



# Supporting Divergent Thinking during & Revising models

Toward Justice-Centered Ambitious Science Teaching (AST) © 2023



# Divergent thinking & critical reflection

As we lead students through sensemaking activities we want to emphasize the validity of different forms of evidence.

Hands-on learning can be powerful because it gives students a common experience (and evidence) to collectively reason around but we need to think about ways to empower diverse ideas and perspectives.



Beginning of a unit



End of a unit

**Example 1: 4th  
grade**

# Revising Ideas with models



# Example 2: 3rd grade

# 3rd grade Student S's Initial Model


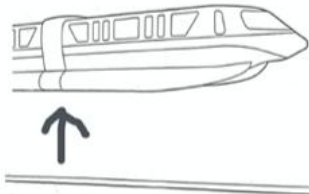
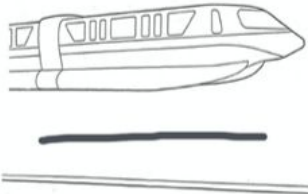
Name: \_\_\_\_\_ Date: \_\_\_\_\_ Version: \_\_\_\_\_

**How Does the Floating Train Work?**  
 Directions: Draw, label and write what you think is happening about what we can see and what we can't see.

How does the train rise?

How does the train float?  
 Challenge Question: How does the train move forward?

How does the train fall?

How does the train rise?

by magnets,  
 because it is  
 made of  
 metal

How does the train float?

by using the  
 sides to keep  
 balance and  
 let it float

**it wil move  
 by using  
 either  
 motors**

How does the train fall?

by turning off  
 the magnets

# S created a magnet trick

Reasoning with the differing strengths of magnets, distance between magnets and their forces and the positioning of magnets with grandma.

## Directions:

1. Write about one of the magnet tricks you created or observed. Explain how you think it worked. You can look back at the reference book, **Handbook of Forces**, if it helps you explain the magnet trick.
2. Use the words in the Word Bank when you write.

### Word Bank

attract	exert	magnet	magnetic force
evidence	change	repel	

## Type your answer here

**i think how it work is like this, so the magnet is big right? if itd big enough then it could do that**

and how it didnt fly is like this, the top magnet is far and is ontop of it and the bottom one is too heavy to go up from a far distance but it can try to connect but it didnt cuz its hevyy so it moves where the bottom one movess

The screenshot shows a web browser window with the URL `app.seesaw.me`. The page displays a video player with a video of a child in a dark t-shirt with a Batman logo, sitting at a table and holding two magnets. A text box above the video reads "Video or draw your magnet trick here then go to". The browser's address bar shows "Multimodal & Hands-on Learning with Amplify - Google Slides". At the bottom right, there are icons for "GET IT ON Google Play" and "Download on the App Store".

**What did you notice about  
how the S engaged in  
making sense of the  
activity?**





# Some other magnet tricks from this class.



magnet  
magnet table



## S shared his ideas during a class discussion

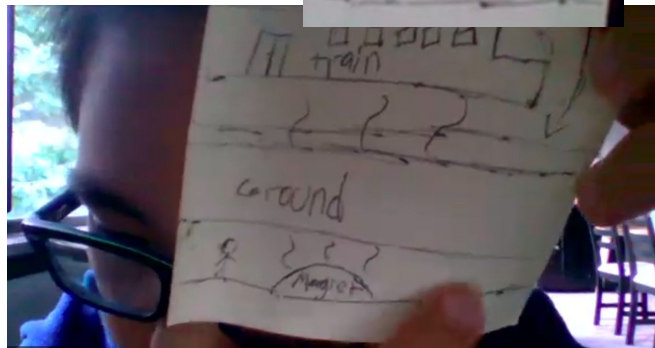
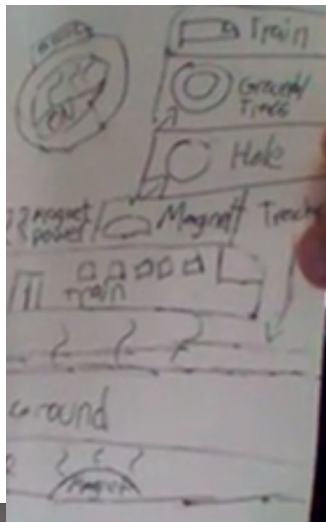
**Student S:** So this is how I think the train floats---so like--you see that rock underground, right? [Hmm huh.] That is the magnet. And the hole under, that is where the magnet is going to go. And then the magnet can feel the big magnet under it. So the magnet power goes underground and through the tracks on onto the train. [hmmm.] And here is this thing. It tells you what they are.

**Teacher:** Oh! You added a key! Awesome. Okay, let's get two people to ask SG a question because this is something scientists do.. Who has a question?

...

**Student G:** Uhm, S, uhm, my question for you is...my question for you is...uhmm... I really like your drawing, and how there is a ton of details but umm like but are those lines air?

**Student S:** Oh, that is the magnet power. Like you know when a magnet like repels you can't see the air going up? That is just the magnet power so you know what's happening.



# Student S's revised his thinking after chapter two...

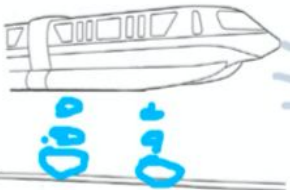
Now SG has ideas about how the train is stabilized and moves forward with different forms of "focused power". We see that he is wrestling with the position of magnets, their strength and is using force vocabulary to explain his ideas more clearly.

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Version: \_\_\_\_\_

**How Does the Floating Train Work?**  
 Directions: Draw, label and write what you think is happening about what we can see and what we can't see.

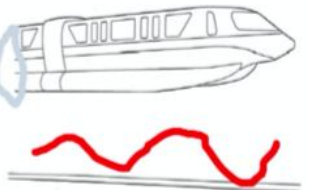
*You must draw and type!  
 Closer up picture in the next pages*

How does the train **rise**?



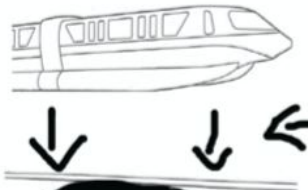
it rises by magnets, because the track turns on a big magnet to make it float, and the bottom part of the train is supposed to repel.

How does the train **float**?  
 Challenge Question: How does the train **move forward**?



type by letting the magnets focus so it wont wobble so you just have to wait and it moves by supersonic fans that spin super fast like a helicopter but its at a angle so it pushes it

How does the train **fall**?

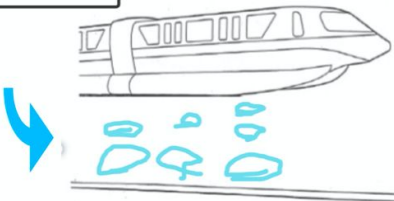


type it falls by turning off the underground magnet

ON  
OFF

**magnet power**

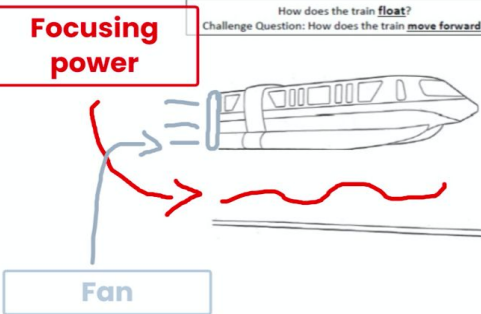
How does the train **rise**?



type It rises by magnets, because the track turns on a big magnet to make the bottom part of the train to repel and float.

**Focusing power**

How does the train **float**?  
 Challenge Question: How does the train **move forward**?



Fan

type By letting the special magnet focus so the train wont fall or wobble. The train moves by air, they turn on really strong fans to make it go fast, they can make the power go down or up so the train would stop and also go slow.

**What did you notice about  
how S changed his  
thinking?**

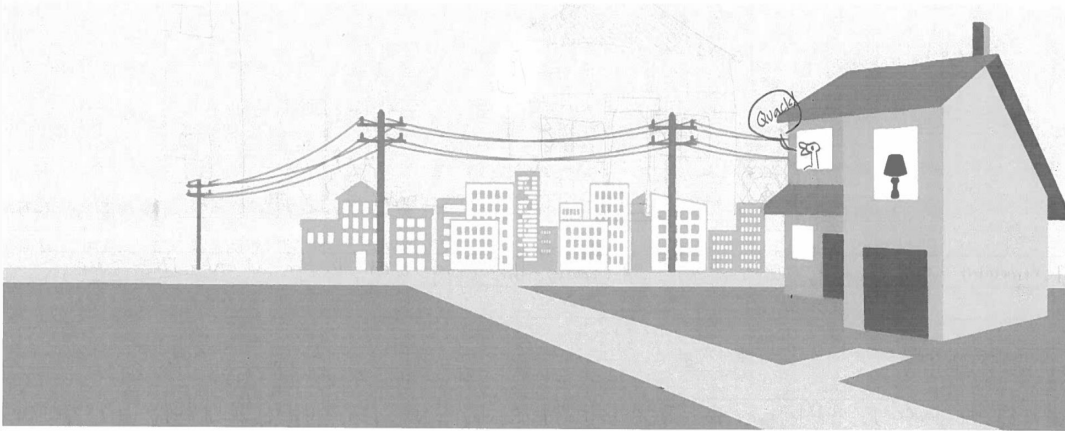


# Example 3: 4th grade

# Initial Model

## Why does Ergstown lose power so often?

Instructions: Draw and write why Ergstown loses power so often. There are multiple answers!



### Explain why Ergstown loses power so often:

Ergstown is a common thunder+lightning storm area & the thunder + lightning is striking the power lines down. Also alot of birds in Ergstown have a disease making them really heavy and they have have heart attacks alot so they fall out of the air and snap the wires on the power lines.

## Noticings and Connections:

- Thunder and lightning is striking power lines
- There are lots of birds in Ergstown. They have a disease which makes them heavy and have heart attacks
- The birds fall out of the air and snap the wires on the power lines

## Potential back pocket questions:

- Can you tell me more about why the birds are getting sick?
- I notice that you are saying that the thunder and/or the birds hit the power lines. How might this cause a blackout? **[System has many parts that work together; relationships between the parts]**

# Final Model

**Why does Ergstown lose power so often?**

Instructions: Draw and write why Ergstown loses power so often. There are multiple answers!

Lightning causes tree to fall down

electrical energy going through electrical grid

storm causing wires to snap causing energy to stop going through electrical grid

system malfunction in energy source causing power to go out b/c of part not working in energy source/converter

electrical grid stopping electrical energy to houses/buildings

tree connection

connection lost b/c of broken power source

power out b/c of broken wires or source breaking down

tree falling causing electrical grid to stop working

Explain why Ergstown loses power so often:

I think one reason why the power is going out in Ergstown, is b/c on the weather report states that there is a lot of stormy weather in Ergstown causing trees to fall down on electrical grid causing Electrical grid to stop transferring electrical energy to houses/buildings in Ergstown causing a blackout. Another reason is b/c the power source has a part missing/broken that it needs for it to work. Due to the part, the electrical power source breaks down, & stops giving energy to Ergstown causing another blackout.

## Noticings and Connections

- Stormy weather is causing trees to fall on electrical grid
- Electrical grid stops transferring electrical energy to buildings causing a blackout
- The power source has a missing part/is broken, so it stops giving energy.

## Potential back pocket questions to elicit students' ideas:

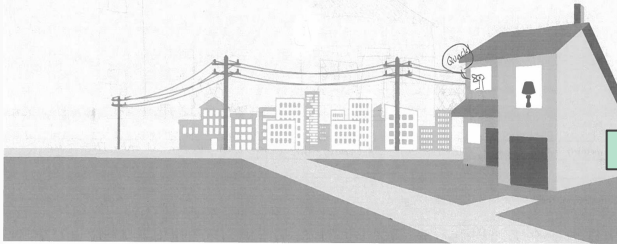
- I notice that you said that the electrical grid stop working. What are the different ways that the electrical grid can stop working? **[Electrical grid must have a source and a source converter; so there wasn't enough energy from the source, there weren't enough source converters, or the source converters were broken]**
- From your picture, it looks like the tree can also fall on the power lines. How might this cause a blackout? **[Wires can transfer electrical energy from place to place; electrical devices won't function if the wires that connect the source converter and devices are broken]**

# Changes in thinking: Initial & Final Models

## Initial Model

**Why does Ergstown lose power so often?**

Instructions: Draw and write why Ergstown loses power so often. There are multiple answers!

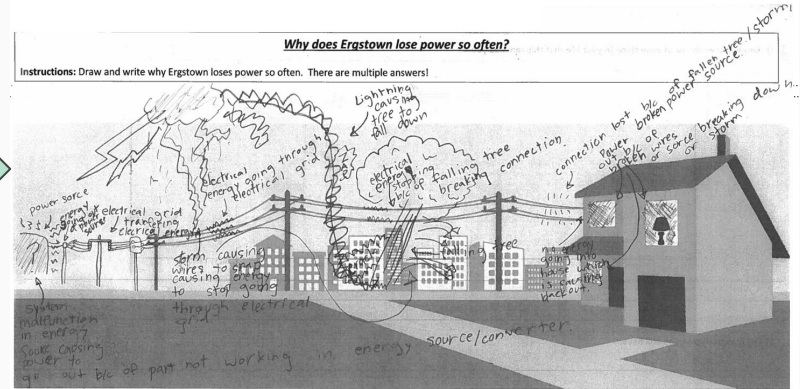


**Explain why Ergstown loses power so often:**  
Ergstown is a common thunder/lightning storm area & the thunder + lightning is striking the power lines down. Also a lot of birds in Ergstown have a disease making them really heavy and they have have heart attacks alot so they fall out of the air and snap the wires on the power lines.

## Final Model

**Why does Ergstown lose power so often?**

Instructions: Draw and write why Ergstown loses power so often. There are multiple answers!



**Explain why Ergstown loses power so often:**  
I think one reason why the power is going out in Ergstown is b/c on the weather report states that there is alot of stormy weather in Ergstown causing trees to fall down on electrical grid causing electrical grid to stop transferring electrical energy to houses/buildings in Ergstown causing a blackout. Another reason is b/c the power source has a part missing/broken that it needs for it to work. Due to the part, the electrical power source breaks down, & stops giving energy to Ergstown causing another blackout.

Handwritten annotations in the drawing include: "Lightning causes tree to fall down", "electrical energy going through electrical grid", "falling tree breaking connection", "connector lost b/c of broken power source", "power source", "storm causing wires to snap causing energy to stop going through electrical grid", "system malfunction in energy source causing power to go out b/c of part not working in energy source/converter", "electrical grid", "falling tree", "breaking connection", "connector lost b/c of broken power source", "power source", "storm causing wires to snap causing energy to stop going through electrical grid", "system malfunction in energy source causing power to go out b/c of part not working in energy source/converter".

## How did the student grow?

- The student expands on their initial hypothesis (e.g., Stormy weather is causing trees to fall on electrical grid)
- The student explains theoretical principles (e.g., Electrical grid stops transferring electrical energy to buildings causing a blackout)
- The student was able to draw the connections between different parts of the electrical system (please see drawing)

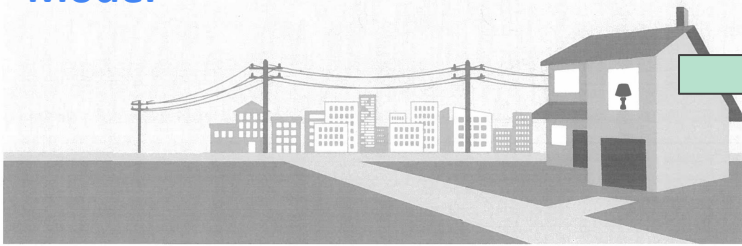


# Changes in thinking: Initial and final models

## Initial Model

Why does Ergstown lose power so often?

Instructions: Draw and write why Ergstown loses power so often. There are multiple answers!

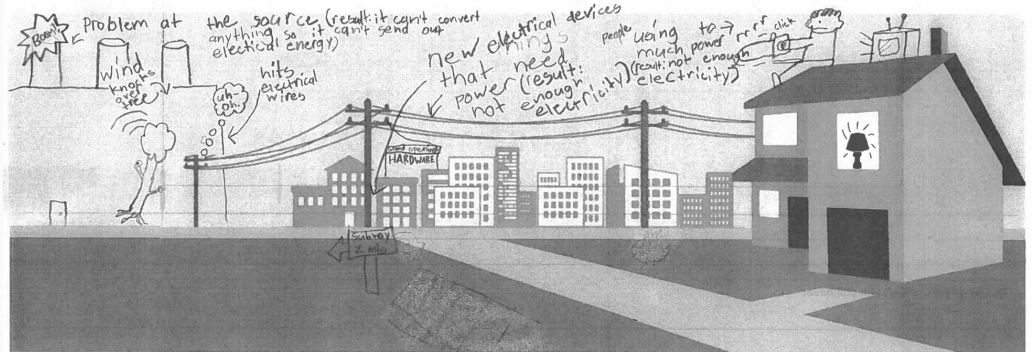


Explain why Ergstown loses power so often:

they use so much power that they can't keep it on very often.

Why does Erastown lose power so often?

Instructions: Draw and write why Ergstown loses power so often. There are multiple answers!



Explain why Ergstown loses power so often:

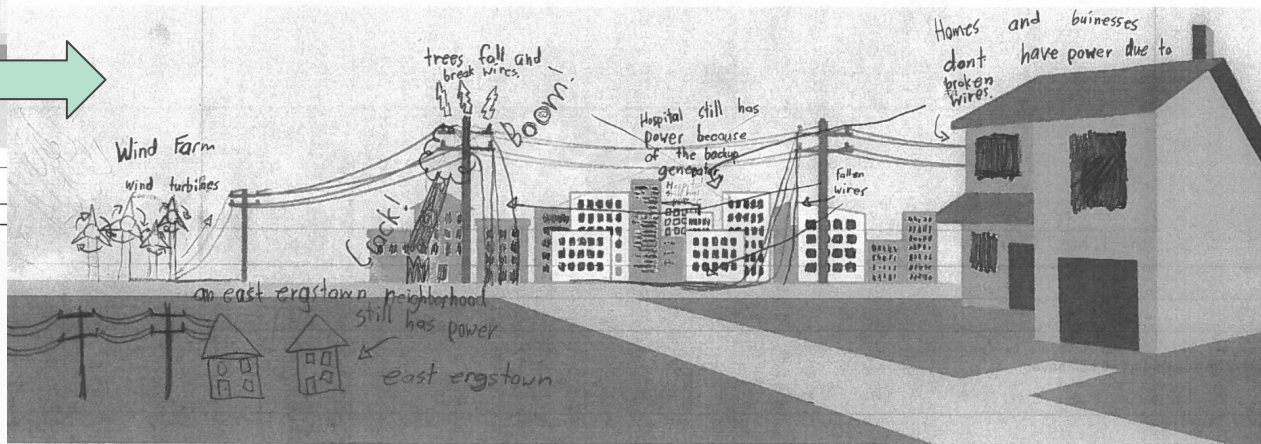
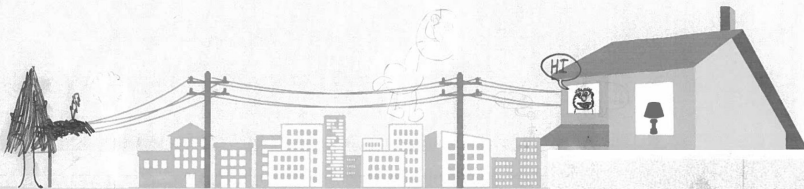
People use a lot of power and the wind could also be a problem since it can knock over power lines. Also, we don't know what the source of electrical energy comes from so that could be a problem too. Ergstown is adding new hardware stores and a subway which both need a lot of energy.

## Final Model

# Changes in thinking: Initial & Final Models

Why does Ergstown lose power so often?

Instructions: Draw and write why Ergstown loses power so often. There are multiple answers!



Explain why Ergstown loses power so often:

because trees hit the power line.

Initial  
Model

Final  
Model

Explain why Ergstown loses power so often:

Because trees are falling on the power lines/poles.  
The wires can't transfer energy to businesses and homes because they're broken.

# **Example 4: Kindergarten**

# Initial Model

**Student F Initial Model:**

Nombre: [Redacted] Fecha: 13/11/17

¿Cómo se forma el charco?

¿Porque, ahora, el charco es más pequeño?

The diagram is divided into two panels by a vertical line. The left panel is titled '¿Cómo se forma el charco?' and shows a cloud with rain falling into a large blue puddle. The right panel is titled '¿Porque, ahora, el charco es más pequeño?' and shows a smaller puddle with a rainbow above it and a stick figure splashing water. A sun is drawn in the upper right of the right panel. A large grey arrow points from the left panel to the right panel.

## The Teacher Notices these Anticipated Scientific Ideas through Student Modeling:

- clouds bring rain
- rain makes puddle
- puddles form when it rains a lot
- puddles get smaller when there is more sun/heat
- puddles get smaller when people splash water out

## The Teacher Notices these Unexpected Scientific Ideas through Student Modeling:

- rainbow is present when there are clouds
- the rainbow covers the rain from reaching the puddle and with time makes the puddle shrink

## Teacher Reflection after Initial Modeling Interaction with Student F

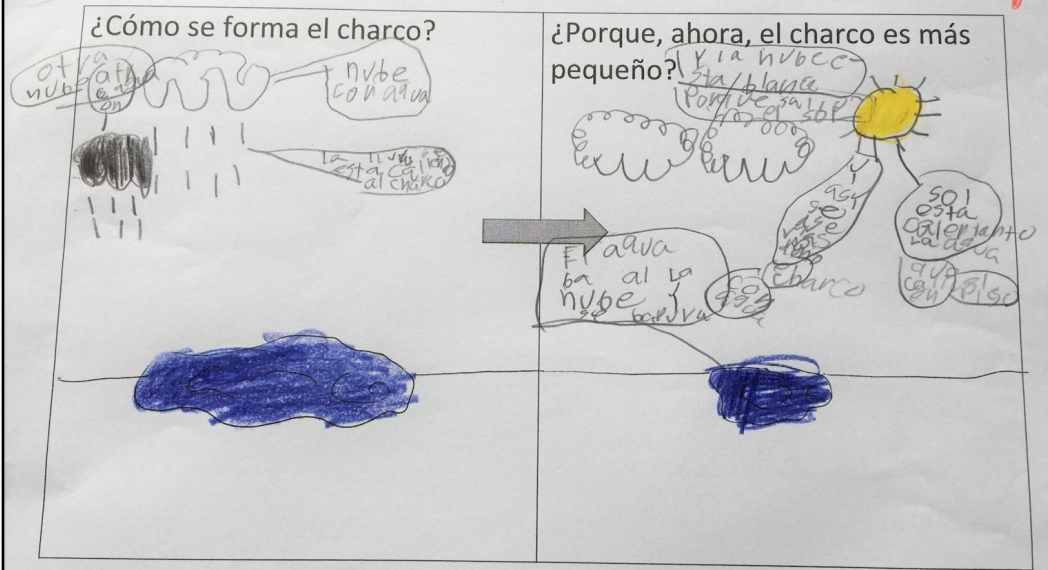
“Student F knew that rain makes the puddle and that rain comes from clouds but he can explore more the concept of where clouds come from. Also, he was a little confused about the relationship between clouds, rain, sun and rainbow and the disappearing of the puddle” (GGG, Lesson 1 Reflection).

# Final Model

## Student F Final Model:

Nombre: \_\_\_\_\_

Fecha: 17/4/17 \_\_\_\_\_



## Teacher Notices Student's Scientific Thinking in Final Modeling Interaction:

- clouds bring rain
- rain makes puddle
- puddles form when it rains a lot
- puddles get smaller when there is more sun/heat
  
- water changes from a liquid to a gas and goes into the sky (evaporation)
- heat comes down to the puddle and makes little bits of water move fast and break away

NOTE: Sticky notes are teacher recorded notes about student ideas

# Example 5: Kindergarten

Name: \_\_\_\_\_

Student #1

INITIAL MODEL

How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?



Transl. from Spanish:  
(The kids made a garden & so they went somewhere else.  
I don't know where they went.)

---

---

---

Name: \_\_\_\_\_

Student #2

Date: \_\_\_\_\_

INITIAL MODEL

How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?



I think they died. Maybe they ran away.



MR. JIMMY



Name: \_\_\_\_\_

**Student #3**

Date: \_\_\_\_\_

INITIAL MODEL

*How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?*



They're gone. They're  
dead.

Two sets of horizontal lines for writing, each consisting of a solid top line, a dashed middle line, and a solid bottom line.

Name

Student #4

Date: \_\_\_\_\_



*How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?*

INITIAL MODEL



They died.

Name: \_\_\_\_\_

Student #5

Date: \_\_\_\_\_

How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?



INITIAL MODEL



maybe the animals ate the caterpillars.

A A B H Q X F R A O A T H C A D P F L L O

Name: \_\_\_\_\_


Student #1



How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?



FINAL MODEL

El gusanos y las plantas necesitan agua.  
Después  El g

WAX P KNOFOA



Name:

Student #2

e: \_\_\_\_\_



FINAL MODEL

How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?



caterpillar  
Sun  
Water  
they need the milk  
weed so they don't  
die

Milk weed. The  
caterpillars need  
to eat milkweed.  
And the milkweed  
needs water &  
sunlight.

Name:

Student #3

Age: \_\_\_\_\_

k ✱

How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?

FINAL MODEL



Nam

Student #4

ate: \_\_\_\_\_



FINAL MODEL

How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?



Rain + sun

THEY'RE SURVIVING THEM

Name: \_\_\_\_\_

Student #5

te: \_\_\_\_\_

FINAL MODEL

How can the kids in Mariposa Grove bring back caterpillars to their neighborhood?



THE CATERPILLAR IS EATING THE APPLE WOOD