology to solve quadratic equations and inequalities.

**Understandings:** *Students will understand that…*
- Quadratic equations can be solved by a variety of methods including factoring, completing the square, graphing and the quadratic formula.
- Quadratic equations can have zero, one or two solutions.
- The appropriateness of the solutions depends on the context of the original problem.
- Technology can be used to solve and check answers.

**Essential Questions:**
- How do we solve quadratic equations?
- How can we use quadratic equations to solve word problems?

**Students will know:**
- How to solve quadratic equations using the quadratic formula.
- How to set up a quadratic equation to solve a word problem.
- Quadratic equations yield two answers which may or may not be appropriate within the context of the problem.

**Students will be able to:**
- Set up and solve quadratic equations from word problems.
- Determine the correct answer given the context of the problem.

### STAGE 2 – ASSESSMENT EVIDENCE

**Performance Tasks:**
Students will solve word problems by setting up quadratic equations and solving those equations.
Students will present problems on the board in groups to the rest of the class.

**Other Evidence:**
Teacher observation

**Key Criteria:**
Assessment of Classwork
**STAGE 3 – LEARNING PLAN**

**Summary of Learning Activities:**
Warm-Up (5 minutes): Three questions will be on the board when students enter the room. When the bell rings, teacher will play song to indicate the start of class. When the song is over, class will go over the warm-up.

1. Evaluate \(-3x + 4y\) if \(x = -2\) and \(y = 5\)
2. Evaluate and round to the nearest hundredth \(\sqrt{85}\)
3. Evaluate \(2(-3)^3 + (2 + 6)^2 - (-5)\)

Whole Group (10 minutes): Teacher will inform class they will be working in groups to solve quadratic word problems and then will present a problem to the class. Teacher goes over one problem on board to review. Review problem: Maya throws a softball into the air. The height of the ball after \(t\) seconds is given by the function \(h(t) = -16t^2 + 32t + 40\). When will the softball reach a height of 50 feet?

Teacher assigns group and problem(s) to be presented. Each group will have three members, one member will read problem to class and set-up the equation, one member will solve the problem, one member will select the correct answer and double check the work of the solver.

Work Time (10 minutes): Students work on problems in their group. Teacher walks room to keep students on task and answer any questions.

Student Presentations (20 minutes): With their group, students present and solve their given problem. The rest of the class checks their work as groups present.

Exit Ticket (5 minutes): Students answer one word quadratic word problem to be turned in as they leave the room. Problem: George is diving from a cliff into the ocean. The height, \(h\), in feet above the water is modeled by the function \(h(t) = -16t^2 + 25x + 11\), where \(t\) represents the time in seconds. After how many seconds does George reach the water?
1. The Empire State Building is 1250 feet tall. If an object is thrown upward from the top of the building at an initial velocity of 38 feet per second, its height \( s \) seconds after it is thrown is given by the function \( h(s) = -16s^2 + 38s + 1250 \). How long will it take for the ball to hit the ground?

2. The height in feet of a basketball that is thrown can be modeled by \( f(x) = -16x^2 + 32x + 6.5 \), where \( x \) is the time in seconds after it is thrown. What is the height of the basketball after 1.25 seconds?

3. In baseball, the flight of a pop-up may be described as \( d = -16t^2 + 80t + 3.5 \) where \( d \) gives the ball’s height above ground in feet as a function of time \( t \). How long does the catcher have to get into position under the ball after it is hit?

4. The height of a golf ball can be approximated by the function \( y = -5x^2 + 20x + 8 \), where \( y \) is the height in meters above the ground and \( x \) is the time in seconds after the ball is hit. When will the golf ball reach a height of 12 meters?

5. A diver begins on a platform 10 meters above the surface of the water. The diver’s height is given by the equation \( h(t) = -4.9t^2 + 3.5t + 10 \), where \( t \) is the time in seconds after the diver jumps. How long does it take the diver to reach the water?

6. The height of a golf ball can be approximated by the function \( y = -5x^2 + 20x + 8 \), where \( y \) is the height in meters above the ground and \( x \) is the time in seconds after the ball is hit. How long does it take for the golf ball to reach a height of 30 feet?

7. A foul ball leaves the end of a baseball bat and travels according to the formula \( h(t) = -16t^2 + 64t + 6 \) where \( h \) is the height of the ball in feet and \( t \) is the time in seconds. How high will the ball be after 2.3 seconds?

8. The height in feet of a falling object on the Earth’s surface is given by the equation \( h(x) = -16t^2 + 64t + 32 \), where \( h \) is the height of the object and \( t \) is the time in seconds. If an object were dropped from 32 feet in the air, how long will it take to reach half of its height?

9. The height of a flare, in feet, fired from the deck of a ship in distress can be modeled by \( h(t) = -16t^2 + 104t + 56 \), where \( h \) is the height of the flare above water and \( t \) is the time in seconds. When will the rocket reach a height of 175 feet?

10. One of the games at a carnival involves trying to ring a bell with a ball by hitting a lever that propels the ball into the air. The height of the ball is modeled by the equation \( h(t) = -16t^2 + 39t \). If the bell is 25 feet above the ground, will it be hit by the ball?

11. The height in feet of a bottle rocket is given by \( h(t) = -16t^2 + 160t \) where \( t \) is the time in seconds. What is the height after 2 seconds?

12. While playing basketball this weekend Frank shoots an air-ball. The height in feet of the ball is given by \( h(t) = -16t^2 + 32t + 8 \). What is the initial height of the basketball?

13. The height in feet of a basketball that is thrown can be modeled by \( f(x) = -16x^2 + 32x + 6.5 \), where \( x \) is the time in seconds after it is thrown. How long will it take the basketball to reach the hoop if the hoop is 12 feet in the air?
### Jigsaw Learning Lesson Plan

#### STAGE 1 – DESIRED RESULTS

**Unit Title: Parent Functions and Their Graphs**

**Established Goals:**

9.2.2.6 Sketch the graphs of common non-linear functions such as the square root, absolute value, inverse and cubic functions, and translations of these functions. Know how to use graphing technology to graph these functions.

<table>
<thead>
<tr>
<th>Understandings: <em>Students will understand that…</em></th>
<th>Essential Questions:</th>
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<tbody>
<tr>
<td>• Key features of a function determine the shape of its graph</td>
<td>• What is the shape of each parent function’s graph?</td>
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<td>• What are the key features of common non-linear functions?</td>
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<table>
<thead>
<tr>
<th>Students will know:</th>
<th>Students will be able to:</th>
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<tr>
<td>• The basic shape of each parent function’s graph</td>
<td>• Name the parent function based on it’s equation</td>
</tr>
<tr>
<td>• Key features of each parent function’s graph and equation</td>
<td>• Name the parent function based on it’s graph</td>
</tr>
<tr>
<td>• How to graph a parent function without plotting specific points</td>
<td>• Draw an accurate sketch of a function based on it’s equation</td>
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#### STAGE 2 – ASSESSMENT EVIDENCE

**Performance Tasks:**

Students will research the function and graph of their given parent function. Students will discuss what they found with others who had the same parent function. Students will teach their group what they learned about their parent function. Students will complete Parent Functions Classwork.

**Other Evidence:**

Teacher observation

**Key Criteria:**

Assessment of Parent Functions Reference Sheet
Assessment of Parent Functions Classwork

#### STAGE 3 – LEARNING PLAN

**Summary of Learning Activities:**

Warm-Up (5 minutes): Three questions are posted on board when students walk in. When the bell rings, teacher plays song to indicate the start of class. When the song is over, class goes over warm-up.
1. Is this a function?
2. What is 15% of 50?
3. Sketch the graph of \( y = \frac{2}{3}x - 1 \)

Introduction (10 minutes): Have each student find a partner. Teacher hands out paper with a blank coordinate graph and a coordinate graph with a graph drawn in. Students put a folder up around their paper so partner can not see. Taking turns, one partner is to describe their graph to their partner only using words and without seeing what their partner is actually drawing. It is the partners’ job to, as accurately as possible, re-create their partners’ graph. Graphs can be found at this link: https://www.dropbox.com/s/4e8sbjce1qynen5/Domain%20and%20Range%20Sketch%20Game.pdf Teacher brings class back together and asks students to describe the process. What was it like to only use words? Did your partner understand your explanation? What types of phrases did you use to describe your graphs? Teacher explains that this next unit will focus on parent functions, that is, common non-linear functions and their graphs. The class will be talking about important key features of these graphs and it is important to have similar vocabulary when describing these graphs. Today will focus on the basic forms of the eight common graphs this unit will focus on.

Whole Group (5 minutes): Teacher explains that today’s task will be the students becoming the teacher. The teacher has made predetermined groups of four. Each student will be assigned two parent functions. Teacher explains that parent functions are the most basic form of a function. The class will be learning about eight parent functions, some of which will be familiar, some will be new. Each person will research their parent function to find out the equation, the shape of its graph and any important features of the graph. Students may use the internet or any textbooks in the class. Next, they will have a few minutes to discuss with other students who had the same parent functions before returning to original group to teach their classmates what they learned. They will have a handout to record all their information.

Jigsaw (20 minutes): Teacher gives group assignments and assigns each student two parent functions (constant function and inverse function, linear function and exponential function, quadratic function and absolute value function or square root function and cubic function). Teacher walks room to monitor progress. When it seems most students are done researching, instruct students with the same parent functions to meet in different corners of room to discuss findings. After a few minutes, ask for original groups to reform. Taking turns, each student presents their parent functions, its equation, its graph and any important information regarding its graph. Group members fill out Parent Function Reference Sheet as each student is presenting.

Closing (10 minutes): Teacher hands out Parent Function Classwork for students to finish before end of class.

Images on Classwork Citations

Question 1: “Linear equation for y=3x+1” by Nerfer licensed under CC BY-SA 3.1
Question 2: “Hyperbola g2 continous” by Rollingfrenzy licensed under CC BY-SA 3.0
Question 3: “Exp” by Perter John Acklam licensed under CC BY-SA 3.0
Question 4: “Absolute Value Function” by H Padleckas at English Wikibooks licensed under CC BY-SA 3.0
Question 5: “Cube root” by Qef, Electrick licensed under CC BY-SA 3.0
Question 6: “Quadratic01” by Matrix at English Wikibooks licensed under CC BY-SA 3.0
Question 7: “Constant function 3” by Fulvio314 licensed under CC0 1.0
Question 8: “Cubic function” by Adrien1018 licensed under CC BY-SA 3.0
**Parent Function Reference Sheet**

Fill in the information as your classmates describe each parent function.

**Constant**

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<th>Parent Function:</th>
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**Linear**

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**Quadratic**

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**Square Root/Radical**
### Absolute Value

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### Rational/Inverse

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### Cubic

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**Exponential**

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<th>Parent Function:</th>
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Parent Function Classwork

Name: ______________________
Fill in the missing information. You may use your Parent Function Reference Sheet.

1. Name: ____________________________
   Function: ____________________________

2. Name: ____________________________
   Function: ____________________________

3. Name: ____________________________
   Function: ____________________________

4. Name: ____________________________
   Function: ____________________________

5. Name: ____________________________
   Function: ____________________________

6. Name: ____________________________
   Function: ____________________________
7. Name: ______________________________
   Function: ____________________________

8. Name: ______________________________
   Function: ____________________________
Lesson Title: Introduction to Sequences and Series

Established Goals:
9.2.2.4 Express the terms in a geometric sequence recursively and by giving an explicit (closed form) formula, and express the partial sums of a geometric series recursively.  
9.2.2.5 Recognize and solve problems that can be modeled using finite geometric sequences and series, such as home mortgage and other compound interest examples. Know how to use spreadsheets and calculators to explore geometric sequences and series in various contexts.

Understandings: Students will understand that…
- sequences are a set of numbers and a series is a list of numbers (never ending)
- arithmetic sequences and series are linear
- geometric sequences and series are exponential
- an explicit formula and a recursive formula can be used to find a specific term

Essential Questions:
- What is the difference between an arithmetic sequence and series and a geometric sequence and series?
- How can an explicit formula be used to find a specific term?
- How can a recursive formula be used to find a specific term?

Students will know:
- How to identify sequences and series as arithmetic or geometric
- How to use the explicit and recursive formulas to find a given term

Students will be able to:
- Label sequences and series as arithmetic or geometric
- Use the formula to find a specific term

Card Sort Lesson Plan

STAGE 2 – ASSESSMENT EVIDENCE

Performance Tasks:
Students will work with a partner to sort sequences into categories and complete Card Sort Reflection. Students will work on examples problems during notes. Students will work on labeling sequences and series and using formulas to find a specific term.

Other Evidence:
Teacher observation during notes and classwork

Key Criteria:
Assessment on classwork

STAGE 3 – LEARNING PLAN

Summary of Learning Activities:
Warm-Up (5 minutes): Three questions on the board when students walk in. When the bell rings, teacher plays song to indicate the start of class. When the song is over, class goes over the warm-up.

1. Evaluate $4x - 3y$ if $x = -2$ and $y = 5$
2. Simplify $-2x^2 + 5x - 2x - 3x^2$
3. Evaluate $(-3 - 1)'2^2 + 5:2 - 6$

Card Sort (10 minutes): Students find a partner. Teacher passes out card sort activity to each pair. Teacher instructs students to look at the list of numbers on the cards and group however they would like.

Notes (20 minutes): Notes start with learning goal for the day and the new vocabulary that will be included in the lesson. New vocabulary includes: sequence, series, arithmetic, geometric, explicit formula, recursive formula, term. Teacher begins with asking students what they think sequence and series means, where have they seen the words and in what context. Teacher verifies students have an understanding of mathematical definition of the two words. Teacher continues with definitions of arithmetic and geometric. Teacher gives examples of labeling items as sequence or series and as arithmetic or geometric. Teacher puts four examples up for students to work on independently. Teacher walks the room. Next, teacher explains explicit formula. Students should be fairly familiar with explicit formulas as they are algebraic equations but have different notation. Teacher gives example of how to use an explicit formula to find a given term. Teacher gives three examples for students to work on independently, teacher walks the room. Finally, teacher explains recursive formula. Recursive formulas are possibly a new concept for students. The notation is different than what most are used to. Teacher gives two examples of how to use recursive formulas to find a given term. Teacher puts three examples on the board for students to work on independently, teacher walks the room.

Classwork (10 minutes): Students work independently or with a partner on classwork to practice labeling items as sequences or series and arithmetic or geometric and using explicit and recursive formulas to find a given term.

Conclusion (5 minutes): How did they originally sort the items? Did they naturally sort them into arithmetic and geometric patterns?

Sequences to be put on cards for Card Sort Activity
4, 9, 13, 19, 24
3, 6, 12, 24, 48
5, 2, 1, 4, 7
24, 12, 6, 3, 1.5
5, 5, 5, 5
2 4 8 16 32
3' 9' 27' 81' 243
4, 40, 400, 4000, 40000
2, 5, 8, 11, 14
24, 6, 3 3 3
2 8 32
- 6, - 9 2, - 3, - 3 2, 0
94, 67, 40, 13, 14
- 4, 16, 64, 256, 1024
90, 30, 10, 10 3, 10 9

Card Sort Classwork                          Name: __________________________
Find the first four terms of the sequence. State whether the sequence is arithmetic or geometric. State whether the formula is an explicit formula or recursive formula.

1. \( a_1 = -4 \)  
   \[ a_n = a_{n-1} + 10 \]

2. \( a_n = 2(3)^{n-1} \)

3. \( a_1 = 8 \)  
   \[ a_n = -\frac{1}{2}a_{n-1} \]

4. \( a_n = 27(\sqrt[3]{3})^{n-1} \)

5. \( a_n = 4(-2)^{n-1} \)

6. \( a_1 = 8 \)  
   \[ a_n = -3a_{n-1} \]

Find the 6th term of the sequence. State whether the sequence is arithmetic or geometric. State whether the formula is an explicit formula or recursive formula.

7. \( a_1 = -3 \)  
   \[ a_n = 3a_{n-1} \]

8. \( a_1 = 11 \)  
   \[ a_n = a_{n-1} + 9 \]

9. \( a_n = 3n - 15 \)

10. \( a_n = -3(2)^{n-1} \)

11. \( a_n = 15(\frac{3}{4})^{n-1} \)

12. \( a_n = -7n - 4 \)
<table>
<thead>
<tr>
<th>STAGE 1 – DESIRED RESULTS</th>
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<tbody>
<tr>
<td><strong>Unit Title:</strong> Radical Equations</td>
</tr>
<tr>
<td><strong>Established Goals:</strong></td>
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<tr>
<td>9.2.4.7 Solve equations that contain radical expressions. Recognize that extraneous solutions may arise when using symbolic methods.</td>
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<th>STAGE 2 – ASSESSMENT EVIDENCE</th>
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<tr>
<td><strong>Performance Tasks:</strong></td>
</tr>
<tr>
<td>Students will complete class activity that requires them to solve several radical equations.</td>
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<td><strong>Other Evidence:</strong></td>
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<tr>
<td>Teacher observation during class activity.</td>
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| **Key Criteria:** |
| Assessment of class activity |

<table>
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<tr>
<th>STAGE 3 – LEARNING PLAN</th>
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<tr>
<td><strong>Summary of Learning Activities:</strong></td>
</tr>
<tr>
<td>Warm-Up (5 minutes): Three questions on board when students walk in. When the bell rings, teacher starts song to indicate the start of class. When the song is over, class goes over warm-up.</td>
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</tbody>
</table>
| 1. Evaluate and round to the nearest tenth \( \sqrt{32} \)  
  2. Solve for \( x \) \( 4x = 48 \)  
  3. Evaluate \( 4 - 5(1 - 3)^2 + 3 \)  
| Whole Group (10 minutes): Teacher reviews how to solve radical equations and has two problems on board for class to go over. Teacher clears up any confusion and answers any questions students may have. Problem #1: \( \sqrt{3x - 8} + 5 = 7 \) Problem #2: \( \sqrt{3x + 10} = x + 4 \) |
Walk-Around Activity (30 minutes): Students will be solving several radical equations in a Walk-Around. Each equation will be posted in various places around the classroom. A piece of paper is folded in half. An answer is located on the outside flap and an equation is located in the inside flap. Students start with any problem of their choosing. They write the equation on their Walk-Around Worksheet. They return to their desk to answer their problem. Once a solution is found, they find the answer on the wall and lift the flap up to find their next problem to work on. Students continue in this fashion until all problems are solved. To set up problems: print problems double sided and fold along the middle. The answer should show on the outside and the problem should be on the inside.

Conclusion (5 minutes): Teacher brings class back together and informs students there will be a quiz tomorrow. On a piece of paper, teacher asks students to rate their confidence in solving radical equations and write down one question they still have.
Walk-Around Answer Sheet

Directions: Around the room are fifteen problems for you to solve. Write the problem in the left column. Return to your seat and solve the problem in the right column. When you have your solution, search around the room for the answer. Lift the answer up to reveal your next problem. You may choose your first problem.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Worked-Out Solution</th>
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<td>Problem</td>
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Walk-Around Problems

$$\sqrt{10x - 25} = x$$
\[ \sqrt{4x + 5} = 3 \]
51 - 15 = x
\[ \sqrt{x + 6} = x + 4 \]
5 \cdot 4 = x
\sqrt{-3x - 4 - 2} = 4
\[ \sqrt{8x + 7} = \sqrt{2x} - 5 \]
7 = x
\[
\sqrt{3x + 6} = x + 2
\]
g = x
\[ \sqrt{3x - 11} = x - 3 \]
\[ x = -2, 1 \]
\[
\sqrt{2x + 5} = \sqrt{3x - 1}
\]
$3\sqrt{5x} - 11 = 24$
Solution

Extraneous

$x = 9$
- 8 = \sqrt{7x} + 1
-3\sqrt{4x} - 8 - 2 = - 8
\[-5 + \sqrt{7x} - 6 = 3\]
2 - 2 = x
\[ \sqrt{4x + 8} = x + 3 \]
\[ x = -5 - 2 \]
\[ \sqrt{10x - 16} = x \]
95 \times \text{=} \boxed{15}
$2\sqrt[3]{4x-1} = 6$
9 = x
Culturally-Relevant Teaching Lesson Plan

STAGE 1 – DESIRED RESULTS

Unit Title: Scatterplots

Established Goals:
9.4.1.3 Use scatterplots to analyze patterns and describe relationships between two variables. Using technology, determine regression lines (line of best fit) and correlation coefficients; use regression lines to make predictions and correlation coefficients to assess the reliability of those predictions.

Understandings: Students will understand that...
- Scatterplots show relationships between variables
- Linear models can be made to fit data
- Regression lines can be used to make predictions about data
- Technology can be used to display data and to calculate regression lines

Essential Questions:
- How can we use technology to find linear models to fit data?
- How can we make accurate predictions about data?

Students will know:
- Relationships between variables can be displayed in a scatterplot
- How to use technology to find a regression line
- How to make predictions using a regression line

Students will be able to:
- Use a graphing calculator to find a linear model to fit data
- Interpret the slope and y-intercept of the regression line in the context of the data
- Use the regression line to make predictions

STAGE 2 – ASSESSMENT EVIDENCE

Performance Tasks:
Students will create a scatterplot.
Students will use a graphing calculator to calculate a regression line of their scatterplot.
Students will use the regression line to make predictions.
Students will interpret the slope and y-intercept of the regression line in context.

Other Evidence:
Teacher observation

Key Criteria:
Assessment of Scatterplot Activity

STAGE 3 – LEARNING PLAN

Summary of Learning Activities:
Warm-Up (5 minutes): Three questions will be on the board when students walk into the room. When the bell rings, teacher will play a song to indicate the start of class. When the song is over, class goes over warm-up.
1. Sketch the graph \( y = -\frac{2}{3}x + 2 \)
2. Evaluate \(- (3 + 2)^2 + \frac{10}{2} - 4 : 3\)
3. Evaluate \(2x - 5y\) if \(x = 3\) and \(y = -2\)

Whole Group (15 minutes): Teacher explains the class will be doing an in-class activity to practice the skills they have been working on the last few days (making scatterplots, using graphing calculators to make scatterplots and calculate regression lines). For the day’s activity, the class will be shown twenty different celebrities. The students are to guess the age of that celebrity and record it on their paper. At the end, the teacher will give the actual age of each celebrity. The students will then answer the questions on their paper about their scatterplot. (To make lesson more engaging and relevant to students, teacher has asked students in the previous days to give them the name(s) of 1-2 celebrities they like. Teacher uses these celebrities for activity) Teacher goes through Power Point of celebrities.

Classwork (25 minutes): Students work on answering questions. Teacher walks room to keep students on-task and to answer questions.

Closing (5 minutes): Teacher brings class back together and asks each student to share their estimated age based on their equation for age.
Record the name of each celebrity and your guess of their age.

<table>
<thead>
<tr>
<th>Celebrity Name</th>
<th>Estimated Age</th>
<th>Actual Age</th>
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1. Using a graphing calculator, create a scatterplot using the estimated age on the x-axis and the actual age on the y-axis. Sketch the scatterplot on the grid below. Be sure to label your axes and scale.
2. Choosing two points, find the equation of the line of best fit for your data.

   Points: (     ,     ) and (     ,     ) Slope: ___________

   Equation: __________________________

3. Using your graphing calculator, find the linear regression equation.

4. What is the correlation coefficient? What does it tell you about the fit of the calculator’s linear regression?

5. What is an appropriate domain for graphing age data in general?

6. If you had guessed all of the ages correctly, what would be the equation of the line representing these correct guesses?

7. Did you, in general, overestimate or underestimate the ages?

8. a. What percent of your estimated ages were correct?

   b. What percent of your estimated ages were above the actual ages?

9. **Interpolate:** If you guessed that a person’s age was 26, what would be the exact age based upon the calculator’s model equation?
10. *Interpolate:* If a person’s actual age was 37, what would have been the estimated age based upon the calculator’s model equation?

11. *Extrapolate:* If a person’s estimated age was 80, what would have been the actual age based upon the calculator’s model equation?

12. a. What is your age?

   b. Based upon the calculator’s model equation, what is your estimated age?

13. a. Which celebrity had the greatest difference between the estimated age and the actual age?

   b. What is the average of the differences between the actual ages and the estimated ages for all of the celebrities?
# Vocabulary Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>How to use it in classroom</th>
<th>Why is it effective</th>
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<tbody>
<tr>
<td>Notecards</td>
<td>Students use an index card to put information about each vocabulary word. The front of the index card has the vocabulary word in the middle. The back of the index card is divided into four parts. The top left has the definition of the word in the students’ own words. The top right is for a picture or image of the word. The bottom left is for important information the teacher wants students to know. This can be common misconceptions, specific situations where word is used, important pieces of the definition, etc. The bottom right is for synonyms if applicable.</td>
<td>Teacher gives students a list of new vocabulary words at the beginning of each new unit. Teacher gives students a deadline as to when notecards need to be completed (I suggest 3-5 days). Students keep notecards in class where they can be easily accessible. Notecards can be used when students come across vocabulary words in context of problems or during vocabulary games and activities.</td>
<td>Incorporates steps 1-3 from Robert Marzano’s Six Steps Process for teaching vocabulary. The remaining activities address steps 4-6. 1. Provide a description, explanation, or example of the new term. 2. Ask students to restate the description, explanation, or example in their own words. 3. Ask students to construct a picture, pictograph, or symbolic representation of the term. 4. Engage students periodically in activities that help them add to their knowledge of the terms in their vocabulary notebooks. 5. Periodically ask students to discuss the terms with one another. 6. Involve students periodically in games that enable them to play with terms.</td>
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<td>Whiteboards</td>
<td>Each student gets an individual whiteboard with a whiteboard marker.</td>
<td>Teacher can use individual whiteboards as a warm-up activity or</td>
<td>All can participate – students who may be slower to answer will not feel</td>
</tr>
<tr>
<td>Activity</td>
<td>Description</td>
<td>Benefits</td>
<td>Notes</td>
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<td>BINGO</td>
<td>Classic game of BINGO that uses vocabulary words rather than numbers.</td>
<td>Students are typically more engaged in games and if teacher is willing to give prizes, students are eager to win.</td>
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<td>Crossword Puzzles</td>
<td>Crossword puzzles using definitions as the clues to the puzzle.</td>
<td>Individual activity or one that could be done in partners. Students have freedom to work in the order of their choosing. Quick and easy way to practice how well they know the definitions.</td>
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<td>Password</td>
<td>A class game in which two students sit in front of the class facing their classmates. Teacher has a word on the board behind them. The class is split into two teams. Each team takes turns giving one word clues to their player until someone at the front says the word.</td>
<td>Students are typically more engaged in games and if teacher is willing to give prizes, students are eager to win. Students working in groups to decide on clues together means no one individual student is responsible for knowing all the words. Teacher is in charge of picking the word to give so they can decide how challenging of a word to give. Teacher may decide to give easier word to a struggling student or a</td>
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Slap | In partners, students use one set of note cards and faces the cards with the word facing up. Teacher says a definition and the first person to slap the correct word gets the card. The player with the most cards at the end wins. | A fun game that can be played anytime once students are familiar with the vocabulary words. Can be used as a warm-up or closing activity. | This is a fast-paced game and students usually engage well in games. |

Fly Swatter | Teacher writes vocabulary words on the board. Two at a time, students come to the board with a fly swatter. The teacher reads a definition and the first person to slap the word with their fly swatter gets the point. | A fun game that can be played anytime once students are familiar with the vocabulary words. Can be used as a warm-up or closing activity. | This is a fast-paced game and students usually engage well in games. |
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