Have You Ever Been Puzzled?

Brett Denney

Grades 6-8

July 25, 2018

Introduction

Why solve a puzzle? Because they are fun and challenging! They engage our brain and enhance our problem-solving skills. No matter what your age, you are always going to run into problems that need solving. Having perseverance, a skill needed when doing a challenging puzzle, makes you try and try again. In every math curriculum, from first through twelfth grade, problem solving is found. Below are some of the problem-solving skills specific to 7-8 grades:

NC.7.EE.3 Solve multi-step real-world and mathematical problems posed with rational numbers in algebraic expressions.
7.EE.3 - Solve multi-step real life and mathematical problems posed with positive and negative rational numbers in any form(whole numbers, fractions, decimals, and percents) using tools strategically, Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

- 7.NS.1 - Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram.
    - a. Describe situations in which opposite quantities combine to make 0.
    - b. Understand p+q as the number located a distance $|q|$ from p, in the positive or negative direction depending on whether q is positive or negative. Show that a number and its opposite have a sum of 0 (are additive inverses). Interpret sums of rational numbers by describing real-world contexts.
    - c. Understand subtraction of rational numbers as adding the additive inverse, p-q = p+(-q). Show that the distance between two rational numbers on the number line is the absolute value of their difference, and apply this principle in real-world contexts.
    - d. Apply properties of operations as strategies to add and subtract rational numbers.
- 7.NS.2 - Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers.
    - a. Understand that multiplication is extended from fractions to rational numbers by requiring that operations continue to satisfy the properties of operations, particularly the distributive property, leading to products such as (-1)(-1) = 1 and the rules for multiplying signed numbers. Interpret products of rational numbers by describing real-world contexts.
    - b. Understand that integers can be divided, provided that the divisor is not zero, and every quotient of integers (with non-zero divisor) is a rational number. If p and q are integers, then –(p/q) = (-p)/q = p/ (-q). Interpret quotients of rational numbers by describing real-world contexts.
    - c. Apply properties of operations as strategies to multiply and divide rational numbers.
    - d. Convert a rational number to a decimal using long division; know that the decimal form of a rational number terminates in 0s or eventually repeats.

- 7.NS.3 - Solve real-world and mathematical problems involving the four operations with rational numbers. Computations with rational numbers extend the rules for manipulating fractions to complex fractions.

CCSS Mathematical Practices – grade 7 Make sense of problems and persevere in solving them.
Use appropriate tools strategically.

- CCSS.Math.Content.8.G.A.2

Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them.

- CCSS.Math.Content.8.G.A.3

Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.

- CCSS.Math.Content.8.G.A.4

Understand that a two-dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two-dimensional figures, describe a sequence that exhibits the similarity between them.

Understand and applies basic and advanced properties of the concepts of numbers.

In this unit, various lessons were designed to use multiple strategies to enhance problem solving skills. The types of lessons, TABA, VTS, questioning and problem-based learning are all lesson plan designs that involve higher order thinking skills. Students worked in pairs and small groups to practice their communication and social skills. Students were introduced to mathematical concepts beyond what they receive in grades 6-8. VTS promotes critical thinking and models active listening. The Kakuro and Ken Ken puzzles were of differing difficulty levels and assigned, based on the readiness of the students. The performance task was to create a puzzle or game of their own incorporating mathematical strategies. This used imagination, understanding of strategy, and challenged them to think creatively. All of these are instructional methods that are appropriate for gifted students. They push them to think critically and in depth.

Goals and Outcomes

Content Goal and Outcomes

Goal 1: To develop and implement problem-solving strategies in various situations.

Students will be able to:

- Articulate different problem-solving strategies and understand when to apply them
- Demonstrate their ability to use various problem-solving strategies when solving puzzles
- Analyze when best to use the various problem-solving strategies
- Students will learn to identify different strategies involved in various games.

Process Goal and Outcomes

Goal 2: To develop strategies and reasoning skills and apply them to solving various puzzle types

Students will be able to:

- Articulate various problem-solving strategies
- Explain why a problem-solving strategy is applicable to a particular puzzle
- Formulate a plan to solve a certain puzzle
- Students will be able to use strategies to play various games
- Students will be able to make strategic guesses using logical reasoning

Concept Goals and Outcomes

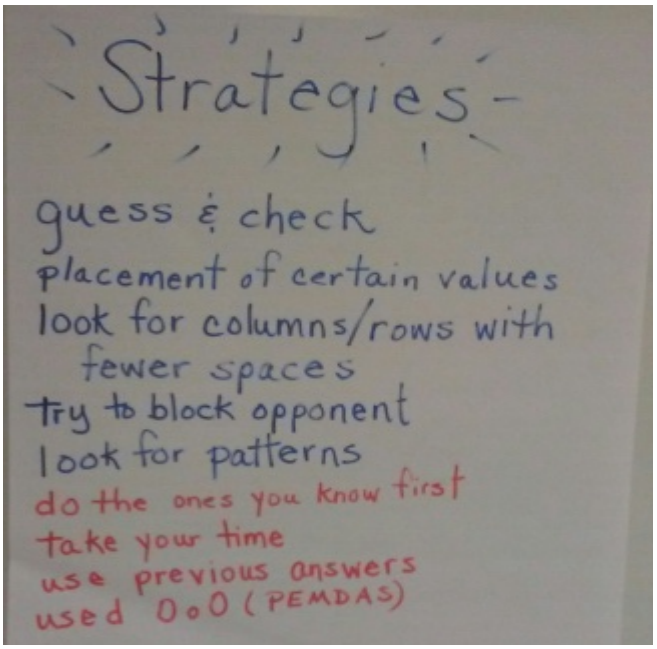
Goal 3: Understand how strategy enhances problem-solving

Students will be able to:

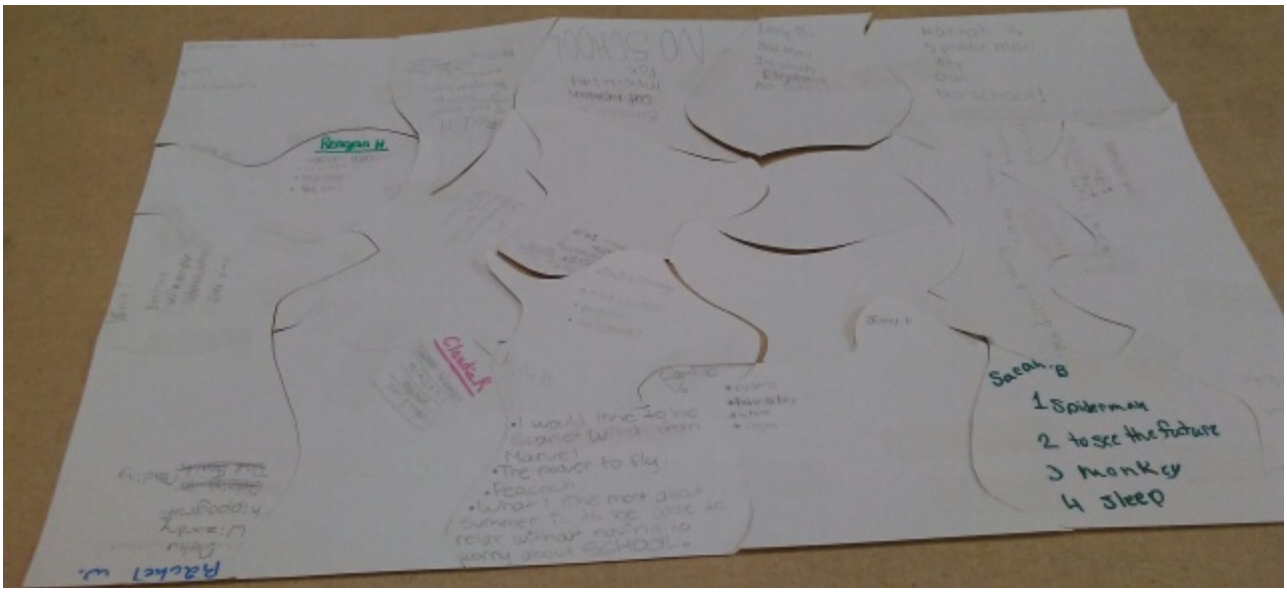
- Explain how a particular strategy or strategies enhance problem-solving when applied to a certain situation

Assessment Plan

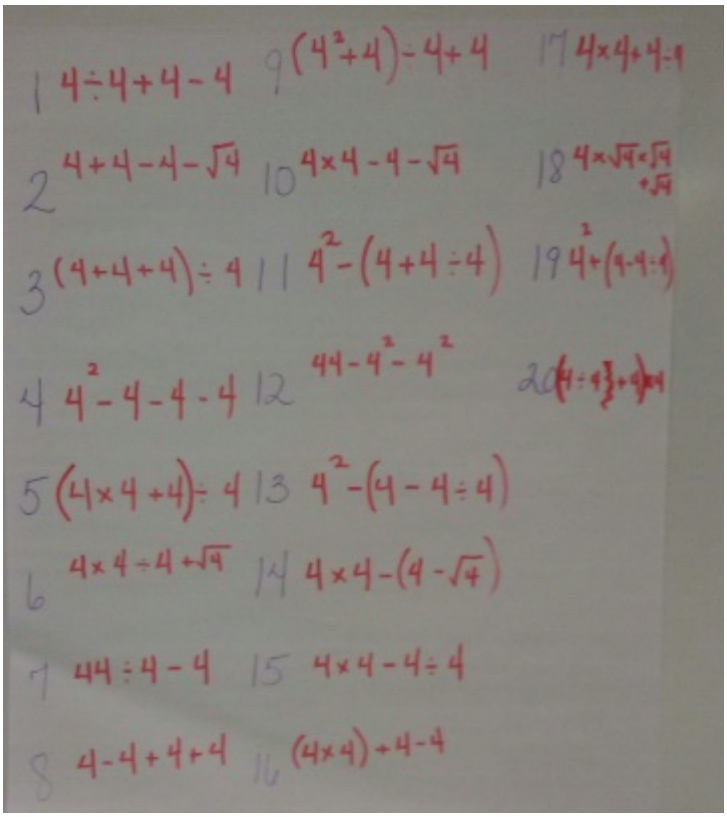
Throughout the unit, students were asked to come up with various strategies they used when solving different puzzles. A list of the strategies was compiled as the week progressed. The first day was focused on strategies used in various games and puzzles the students played.



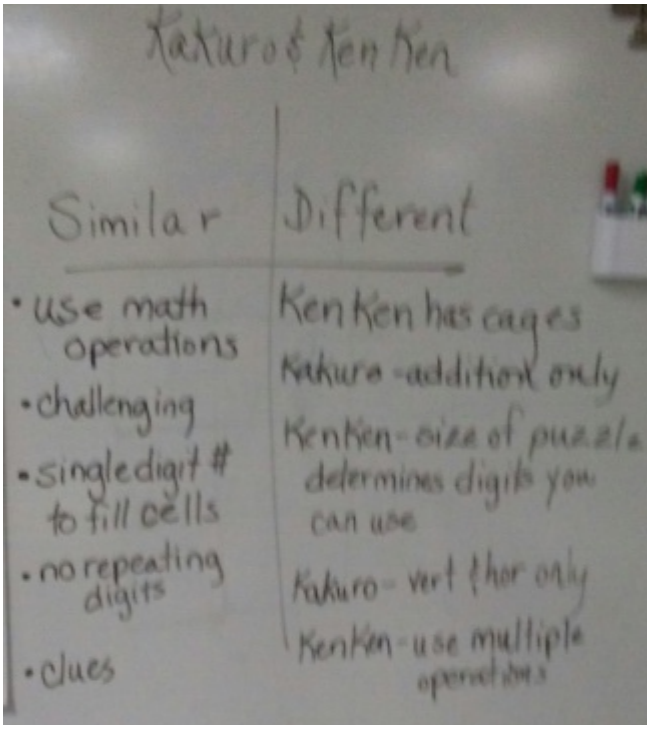
The ice breaker had students give some information about themselves and then they had to put the pieces together to form a puzzle.



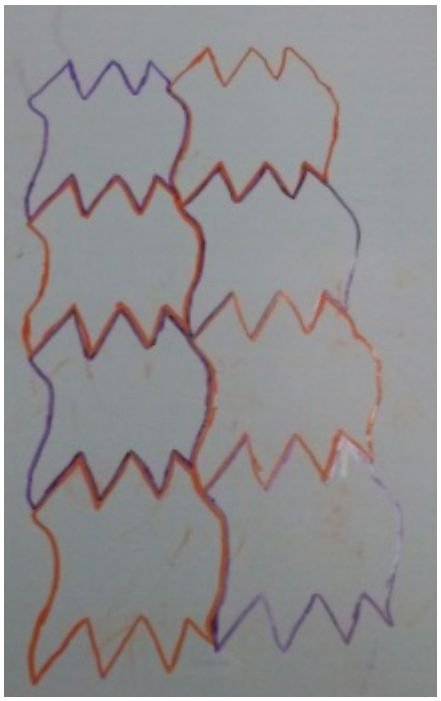
On the second day, students were asked to find equivalent expressions for the numbers 1-20 using only four 4's and specific mathematical operations. In pairs and then in groups of four, they were able to find equivalent expressions for all 20 numbers.

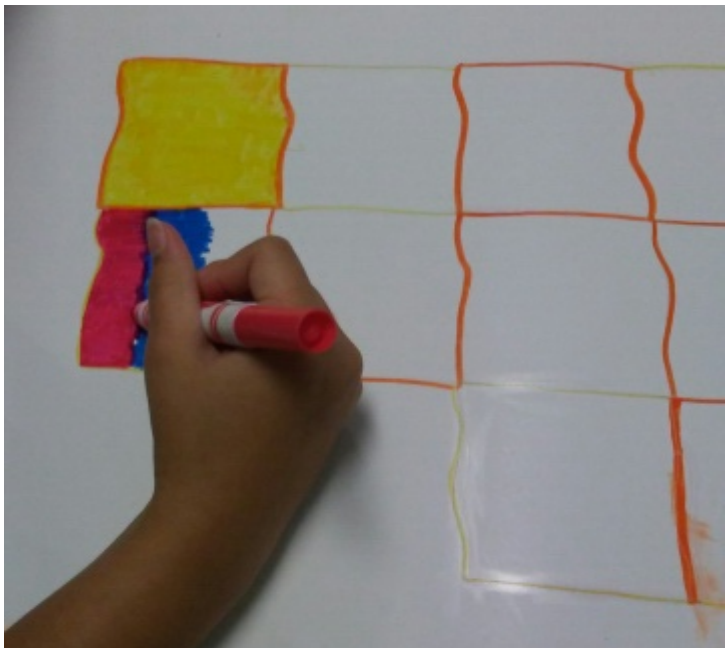


When students studied the Kakuro and Ken Ken puzzles, they were asked to compare and contrast the two puzzle types.

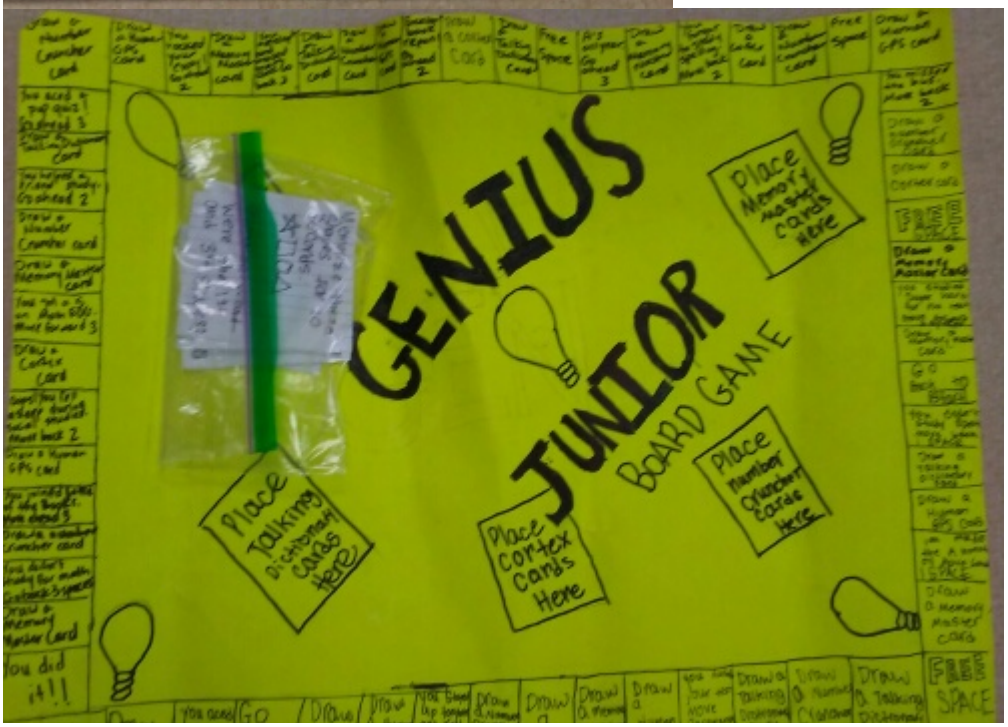


The final day was the study of tessellations and their performance task presentations. Even though only a few students brought in their own games and puzzles, it was evident from their exit cards on how strategies enhance problem solving that they had learned that knowing strategies and applying them in a thoughtful manner helped make problem-solving easier.





Performance Task Products



Lesson Plans

TEACHER NAME		Lesson #
Brett Denney		#1 for ASPIRE
MODEL	**CONTENT AREA**	**GRADE LEVEL**
Taba	**math**	**6-8**
CONCEPTUAL LENS	**LESSON TOPIC**	
Strategy	**Game strategies**	

LEARNING OBJECTIVES *(from State/Local Curriculum)*

CCSS Mathematical Practices – grade 7

Make sense of problems and persevere in solving them.
Use appropriate tools strategically.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	**THE ESSENTIAL QUESTION** *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Strategy enhances problem solving.	How does strategy enhance problem solving?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	**PROCESS SKILLS** (What will students be able to do as a result of this lesson?)
Students will learn to identify different strategies involved in various games.	Students will be able to use strategies to play various games.

GUIDING QUESTIONS *What questions will be asked to support instruction?* *Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding*		
Pre-Lesson Questions:	**During Lesson Questions:**	**Post Lesson Questions:**
What is strategy? What are some examples of strategies used in problem solving? Why do you use different strategies for different problems?	What strategies did you identify? Why did you group them this way? Can you label the groups you have formed? What 1-3 word label would best describe this group? Which items under one group could also go under another group? Now what completely new ways can you find to group the items on the list? Why did you re-group them this way?	What is the relationship between different games and the strategies used to solve them? Why do you adjust your strategy throughout different games? Based on the original groups and the regrouping, what can you conclude about strategies? How does strategy enhance problem solving related to the games?

DIFFERENTIATION *(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.*			
Content	**Process**	**Product**	**Learning Environment**
	Students engage in in-depth critical thinking exercises as they analyze strategies through grouping and regrouping.		Students will work in small groups to practice their communication and social skills.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Before the lesson begins, we will do an ice breaker activity and set the norms for the class.

Puzzles Game

Give participants a blank piece of puzzle (cut up a sheet of index card stock). Each person writes on the piece one problem solving strategy they use. The puzzle is then assembled to show that everyone has something to contribute to the whole group.

Students will begin by rotating though stations where they will play checkers, 24, Mastermind, 4 in a line and other games found online at a specified web site. http://www.webgamesonline.com/

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Listing

As students played their games, they will record different strategies (3 or 4 words in length) they use in solving each game. Students will share their lists and the teacher will make a comprehensive list on the board.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Grouping and Labeling

In groups of 3, students will create smaller strategy lists based on similarities. Groups will work together to decide which items in the comprehensive list go together because they are alike in some way. They must make at least 3 different lists with 3 or more strategies in each list with no repetition.

The teacher will move throughout the room to check in with each group. If needed, guiding questions will be asked such as Do any of these strategies belong together? Why did you group them this way? Can you label the groups you have formed? What 1-3 word label would best describe this group?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Subsuming, Regrouping, and Renaming

Student groups will then be challenged to regroup the items. The new groups must have new categories, Rules for regrouping include: items can be used again, categories must be new, each category needs at least 4 items. The teacher will remind the groups that categories must be based on some aspect of strategy. Groups will then share their categories.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

The lesson will end with the teacher asking the class to explain the relationship between strategy and problem solving based on the games they played. Students will be asked to write a summary of how strategies enhanced their problem solving while playing the games. Students will turn in their summaries at the end of the class.

The students will be introduced to their performance task for the week. They can use the rest of the available time to discuss/brainstorm ideas with their peers and the teacher.

TEACHER NAME	Lesson #
Brett Denney	1

MODEL	CONTENT AREA	GRADE LEVEL
Problem-Based Learning	Math	6-8

CONCEPTUAL LENS	LESSON TOPIC
Strategy	Four 4's Problem

LEARNING OBJECTIVES *(from State/Local Curriculum)*

7.EE.3 - Solve multi-step real life and mathematical problems posed with positive and negative rational numbers in any form(whole numbers, fractions, decimals, and percents) using tools strategically, Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

- 7.NS.1 - Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram.
  - a. Describe situations in which opposite quantities combine to make 0.
  - b. Understand p+q as the number located a distance $|q|$ from p, in the positive or negative direction depending on whether q is positive or negative. Show that a number and its opposite have a sum of 0 (are additive inverses). Interpret sums of rational numbers by describing real-world contexts.
  - c. Understand subtraction of rational numbers as adding the additive inverse, p-q = p+(-q). Show that the distance between two rational numbers on the number line is the absolute value of their difference, and apply this principle in real-world contexts.
  - d. Apply properties of operations as strategies to add and subtract rational numbers.
- 7.NS.2 - Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers.
  - a. Understand that multiplication is extended from fractions to rational numbers by requiring that operations continue to satisfy the properties of operations, particularly the distributive property, leading to products such as (-1)(-1) = 1 and the rules for multiplying signed numbers. Interpret products of rational numbers by describing real-world contexts.
  - b. Understand that integers can be divided, provided that the divisor is not zero, and every quotient of integers (with non-zero divisor) is a rational number. If p and q are integers, then –(p/q) = (-p)/q = p/ (-q). Interpret quotients of rational numbers by describing real-world contexts.
  - c. Apply properties of operations as strategies to multiply and divide rational numbers.
  - d. Convert a rational number to a decimal using long division; know that the decimal form of a rational number terminates in 0s or eventually repeats.

- 7.NS.3 - Solve real-world and mathematical problems involving the four operations with rational numbers. Computations with rational numbers extend the rules for manipulating fractions to complex fractions.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	THE ESSENTIAL QUESTION *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Strategy enhances problem solving.	How does strategy enhance problem solving?

CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will learn the meaning of factorial, !, a number times all the integers below it through 1 (ex 3!=3x2x1)	Students will be able to analyze different equivalent expressions Students will be able to create numerous equivalent expressions Students will be able to calculate and understand the

Students will learn that different arrangements of four 4's and different operations can create the same equivalent values	meaning of factorials and simple square roots

GUIDING QUESTIONS

What questions will be asked to support instruction?

Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
How did you use strategy to solve the magic square puzzles? What are the order of operations? How do you decide which one to perform first in a multi-step equation? What is the difference in "the same as" and "equivalent in value?" How are these ideas the same or different? What are all the mathematical operations you know and use? Why do we use parentheses in math? What are some strategies you have used to solve problems in the past?	Describe in your own words what ! means mathematically? What does () mean mathematically? What is a square root? How are ! and square roots calculated? What does it mean to be equivalent to any integer value? What values from 1-20 were we able to find different equivalent values?	-What were some of the more difficult numbers to find? What made them difficult? How can this process be extended to even more numbers? What, if any, new concepts did you use? What were the benefits or drawbacks to working as a team? When looking for equivalent expressions, what strategies did you use?

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
Students will be introduced to the mathematical concept of factorials and square roots, two higher level mathematical terms.		There will be multiple ways to create many different solutions	Students will be working in small groups and will have to use communication and team building skills.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Students will begin the lesson by looking at a Magic Square puzzle. They will work individually in a worksheet with 3x3 Magic Squares on it. Once they have had a few minutes to work, they will be allowed to pair up and help one another. In their pairs, they will be asked to write down what strategies they used to complete the puzzles.

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students*

observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

Problem Definition:
Students will be posed the problem to using four 4's and the operations of +, -, *, /, () brackets, . (decimal point), squares of numbers, square roots and ! (factorials) to compute integer values from 0-20. The values from 0-20 are written down on the board or chart paper.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Problem Resolution:
Students are given 35 minutes to work in pairs to find solutions. At that time, students are asked to come to the board one person from each pair at a time and write their solutions to one of the integers. This will continue until all the solutions are recorded. If the timing is appropriate, a break will be taken. After the break, if there are any numbers that have no solutions at this time, student pairs will then be asked to collaborate with another pair to work on those specific values for about 20 minutes. Then the class will come back together and see if any groups found an equivalent expression for the still unsolved problems.

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Problem Debriefing:
Once the student's responses are recorded, the teacher can discuss with them how they came up with their responses. Were there some values from 0-20 for which they could not find equivalent values? The students will be asked to think about any unsolved values and see if they can come up with answers by tomorrow

Students will be asked to discuss the methods they used to fine these values. Did they use any of the new concepts introduced in the lesson? If so, how?

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Students will be assessed formatively throughout the lesson by their explanations and discussion.

Any time left at the end of the lesson will be devoted to working on their performance task.

TEACHER NAME	Lesson #
Brett Denney	3 for ASPIRE

MODEL	CONTENT AREA	GRADE LEVEL
Questioning	**Math**	**Grades 5-8**

CONCEPTUAL LENS	LESSON TOPIC
Strategy	**Solving Kakuro, Sudoku and Ken Ken Puzzles**

LEARNING OBJECTIVES *(from State/Local Curriculum)*

7.EE.3 - Solve multi-step real life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, decimals, and percents) using tools strategically, Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	THE ESSENTIAL QUESTION *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Strategy enhances problem solving	***How does strategy enhance problem solving?***

CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will know that not all combinations of addends will solve the problem. Students will know that puzzles contain clues for combinations of addends. Students will know that combinations of addends are logical. Students will understand that Kakuro puzzles should be solved starting with the strategy of smaller sections. Students will know that smaller sections give clues for larger sections.	Students will be able to apply the rules for Kakuro, Sudoku, and Ken, Ken puzzles to solve them. Students will be able to make strategic guesses using logical reasoning. Students will be able to use strategy to make informed choices when choosing numbers to use within a Kakuro, Sudoku, and Ken, Ken puzzle. Students will be able to explain the rules for playing Kakuro, Sudoku, and Ken, Ken. Students will be able to apply the rules for Kakuro, Sudoku, and Ken, Ken puzzles to solve them.

GUIDING QUESTIONS

What questions will be asked to support instruction?
Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:

What types of puzzles have you done in the past? **What makes solving puzzles enjoyable?** **What kinds of strategies did you need to solve them?** **If you have ever worked a crossword puzzle, what helped you find the words?** **What information is given to you in the puzzle?**	**What are addends?** **How do you use strategy and logical reasoning to look for possible solutions?** **What are some things you need to pay attention to when solving this type of puzzle?** **Which of these people look familiar?** **What are the similarities to something else you have seen?** **What is the structure of the puzzle?** **What is important about the numbers in gray in the puzzle?** **What strategies will you use in the creation of your own Kakuro puzzle?**	**How are Kakuro, Sudoku, and Ken Ken similar or different from one another?** **How would you explain to a friend the rules to play Kakuro, Sudoku, and Ken, Ken?** **How did you use strategy to help you solve the Kakuro, Sudoku, and Ken, Ken puzzles?** **How did you use strategy in the creation of your own puzzle?** **How did you use strategies to create your own puzzle?**

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
Students will have an opportunity to work Kakuro, Sudoku and Ken Ken puzzles with different levels of difficulty.			**Students will be given opportunities to collaborate and effectively communicate with others.**

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

The lesson will begin with a discussion of different types of math puzzles the students have worked in the past. We will talk about several types of puzzles and the strategies used in completing them, with examples such as Magic squares.

An incomplete Kakuro puzzle will be shown. Students will brainstorm what the object of the puzzle is. Why does Kakuro look familiar? What are the similarities to something else you have seen? The similarities will be recorded on the board. The same will be done for the Sudoku and Ken Ken puzzles.

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

The students will be introduced to the Kakuro mathematical puzzle. They will look at a completed puzzle and see if they can develop the puzzle rules through small group collaboration. What is the structure of the puzzle? They will be asked to explain what they think the meaning is of the clues provided. They will look for a strategic "starting point" within the puzzle. The same activity will be done with Sudoku and Ken Ken.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

The class will come back together and outline the rules they have come up with for each puzzle type and compare their responses. If needed, the teacher will use questioning to help students develop the full set of rules for the puzzles. What do the numbers in the gray areas tell us about Kakuro? What are the clues for Sudoku and Ken Ken? What is needed to complete the puzzles? Once the rules are the derived, they will discuss their strategy to begin the different puzzles.

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Students will be given an easy level Kakuro, Sudoku, and Ken, Ken puzzle to try to complete. They may collaborate with a partner if needed. If they wish, they may go on to puzzles of increased difficulty.
Students will create a Kakuro, Sudoku or Ken Ken puzzle of their own.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

The teacher will look at the puzzles the students have attempted and give feedback on areas that are correct and areas that may need more thought and attention. The strategies they are using will be discussed among the small groups and the teacher. Afterward, there will be a discussion on how various strategies helped the students to solve the puzzles. The puzzles they created will be used to gauge their understanding of the game. If time allows, they can challenge each other to solve the puzzles they created, or they can take them home and challenge a family member to solve them.

Any time left will be given to students to work on the performance task due tomorrow.

TEACHER NAME	Lesson #
Brett Denney	#4 for ASPIRE

MODEL	CONTENT AREA	GRADE LEVEL
Visual thinking strategies	Mathematics	5-8

CONCEPTUAL LENS	LESSON TOPIC
Strategy	Tessellations

LEARNING OBJECTIVES *(from State/Local Curriculum)*

- CCSS.Math.Content.8.G.A.2

Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them.

- CCSS.Math.Content.8.G.A.3

Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.

- CCSS.Math.Content.8.G.A.4

Understand that a two-dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two-dimensional figures, describe a sequence that exhibits the similarity between them.

Understand and applies basic and advanced properties of the concepts of numbers.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	THE ESSENTIAL QUESTION *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Strategy enhances problem solving	**How does strategy enhance problem solving?**

CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will learn that tessellations are an arrangement of closely fitted shapes without gaps or overlaps. Students will learn the difference between a regular and semi-regular tessellation. Students will learn about M.C.Escher and how he used tessellations in the creation of his art.	Students will be able to analyze the creation of a tessellation pattern. Students will be able to create regular and semi-regular tessellation patterns. Students will be able to compare and contrast regular and semi-regular tessellations.

GUIDING QUESTIONS

What questions will be asked to support instruction?
Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
What is a polygon? **What is a regular polygon?** **What is a tessellation?** **What strategy does it appear was used to create the fish tessellation?** **Where do you see repeating patterns in everyday life?** **Why do some shapes fir together and others do not?**	**What is going on in this picture?** **What do you see that makes you say that?** **What else do you see?** **After watching the video, what are the shapes that tessellate and what are the three ways to create them?** **How does it combine math and art?** **What strategies did Escher use to create his patterns?** **How can you tell in advance if shapes will tessellate without using interactivity?** **Why is it important to have a strategy before designing a tessellation?**	**What makes a tessellation pattern appealing to you?** How can combinations of rotation, translation, and reflection be used to create tessellations? How do colors and patterns impact tessellations? **What are the 8 semi-regular tessellation patterns?** **What strategy or strategies did you use to create your own regular tessellation art?**

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
	VTS promotes critical thinking and models active listening.	**Students will be creating a work of art using tessellations.**	

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

The image will be shown and questions asked about the image.

What is going on in this picture?
What do you see that makes you say that?
What else do you see?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

We will define polygons and regular polygons and how they relate to tessellations. Students will read an article on tessellations. tessellation article While reading, students should take notes on terms and ideas they find. Students will look at different images of tessellations to get a better idea about the possible images and how they can be illustrated to make art. https://www.youtube.com/watch?v=7GiKeeWSf4s Students should take notes on the shapes and techniques used to create tessellations.

We will discuss regular and semi-regular tessellations and how they are alike and different.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Students will be taught how to make a tessellation pattern to use in the evaluation portion of the lesson. How to make a tessellation pattern . We will discuss the different strategies that can be used to create regular tessellations.

Students will work in small groups to find all 8 of the semi-regular tessellations using tiles of various polygon shapes.

Elaborate *—Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*
Students will research regular and semi-regular tessellations and how to tell if a shape will tessellate or not mathematically.
Students will look at artwork by M. C. Escher and see how he uses patterns in many of his drawings.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Students will create a poster using tessellations and illustrate it. They will have to use 2 of the 3 strategies to create their poster.

Resources

Tessellation Lesson Plan https://study.com/academy/popular/tessellation-lesson-plan.html. This lesson plan aided me in the standards that were applicable to tessellations. It also helped shape the structure of the lesson plan implemented in lesson 4.

Geometry Playground http://www.exploratorium.edu/files/geometryplayground/Activities/GP_Activities_6-8/ExploringTessellations_%206-8_v4.pdf This lesson is where the activity used for the students in making their own tessellations was located.

Math Worksheets: Magic Square: Magic Square 3x3 Magic Square Normal Set 1 https://www.dadsworksheets.com/puzzles/magic-square/3x3-normal-1-v1.html This is the resource used for the activity when the students solved magic square puzzles.

Shaping Up With Tessellations https://nrich.maths.org/2577&part This is the article the students read when becoming familiar with tessellations. It outlined the difference in regular and semi-regular tessellations.

What is Tessellation? | by M. C. Escher inspired Tessellation Art https://www.youtube.com/watch?v=7GiKeeWSf4s This short video showed students what 3 basic shapes tessellate and the 3 ways to create tessellations.

A Simple Method For Creating Tessellations From Rectangles https://docs.google.com/document/d/19MSBjQPpOMCiTJreKHPO4QFaL2HkMsxtlTB28yYkD0w/edit?pli=1 This document also aided in the instruction for students to create their own tessellation patterns

8 Heads Tessellation by M. C. Escher https://www.pinterest.com/pin/294000681901112251/?lp=true This was the image used in the VTS lesson on tessellations.

Games for the Brain http://www.webgamesonline.com This website was used for students to play various games when the unit began. Students were asked to list different strategies they used in the various games they chose to play.

Crazy Dad Games (https://krazydad.com/) This website was the source for the Kakuro and Ken Ken (Inkies) used when students solved their own puzzles.