**Lesson Plan: 6.EE.A.1 Writing and Evaluating Exponents**

*(This lesson should be adapted, including instructional time, to meet the needs of your students.)*

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| **Background Information** | |
| **Content/Grade Level** | Expressions and Equations/Grade 6 |
| **Unit/Cluster** | Apply and extend previous understandings of arithmetic to algebraic expressions. |
| **Lesson Topic** | Writing and Evaluating Numeric Expressions Involving Exponents |
| **Essential Questions/**  **Enduring Understandings Addressed in the Lesson** | * Why are exponents necessary?   Why is an exponent of 2 considered squared?  When would we evaluate exponents in the order of operations?   * Repeated multiplication can be written using a base (number that is being multiplied by itself repeatedly) and an exponent (the number of times the base is written and then multiplied against itself).   There exists a predetermined order for simplifying expressions; referred to as the Order of Operations.  Numerical expressions can be represented in many equivalent forms. |
| **FOCUS** | **6.EE.A.1** Write and evaluate numerical expressions involving whole-number exponents. **(Major Standard)** |
| **COHERENCE** | **Across-Grade Coherence: Content Knowledge from Earlier Grades**  **3.OA.A.3:**  Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem  **5.NBT.A.2:**  Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole number exponents to denote powers of 10.  **5.OA.A.1:** Use parentheses, brackets, or braces in numerical expressions, and evaluate expressions with these symbols.  **Within-Grade Coherence: Content from Other Standards in the Same Grade that Provide Reinforcement**  **6.EE.A.3:** Apply the properties of operations to generate equivalent expressions  **6.EE.A.4:** Identify when two expressions are equivalent (i.e., when the two expressions name the same number regardless of which value is substituted into them). |
| **RIGOR** | **Procedural Skill**  Students must be able to fluently move between equivalent values of repeated multiplication and exponential form. Students must use exponential notation to represent large numbers (i.e. 228 = 268,435,456).  **Conceptual Understanding**  Students explore various representations of exponential values (24 = 2 x 2 x 2 x 2 = 16).  **Modeling/Application**  Students calculate powers to determine if a given power is greater than a given standard number (i.e., Is 228 greater than 50,000?) |
| **Student Outcomes** | * Students will write numeric expression into exponential form from repeated multiplication problems. * Students will write repeated multiplication problems from numeric expressions in exponential form. * Students will evaluate numeric expressions using order of operations. |
| **Method for determining student readiness for the lesson** | * Given dot paper, graph paper or Geoboards, students will be given a length of 5 units and width of 4 units and asked to find the area of a rectangle (check for misconception between finding area and perimeter). Then given an area of 36 square units, draw a quadrilateral that has an area of 36 square units. (Teacher note: They can make multiple representations: e.g. 2 x 18, 3 x 12, 9 x 4, and 6 x 6). Then teachers discuss the difference between a rectangle and a square. |

| **Learning Experience** | | |
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| ***Component*** | ***Details*** | ***Which Standards for Mathematical Practice(s) does this address? How is the Practice used to help students develop proficiency?*** |
| ***Warm Up*** | * Pose two questions to students on the chalkboard/Smartboard, etc.: Why is 103 equal to 1000? and Why is 104 equal to 10,000? (Provide visual model with arrows that identifies 10 as the base and 3 and 4 as the exponents) |  |
| ***Motivation*** | * The Olympic Committee is planning to put different padding on the square floor exercise mat for the next Summer Olympic Games. The teacher will show a video or picture on floor exercise to contextualize the meaning of the following problem. (A video example: <http://www.youtube.com/watch?v=hjoDzK0siaM> The video is 37 minutes in length so select a portion that shows the mat exercise.) The area of the performance mat must be 144 square meters. What is the length of one side? |  |
| ***Activity 1***  UDL Components   * Multiple Means of Representation * Multiple Means for Action and Expression * Multiple Means for Engagement   Key Questions  Formative Assessment  Summary | UDL Components:   * Principle I: Representation is present by the use of the graphic organizer with square grid template. There is also an opportunity for discussion and practice during the gallery walk activity. * Principle II: Expression is present in the activity. Students physically move around the room through a gallery walk activity. Students can be given a graphic organizer to complete the gallery walk. * Principle III: Engagement is present by the active participation in the activity. Also, outcomes are authentic with connection to the Olympic Games, with which many students are familiar. Students will also work in cooperative groups to complete the gallery walk activity.   Students will be given the Square Grid Template **(Attachment # 1)**. Using the key questions below, the teacher will go over the first three examples and help students relate them to the repeated multiplication.  Key Questions:   * What do you notice about the length of each side compared to the number of total squares? * Using what you know about exponents and bases, is there another way to write the area using exponents? If so, how would you write this? * Students will then complete the grid, individually, up to a side length of 15. By circulating around the room, the teacher will check for understanding as students complete the grid as a formative assessment.   Students will be asked to respond to the following question, “What would the area be if we had a side length of 17 and wanted to create a square?” The teacher will take multiple responses, such as 17 x 17, 172, 289 square units, and a drawing that represents the area.   * Relating now to the opening question about the Olympic mat, use what you know to determine the side length of the Olympic mat. Justify your reasoning and solution method.   Ask them if there is a relationship between exponents and repeated multiplication. If so, what is the relationship?   * Teacher will have prepared posted problems on the walls **(Gallery Walk**—**Attachment #2)**. Students will participate in a gallery walk activity where groups of students will either write the multiplication problem from given exponential form or write the exponential form from the given repeated multiplication problem on an index card or piece of paper. Summary: Upon completion of the gallery walk, assign each group a problem to share their solution with the class. Use thumbs up/thumbs down strategy to see if their solution is correct. * As a formative assessment, students will respond to the following exit ticket question, “Cindy states that 43 equals 12. Do you agree or disagree? Justify your reasoning.”   (SMP #1, #4, #6 and #7) | Students make sense of the square array by displaying the correct multiplication problem while referring to the drawn square. Students then relate the exponent of two to the shape of a square.  (SMP#1)  Students use a square array to describe a situation which can be represented using exponents. Students apply their understanding of the square array model to larger exponential situations.  (SMP#4)  Students accurately draw their squares to represent the area of the figures and the multiplication problems that arise. Students use exponents correctly to represent repeated multiplication. Also, students write correct multiplication problems to represent exponential form.  (SMP#6)  Students recognize that exponents are repeated multiplication problems.  (SMP#7) |
| ***Activity 2***  UDL Components   * Multiple Means of Representation * Multiple Means for Action and Expression * Multiple Means for Engagement   Key Questions  Formative Assessment  Summary | UDL Components:   * Principle I: Representation is present with the multiple means of symbolic representations (e.g. an illustration, graphs and exponential forms). * Principle II: Expression is present by a graphic organizer to complete the magic coin activity. Students are also being provided prompts for systemizing their thinking to reflect on their prediction and the mathematical process. * Principle III: Engagement is present by working in groups to share their thinking and representations of the problem. Partners will use discussion and a graphic organizer to determine which option produces the most coins after 28 days. Students are invited for personal responses through their predictions prior to completing the task. Students will self-reflect on their prior predictions after completing the task.   This activity is from Illustrative Mathematics  <http://illustrativemathematics.org/illustrations/532>  6.EE.—The Djinni’s\*\* Offer  \*\*Referred to as genie in the task   * Have your students work in groups of two and complete the “The Djinni’s Offer” problem. **(Attachment #3)**  When they have finished the problem, have a class discussion about their answers. The teacher can ask, what mathematics did you use to determine each solution? (Teacher note: Students should use language including exponents and repeated multiplication in their explanation.)   (SMP #1, #2, #3 and #6) | Students make sense of the genie problem (Djinni’s Offer) and devise methods on how to produce a solution. Students then monitor and analyze their work to determine reasonableness of their solution.  (SMP#1)  Students decontextualize the genie problem (Djinni’s Offer) to abstract a given situation and represent it symbolically by determining which option is best and supporting their choice through multiple representations.  (SMP#2)  Students justify their conclusions, communicate them to others, and respond to the arguments of others through their predictions and reflections via their work with a partner.  (SMP#3)  Students calculate and communicate the two options accurately using correct mathematics that represent each situation.  (SMP#6) |
| ***Activity 3***  UDL Components   * Multiple Means of Representation * Multiple Means for Action and Expression * Multiple Means for Engagement   Key Questions  Formative Assessment  Summary | UDL Components:   * Principle I: Representation is present by activating prior knowledge by pre-teaching critical prerequisite concepts through models. Emphasis on key understanding of grouping symbols in an expression. Students are also being given explicit prompts for each step in a sequential process. * Principle II: Expression is present by giving an alternative method of responding by using the whiteboards. Students are also being provided with a structure for effectively evaluating expressions. * Principle III: Engagement is present in this lesson by optimizing choice where students create their own problems. Students will also check for understanding with partners before displaying their order of operations problems. * As a pre-assessment of student understanding of order of operations from 5th grade, students will evaluate the following numeric expressions on whiteboards: * 10 + 25 ÷ 5 • 4 * 3 • (45 -30) - 9   Students will share their responses with the teacher. The teacher will look for a variety of responses (correct/incorrect) to generate a discussion of how they solved the problem. Have students share using a document camera/board to explain their method and justify their thinking. The teacher will reinforce the concept of order of operations.   * Introduce the following expressions:   25 + 23  25 + (2 • 2 •2)  Engage students in a discussion of how the two expressions are similar (stress the importance of rewriting the exponential form into a multiplication problem with grouping symbols). The expression 25 + (2 • 2 • 2) would reinforce their prior learning to do grouping symbols first in order of operations. After the discussion, the teacher will pose the following expression with exponents:  24 + (8 + 7)  Engage students in a discussion of the method for evaluating this expression. Reinforce to students that grouping symbols is always first after rewriting the expression (2 • 2 • 2 • 2) + (8 + 7).   * Using whiteboards, have the students individually evaluate the following expressions one at a time to reinforce understanding of order of operations with exponents: * 4 • 72 * 52 – 4 •5 + 16 * 10 ÷ 2 – 3 + 24 * 28 ÷ 22 – 36 ÷ 32 * 10 ÷ (5 – 3) + 22   Answers: 196  21  18  3  9  Students will work with partners to check their understanding and solutions, then display their answer as a class to the teacher. The teacher will answer student questions that arise and help determine correct solutions.  Using index cards, students will create their own expression (one on each side) including exponents. Students will trade with a partner and then evaluate their partner’s expression. The teacher will call on students to put their partner’s expressions with solution on the board. The teacher will then ask class if they agree or disagree with the given solution method and facilitate clarification of student understanding.   * Formative Assessment: Using an index card, students will create an expression including exponents on one side of the card and evaluate their expression on the other side of the card. The teacher will collect and review the cards. (Suggestion: You may use these student created expressions for warm-ups or activities in future lessons.) (SMP #1, #6 and #7) | Students analyze expressions to determine a solution pathway.  (SMP#1)  Students will accurately evaluate expressions using order of operations with whole number exponents and justify their calculations.  (SMP#6)  Students make use of structure by rewriting the order of operation expressions with whole number exponents into an equivalent expression with grouping symbols. Students make use of structure by evaluating expressions using the conventions of order of operations.  (SMP#7) |
| ***Closure*** | Students will create three expressions using exponents, whose solutions are greater than 80 and less than 100. |  |

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| **Supporting Information** | |
| Interventions/Enrichments   * Students with Disabilities/Struggling Learners * ELL * Gifted and Talented | Students with Disabilities/Struggling Learners   * Teachers can provide a graphic organizer for students displaying the repeated multiplication with exponential form and for the correct order of order of operations * Calculator for Activity 2 * Videos from to reinforce the previous learned concepts   ELL Students   * Provide additional vocabulary scaffolding for the following words: genie, exponent, base, multiplication, repeated, order of operations, evaluate, expression, numeric   Gifted and Talented Students   * Order of Operations with multiple grouping symbols Ex: [28 ÷ (22 + 3)] + 32   [(5 + 2 • 2)2 ÷ 3] – 20   * Instead of using grid template (Activity 1), provide blank grid paper and let students create perfect squares |
| Materials | * Geoboard * Dot Paper * Graph Paper * Index Cards |
| Technology | * Document Camera * Calculator * Video of floor exercising from Olympics <http://www.youtube.com/watch?v=hjoDzK0siaM> |
| Resources | ([www.illustrativemathematics.org/standards/k8](http://www.illustrativemathematics.org/standards/k8))  6.EE.—The Djinni’s Offer (Found in Grade 6, EE, A1 see illustrations) |

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|  | 1 • 1 = 1= \_\_ | 2 • 2 = 4= \_\_ | 3• 3 = 9= \_\_ | . | . | . | . | . | . | . | . | . | . | . | . | . |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |  |
| 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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Square Grid Template Attachment #1

Attachment #2

A

7 • 7 • 7 • 7

Attachment #2

B

63

Attachment #2

C

8 • 8 • 8 • 8 • 8

Attachment #2

D

92

Attachment #2

E

10 • 10 • 10

Attachment #2

F

234

Attachment #2

G

4 • 4

Attachment #2

H

111

Attachment #2

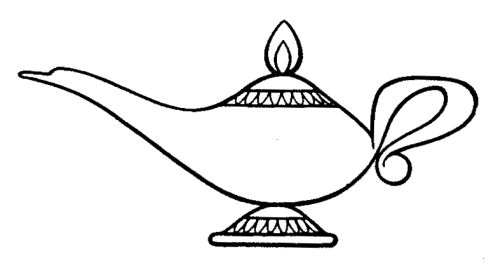
I

17

Attachment #2

J

76

 Attachment #3 Magic Coin

**Would you choose 50,000 coins or the Magic Coin?**

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| **Day** | **# of coins** | **Equivalent Exponent** |
| **1** |  |  |
| **2** |  |  |
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