SCED 480

Name: Wendelin Dunlap **Curriculum (Kit) Title:** Water
Lesson Title: Investigation 4: Waterworks – Part 2: Water Wheels
Grade level: Third

Curriculum Context/Long Term
Goals: How does this lesson contribute to the big idea(s) of the curriculum (kit) and specific unit?

Big Idea & Connection of Lesson:

1) What are the big ideas of the curriculum?

Water is one of the most important substance on earth. The focus for this lesson will be the discovery of how water responds to temperature variations such as condensation, the properties of surface tension, and interaction with different materials. Water expands when it is heated and retracts when heat taken away. Surface tension causes water to stick together causing it to form into a ball. Dissolving materials into water effects properties of surface tension. Water flows more easily through some earth materials than others such as soils verses gravel. Condensation occurs when water vapor touches a cool surface and changes into liquid. Evaporation can be used to detect materials dissolved in water. Flowing water can be used to do work.

2) How does this lesson fit with one of the big ideas of the curriculum? How does this lesson help students make those connections?

Now that students have learned that water flows through non-porous materials more easily than porous materials; they will learn that flowing water can be used to do work and that waterwheels are a kind of machine that flowing water can power to lift loads or create electricity.

3) Are there any specific lessons that need to have preceded this lesson? Are there specific areas of knowledge, skills, or background experience that are necessary for the students to be able to successfully engage in this lesson (**content or practice**)?

Content: Students should have already completed Surface Tension which is the introductory lesson for water. From that lesson, students should have begun to understand what happens to water when poured onto a waterproof surface. They should also have completed the Water in Earth Materials lesson so that they understand that water flows in different amounts depending on the material.

Practice: It would be beneficial if students have had prior experience building models, but since children are natural builders, they should catch on to the process quickly.

Learning Targets for this lesson:

1. **Content**
    a. **Content Learning Target**

Water can do work when used to power specific machines such as waterwheels.

b. **Content Learning Target Assessment**

After building water wheel in groups, students will explain that most effective design is one where the plastic disk grips the shaft most firmly and the water from the plunger hits the blades more closely to a vertical position verses horizontal because this creates the strongest downward force for lifting the binder clip.

c. **NGSS Standard from DISCIPLINARY CORE IDEAS**
ETS1.A: Defining and Delimiting Engineering Problems
Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

2. **Science Practice Learning Targets**
   a. **Write a target for one science practice that is the focus in your lesson. This is just a statement of the practice such as "Scientists build claims based on evidence."**
   Scientists use models to evaluate systems that are too large or expensive to test and manipulate in real scale.

   b. **Science Practice Learning Target Assessment:**
   Students will be able to draw and label the essential parts of a water wheel, explain how those parts function to create force and critique each other's designs by providing ideas about how the water wheel can be made to function more effectively. Students will learn that by building a model, it is easy to test multiple different designs in a short amount of time to determine the most effective solution to an engineering problem.

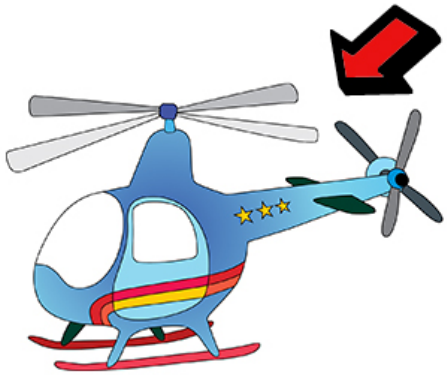
   c. **NGSS Language from Appendix F**
   Practice 2 Developing and Using Models - Grades 3-5
   Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.

3. **Academic Language-**
   a. What are the key vocabulary items (content-specific terms) or language necessary to understand this lesson?
   1. water wheel – a machine that can be used with water to do work.

2. model – a smaller copy of something

model

3. blade – a part that spins around and moves air or water

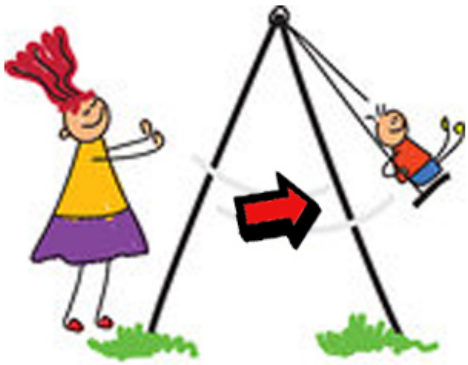


blade

4. shaft – a long thin stick

shaft

5. force – to push in a direction



force

b. How will you teach students that vocabulary/language? (LAST LESSON ONLY)
As the vocabulary words come up in the lesson, the teacher will ask students what they think the word means and record different answers on an overhead projector. Teacher will ask the students which answers they feel are correct and ask why or why not.

SIOP Strategies:

1. If it is possible to demonstrate the definition: the teacher will demonstrate the property but rely on students to create and refine the definition then write it in their own words in their notebook.
2. The teacher will leave the overhead projector on during the entire assignment with the correct answers circled so that emerging ELLs can have more time to write their answers in their notebooks, ask questions as the lesson progresses and refer to the answers throughout the lesson as more hands on experience is gained.
3. The teacher will provide photos to help students see examples of the definition and associate it with other prior knowledge when possible.

YOU DO NOT NEED TO LIST MATERIALS IN SCED 480

ASSESSMENT PLAN:

What are the known misconception(s)?
Common misconceptions about energy, movement and force:

- Many children appear to link energy with movement and force thinking that movement determines whether energy is present and therefore not present in non-moving systems.
- Children often do not differentiate between energy, work, force and power.
- Confusion between energy, force, friction, work, gravity and "potential energy" with the potential to have energy.
- Merging of the ideas of energy and fuel leading of thoughts that the earth will eventually run out of fuel/energy and not realizing that energy can be made without fossil fuels.

Pre-Assessment: (**content and practice**):
How will you find out what/how **ALL** students think about the targeted content and science practice addressed in this lesson?
Content:

Water can be put to work by creating a water wheel. What is a water wheel and how does it work?

Each student will be given a printout for their notebooks that has a picture of a water wheel in isolation. They will then be asked to draw what is missing to make the water wheel work and label the parts.

Practice:
After being asked to draw the missing parts of the water wheel, they will be asked how they could test their drawings. Students may have ideas about needing to go outside to a stream or a water wheel that is already working. Students will be taught that they can make a smaller, simpler model of a water wheel without leaving their classroom. Once they make their model, they can use it for testing what they can do to improve the performance of their water wheel.

Formative Assessment: (**content and practice**):
How will you monitor students' emerging understandings?

Content:
As the teams work to build their water wheel, they will see what "makes water work" and what does not. Once they build a model that functions properly, they will see how water can make a water wheel do the work of pulling the binder clip.

Practice:
Students will realize the benefit of building a model because it allows them to test their initial idea drawn on their papers during the pre-assessment and then make changes necessary for the water to make the water wheel work. Once they get the water wheel working a bit, then they can alter their model to make it work better. Finally, they can discuss what other groups are doing and use that information to make sure that they have built the most effective/efficient water wheel possible.

What questions could you ask about content? About science practice?

Content:
- What is a water wheel?
- How can water be used to make a water wheel do work?
- What can a working water wheel do?

Practice:
- What is a model?
- Why build a model?
- How is building a 3-D model more useful that just doing a drawing?
- How can a model be used to communicate and share ideas?
- Why can building a model before building the actual item make the final product better?

What should student answers look like if learning is on target?

Students' answers should contain evidence to support or disprove the initial ideas on the pre-assessment and what parts and functions are important for water to make a water wheel do work. The students' notebooks should have drawings and written observations of how different models they build function, what works better or not and why.

Content:
- A water wheel can be used to make water do work.
- A water wheel can be designed to pull a string that lifts a binder clip.

Practice:

- A model is a smaller version of something.
- Models can be built when the actual system is too large or difficult to work with.
- When you build a 3-D model, you can actually test how different parts and different designs work.
- A model can be used to communicate and share ideas because you can look at what other teams built and see why theirs works better or not.
- When you build a model, it is easy to build and re-build it to test different designs and ideas.

Summative Assessment: (**content and practice):**
How will students demonstrate that they have met both of your learning targets?
Is your assessment measurable or observable?

Content:
Students will be able to explain that a correctly designed water wheel can use the ability of water to create force. That force can be transferred to an action, such as pulling a string, to do the work of pulling up the binder clip. Students will be able to see what was missing or incorrect in their pre-assessment designs helping to create mental maps for what systems using force need to function.

Practice:
Students will be able to correctly state why models are beneficial for testing their initial ideas, revising their design and communicating with their classmates to create the most effective water wheel possible.

REQUIRED LESSON COMPONENTS

COMMUNICATING LEARNING TARGETS:
DO NOT state the Learning Target you developed for the lesson. One option is to state the general expectations. Another option is to state the challenge question for this lesson; e.g., "How does electricity flow?" or "Why are plankton important to the ocean ecosystem?"

Teacher	Student
Content: Can you build a water wheel that can lift a binder clip? Practice: How can I use a model to help understand how water wheels work?	Content: We can build a water wheel that collects the force of water on its blades causing it to turn on its shaft creating movement which lifts the binder clip. Practice: I can experiment and rebuild my water wheel until it works. Once my water wheel is working, I can share my design with others to see which design works best.

ELICITING INITIAL IDEAS
How will you structure the lesson so that students:

- become aware of their initial ideas
- explain their thinking
- record initial ideas
- share their ideas in a small group and/or whole class

(Note: this is not just a review of previous lessons or past experiences –it is what they know about the learning targets *IN THIS LESSON*)

Teacher	Student
For this entire lesson, students should be divided into small groups – 4 per group would be optimal.	Students divide into groups of 4 at their science tables.
Pre-assessment –	
Teacher: People have been using water to do work for over a thousand years.	Students listen quietly.
What do you think it means to "use water to do work"? Does anyone have ideas? Raise your hands. [Wait] Solicit answers to see if anyone thinks of water wheels. Record answers on the overhead projector to use in the making sense section.	Students raise their hands with answers.
The teacher uses the color "Water wheel" sheet for teachers on the overhead projector for reference while telling the "Water Wheel Story." 	
Teacher: What do you think this is a picture of? [Wait] If they have not already come up with water wheel, solicit answers to see if anyone thinks of water wheels. If not, then tell them it is a water wheel.	Students raise their hands with answers.
Does anyone know what a water wheel is? Raise your hands. [Wait] Solicit answers to see if anyone knows.	Students raise their hands with answers.
Teacher writes all guesses that help students to form their own definition of the vocabulary words on the overhead projector and leaves that up throughout the class so ELLs and slower learners can have more time to develop their understanding	

of the word and write down a definition in their own words.	
Everyone write the definition of a water wheel in your own words in the vocabulary section of your notebook. [Wait]	Students will write down their version of the definition in the vocabulary section of their notebooks.
Continue on with the story: Originally water wheels were used to crush corn and wheat into flour. Flour is what is used to make cakes and cookies. Later, people used them to do other work and even make electricity.	Students listen quietly.
Teacher passes out the print outs of the water wheel in black and white and makes sure students have materials to draw with.	Students receive papers.
Teacher: I would like each of you to quietly think about how you think a water wheel works. Then when you have some ideas, without talking to anyone in your group draw the missing parts and label them. When you are finished with your drawing, turn the page over so I know you are finished. [Wait]	Students think and then draw what parts are missing and then label the parts without talking to others. When students are finished they turn their papers over.
Once everyone seems to have their papers turned over, ask students to raise their hands if they are not finished.	Students who are not done raise their hands.
So now you have your drawings of how you think a water wheel works. How could you test your drawing to see if your water wheel works the way you think? Raise your hands. [Wait] Solicit answers. If they say that they would "try it out," ask them to say how they would try it out – ie. going outside to try it in a stream.	Students raise their hands with answers.
What if I told you that you could test your drawing without leaving the classroom? How do you think you could test your drawing? Raise your hand. [Wait] Solicit answers to see if anyone guesses anything close to "building a model."	Students raise their hands with answers.
Does anyone know what this is a picture of?	Students raise their hands with answers.

 [Wait] Solicit answers to see if anyone guesses anything close to "model cars." If not, tell them that they are model cars. If they do guess, continue without telling them.	Students raise their hands with answers.
What can you tell me about how a model car is different than a real car? Raise your hands. [Wait] Solicit answers until you get answers like "it is smaller, it moves but not on its own, it is lighter, you can't get inside, the engine/trunk/doors don't work."	Students raise their hands with answers.
If a model car doesn't actually work just like a real car, why would you want one? Raise your hands. [Wait] Solicit answers until you get answers like "they are fun, you can build ramps/roads/race/crashes, they look cool."	Students raise their hands with answers.
Right, even if a model can't do all of the same things as the real car, it can still be used to test ramps, race and see what happens when they crash.	Students listen quietly.
Now how do you think you could use a model to test your water fall drawing? Raise your hands. [Wait] Solicit answers until you get answers like "to see if it works."	Students raise their hands with answers.
Now write the definition of model in the vocabulary section of your notebooks.	Students will write down their version of the definition in the vocabulary section of their notebooks.
Teacher tells students to leave their "Water Wheel" papers out and to clear everything else off of their desks.	Students keep their "Water Wheel" papers out and clear their desks.

By the end of the lesson students should be able to help tell why building a model helped them understand how a water wheel makes water work.	
ENGAGING with DATA/EVIDENCE This is the section in which the students engage in an investigation to gather evidence and make observations. Students should connect the data collected to the investigative question (why are these data important?) Students should record their data Generally the teaching of the science practice begins here (but that can vary)	
Teacher *For each group of students, prepare the items that the students will use for the experiment. Also prepare a set for the teacher's demonstration.* *Introduce the investigation procedure – show students each of the materials used and bag all but the basins and put post them on the wall in a labeled bag. Label the basin and leave it on the front table. Go show two plastic disks can be fit together but do not build any more of the water wheel model.* **Teacher:** I am going to show you how to do today's experiment. Please pay close attention while I show you the different parts you can use. Does anyone know what this is called (hold up the shaft)? [Wait] Collect answers on the overhead projector until the students say that "it is a stick." Here is a picture showing a shaft being used as part of an arrow. The shaft is what connects the front part and back part of the arrow.  Everyone write the definition in your own words in the vocabulary section of your notebook. [Wait]	Student Students watch and listen quietly. Students raise their hands with answers. Students watch and listen quietly. Students will write down their version of the definition in the vocabulary section of their notebooks.

Now I want to show you that two plastic disks can be put together like Legos.	Students watch and listen quietly.
Teacher: Now look at everyone in your group's drawings of how they think a water wheel works. Starting at the top-left seat at your table and going in a circle, each person take a turn showing the missing parts you drew and why you labeled them the way you did. When your group is done, turn your papers over so I know you are finished. [Wait]	Students describe their drawings and labels. Students turn their papers over when finished.
Once everyone seems to have their papers turned over, ask students to raise their hands if they are not finished.	Students raise their hands if they are not finished.
Pass out the duplexed "Putting Water to Work" student sheets.	Students receive the handouts.
Now I would like you to work in your groups to come up with a design for your group's water wheel using the parts that I showed you.	Students work in groups on the design.
When you agree on a design, each person draw the design on you papers.	When students agree on a design, they draw it on their papers.
Make sure you label the different parts that you want to use for your water wheel.	Students label the different parts.
When your group is done, turn your papers over so I know you are finished. [Wait]	Students turn their papers over when they are done.
Once everyone seems to have their papers turned over, ask students to raise their hands if they are not finished.	Students raise their hands if they are not finished.
Now your group can work together to build one water wheel that works to pull the binder clip up to the table. Stay in your groups and do not walk around to other tables.	
Get equipment and begin **Teacher:** Getters please get all of the things you need for your experiments and return to your groups and begin. Walk around the room to answer remaining questions and monitor methods and progress.	Getters get the materials from the stuff table. Groups begin working to build a water wheel similar to their group drawing.
**Note: If all groups are making steady progress after approximately 10 minutes, let them continue.*	

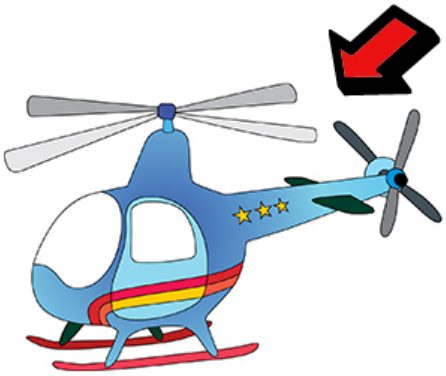
If groups are floundering, ask the student to stop what they are doing and sit down. Assign a group that is making good progress and one that is not and pair them up and ask each group to show their design. Once each group shows their design, tell both groups to go back to their tables and continue working.	
As groups get their water wheels working with pouring the cup of water, ask them to fill the syringe with 50 ml of water and use that instead of the cup. Once they get that working, ask them to count the number of syringes of water they needed to get the binder clip up to the bottom of the table.	Students try using the syringe and write down how many syringes of water it takes to life the binder clip.
Have the groups finish earlier try lifting different items on the end of the string.	
Once every group has a water wheel that is able to lift a binder clip using the syringe to power the water wheel, ask everyone to sit down.	
Teacher: Okay class, now that everyone has their water wheel working with their syringe, please sit down.	Students stop working and sit down quietly.
I would like each of you to draw your group's final working water wheel on the back of your paper.	Students draw their final working model on the backs of their papers.
When you are finished, please put down all pens, crayons and markers so I know that you are finished.	Students put their writing implements down when they are finished.

USING EVIDENCE to DRAW CONCLUSIONS and MAKE CLAIMS

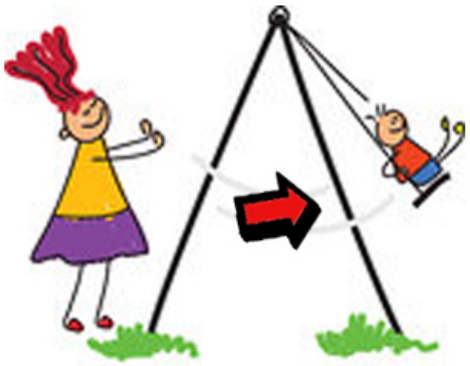
In the lesson, students should:

- Reflect on meaning of the data/experience.
- Facilitate interpretations of the data/experience.
- Use evidence to support their own claims - use evidence from investigation to create claims about bug.
- Critique claims of other students - done in the investigation.
- Draw conclusions - from pre-assessment and investigation - find similarities.
- Make sure that you have taught the learning target for practice as well.

Teacher	Students
Discuss results	
Teacher: Now that every group has built a working water wheel I would like to show you another vocabulary word. It is a blade. Does anyone know what a blade is? Raise your hand.	Students listen quietly.
[Wait for answers]	Students raise their hands with answers.
Here is a picture of some blades on this helicopter.	

 **blade**	
What do you think the blades do for the helicopter? Raise your hand. [Wait] Collect answers until they say something like, “keep it in the air, make it fly.”	Students raise their hands with answers.
How do you think the blades make a helicopter fly? Raise your hand. [Wait] Collect answers until they say something like, “they move air.”	Students raise their hands with answers.
Right, they move the air like a bird’s wings do to make it fly.	
What else from today’s model could work like a blade? Raise your hand. [Wait] Collect answers until they say something like, “the plastic disks sticking out of the water wheel.”	Students raise their hands with answers.
Yes, the blades move water like the helicopter blades move air to make it work.	
So now, what would you write down as a definition for blade? Raise your hand. [Wait] Collect answers on the overhead projector until the students say something like “a part that spins around and moves air or water.”	Students raise their hands with answers.
Everyone write the definition in your own words in the vocabulary section of your notebook. [Wait]	Students write the definition in their own words in the vocabulary section of their notebooks.

Now each group will come up to the front one at a time and show us how their water wheel works. Make sure that two students make the wheel work and two students tell the class about what different designs you tried.	One group of students at a time comes up with their water wheel and two students show how it works. The other two students tell the class about the different designs they tried.
Teacher draws the results chart on the overhead projector while a student passes out printed copies of the Student Water Wheel Results chart.	Students wait quietly.
Now that we have seen all groups models of their water wheels, let's talk about what was the same in all of the models. Raise your hands with ways that each model was the same. Write down the class answers in your charts while I write them on the board.	Students raise their hands with answers.
Teacher writes student answers under the "same" column.	Students write class answers in their charts.
Okay, now think about how the models were different. Raise your hands.	Students raise their hands with answers.
Teacher writes student answers under the "different" column.	Students write class answers in their charts.
Now we can go through the ways that the models were the same and think about if each of the ways they are the same made them work better or not.	Students raise their hands with answers.
The first way they are the same is _____, did having _____ make them work better or not?	Students raise their hands with answers.
Teacher writes student answers under the "Better" column for the "same" column.	Students write class answers in their charts.
Now we can go through the ways that the models were the different and think about if each of the ways they are the different made them work better or not.	
The first way they are the different is _____, did having _____ make them work better or not?	Students raise their hands with answers.
Teacher writes student answers under the "Better" column for the "different" column.	Students write class answers in their charts.
One thing that could have made some models work better is if they had more force on the water wheel blades.	

Does anyone know what force means? Raise your hand. [Wait] Here is a picture showing force, now what do you think it means?  **force** [Wait] Collect answers on the overhead projector until the students say something like “to push in a direction.”	Students raise their hands with answers. Students raise their hands with answers.
Everyone write the definition in your own words in the vocabulary section of your notebook. [Wait]	Students write the definition in their own words in the vocabulary section of their notebooks.
What parts of your models do you think you could use to show force? Raise your hand. [Wait] Collect answers until the students say something like “syringe squirting water on the water wheel blade.”	Students raise their hands with answers. Students raise their hands with answers.
Great, so now that we know that models with more force on the water wheel blade worked better, what changes gave the better working water wheels more force? [Wait] Collect answers until the students say something like “squirting the syringe water on the water wheel blade in a certain place _____.”	
Now everybody write their own answers in the “What worked best” box at the bottom of your charts. [Wait] After discussing which model designs worked better and which didn’t, students will be able to explain that the design of the water wheel and how the water hits the water wheel to create force can affect the amount of lifting power that is generated. They will also have	Students write their answers in their own words on their papers.

presented their designs and critiqued other student's designs.	

MAKING SENSE OF THE LESSON:

Students are led to reflect on what they learned and connect it back to the big idea. Teacher organizes this through questions! Students must be expected to make sense – the teacher cannot do it for them. You must list specific questions you plan to ask students in this section.

1) SYNTHESIS

Use evidence to support and critique claims about the learning target

2) CONNECTIONS

Students connect what they did to learning targets

Connect to other ideas they already know (such as what I know about shadows helps me understand the phases of the moon)

3) REFLECTION

Compare their emerging ideas to initial claims

What made ideas change?

How do the ideas in this lesson help us understand the bigger ideas of the unit?

Teacher	Student
Now that you all have built models of water wheels, why do you think it is a good idea to build a model? [Wait] Collect answers and prompt until students say things like: • Models can be built when the actual system is too large or difficult to work with. • When you build a 3-D model, you can actually test how different parts and different designs work. • A model can be used to communicate and share ideas because you can look at what other teams built and see why theirs works better or not. • When you build a model, it is easy to build and re-build it to test different designs and ideas.	Students raise their hands with answers.
Teacher writes them on the board and asks students to write their answers in the "Why build a model" section on the back of their papers.	Students write their answers on the back of their papers.
Now look at your drawings of what was missing from the water wheel to make it work. How is it different from the water wheel that worked best? Raise your hand. [Wait]	Students raise their hands with answers.
What made you change your ideas about what a water wheel needs to work? [Wait]	Students raise their hands with answers.

What other work do you think a water wheel could do? [Wait] What other models have you seen or built? [Wait] We have already learned a lot about water. What did you learn about water today? Write your answers in the "What I learned about water today" section on your papers. [Wait] Why is water one of the most important materials on earth? Write your answers in the "Why is water so important" section on your papers. [Wait]	Students raise their hands with answers. Students raise their hands with answers. Students raise their hands with answers. Students write their answers on the back of their papers. Students raise their hands with answers. Students write their answers on the back of their papers.
APPLY OR EXTEND NEW UNDERSTANDING IN A NEW CONTEXT Students apply or extend their learning to a slightly different context. This can lead into next lesson.	
<u>Teacher</u>	<u>Student</u>
If I asked you to make a simple model of a helicopter, what parts do you think you would need? Draw a simple model of a helicopter in the box on your paper and label the parts. [Wait] If I asked you to test it, what would you do? Write your answers in the "How I would test my drawing" section on your papers. [Wait] Now that you have built this model, what others do you want to build? [Wait] Okay, now it is time to clean up. Please have one student take apart your water wheel, have one student bring the basin over to the sink to pour the water out. Once that is done, put all of the parts back into the basin and have the getter bring it to the stuff table.	Students draw a simple model of a helicopter on their papers. Students write their answers on the back of their papers. Students raise their hands with answers. One student takes apart your water wheel, one student brings the basin over to the sink to pour the water out. Once that is done, the group puts all of the parts back into the basin and the getter brings it to the stuff table.