SPICE | Science Projects Integrating Computing and Engineering

Name:______________________________

Walker Water Runoff Challenge

Student Notebook

SRI Education

Digital Promise

University of Virginia | School of Education and Human Development

Vanderbilt School of Engineering

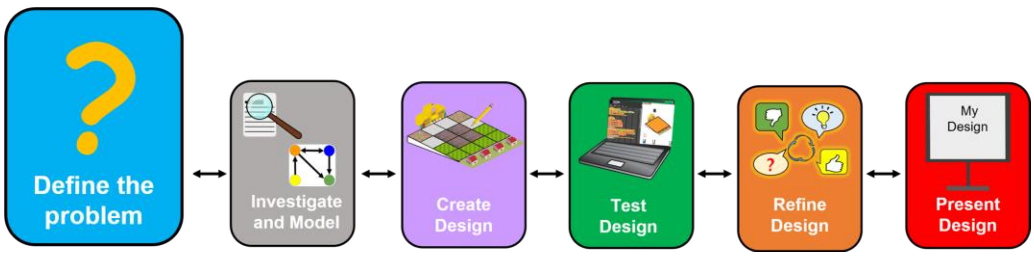
Class Discussion: What do engineers do?

Talk to a partner about your ideas, and then share out with the class.

You are going to be engineers and help Walker Upper Elementary school.

One of the first steps of engineering is to figure out the problem to solve.

Engineering Design Map



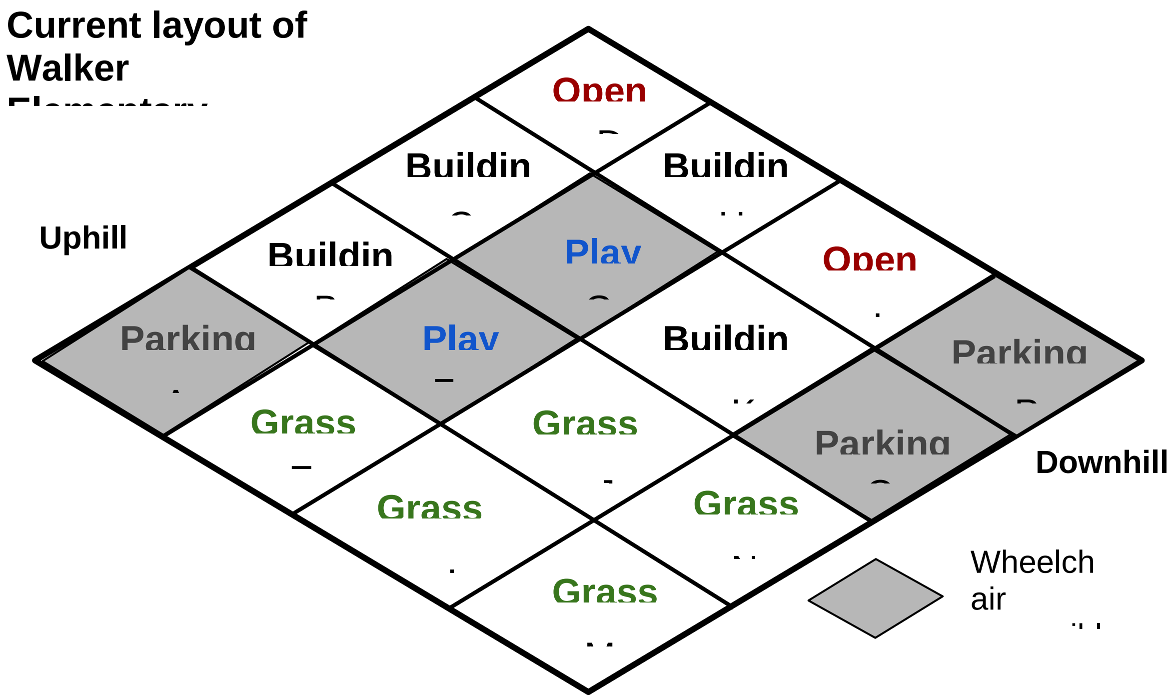
After watching the video as a class, help define the problem at Walker:

1.1. What problems are there at Walker Upper Elementary School?

1.2. How do you think Walker's problems affect the students and teachers?

1.3. How do you think Walker's problems affect the environment?

In this project, you will create designs for different spaces and uses at Walker. Use the following diagram to help you understand the current layout of Walker School.



1.4. For Walker School **now,** how many squares are for:

Building	Grassy field	Play area	Parking	Accessible

The students and teachers at Walker have the following needs:

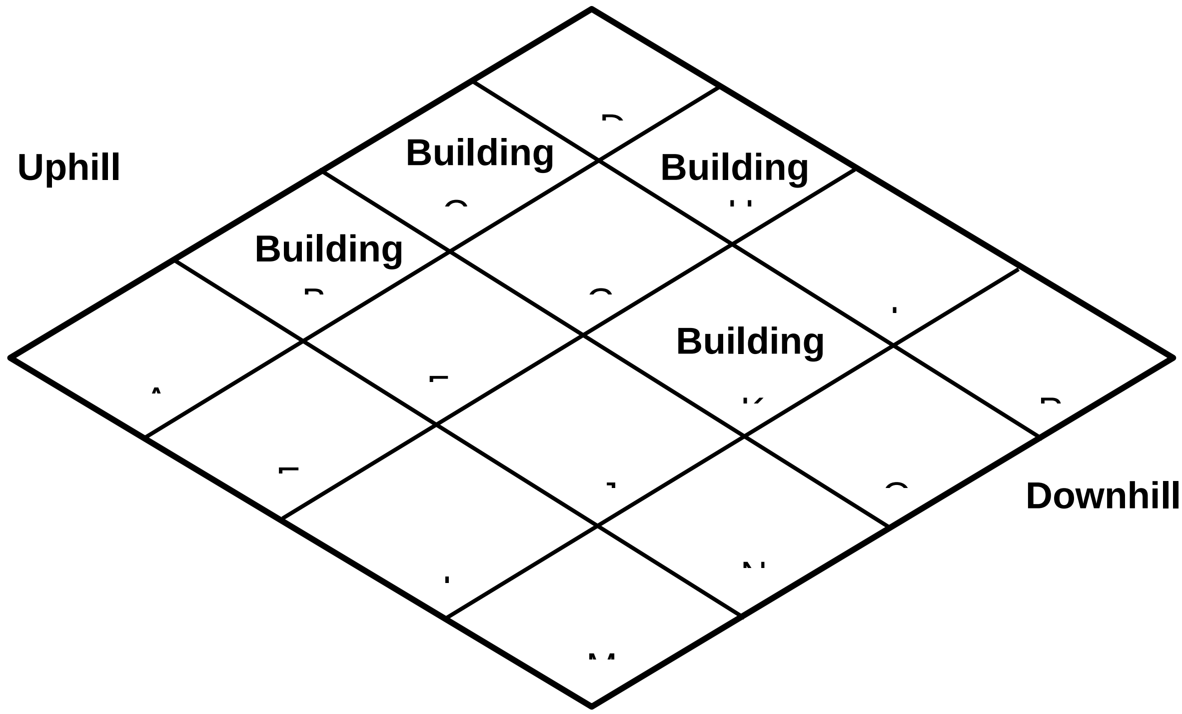
Building	Grassy field	Play area	Parking	Accessible
4 squares (B, C, H, K)	At least 4 squares	At least 2 squares	At least 3 squares	At least 6 accessible squares

1.5. Does the current design meet the needs of the students and teachers?

Yes No

Can you come up with a different plan that meets the needs of the students and teachers?

1.6. Use the blank grid below to make a plan by writing **grass**, **play**, and **parking** in the squares. Shade the squares you think should be wheelchair accessible:



1.7. For your new plan**,** how many squares are for:

Building	Grassy field	Play area	Parking	Accessible

Remember, the students and teachers at Walker have the following needs:

Building	"Grassy" field	Play area	Parking	Accessible
4 squares (B, C, H, K)	At least 4 squares	At least 2 squares for hardcourt, 1 square for swings	At least 3 squares	At least 6 accessible squares

1.8. Does your design meet the needs of the students and teachers?

Yes No

Project Criteria

We just explored the students' and teachers' needs for different areas. But there were other criteria mentioned in the video. Here is a complete list of project criteria:

A. The students and teachers at Walker have the following **needs:**

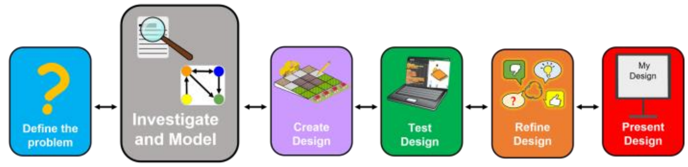
Building	Grassy field	Play area	Parking	Accessible
4 squares (B, C, H, K)	At least 4 squares	At least 2 squares for hardcourt, 1 square for swings	At least 3 squares	At least 6 accessible squares

B. Your design needs to **minimize water runoff** after **heavy rains** (2 inches of rainfall).

C. Your design needs to stay **under budget of $750,000.**

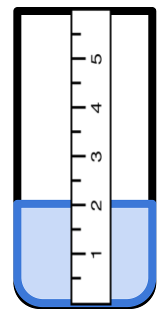
Closing question: What is the problem we are trying to solve? Draw a picture of the problem below.

Lesson 2: How much does it rain at Walker?



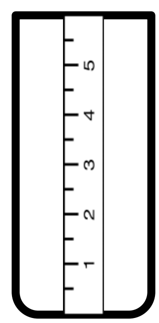
Discussion Question: How do we know how much water falls when it rains?

A rain gauge is used to measure the amount of rain that falls. Usually rain is measured in inches. For example, the rain gauge on the right shows **2 inches** of rain that fell in a heavy rainstorm:

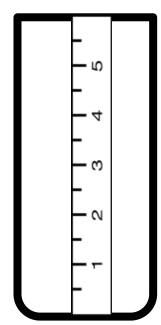


2.1. Fill in rain gauges

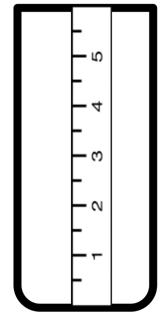
A. A moderate rain fell on Walker with a total of 1 inch of rain. Draw what the rain gauge would look like:



B. A moderate rain fell on Walker with a total of 0.5 inch of rain. Draw what the rain gauge would look like:

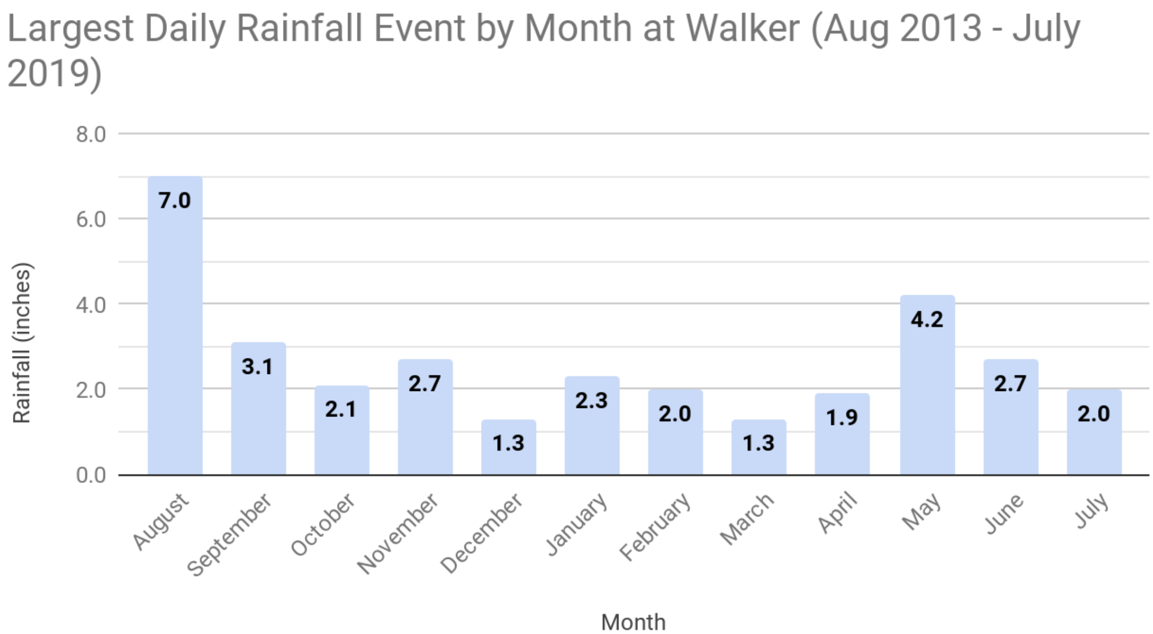


C. A heavy rain fell on Walker with a total of 2.5 inches of rain. Draw what the rain gauge would look like:



2.2. How much rain does Walker get?

Look at the rainfall chart below.



A. Looking at the graph:

Which month(s) had the largest one-day rainfall? ____________________

Which month(s) had the smallest one-day rainfall? ____________________

Your design must reduce water runoff after a heavy storm that rains **at least 2 inches**.

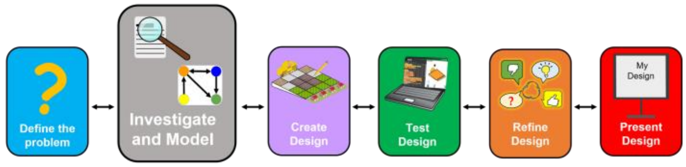
B. How many months have rainfall events 2 inches or

more?____________________

C. How many months have rainfall events under 2 inches?____________________

2.3. Closing question. Why do you think we need to design for at least 2 inches of rainfall?

Lesson 3: Where does the rain go?



Discussion Question: When it rains, where does the rain go?

3.1. Draw your best ***prediction*** below of where rain goes. A **prediction** says what you *think* will happen based on observation.

3.2. Explain your drawing.

3.3 Investigation: Make it rain!

Go outside and pour water to make it rain. You will need:

- A large container of water
- A small container for pouring
- Your notebook

Record your observations:

Pick a ground surface.	Pour **a very small amount of water on the surface**. What happens to the water?	Pour **a lot of water on the surface**. Does anything different happen?
Surface #1: ___________	*I observe that the water...*	*I observe that the water… (note any differences from the small amount)*

Surface #2: ___________	*I observe that the water...*	*I observe that the water…* *(note any differences from the small amount)*

3.4. Look at observations from other students. List something that another student observed that you didn't observe. (You can also use a different color and put it into your observation table above.)

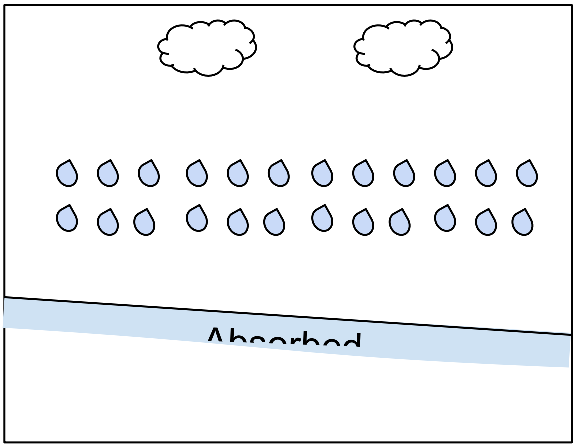
3.5. Based on your observations, explain where rainwater goes after it hits the ground.

After it hits the ground, rainwater…

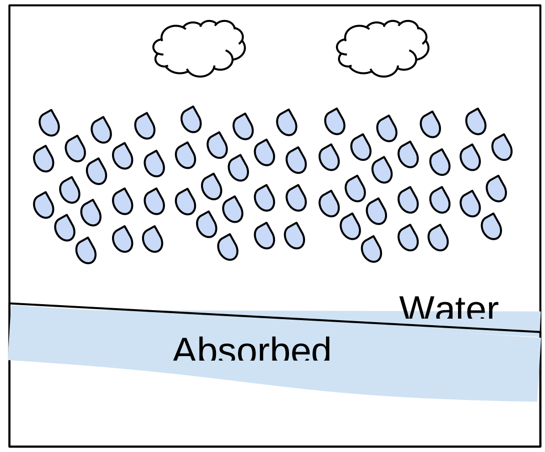
3.6. Based on your observations, explain how water flows differently on different surfaces.

3.7. What is water runoff?

You need to reduce ***water runoff*** at Walker. Every surface material can **absorb** different amounts of water. If the total rainfall is more than the surface can absorb, the rest of the water stays on the surface and runs off downhill. We call this **water runoff**.



(a) All rainfall is absorbed into

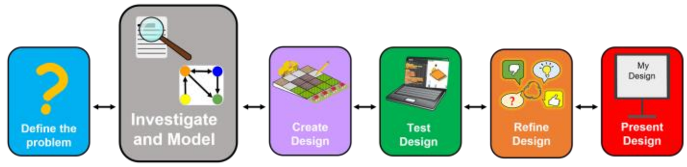


(b) The ground has absorbed

Using what you and your classmates observed, and what you have read above, revise what you drew in 3.1 to show what you have learned. Where does all the rainwater go?

3.8. Closing question. How is this picture different from what you predicted in 3.1?

Lesson 4: How can we make a model of water runoff?



4.1. What is a model?

Give an example of a model from your daily life: ______________________________

What is it a model of? ____

Why is this model needed? ____

Discussion: Share your example with the class. What makes something a model?

4.2. Models in science

A science model **explains how we think something happens** or **predicts what we think will happen.** When making models, **we choose to include things that are most important to explain** (and leave out other things).

Remember our engineering challenge:
To design the ground surface of Walker School to minimize water runoff.

- We will make models of the **ground surface of Walker School**.
- Your models will **explain and predict how water flows**. (All water has to go somewhere.)
- These models will help us **test how well different school ground designs reduce runoff**.

4.3. Draw a runoff model

Model requirements:

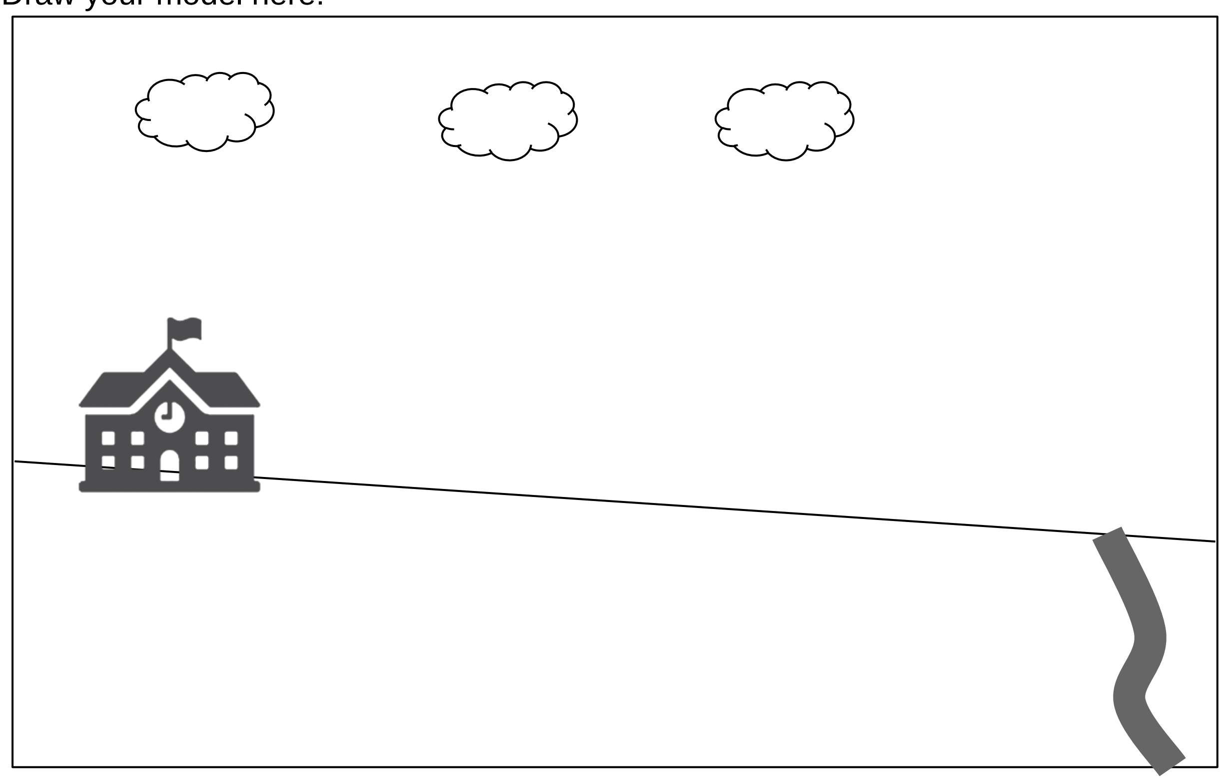
Your model should show **all 3 types of water flow** in and out of the ground surface:
- Rainfall
- Absorption to the ground (soaking in)
- Surface runoff (downhill)

Your model should also show **how much** of these types of water flow there is.

Here are some ways you could show water flow. Use one, more than one, or invent your own way!

arrows of different sizes and directions | water drops | rain gauge | words

Draw your model here:



4.4. Compare models. Find a partner and compare your model with another student.

How did they show different **types** of water flow? (arrow, rain gauge, words, etc.)

How did they show different **amounts** of water flow? (bigger arrows, more arrows, etc.)

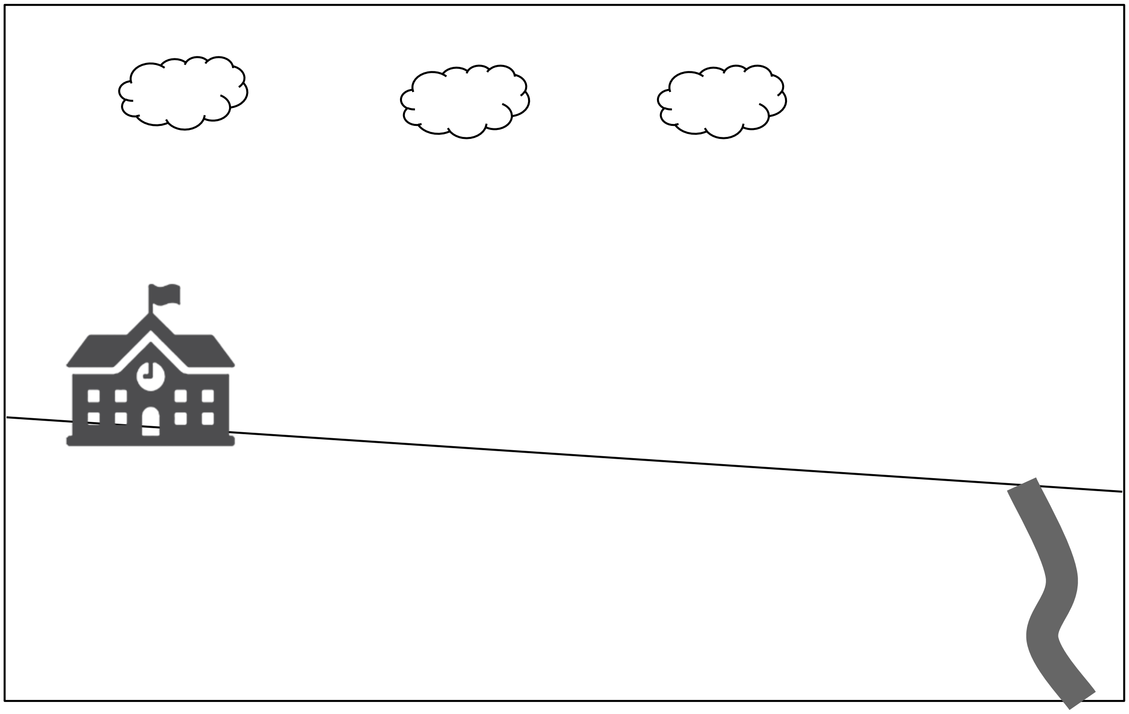
What is similar and different about your models?

Similarities:

Differences:

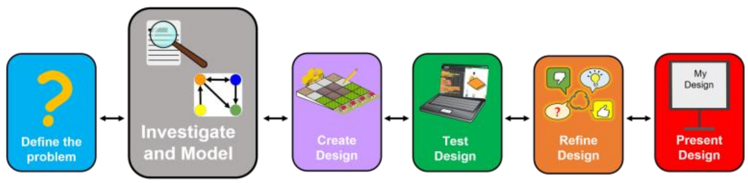
4.5. Improve your model.

Based on what you saw in other students' models, improve your model here:



4.6. Closing discussion. What are the best ways to show how water flows? What are we including in our model? What are we leaving out?

Lesson 5: How can our model help us predict the amount of water runoff?



5.1. Imagine a rainstorm has just passed. The storm has dropped **3 inches of rainfall**!

But the ground surface can **absorb at most 1 inch** of water. Where does the water go?

A. How much rain will be **absorbed**? ____________ inches

Explain how you know:

____

____

B. How much rain will be **runoff**? _____________ inches

Explain how you know:

The most amount of water a surface material can absorb is called the **absorption limit**.

If the rainfall is **more** than the absorption limit, the rest of the water stays on the surface and becomes runoff.

5.2. Predicting water runoff

Now you are going to use the model you built in 4.5 to ***predict*** how much runoff there will be after different amounts of rain. Remember, you need to show **total rainfall**, **water absorbed**, and **runoff** in your models.

A. How will you show different types of water flows? (arrows, raindrops, etc.)

____

B. How will you show different amounts of water flows? (bigger arrows, more, etc.)

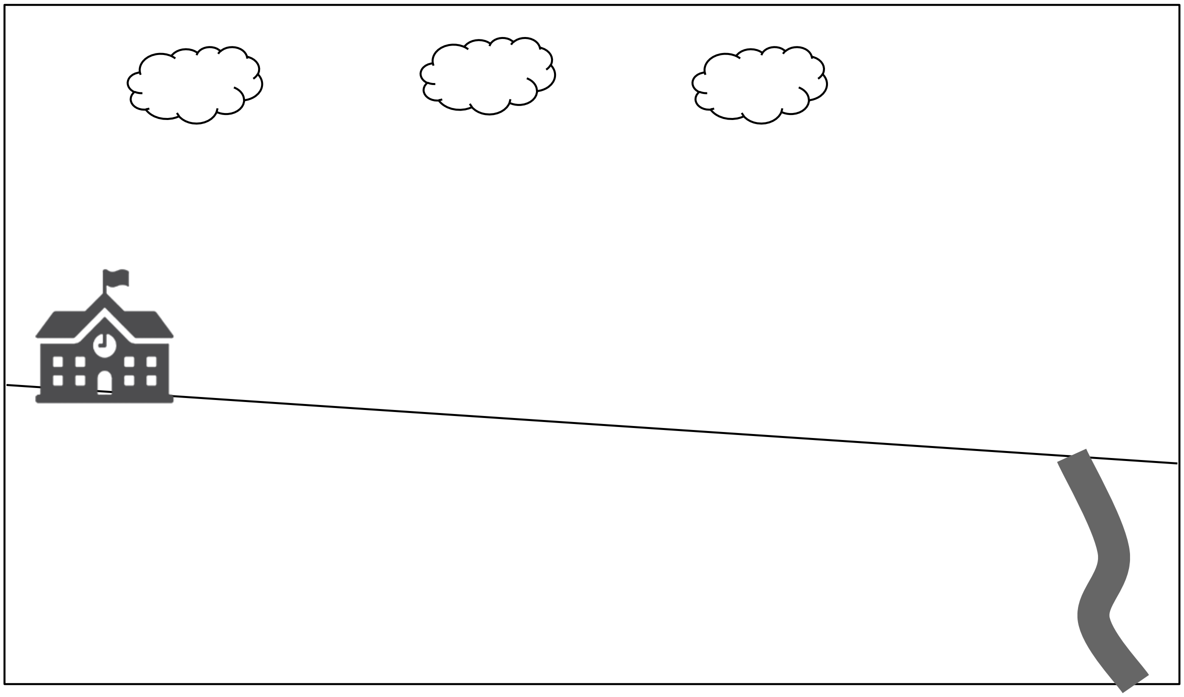
____

5.3. Predict the amount of absorption and runoff in each scenario using your model:

What if there are **3 inches of rainfall**, and the ground's **absorption limit is 1 inch**? Draw a model that shows the amount of rainfall, absorption, and predicts the amount of runoff.

Absorption limit: 1 inch

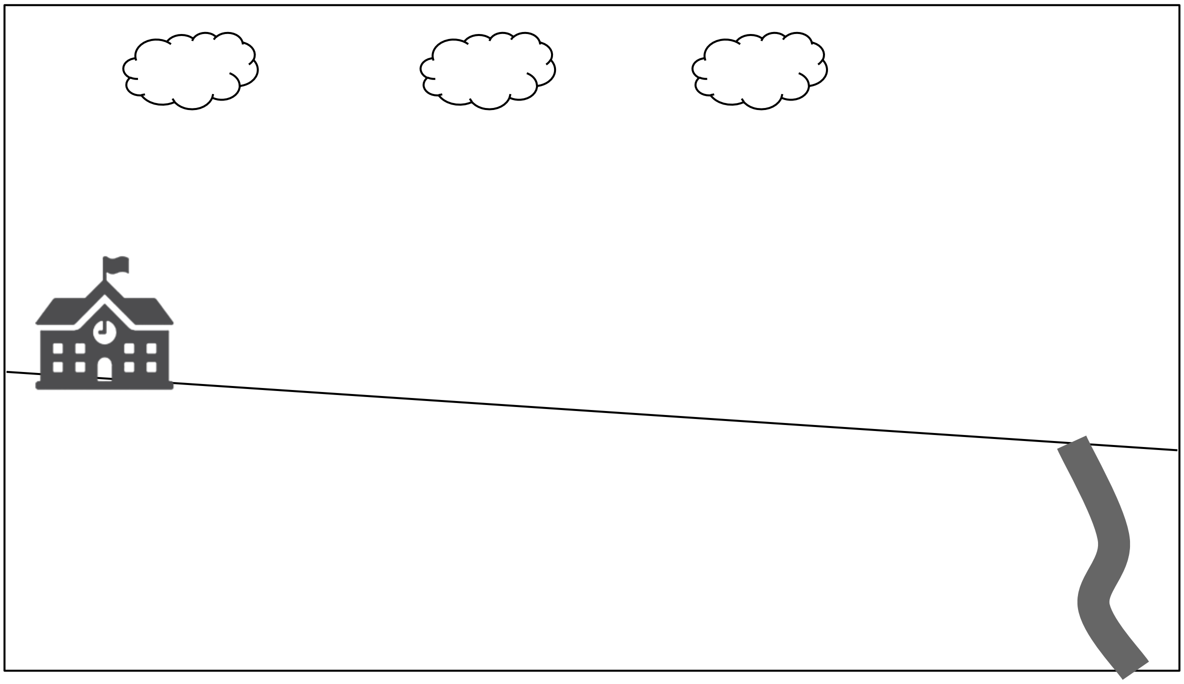
Total Rainfall: 3 inches **Total Absorption:__________** **Total Runoff**:__________



5.4**.** What if there are **3 inches of rainfall**, and the ground's **absorption limit is 2 inches**? Draw a model showing the amount of rainfall, absorption, and runoff.

Absorption limit: 2 in

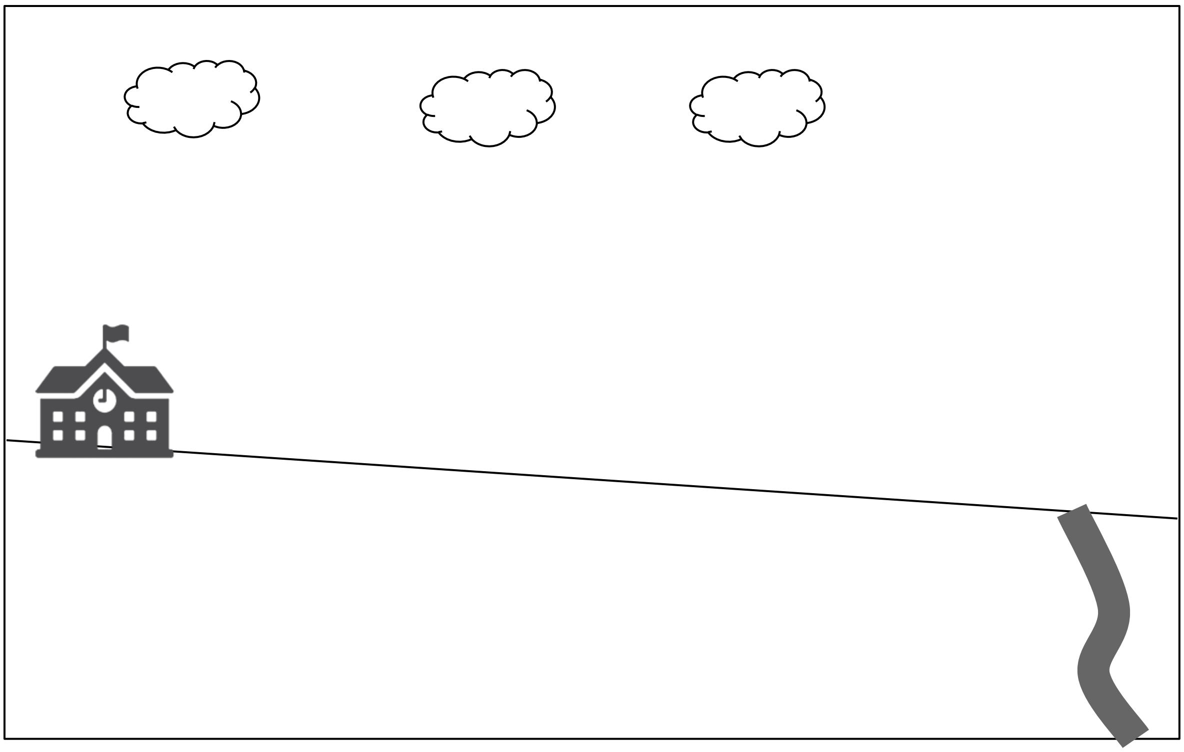
Total Rainfall: 3 in **Total Absorption:**__________ **Total Runoff**:__________



5.5. What if there are **2 inches of rainfall**, and the ground's **absorption limit is 2 inches**? Draw a model showing rainfall, absorption, and runoff (if there is any).

Absorption limit: 2 inches

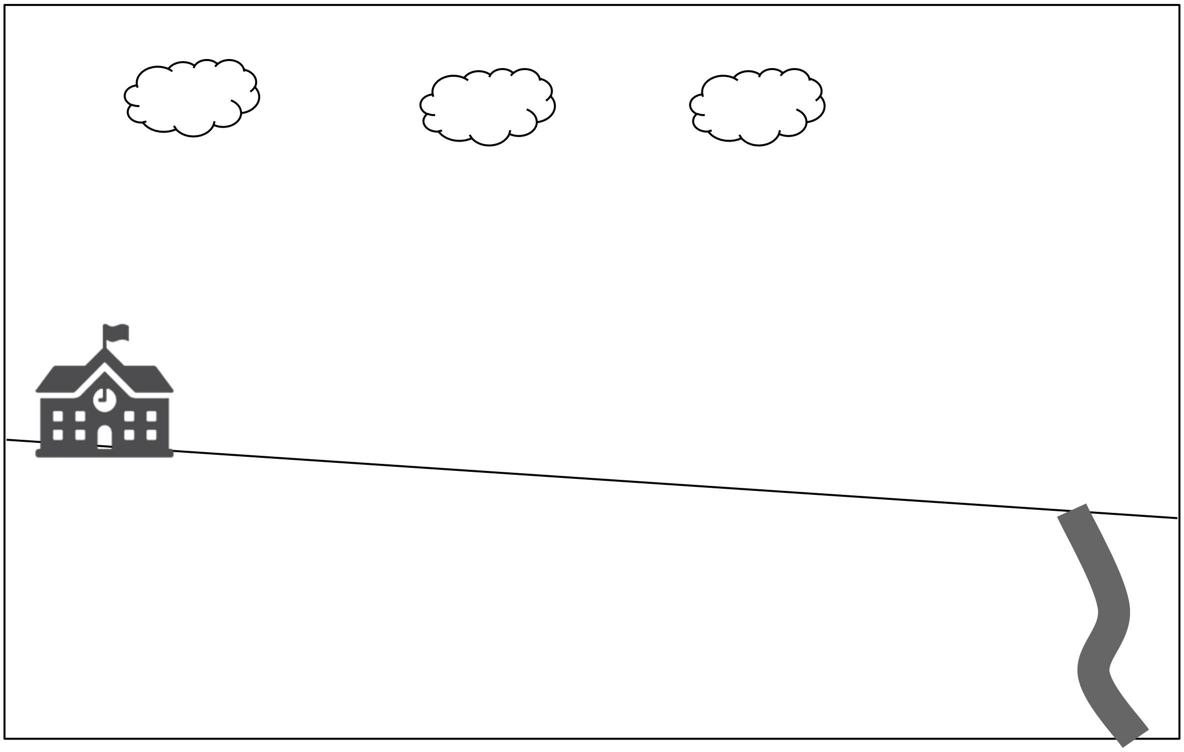
Total Rainfall: 2 inches **Total Absorption:**__________ **Total Runoff**:__________



5.6. What if there is **1 inch of rainfall**, and the ground's **absorption limit is 2 inches**? Draw a model showing rainfall, absorption, and runoff (if there is any).

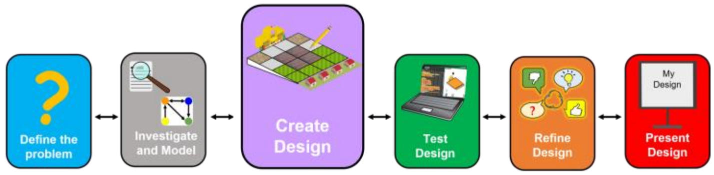
Absorption limit: 2 inches

Total Rainfall: 1 inch **Total Absorption:**__________ **Total Runoff**:__________



5.7. Closing Question: How can you predict the total runoff if you know the total rainfall and the absorption limit?

Lesson 6: How can we design Walker to reduce water runoff?



Opening Discussion

The following table are the surface materials that you can choose to use for your designs. Which ones have you seen before, and where?

Material	Description	Picture	Absorption limit	Accessible ?	Cost
Standard Concrete	Poured material that hardens into a solid and seamless surface	 (gray)	Low	Yes (all students can use surface)	$37,500 per square
Permeable Concrete	Loosely packed material that looks and feels like concrete	 (dark gray)	High	Yes (all students can use surface)	$93,750 per square
Grass	Natural grass	 (green)	High	No (not accessible to all students)	$18,750 per square
Artificial Turf	A carpet-like surface that looks and feels like grass	 (dark green)	Medium	Yes (all students can use surface)	$112,500 per square
Wood Chips	Pieces of wood especially designed for playgrounds	 (brown)	High	No (not accessible to all students)	$37,500 per square

Poured Rubber	Rubber that can be poured into different shapes and colors.	 (blue)	High	Yes (all students can use surface)	$187,500 per square

Explore the materials:

6.1. What materials are best for parking lots?

6.2. What materials are best for the “grassy” field?

6.3. What materials are best for the play area?

6.4. What materials have high absorption limit (can absorb the most water)?

6.5. What materials have the lowest cost?

6.6. Are some materials good for absorption but not for cost? **Yes** **No**

Explain your answer:

6.7. Are some materials good for accessibility but not for cost? **Yes** **No**

Explain your answer:

6.8. Are some materials good for absorption, accessibility, AND cost? **Yes** **No**

Explain your answer:

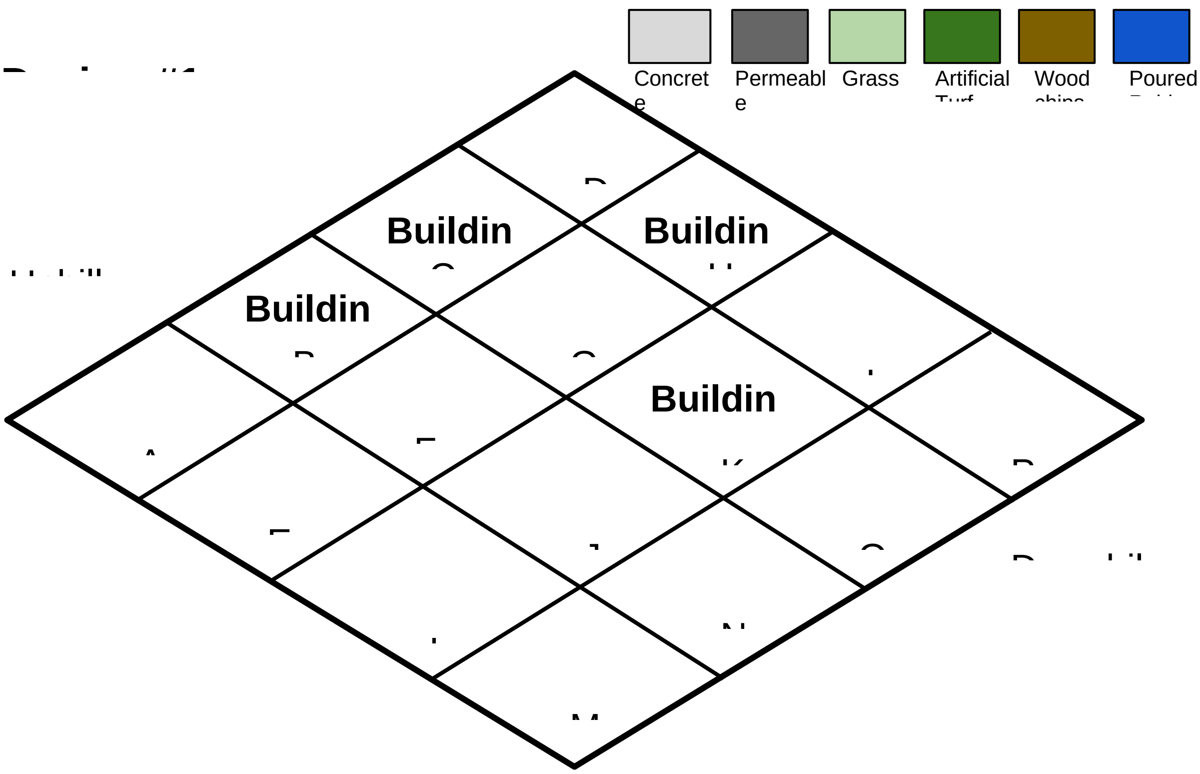
6.9. Make a design for Walker

Remember the **criteria to minimize water runoff after heavy rains**, **stay under budget of $750,000**, and the following:

Building	Grassy field	Play area	Parking	Accessible
4 squares (B, C, H, K)	At least 4 squares	At least 2 squares	At least 3 squares	At least 6 squares

Make Design #1:

- Label spaces with different purposes (grassy field, play area, parking).
- Color in what materials you choose using the key.
- Circle the accessible squares.



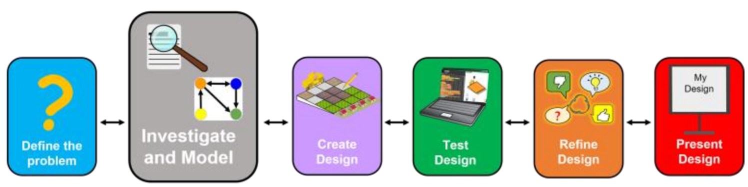
6.10. Check your design. How many squares does it have for each kind of area?

Building	“Grassy” field	Play area	Parking	Accessible

Does your design meet the criteria? **Yes** **No**

Closing Question: Why do we need a computer model to test our design?

Lesson 7: What language does the computer understand?



Opening discussion: What language does a computer understand?

7.1. TRUE/FALSE game (Whole class)

7.2. Play a dice game with your partner!

Instructions: We will play this game in pairs. Make sure you have a partner and start by deciding who will be PlayerA and who will be PlayerB in your group. Both players need to fill out the table in their notebooks.

For each game,

- Both partners roll dice and write down the values. PlayerA's dice is called DiceA and PlayerB's dice is called DiceB.
- Look at the instructions and decide whether each IF-THEN evaluates to TRUE or FALSE
- Based on which IF-THEN statement is TRUE, assign scores to PlayerA and PlayerB.

Player A name: ______________________________

Player B name: ______________________________

Game #1

Instructions	**DiceA** value	**DiceB** value	TRUE/FALSE
Roll your dice			
IF **DiceA** is equal to 3, THEN (Set **PlayerA**_score to 1 Set **PlayerB**_score to 1)			
IF **DiceA** is less than 3, THEN (Set **PlayerA**_score to 3 Set **PlayerB**_score to 0)			
IF **DiceA** is greater than 3, THEN (Set **PlayerA**_score to 0 Set **PlayerB**_score to 2)			

PlayerA_score = ______________ **PlayerB**_score = _______________

Game #2

Instructions	**DiceA** value	**DiceB** value	TRUE/FALSE
Roll your dice			
IF **DiceB** is equal to 5, THEN (Set **PlayerA**_score to 2 Set **PlayerB**_score to 2)			
IF **DiceB** is less than 5,			

THEN (Set PlayerA_score to DiceB Set PlayerB_score to 3)			
IF DiceB is greater than 5, THEN (Set PlayerA_score to DiceB-DiceA Set PlayerB_score to DiceA)			

PlayerA_score = ___________ PlayerB_score = _____________

Game #3

Instructions	DiceA value	DiceB value	TRUE/FALSE
Roll your dice			
IF DiceA is equal to DiceBB, THEN (Set PlayerA_score to 3 Set PlayerB_score to 4)			
IF DiceA is less than DiceB, THEN (Set PlayerA_score to 1 Set PlayerB_score to 2)			
IF DiceA is greater than DiceB, THEN (Set PlayerA_score to 5 Set PlayerB_score to 3)			

PlayerA_score = ___________ PlayerB_score = _____________

Game #4

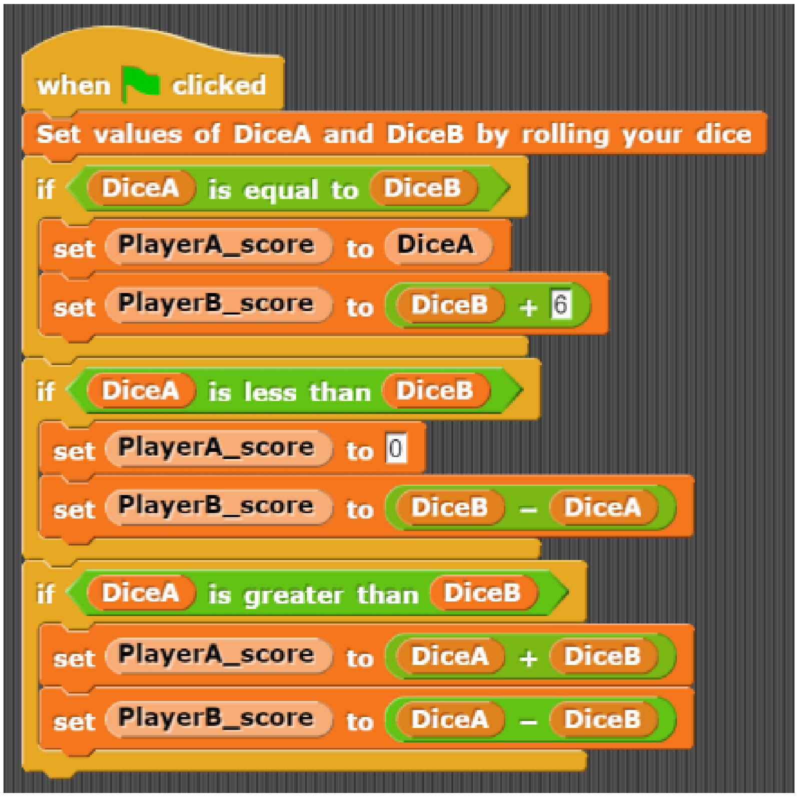
Instructions	DiceA value	DiceB value	TRUE/FALSE
Roll your dice			
IF DiceA is equal to DiceB, THEN (Set PlayerA_score to 3			

Set **PlayerB**_score to **DiceA**-1)			
IF **DiceA** is less than **DiceB**, THEN (Set **PlayerA**_score to **DiceA**+3 Set **PlayerB**_score to **DiceB**+1)			
IF **DiceA** is greater than **DiceB**, THEN (Set **PlayerA**_score to 2 Set **PlayerB**_score to **DiceA**-**DiceB**)			

PlayerA_score = ____________ **PlayerB**_score = ______________

7.3. Play a dice game by reading code (whole class activity)

This game is written in the language you will use to build your computer runoff model.

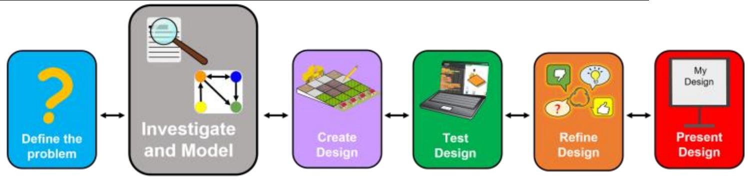


You will play the first 3 rounds as a class, then play 3 rounds with a partner.

	Dice variables		**Score variables**	
Round	**DiceA**	**DiceB**	**PlayerA_score**	**PlayerB_score**
1				
2				
3				
4				

5				
6				

Lesson 8: Build a computer model to calculate runoff from different surfaces



8.1. Create test cases. In our model, wood chips have an <u>absorption limit of 1 inch of rain</u>. How much rain will be **absorbed** and will **run off** for different amounts of rainfall?

We will use these numbers as **test cases** for our computer model.

Rainfall	Absorption limit (wood chips)	Absorption and runoff
1 inch	1 inch	• Absorption: __________ inches • Runoff: _________ inches
0.7 inches	1 inch	• Absorption: __________ inches • Runoff: _________ inches
1.4 inches	1 inch	• Absorption: __________ inches • Runoff: _________ inches
Test cases are numbers used to test whether a computer program is working correctly. You can use these values to test your computer model as you build it.		

8.2. Make the rules for the model: Complete the 3 rules below that the computer can use to calculate total absorption and total runoff when it knows the total rainfall. **Circle a variable or value that makes each rule work.**

Rule #1. If the total rainfall **is equal to** the absorption limit:

- set total absorption to (circle one):

  total rainfall   absorption limit   0 (zero)

- set total runoff to (circle one):

  total rainfall   absorption limit   0 (zero)

Rule #2. If the total rainfall **is less than** the absorption limit:

- set total absorption to (circle one):

  total rainfall   absorption limit   0 (zero)

- set total runoff to (circle one):

  total rainfall   absorption limit   0 (zero)

Rule #3. If the total rainfall **is greater than** the absorption limit:

- set total absorption to (circle one):

  total rainfall   absorption limit   0 (zero)

- set total runoff to: ________________________________ (write an expression)

8.3. Start building your computer model:

1. Login to the C2STEM system as instructed by your teacher.
2. Start building your model by adding the 

block
3. Set the amount of rainfall using the 

block. Drag a variable block or type in a value in each empty space.
4. Use the 

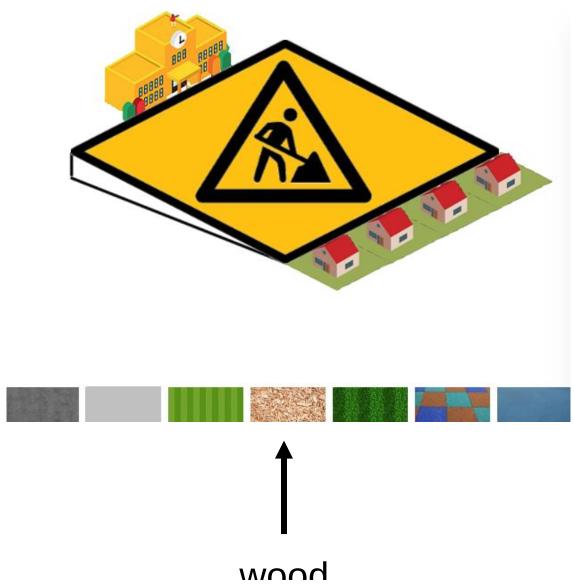
block to get the absorption limit of the material you are selecting.
5. Program **Rule #1** by dragging blocks from the left column. Use 

to assign variable values. Drag a variable block or type in a value in each empty space. Here are SOME of the other blocks you will need to use:

When you have completed Rule #1, be sure to SAVE YOUR WORK!!!

8.4. Now <u>test</u> whether your program is working using the test case:

- Choose **wood chips**, which have an absorption limit of 1 inch



<u>Test rule #1:</u>

- Run your program with 1 inch of rainfall: `set total rainfall (inch) to 1`.
- Move your mouse over the rain gauges to see the absorption and runoff. Record the results below.

Total absorption: __________ inches   Total runoff: __________ inches

- Does your model give the same result as your test case?   Yes   No
- Explain why or why not: ____

<u>Test rule #2:</u>

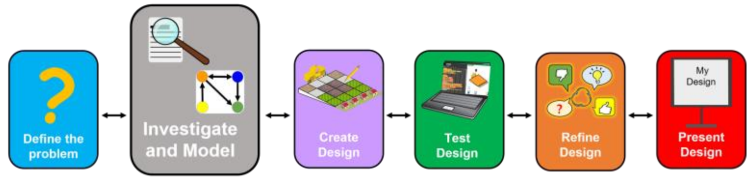
- Run your program with 0.7 inches of rainfall: `set total rainfall (inch) to 0.7`.
- Record results: Total absorption: _______ inches   Total runoff: _______ inches
- Does your model give the same result as your test case?   Yes   No
- Explain why or why not: ____

<u>Test rule #3:</u>

- Run your program with 1.4 inches of rainfall: `set total rainfall (inch) to 1.4`.
- Record results: Total absorption: _______ inches   Total runoff: _______ inches
- Does your model give the same result as your test case?   Yes   No
- Explain why or why not: ____

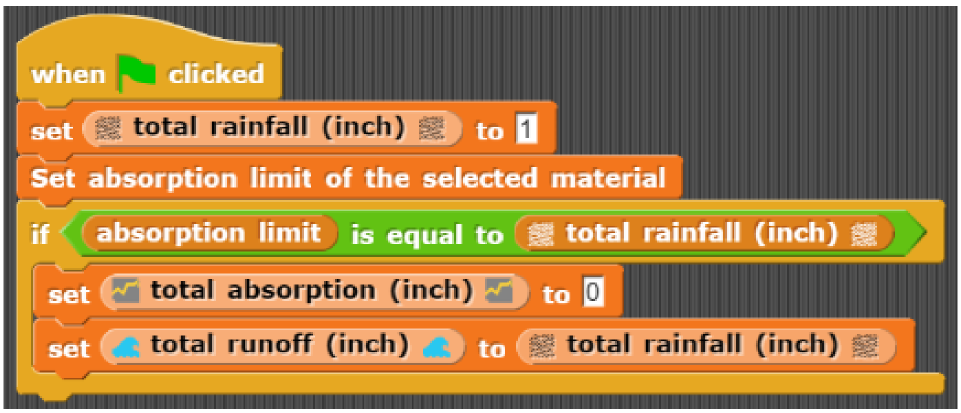
If Rule #1 does not work, try to fix it. **Remember to SAVE YOUR WORK!!**

Lesson 9: Build a computer model to calculate runoff from different surfaces



Opening activity: Debug another student's program

Here is a program a student wrote for Rule #1 from yesterday, but **<u>it does not give the correct results.</u>**



Mistakes in a program are called **bugs**. Fixing a program so that it works correctly is called **debugging**. Explain what is wrong with this program and how to fix it.

9.1. Continue building your computer model:

- Login to the C2STEM system as instructed by your teacher. You programmed Rule #1 yesterday.
- Drag blocks into the program to make Rule #2, **if total rainfall is LESS than the absorption limit**.
- Here are SOME of the blocks you will need to use:

When you have completed Rule #2, be sure to SAVE YOUR WORK!!!

9.2. When you finish making Rule #2, test whether Rule #2 is working.

- Choose wood chips that have an absorption limit of 1 inch.
- Run your program using the **test cases** from yesterday. Record the absorption and runoff from your model below.
- **Your model should give you the same result as your test case.**

Rule #1:

- Run your program with 1 inch of rainfall: 

.
- Record results: Total absorption: _______ inches Total runoff: _______ inches
- Does your model give the same result as your test case? Yes No

Rule #2:

- Run your program with 0.7 inches of rainfall: 

.
- Record results: Total absorption: _______ inches Total runoff: _______ inches
- Does your model give the same result as your test case? Yes No

Rule #3:

- Run your program with 1.4 inches of rainfall: 

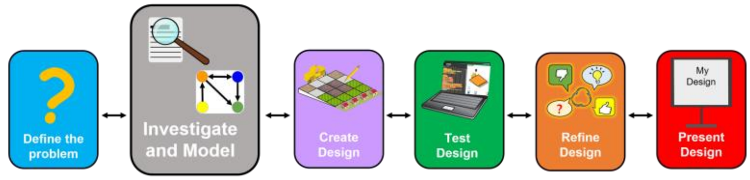
.
- Record results: Total absorption: _______ inches Total runoff: _______ inches
- Does your model give the same result as your test case? Yes No

9.3. Which rules work and which don't? Explain why.

If Rule #1 or #2 do not work, try to fix them. **Remember to SAVE YOUR**

WORK!!

Lesson 10: Build a computer model to calculate runoff from different surfaces



10.1. Continue building your computer model:

- Login to the C2STEM system as instructed by your teacher. You programmed Rule #2 yesterday.
- Drag blocks into the program to make Rule #3 (rainfall is GREATER than the absorption limit).

10.2. Now test whether all the rules are working in your computer model.

- Choose wood chips that have an absorption limit of 1 inch.
- Run your program using the test cases, then record the absorption and runoff from your model below.
- **Your model should give you the same results as the test cases.**

<u>**Rule #1:**</u> For 1 inch of rainfall:

- Run your program with the following input: `set total rainfall (inch) to 1`.
- Record the results below.

Total absorption: __________ inches Total runoff: __________ inches

- Does your model give the same result as your test case? Yes No

<u>**Rule #2:**</u> For 0.7 inches of rainfall:

- Run your program with the following input: `set total rainfall (inch) to 0.7`.
- Move your mouse over the rain gauges to see the absorption and runoff. Record the results below.

Total absorption: __________ inches Total runoff: __________ inches

- Does your model give the same result as your test case? Yes No

<u>Rule #3:</u> For 1.4 inches of rainfall:

- Run your program with the following input: `set total rainfall (inch) to 1.4`.
- Move your mouse over the rain gauges to see the absorption and runoff. Record the results below.

Total absorption: __________ inches Total runoff: __________ inches

- Does your model give the same result as your test case? Yes No

When you have completed Rule #3, be sure to SAVE YOUR WORK!!!

10.3. Bonus Challenge! Create a new test case.

- Your model should work with **any surface material**.
- Create test cases for artificial turf, which has an absorption limit of 0.6 inches. How much rainfall will you use to make sure all 3 rules in your model are working?

Test cases: Artificial turf

Rule	Rainfall	Absorption limit (artificial turf)	Absorption and runoff
#1	_________ inches	0.6 inches	• Absorption: __________ inches • Runoff: _________ inches
#2	_________ inches	0.6 inches	• Absorption: __________ inches • Runoff: _________ inches
#3	_________ inches	0.6 inches	• Absorption: __________ inches • Runoff: _________ inches

10.4. Now use your new test cases to test whether all the rules are still working.

Rule #1: For _______ inches of rainfall:

- Total absorption: __________ inches   Total runoff: __________ inches
- Does your model give the correct result?   Yes   No

Rule #2: For _______ inches of rainfall:

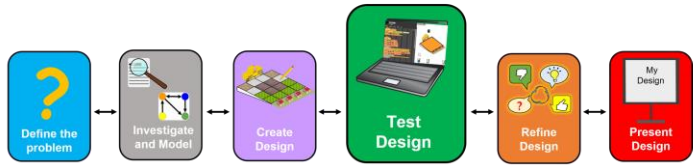
- Total absorption: __________ inches   Total runoff: __________ inches
- Does your model give the correct result?   Yes   No

Rule #3: For _______ inches of rainfall:

- Total absorption: __________ inches   Total runoff: __________ inches
- Does your model give the correct result?   Yes   No

Be sure to SAVE YOUR WORK!!!

Lesson 11: How can we test and improve our designs?



Discussion Question: How can we use our computer model to improve our designs?

The students and teachers at Walker have the following **criteria:**

Design criteria					
Building	**“Grassy” field**	**Play area**	**Parking**	**Accessible**	**Cost ($)**
4 squares (B, C, H, K)	At least 4 squares	At least 2 squares for hardcourt, 1 square for swings	At least 3 squares	At least 6 squares	No more than $750,000

Water flow performance	
Total rainfall	**Total runoff (inches)**
At least 2 inches	As low as possible

11.1. Find Design #1 on page 23. Test your design with your computer model to see how well it meets project criteria. Fill in the tables below.

Design criteria					
# Building squares	**# “Grassy” squares**	**# Play squares**	**# Parking squares**	**# Accessible squares**	**Cost ($)**

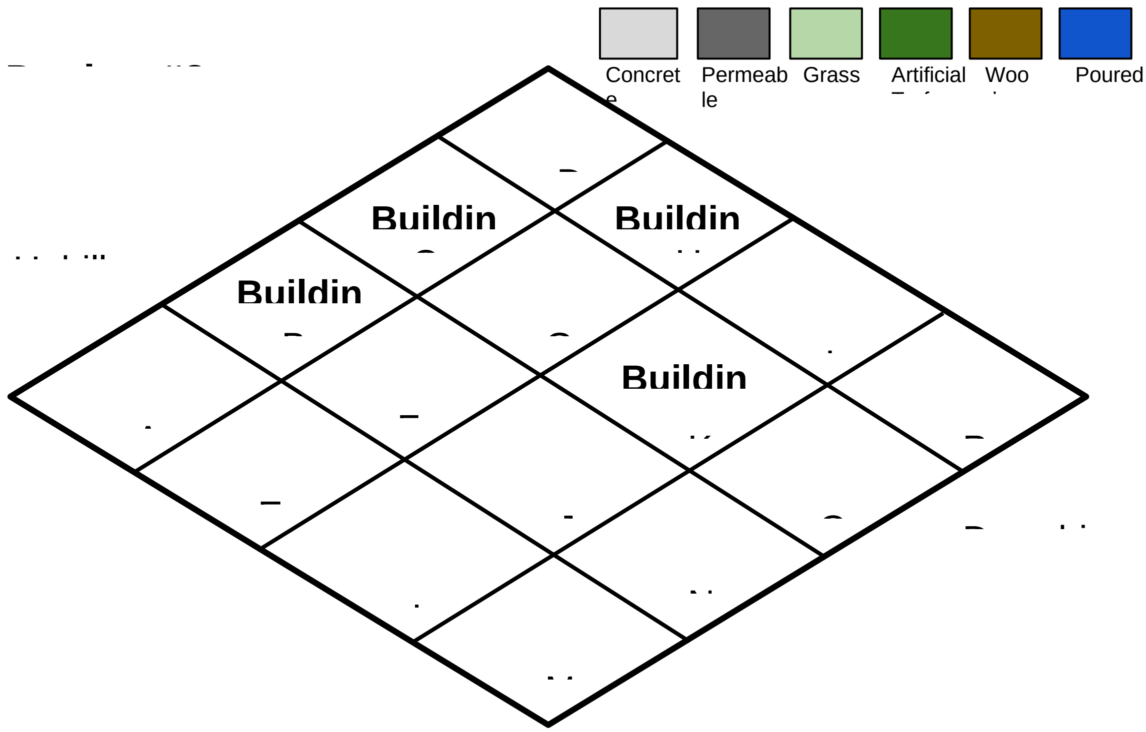
Water flow performance		
Total rainfall (inches)	Total absorption (inches)	Total runoff (inches)

11.2. Does your design meet the criteria for **numbers of squares**? Yes No

11.3. Does your design meet the criterion for **cost**? Yes No

Create more designs. Engineers create many designs before making a decision. Can you improve your design by reducing runoff? Reducing cost? Improving accessibility?

11.4. Create Design #2 to **improve Design #1.**



Use your computer model to test Design #2:

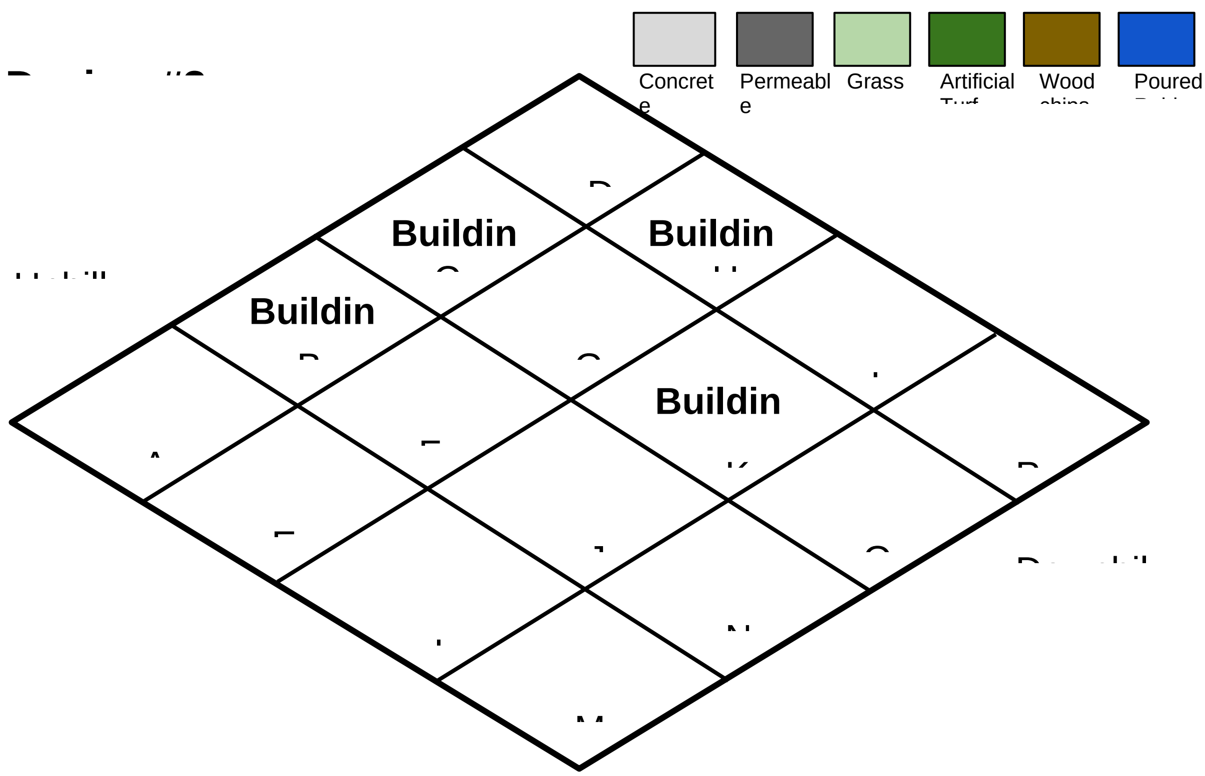
Design criteria					
# Building squares	**# "Grassy" squares**	**# Play squares**	**# Parking squares**	**# Accessible squares**	**Cost ($)**

Water flow performance

Total rainfall (inches)	Total absorption (inches)	Total runoff (inches)

11.5. How does Design #2 improve Design #1?

11.6. Create Design #3 to improve Design #1 or #2.



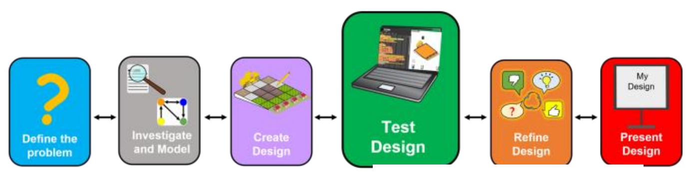
Use your computer model to test Design #3:

Design criteria					
# Building squares	**# "Grassy" squares**	**# Play squares**	**# Parking squares**	**# Accessible squares**	**Cost ($)**

Water flow performance		
Total rainfall (inches)	Total absorption (inches)	Total runoff (inches)

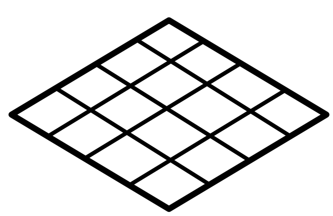
11.7. How does Design #3 improve Design #1 or #2?

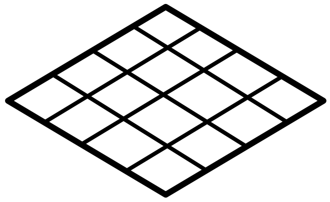
Lesson 12: How do you know what design will be the best?

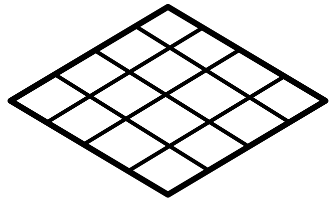


Discussion Question: How can you design a fair race?

12.1. When you test 2 designs to compare them, how can you be sure the test is **fair**? Write down your ideas below.







12.2. Conduct a fair test of your designs by filling in the table below with your 3 designs from your computer model.

	Design 1 (p. 37)	**Design 2 (p. 38)**	**Design 3 (p. 39)**
Total grassy field squares			
Total play area squares			
Total parking squares			
Total accessible squares			
Cost ($)			
Test your design			
Total rainfall (inches)			
Total absorption (inches)			
Total runoff (inches)			

12.3. Circle the part of the table above that makes your test a FAIR TEST.

12.4. What design(s) had the **most** accessible squares? **1** **2** **3**

12.5. What design(s) had the **lowest** cost? **1** **2** **3**

12.6. What design(s) had the **lowest** runoff? **1** **2** **3**

12.7. Is the design with the lowest runoff also the cheapest and most accessible design?

Yes No Explain why or why not: ________________________

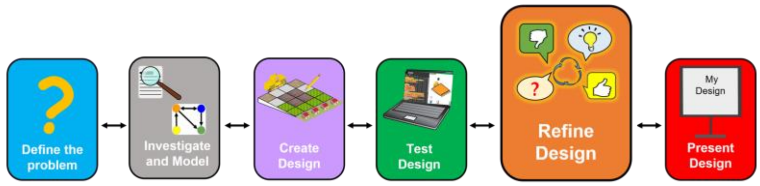
____

12.8. What design do you think is best? (circle one) **1** **2** **3**

12.9. Why did you choose that design? ______________________________________

____

Lesson 13: How can you use the model to improve your design?



13.1. Improve your best design from yesterday

- Login to the C2STEM environment as instructed by your teacher
- What was your best design from yesterday? Design # ________
- Put this design into the computer model.

Now try to improve on this design by changing it, testing it, and comparing the results to a previous design.

Each time you find a design you like, record it on your **"New and Improved" design data sheet**. Use as many sheets as you like.

13.2. Work with your team to make the best design

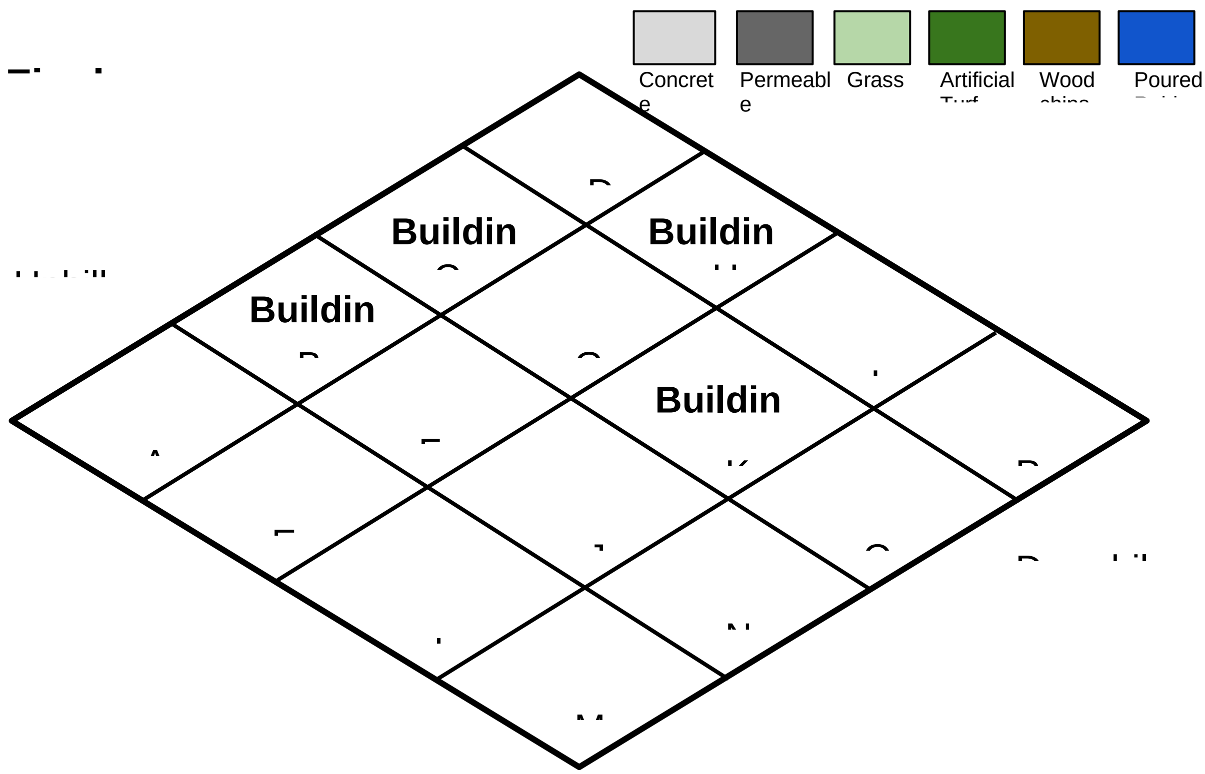
- Compare different students' designs. (Are you conducting a fair test?)
- Can you combine parts of 2 different designs into a single design?
- Test the design to make sure it meets all the criteria:

Design criteria					
Building	**"Grassy" field**	**Play area**	**Parking**	**Accessible**	**Cost ($)**
4 squares (B, C, H, K)	At least 4 squares	At least 2 squares for hardcourt, 1 square for swings	At least 3 squares	At least 6 squares	No more than $750,000

Water flow performance	
Total rainfall	**Total runoff (inches)**
At least 2 inches	As low as possible

13.3. Finalize your group's design

- Below, make your final sketch of your design that you will present to the class.
- Complete the table to show that your design meets the criteria.



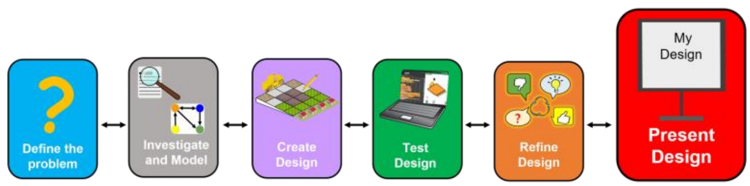
Use your computer model to test your Final Design:

Design criteria					
# Building squares	**# "Grassy" squares**	**# Play squares**	**# Parking squares**	**# Accessible squares**	**Cost ($)**

Water flow performance		
Total rainfall (inches)	Total absorption (inches)	Total runoff (inches)

Why did you decide on this final design over other ones?

Lesson 14: How can you convince the Principal at Walker to use your design?



Discussion Question: What makes a good presentation?

14.1. Create a presentation to convince the Principal at Walker to use your design. Use the template given to you by your teacher. You will want to show:

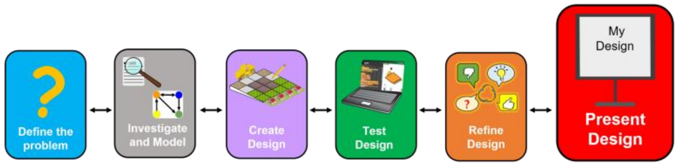
- **The problem**
  - Your understanding of the problem. What is the problem at Walker School? (Hint: Look back at Lesson 1).
  - What problem does this cause for the school and the environment? (Hint: Look back at Lesson 1).
  - What happens when it rains at Walker? (Hint: Look back at Lessons 2-5)
- **Our scientific model of the problem**
  - What is your scientific model of what happens when it rains? (Hint: Put your models from Lessons 4-5)
- **Our design and evidence**
  - Put in a picture of your 16-square design (you can take a screenshot of your computer model)

    - Test data supporting your design (put numbers into the tables)

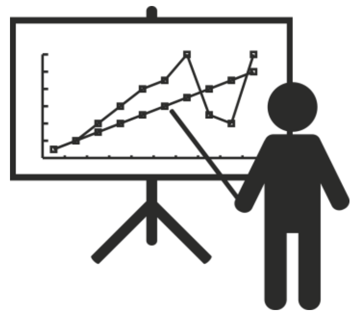
- **Why our design is better than others we tried**
    - Describe at least 2 designs, including your final design. Include a table or pictures of the designs you tried. Why did you choose your final design? What trade-offs did you have to consider? Was there another design you could have chosen?
    - Why the principal should choose your design--Summarize how your design solves the problem at Walker School.

14.2. Once you have your presentation, practice your presentation to yourselves. Who in your group is going to say what parts? You can take notes below.

Lesson 15: Final Presentations



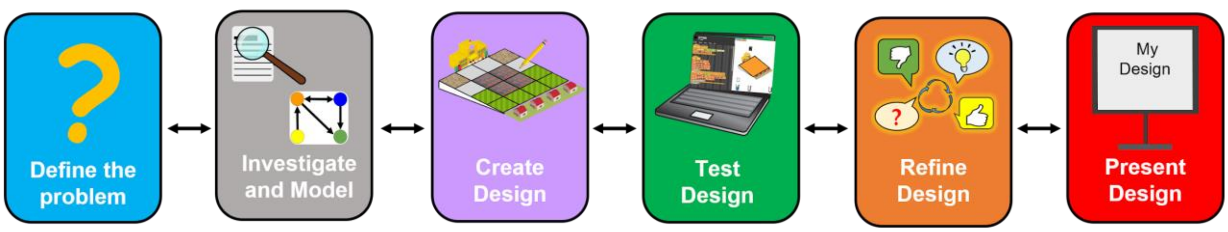
Be sure to be excellent audience members for your class and provide the same respect that you would like during your presentation!



Congratulations!

You have finished the project. You were engineers that helped design solutions that helped the students and teachers at Walker as well as helped the environment.

You have done so much during this project, including all of these design phases!



Be sure to keep thinking of how you can apply the science you learn in the future to solve engineering problems that benefit all of us!

Glossary of key terms

Science terms

Absorption	Rainwater that soaks into the ground surface
Absorption limit	The maximum amount of water that a surface material can absorb
Model	A scientific model explains how we think something happens or predicts what we think will happen. A model could be an object, drawing, mathematical expression, or computer program
Prediction	A statement about what you think will happen based on observation
Rainfall	Water that comes out of the sky as rain
Rain gauge	A device used to measure the amount of rain that falls (usually in inches)
Runoff	Rainwater that stays on top of the ground surface and flows downhill

Engineering terms

Design criteria	Requirements for how something should be designed
Engineering	A process of reaching a problem solution. A person who solves problems that address our wants and needs is an *engineer*.
Fair test	A way to test 2 or more solutions so that they can be compared to each other
Trade-off	Where designs must sacrifice one thing to improve on another

Computing terms

Bug	A mistake in a computer program. Fixing these mistakes is called *debugging*
Expression	A statement combining variables and operators, such as “Your_Age is equal to 10”
Operator	A word or symbol that acts on one or more numbers. Examples include plus, minus, equal to, and less than.
Test case	A set of values used to test whether a computer program is working correctly
Variable	An amount or quantity that can be changed