



**Number Operations:
Caterpillars and Leaves
Grade K-3**

**Formative Assessment Lesson
Problem Solving**

Designed and revised by the Kentucky Department of Education
Field-tested by Kentucky Mathematics Leadership Network Teachers

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Mathematical goals

This lesson unit is intended to help you assess how well students are able to use addition and subtraction in a problem solving situation. In particular, this lesson aims to identify and help students who have difficulties with:

- Choosing an appropriate, systematic way to collect and organize data.
- Examining the data and looking for patterns
- Describing and explaining findings clearly and effectively.

Kentucky Academic Standards

This lesson involves a range of mathematical practices from the standards, with emphasis on:

MP1. Make sense of problems and persevere in solving them.

MP4. Model with mathematics.

MP8. Look for and make use of repeated reasoning.

This lesson asks students to select and apply mathematical content from across the grades, including the content standards:

Kindergarten Operations and Algebraic Thinking

Cluster: Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from.

Kindergarten Numbers and Base Ten

Cluster: Work with numbers 11-19 to gain foundations for place value.

Grade 1 Operations and Algebraic Thinking

Cluster: Represent and solve problems involving addition and subtraction.

Grade 2 Operations and Algebraic Thinking

Cluster: Represent and solve problems involving addition and subtraction.

Grade 3 Operations and Algebraic Thinking

Cluster: Solve problems involving the four operations, and identify and explain patterns in arithmetic.

Introduction

This lesson unit is structured in the following way:

- Before the lesson, students attempt the task individually. You then review their work and formulate questions for students to answer in order for them to improve their work.
- At the start of the lesson, students work to answer your questions.
- Next, they work collaboratively, in small groups, to produce a better collective solution than those they produced individually. Throughout their work, they justify and explain their decisions to peers.
- In the same small groups, students critique examples of other students' work.
- In a whole-class discussion, students explain and compare the alternative approaches they have seen and used.
- Finally, students work to reflect on their initial response and compare their response to the collective thinking from the group or students can return to their initial response and make corrections or revisions. In the final part of the lesson, students spend ten minutes reviewing what they have learned.

Materials required

Each individual student will need two copies of the initial task *Caterpillars and Leaves*.

- Each small group of students will need a copy of *Sample Responses to Discuss* and whichever samples of student work chosen.

Time needed

Approximately fifteen minutes before the lesson, a one-hour lesson, and ten minutes in a follow-up lesson. All times are approximate. Exact timings will depend on the needs of the class. For primary grades, these times are flexible depending on the needs of your class.

Before the lesson

Assessment task:

Have the students do this task in class a day or more before the formative assessment lesson. This will give you an opportunity to assess the work and to find out the kinds of difficulties students have with it. Then you will be able to target your help more effectively in the follow-up lesson.

Give each student a copy of *Caterpillars and Leaves*. Introduce the task briefly and help the class to understand the problem and its context.

Framing the Lesson



Today you are going to work on using your number sense to answer questions about class pets.

What is a caterpillar? What does a caterpillar eat? This question is about feeding a class pet caterpillar. On your own, answer the question. Show your work.



Don't worry if you are not sure if your solution is correct. There will be a lesson on this material [tomorrow] that will help you improve your work.

Your goal is to be able to answer this question with confidence by the end of that lesson. You will have 15 minutes to work.

K-1 Student Task

<p>Caterpillars and Leaves</p> <p>A kindergarten class needs 2 leaves each day to feed 1 caterpillar. How many leaves would they need each day for 3 caterpillars?</p> 
NAME _____
<p>Frogs and Crickets</p> <p>The class has 3 pet frogs. 1 frog needs to eat 4 crickets every day. How many crickets would they need each day to feed 3 frogs?</p> 
Name _____

2-3 Student Task

<p>Caterpillars and Leaves</p> <p>A third grade class needs four leaves each day to feed its two caterpillars. How many leaves would they need each day for 12 caterpillars?</p> 
NAME _____
<p>Frogs and Crickets</p> <p>A third grade class needs five crickets each day to feed two frogs. How many crickets would they need each day to feed 12 frogs?</p> 
Name _____

It is important that students answer the question without assistance, as far as possible. Students who sit together often produce similar answers, and then, when they come to compare their work, they have little to discuss. For this reason, we suggest that when students do the task individually,

you ask them to move to different seats. Then at the beginning of the formative assessment lesson, allow them to return to their usual places. Experience has shown that this produces more profitable discussions. For lower primary grades, students may work with an adult individually.

If students finish the first prompt easily, give them the second prompt to complete.

Assessing students' responses

Collect students' responses to the task. Make some notes on what their work reveals about their current levels of understanding and their different problem solving approaches. The purpose of this is to forewarn you of the issues that will arise during the lesson, so that you may prepare carefully.

We suggest that you do not score students' work. The research shows that this is counterproductive, as it encourages students to compare scores, and distracts their attention from how they may improve their mathematics.

Instead, help students to make further progress by asking questions that focus attention on aspects of their work. Some suggestions for these are given on the next page. These have been drawn from common difficulties observed in trials of this unit.

We suggest that you write your own lists of questions, based on your own students' work, using the ideas below. You may choose to write questions on each student's work. If you do not have time to do this, select a few questions that will be of help to the majority of students. These can be written on the board at the beginning of the lesson.

Common Issues	Suggested Questions and Prompts
Student ignores number of caterpillars and/or number of leaves.	<ul style="list-style-type: none"> • What sort of diagram might be helpful? • How can you show the number of caterpillars and leaves? • Is there any information in the task that you missed? •
Student work is unsystematic.	<ul style="list-style-type: none"> • What pattern do you notice? • How could you simplify this into an easier task? • How can you organize your work?
Student assumes that the initial pattern does not stay the same.	<ul style="list-style-type: none"> • What assumptions can you make about how many leaves each caterpillar eats?
Student write answer without explanation.	<ul style="list-style-type: none"> • How could you explain/show how you reached your conclusion so that someone in another class understands? • How can you use numbers, words or diagrams to describe what the caterpillars ate?
Student correctly identifies how many leaves the caterpillar eats.	<ul style="list-style-type: none"> • Think of another way of solving the problem. • Is this strategy better or worse than your original one? • Explain your answer. • Can you make a new problem with a different number of leaves and a different number of caterpillars?

Suggested lesson outline

Improve individual solutions to the assessment task (10 minutes)

Return student work on the *Caterpillar and Leaves* problem. Ask students to re-read both the *Caterpillar and Leaves* problem and their solutions. If you have not added questions to students' work, write a short list of your most common questions on the board. Students can then select a few questions appropriate to their own work and begin answering them.

Recall what we were working on previously. What was the task?

Draw students' attention to the questions you have written.

For Kindergarten students the teacher may need to read the questions aloud and repeat them to individual students. Student responses may be oral. The teacher may want to use a limited number of questions. This may be done with small groups of students.

I have read your solutions and I have some questions about your work.

I would like you to work on your own to answer my questions for ten minutes.

Collaborative activity 1:

Organize the students into small groups of two or three. In trials, teachers found keeping groups small helped more students play an active role.

Students should now work together to produce a joint solution.

Put your solutions aside until later in the lesson. I want you to work in groups now.

Your task is to work together to produce a solution that is better than your individual solutions.

You have two tasks during small-group work, to note different student approaches to the task, and to support student problem solving.

Note different student approaches to the task

Notice what strategies students use and how they organize their data. Note the representations they use, including incorrect versions, for use in whole-class discussion. You can use this information to focus the whole-class plenary discussion towards the end of the lesson.

Support student problem solving

Try not to make suggestions that move students towards a particular approach to this task. Instead, ask questions to help students clarify their thinking. If several students in the class are struggling with the same issue, you could ask a relevant question to move their thinking forward without doing the thinking for the students.

The following questions and prompts would be helpful:

What information have you been given? What do you need to find out?

What changes in the question? What stays the same? How will you write down your pattern?

Why do you think your ideas might be true?

You may find that some students do not work systematically when organizing their data.

What can you do to organize your data?

If students have found equations, focus their attention on improving explanations, or exploring alternative methods.

How can you be sure your explanation works in all cases?

Ask another group if your argument makes sense.

Some stronger explanations are shown in the *Sample Responses to Discuss*.

Make a note of student approaches to the task

Give each small group of students a copy of the *Sample Responses to Discuss*. Choose the samples of student work that match your students' level of understanding. Display the following questions on the board or document camera using the provided sheet: *Analyzing Student responses to discuss*.

Describe the problem solving approach the student used.

You might, for example:

- *Describe the way the student has organized the data.*
- *Describe what the student did to calculate the number of leaves the caterpillar eats.*

Explain what the student could do to make his or her solution correct or clearer if they calculated correctly.

This analysis task will give students an opportunity to evaluate a variety of alternative approaches to the task, without providing a complete solution strategy.

During small-group work, support student thinking as before. Also, check to see which of the explanations students find more difficult to understand. Identify one or two of these approaches to discuss in the plenary discussion. Note similarities and differences between the sample approaches and those the students took in small-group work.

Whole-class discussion comparing different approaches (20 minutes)

Organize a whole-class discussion to consider different approaches to the task. The intention is for you to focus on getting students to understand the methods of working out the answers, rather than just numerical solutions. Focus your discussion on parts of the two small-group tasks students found difficult.

Let's stop and talk about different approaches.

Ask the students to compare the different solution methods.

Read through your original responses and think about what you have learned this lesson. Using what you have learned, try to improve your work.

Which approach did you like best? Why?

Which approach did you find it most difficult to understand?

If your group used that method, can you explain that for us?

Improving individual solutions to the assessment task (10 minutes)

If you are running out of time, you could schedule this activity for the next lesson or for homework.

Make sure students have their original individual work on the *Caterpillars and Leaves* task on hand. Give them a fresh, blank copy of the *Caterpillars and Leaves* task sheet.

If a student is satisfied with his or her solution, ask the student to try a different approach to the problem and to compare the approach already used.

Solution

K-1 Task: The class will need six leaves to feed three caterpillars. If it takes two leaves to feed one caterpillar, then they will need to add two leaves for every caterpillar they add to the class collection of caterpillars.

2-3 Task: The class will need 24 leaves to feed 12 caterpillars. If it takes four leaves to feed two caterpillars; then they will need to add two leaves for every one caterpillar. The total number of caterpillars they feed is 12 so they will need 24 leaves each day.

This lesson format was designed from the Classroom Challenge Lessons intended for students in grades 6 through 12 from the [Math Assessment Project](#).

Evaluating Sample Responses to Discuss

What do you like about the work?

How has each student organized the work?

What mistakes have been made?

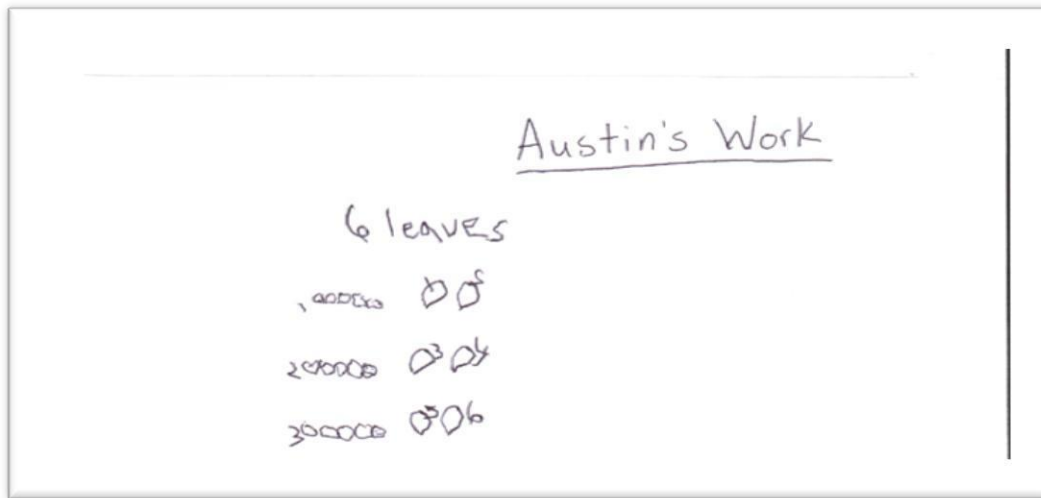
What isn't clear?

What questions do you want to ask this student?

In what ways might the work be improved?

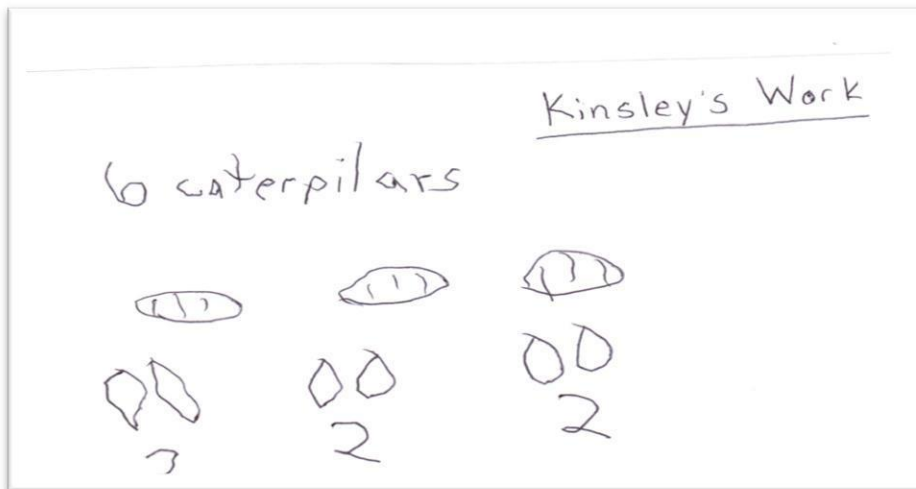
Analysis of Student Responses to Discuss

Austin's Method (K-1 task)



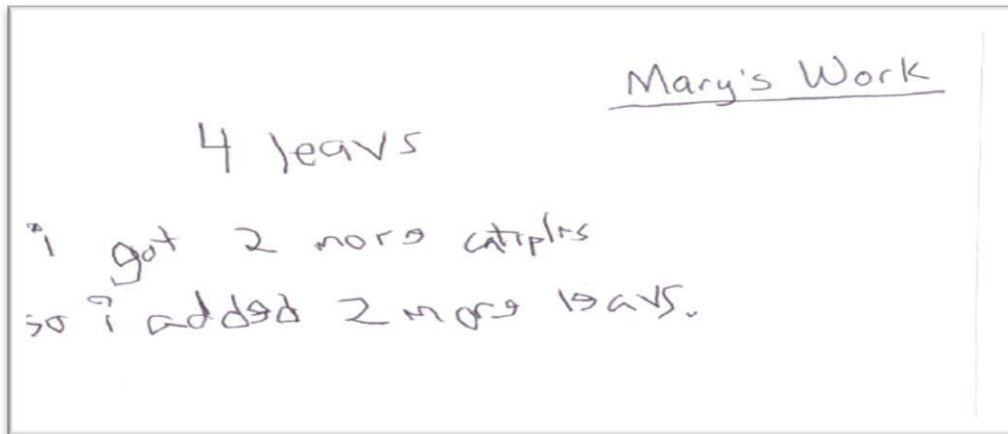
Austin drew 3 caterpillars. Then he drew two leaves beside each of the caterpillars. His work shows an understanding that each caterpillar will consume two leaves. He counted each leaf to arrive at the total of 6 leaves.

Kinsley's Method (K-1 task)



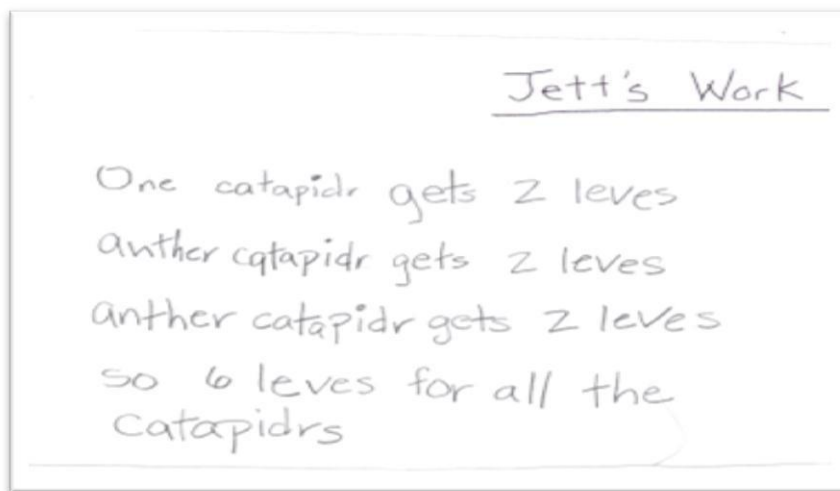
Kinsley began by drawing three caterpillars. She then drew two leaves underneath each caterpillar to represent what they would eat. She is recording her thinking in groups of two. When explaining, Kinsley said, "I know two and two is four and two more make six." Although her thinking is correct and accurate, she recorded her answer as caterpillars instead of number of leaves.

Mary's Method (K-1 task)



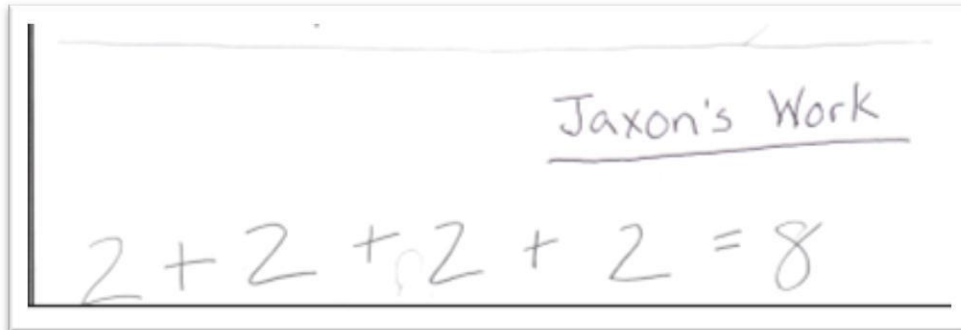
Mary could not transfer the idea that every caterpillar would eat two leaves each. When she counted caterpillars she reverted back to one-to-one correspondence when she counted leaves instead of identifying that each caterpillar eats two leaves.

Jett's Method (K-1 task)



Jett's written explanation shows that he understands that each caterpillar will eat two leaves. He accurately shows the solution of 6 leaves in all will be needed for 3 caterpillars. Jett could have shown the equation to extend his answer.

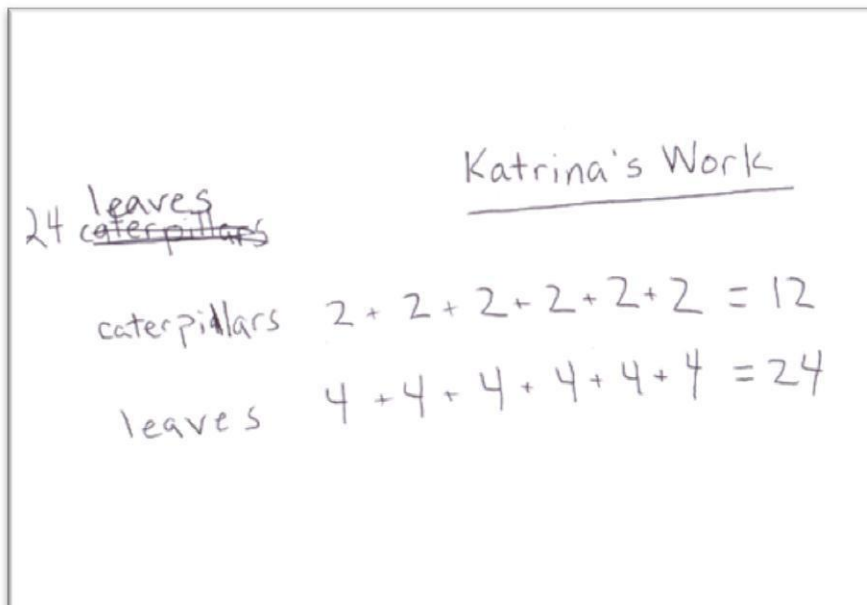
Jaxon's Solution (K-1 task)



A rectangular box containing handwritten work. At the top right, the text "Jaxon's Work" is written and underlined. Below this, the equation $2 + 2 + 2 + 2 = 8$ is written in a simple, childlike script.

Jaxon used repeated addition to solve the problem. Although the calculations are accurate, he did not have an understanding of how many caterpillars and how many leaves each caterpillar eats.

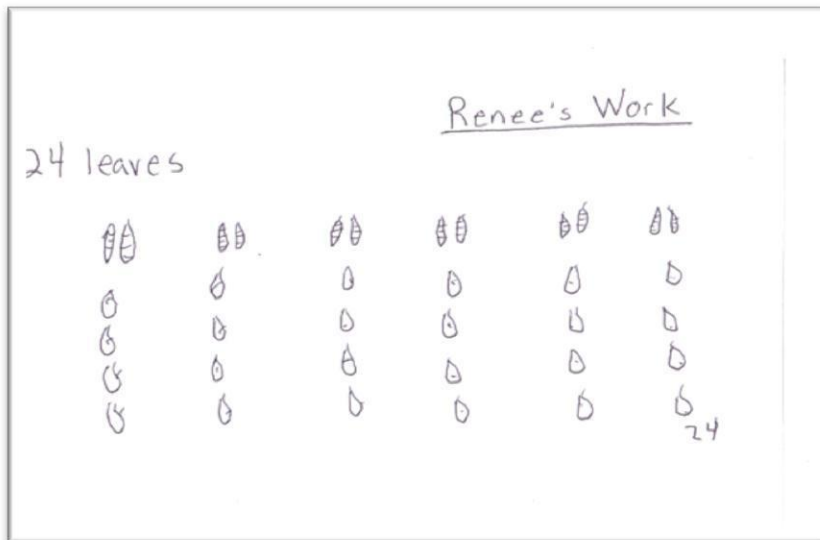
Katrina's Solution (2-3 task)



A rectangular box containing handwritten work. At the top right, the text "Katrina's Work" is written and underlined. On the left side, the text "24 leaves" is written above the text "~~24 caterpillars~~". Below this, two equations are written. The first equation is labeled "caterpillars" and is $2 + 2 + 2 + 2 + 2 + 2 = 12$. The second equation is labeled "leaves" and is $4 + 4 + 4 + 4 + 4 + 4 = 24$.

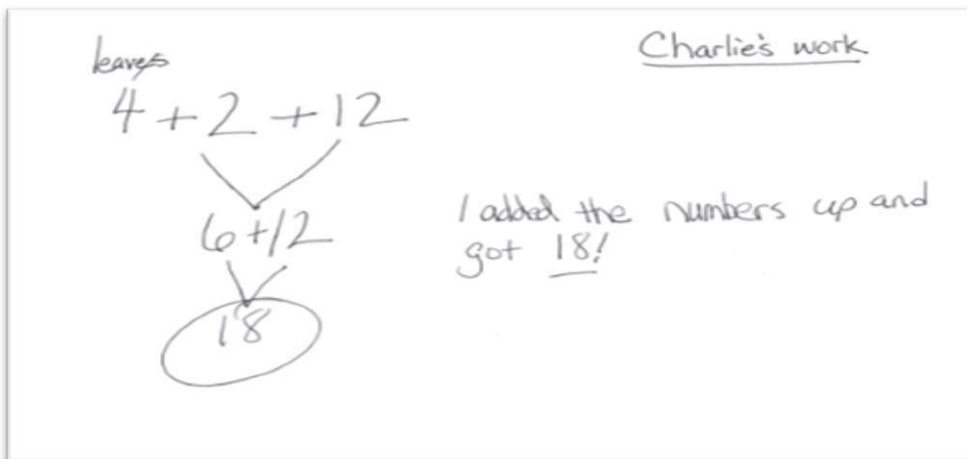
Katrina used repeated addition to solve the problem. She labeled each equation correctly and arrived at the correct solution. She self-corrected the solution at the top of the answer

Renee's Method (2-3 task)



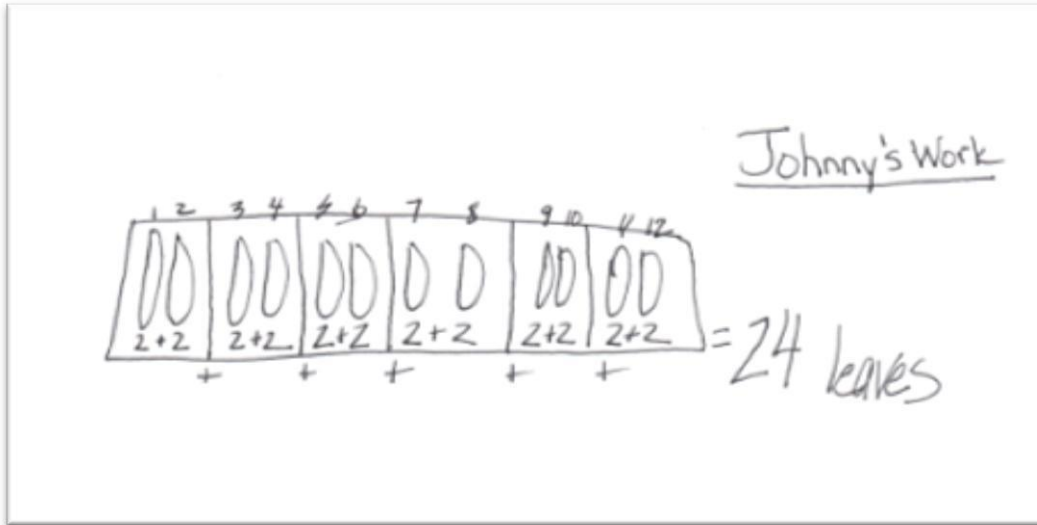
Renee drew pictures to represent both the caterpillars and the leaves. She counted up the leaves individually and arrived at the answer 24 leaves. She could extend her thinking to use numbers and create a more formal table to represent the pictures. Her drawing is well organized. Her work would have been easier for some to interpret if she had used labels on the drawing.

Charlie's Solution (2-3 task)



Charlie used the numbers from the problem and decided to add up the numbers. He did not understand what the problem was asking him to find. He correctly explained his strategy of adding the numbers and he did add correctly. His solution was incorrect because it did not fit what the problem was asking. He showed no understanding of how many leaves each caterpillar needed. He also showed no understanding of what the numbers meant from the problem. He saw three numbers and added.

Johnny's Solution



Johnny used pictures and a table to organize the data from the problem. He drew 12 caterpillars and then showed that each caterpillar ate 2 leaves. His work could have been easier to interpret if he had used labels correctly. He then used repeated addition to correctly calculate 24 leaves would be needed.

Caterpillars and Leaves

A kindergarten class needs 2 leaves each day to feed 1 caterpillar. How many leaves would they need each day for 3 caterpillars?



NAME _____

Frogs and Crickets



The class has 3 pet frogs. 1 frog needs to eat 4 crickets every day. How many crickets would they need each day to feed 3 frogs?

Name _____

Caterpillars and Leaves |

A third grade class needs four leaves each day to feed its two caterpillars. How many leaves would they need each day for 12 caterpillars?



NAME _____

Frogs and Crickets



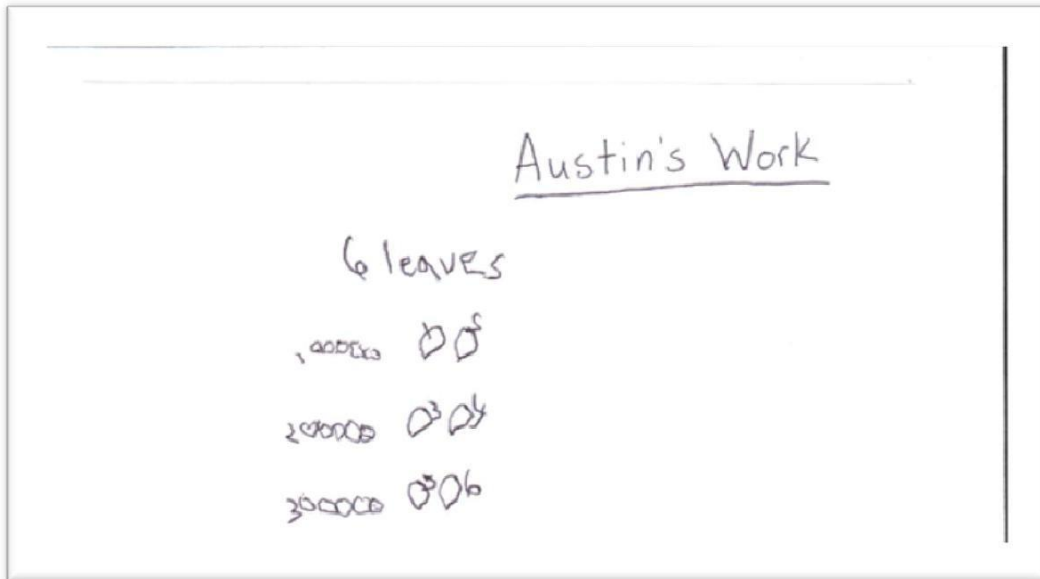
A third grade class needs five crickets each day to feed two frogs. How many crickets would they need each day to feed 12 frogs?

Name _____

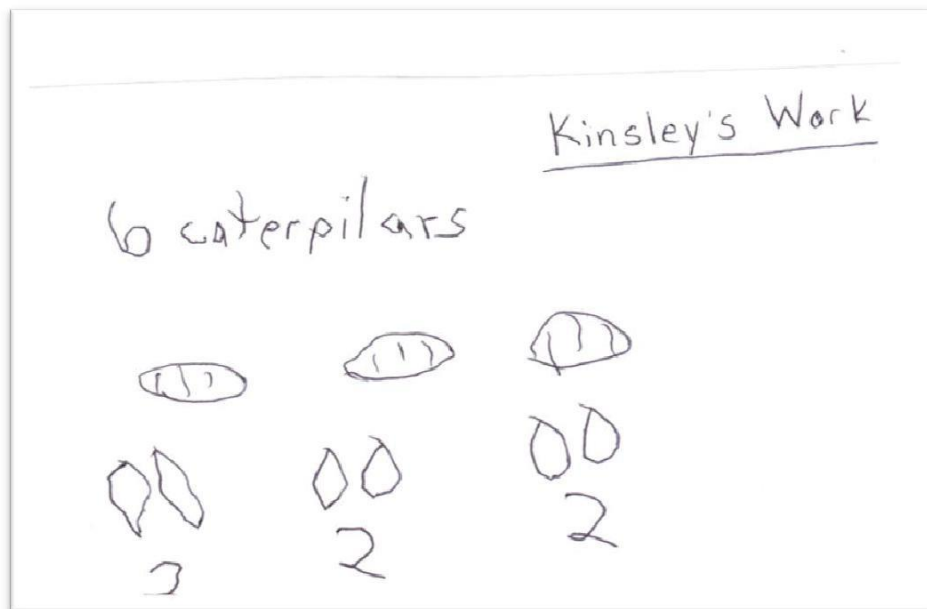
_____ 's Solution

_____ 's Solution

Austin's Solution



Kinsley's Solution



Mary's Solution

Mary's Work

4 years

i got 2 more cats
so i added 2 more years.

Jett's Solution

Jett's Work

One cat gets 2 levers
another cat gets 2 levers
another cat gets 2 levers
so 6 levers for all the
cats

Jaxon's Solution

Jaxon's Work

$$2 + 2 + 2 + 2 = 8$$

Katrina's Solution

Katrina's Work

24 ~~caterpillars~~ leaves

caterpillars $2 + 2 + 2 + 2 + 2 + 2 = 12$

leaves $4 + 4 + 4 + 4 + 4 + 4 = 24$

Renee's Solution

24 leaves

Renee's Work

The work shows six columns of pairs of circles. The first column has 4 pairs, the second has 3 pairs, the third has 2 pairs, the fourth has 2 pairs, the fifth has 2 pairs, and the sixth has 1 pair. The number 24 is written at the bottom right of the pairs.

Charlie's Solution

leaves

Charlie's work

$$4 + 2 + 12$$
$$\downarrow$$
$$6 + 12$$
$$\downarrow$$

18

I added the numbers up and got 18!

Johnny's Solution

Johnny's Work

1 2	3 4	5 6	7 8	9 10	11 12
OO	OO	OO	O O	OO	OO
2+2	2+2	2+2	2+2	2+2	2+2
+	+	+	+	+	

= 24 leaves