CATS & LADDERS
DIGITAL ACTIVITY MATERIAL

Contents:

- **Passcode Cheatsheet (for teachers already familiar with Lesson Plan)**

- **Lesson Plan (for teachers)**

- **Worksheet (for students)**

- **Worksheet Solutions (for teachers)**

- **Review Sheet (for students)**

These draft lesson plans, worksheets, worksheet solution guides, and review sheets are intended to accompany digital activities developed as part of *Thinking Outside the Box: Integrating Dynamic Mathematics to Advance Computational Thinking for Diverse Student Populations*, a National Science Foundation's STEM+C/Core R&D Programs #1543062. These draft versions correspond to those used in classroom research February - March 2017. As drafts, no warrants are made about these materials' completeness or correctness.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
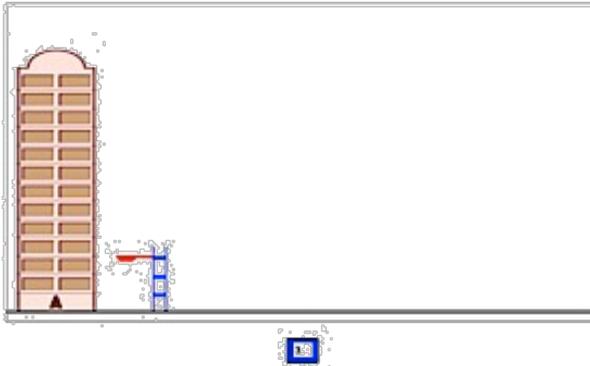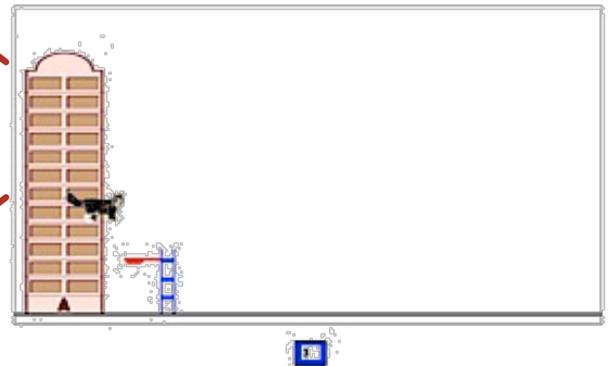
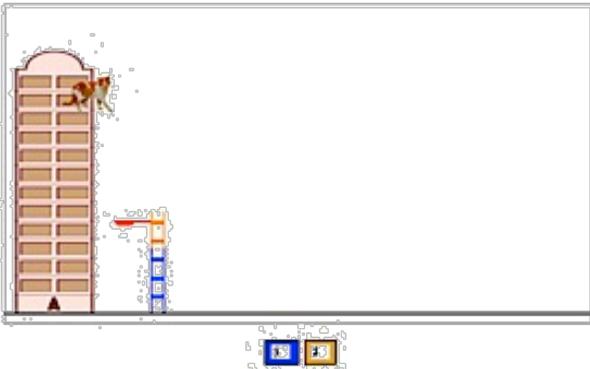## 1. Experiment with the blue ladder.

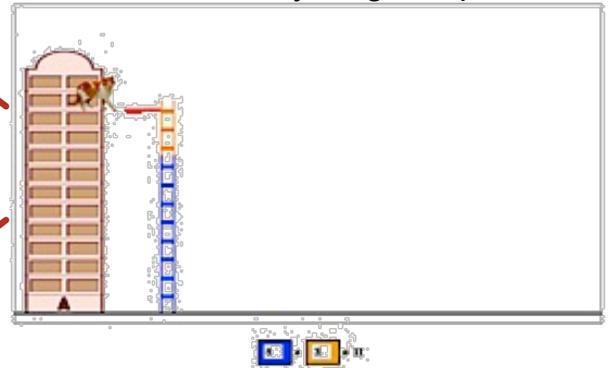passcode: **meow**

2. Rescue cats.

passcode: **orange**

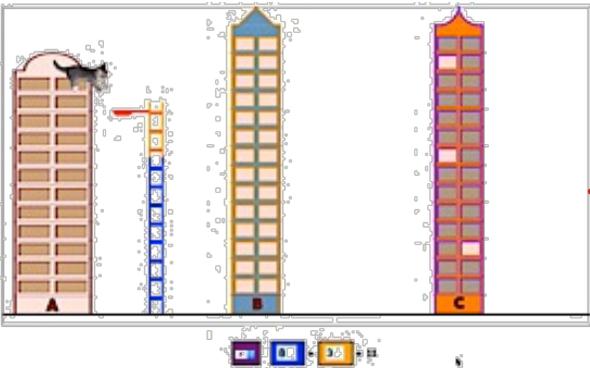## 3. Reach higher floors with the double ladder.

passcode: **add**

4. Verify height expression.

passcode: **city**

5. Target buildings as well as ladder heights for "rescue" solutions.

passcode: **end**

6. Done!

VELA Lesson #6
Cats and Ladders (Non-Scratch)

What comes before:

Story variables (non-Scratch) lesson

What comes after:

Creating and Updating Variables (Scratch) lesson

Summary

Students will be led through a scaffolded discovery of variables and expressions through a simple game. The game makes concrete how variables and expressions can determine the range of behaviors of a program.

Intended Outcomes

Students will be able to . . .
- Define a **variable** in a program as a named quantity that both *has* ONE specific value at all times and that can *change* value over time
- Name variables insightfully, with names that are accurate to and descriptive of the role the variable plays in its context, and that offer potential insight into the variable's possible values.
- Describe how changing **variables** (both computer program user created inputs or variables output by the computer in equations or expressions) can operate within a computational model (or computer program), *controlling* some changing aspects of the computation and *measuring*, *describing,* or *reflecting* other changing aspects
- Identify or recognize how multiple variables may be used in a specific programming context to represent or manipulate different aspects of changing information in that context .
- Understand that **expressions** combine variables, for example through arithmetical operations, to define or model *new* values[1]
- Identify *appropriate ranges* or general *type* of a specific variable or expression values (i.e 0-16, "a number less than 8", or "colors")

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[1] And that these new values can also change, without the expression changing—thus if *TotalLadderHeight* is defined as *BlueLadderHeight* + *OrangeLadderHeight,* we expect *TotalLadderHeight'*s value to change when either *BlueLadderHeight* or *OrangeLadderHeight* changes values, even though the *expression* that defines *TotalLadderHeight*—that is, *BlueLadderHeight* + *OrangeLadderHeight*—stays unchanged.

New Vocabulary Used/(Re-)Introduced:

Variables	Named values or quantities that change over time
Range of a variable	Possible values a variable can have
Expressions	Combination of values and variables using different operators to create a new value
Operator	An operator represents an action on a value or set of values. For example, + is an arithmetic operator that acts on two values and adds them
Arithmetic expression	Combination of values and variables using arithmetic operators to create a new value

<u>If you have not yet completed Review sheets for "Story variables", hand them out now during attendance to start the class (5-7 mins)</u>

Prior Learning Connections:

This lesson builds heavily on the Story Variables lesson. At this point students should understand what variables are and have some practical understanding of how to come up with descriptive names for variables. A good name for a variable is one that is specific, descriptive, and distinctive: it should suggest the types of *values* that might be appropriate for the variable, while also clearly *distinguishing* the variable from any other variables that have similar values. (As an example, if a student named his variable *car*, and the value was *blue*, you might at first think his variable might better be named *color*.This would make the name more *descriptive* of its value, since *car* could also reasonably have values like *Ford Taurus* or *Daddy's* or something else. But hearing that "the *color* is *blue*" leaves open the question of "which color? The color of what?" Thus perhaps *CarColor* would be an even *better* variable name—it is descriptive *and* distinctive.)

Coming from their prior school mathematics background, students may well have some fixed and narrow ideas about variable names—such as that they always need to a single letter, such as a,b,c, or x.! Well into high school mathematics, students will likely only see math problems featuring a single variable, so descriptive and distinctive names are relatively unimportant there. But in computer programs, students will eventually need to work with many different variables at the same time—and often read programs with variables named by their classmates or people they've never met. So descriptive, distinctive names are much more important! Encourage good naming practice wherever you see it, and point out places where proposed variable names are ambiguous or simply uninformative.

Just as in the Story Variables activity, what might seem an excellent variable name at first may be revealed as less ideal or helpful later on in the activity, as students gain deeper understanding of the unique role a specific variable plays within its computing context.

Overview of Tasks:

Activate Prior Knowledge	Have students jot down what they remember from the previous lessons about variables
Hook	Provide context for the Cats and Ladders digital activity (imagine you are a firefighter trying to save stranded cats from window ledges)
Exploration	Students fill out worksheets as they interact with the digital activity; the teacher brings students back to whole class discussion
Closing	Students answer Review questions

Assessments:

- During the Exploration the teacher can monitor students' worksheet responses for misconceptions
- The final review questions should give you an idea of how robust students' understanding of the content is.

Materials:

- A laptop for every pair of students
- Worksheet handout (one for every pair of students),
- Cats and Ladders Review questions handout (one per student)

Differentiation and Accommodations:

Heterogenous pairs will be helpful for students who are still struggling with variable naming.

English Language Learners:

The lesson is highly visual using very little English text. You can still support your ELL students with written definitions of variable and expression on the board. When naming their variables let students suggest variables in other languages.

_____

Procedure:

Activate Prior Knowledge:

Before students open their computers. the class should review what they learned about variables from the previous lesson (Story Variables). This can be done with a shout-out protocol with a student helper taking notes on the board. Spend no more than 3-5 minutes getting answers.

Hook:

Explain that we are going to play a basic computer game. In this game **you will take the role of a firefighter using an extension ladder to try to save some cats stranded on window ledges of high-rise apartment buildings.**

Exploration:

Pass out the worksheets and have students direct their computers to the VELA website:
http://csforall.sri.com/cats_and_ladders/index.html

Phase 1 of game:

[Please note that the term 'phase' has been merely used for structuring the lesson for you - the teacher. Students need not be told that they are working in Phase 1 versus Phase 2 or 3, etc.]

Point out to students that there is a blue box on screen and ask them to try with a partner to find out everything they can about that blue box in three minutes taking notes under **Question 1** of their worksheet.

Then have students put their pencils down and possibly turn their computer monitors off or turn laptops around to know they are coming together as a whole class. Cold call some students to tell you everything they figured out about the box. You or a student volunteer can record ideas on the board. Direct students to pick up ideas they missed. Students should note that

- Changing the value in the box also changes the height of the picture of a blue ladder
- The box only "allows" numbers
- It does not allow negative numbers
- It does not allow zero
- It does not allow decimal numbers or fractions
- It can only go up to eight; otherwise it rejects the entry with some message

Explain that this blue box is going to be useful as the program continues: "When I give you a secret code you are going to see a bunch of cats that are trapped in the building. You will have to be able to use this Blue Box to save them! Let's first come up with a meaningful name for the variable in the blue box. Think about the function of the number you type into the blue box and come up with a meaningful variable name."

Hold a quick informal vote on what the blue box will be called, something like "**LadderHeight**" is fine for now (but know that later in the activity a second ladder will be added and this might need to be changed to "BlueLadderHeight.") You might provide counter examples and have students remember why these would be poor variable names. For instance
- "Height of the Ladder" has too many words separated with spaces.
- "Height" is maybe not specific enough
- "Ladder" won't help you know what's changing

Have student record the variable representing the number in the blue box in **Question 2** of the worksheet, along with the range of the variable (they can enter it anyway that is helpful for them "less than 8" or "0<Variable<8" or "0 - 8"

Have students indicate with a thumbs up or another classroom signal that their partner has something written.

Then give students the password "**meow**" to proceed to Phase 2 (Consider writing these on the board to avoid spelling mistakes)

Phase 2 of the game:

Let students save a few cats by entering numbers into the blue box. After 3-5cats or so they should notice they will get stuck. Ask students to give some ideas for how they could solve this problem **"How can you save this cat?"**, this can be either a cold call, raised hand, or shout out procedure. Maybe students will say: Make the ladder longer, or Add another ladder.

Then tell them to type in the code "**orange**" to proceed to Phase 3.

Phase 3 of the game:

Have students play with the new orange ladder for a few minutes by entering different numbers into the orange box.

Direct students to get together with their partners and try to understand everything about the orange box. Ask the students to name the variable in the orange box. Now, if the students had previously named the blue ladder "LadderHeight", explain how it's going to be important to change it to "BlueLadderHeight." This is a great teaching moment to say that in our own programs we may need to go and change back variables and that that is perfectly okay.

 Ask students to write out this variable name and the range of the variable in **Question 3** of their worksheet.

Next, ask students: What do you think would be a meaningful name for the two ladders combined together?
Help students arrive at the answer: **Combined-ladder-heigh**t, or **Total-ladder-height**
Ask students to write down this variable name under **Question 4** of their worksheets.

Introduce **Expressions** at this point. Tell them that expressions in computer science are the combinations of values and variables WITH operators to create a new value. +, -, *, / are all examples of arithmetic operators that only work on numbers. Expressions that only use arithmetic operators are called arithmetic expressions, for example (5+2), (15/3), (10-3), etc.

Now, direct students to **Question 5** in the worksheet. Challenge pairs to come up with an expression to describe the variable identified in **Question 4** as a combination of other variables.

When most pairs have something written down, ask for pencils down and call on one or two students to share what they have. They should be able to come up with something along the lines of "BlueLadderHeight + OrangeLadderHeight" or "TotalLadderHeight is defined by BlueLadderHeight + OrangeLadderHeight". Get a thumbs up vote for who agrees.

Next, tell them to type in "**add**" as a secret code to proceed to Phase 4 and verify their expressions.

Phase 4 of the game:

Ask students to verify if they got the right expression. Then ask them to fill out **Q6 from the worksheet.**

Then, give them the new secret code--"**city"---**to proceed to Phase 5 of the game.

Phase 5 of the game:

In the context of the multiple buildings in the city, ask students (whole class) what variables they now need to know to find the location of the cat? Is one variable enough or do you need multiple variables to describe the location of the cat?
-   As students identify different variables or names you might need to point out that in this case two different variables help the program figure out where to find the cat. For **Question 7** on the worksheet, students should write CombinedLadderHeight (or the variable your class agreed on) AND BuildingLocation or BuildingName (or the name your class agreed on). Explain that with two variables we can have more complete information.

Students should play and save cats in this new phase for some time.

Then, ask the class to think about some other cases where TWO variables are needed to express a piece of information. Example: In your daily life, what time you wake requires you to know the time of day and what day of the week it is
Possible examples include:
        -Price, you need to know a number and Dollars or Cents
        -Time, AM and PM
        - Date, you need to know Month and Day
        - Area, you need to know width and length

Finally, ask students to get together in pairs and work on **Q8 from their worksheets**. Discuss answers as a class, once students are done.

Closing:

Pass out the review questions and have students complete them.
Time permitting ask students to teach back to the whole class a few things they learned that will help them as they move forward in their programming activities.

Future Learning Connections:

In this activity, the combined *ladder height* moves the ladder up and down and *building choice* moves the ladder left and right. This is similar to the role *y* and *x* play in two-dimensional *(x, y)* coordinate systems that will be used in Scratch to position computer graphics on the screen. In this activity, three variables—*orange ladder height*, *blue ladder height*, and *building choice* — correspond to *parts* of a single solution: where is the ladder's top rung? This is similar to a multiple-variable record or *structured data type* in some programming languages.

Names: _____ and

_____

Cats and Ladders Worksheet:

Question 1:
What did you find out about the blue box:

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Question 2:
Name of the variable describing the number in the blue box:

_____

Range of the variable: _____
(Range is the values that this variable can have)

Question 3:
Name of the variable describing the number in the orange box:

_____

Range of the variable: _____
(Range is the values that this variable can have)

Question 4:
Name of the variable describing the two ladders together:

_____

Question 5:
Predicted Expression describing the variable in Question 4:

_____

Question 6

    a) **What is the topmost floor from which you can rescue a cat using both blue and orange ladders?**

_____

    b) **What is the lowest floor from which you can rescue a cat?**

_____

Question 7:
What Variables do you now need to know as a firefighter to find the cat location: _____

_____

Question 8

Write an expression for the following story:

- Margo wants to calculate how much money she is spending on school supplies and how much of her savings will be left.
- She goes to the store and buys one book and one pen
- Use the variables-
  - i. *PenPrice*,
  - ii. *BookPrice*,
  - iii. *StartMoney* (for how much money Margo has when she goes to the store)

Write an expression for how much money Margo will have left after buying the pen and the book?

_____

_____

Names: _____ **SOLUTIONS** _____ and

_____

Cats and Ladders Worksheet:

Question 1:

What did you find out about the blue box:

> The blue box can only take numbers.
> The number in the box changes the height of the ladder.
> The number cannot be 0 or negative.
> The number cannot be more than 8.
> The number cannot be a decimal.

Question 2:

Name of the variable describing the number in the blue box:
_____**BlueLadderHeight**_____

Range of the variable: _____1 - 8_____
(Range is the values that this variable can have)

Question 3:

Name of the variable describing the number in the orange box:
_____**OrangeLadderHeight**_____

Range of the variable: _____1 - 8_____
(Range is the values that this variable can have)

Question 4:

Name of the variable describing the two ladders together:

_____TotalLadderHeight_____

Question 5:

Predicted Expression describing the variable in Question 4:

_____BlueLadderHeight + OrangeLadderHeight _____

Question 6

    a) **What is the topmost floor from which you can rescue a cat using both blue and orange ladders?**

_____16_____

    b) **What is the lowest floor from which you can rescue a cat?**

_____2_____

Question 7:

What Variables do you now need to know as a firefighter to find the cat location:

_____BuildingName_____

_____BuildingFloor_____

Question 8

Write an expression for the following story:

- Margo wants to calculate how much money she is spending on school supplies and how much of her savings will be left.
- She goes to the store and buys one book and one pen
- Use the variables-
    - *i. PenPrice*,
    - *ii. BookPrice*,
    - *iii. StartMoney* (for how much money Margo has when she goes to the store)

Write an expression for how much money Margo will have left after buying the pen and the book?

_____StartMoney - PenPrice - BookPrice_____

OR

_____StartMoney - (PenPrice + BookPrice) _____

Name: _____

Cats and Ladders Review Questions

1) What is a **variable?** Describe in your own words.

_____

_____

_____

2) What is an **expression?** Describe in your own words.

_____

_____

_____

3) Which of the following things can change in the Cats and Ladders game, and which things cannot change? Put an X or ✓ in one column for each.

	Can change	Can not change
Blue Ladder Height		
Orange Ladder Height		
Combined height of ladders		
Maximum Possible Blue ladder Height		
Maximum possible Orange ladder height		
The expression: Combined height of ladders = Blue ladder height + Orange ladder height		

4) Kayla earns <u>$5 for every hour</u> she tutors children.

The variable **HoursWorked** stores how many hours Kayla tutored last week.

Write an expression to calculate how much Kayla earned last week from tutoring.

_____

_____