ACTIVITY 4

HOW TO USE THE FORCE OF WATER TO LIFT AN OBJECT?

EXPERIMENT OBJECTIVES AND CONTENT

In this activity, students are introduced to the concepts of energy transfer and the use of mechanical force to do work. Students may, in parallel, develop abilities to design and make a functional three-dimensional object.

ESSENTIAL KNOWLEDGE

Energy:

- Forms of energy: sources of energy (moving water)
- Transformation of energy: from one form to another

Systems and interaction:

- Other machines (waterwheel)
- How manufactured objects work

Techniques and instrumentation:

- Use of simple measuring instruments
- Use of tools
- Design and manufacture of machines

Appropriate language:

- Terminology related to an understanding of the material world
- Conventions and types of representations specific to the concept studied: drawings, sketches

SUGGESTED MATERIALS

Scientific equipment:

- Scales and funnels

Perishable non-scientific materials:

- Water

Household materials:

- Two-litre soft drink bottles
- Egg cartons, wooden skewers
- Ribbon spools
- Lids from plastic containers
- Small plastic spoons
- Small cardboard plates
- Fishing line, nuts (metal), straws
- Plumbers tape

School supplies:

- Pencils, scissors, rulers
- Rubber glue, tape, paper clips
- Various types of cardboard
- Modeling clay
- Large plastic tubs
- Paint brushes and acrylic paint medium

School equipment:

- Sink or small water tank

CONTEXT: SITUATIONAL PROBLEM OR RESEARCH QUESTION

The school's cycle 3 classes are invited to present a technology project: to design and build a machine that can lift an object without using human power. You and your friends decide to take up the challenge. You remember that one summer you used to have fun turning your pinwheel by spraying a stream of water on it from the garden hose. So you suggest to your team to build a machine that uses water power to raise an object.

SUGGESTED PREPARATORY ACTIVITIES (INTRODUCTION)

The teacher brings several examples of wheels to class or asks the students to find some at home or at school. The students observe the different types and discuss them. They examine the wheels' structures carefully: Do they have things in common? What makes a wheel strong? Is a large wheel necessarily stronger than a smaller one? Do all wheels have a central axis?

Once the students understand how wheels work, the teacher has the students investigate the structure of wheels and how they might make a wheel capable of raising an object. They could then choose the materials they wish to use to make a water wheel.

Note: Students may believe a wheel can only turn if it is made out of very solid materials. They may also believe that only large-sized materials will be able to lift a weight, which is not necessarily the case. Let them experiment and find the differences for themselves.

STUDENTS MAY HAVE TROUBLE IMAGINING A STRUCTURE IN THREE DIMENSIONS. YOU CAN HELP THEM BY SUGGESTING THEY DRAW THEIR MACHINES FROM THREE DIFFERENT ANGLES: TOP, SIDE AND FRONT.

INITIAL IDEAS AND HYPOTHESES

Here are a few examples of hypotheses the students might formulate based on their initial ideas:

Example 1
I predict that I can build a wheel that will let me lift two paper clips by using plastic spoons. I predict this because the spoons will act as little buckets to collect water and turn the wheel.

Example 2
I predict that I can make a wheel using plastic lids. I predict this because the lids are round and waterproof.

Example 3
I predict that I will be able to build a wheel using light materials like cardboard. I predict this because the wheel must not be too heavy or else the water will never be able to turn it and allow it to lift objects. So that the water does not break down the cardboard, I will waterproof it using acrylic paint medium.

RECORD ALL YOUR IDEAS AND OBSERVATIONS IN YOUR EXPERIMENT WORKBOOK.

WORK PLAN AND EXPERIMENTATION

Here are a few examples of experiments the students can carry out to verify their hypotheses:

Example A
The students cut most of the handle off eight plastic spoons, leaving just enough handle to insert into slits cut into a plastic ribbon spool. The structure is solidified using adhesive or plumbers tape. They then put a pencil through the centre of the spool to create an axis of rotation. They tie a piece of string to one end of the pencil and attach two paper clips to the other end of the string. They then use wooden sticks to build a structure to support the wheel on either side of the sink, allowing it to turn under the stream of water from the tap.

Example B
The students make slits in a plastic lid and curve each segment in the same direction. They punch a hole in the middle, into which they insert a straw, which they affix with plumbers tape or modeling clay. On one end of the straw (the end that will not be in the water), they attach a string with a weight on it, which they have previously weighed on a scale. To allow the wheel to turn, they place a wooden skewer through the straw, the ends of which they place on rulers placed parallel to one another over the sink. The ends of the skewer are attached to the rulers with modeling clay.

Example C
The students use egg receptacles for water wheel blades. They cut out the compartments and stick them between two cardboard discs or small cardboard plates. The egg receptacles can be plastic or cardboard. To make the cardboard waterproof, they coat it with a layer of acrylic paint medium. The students insert a pencil through the centre of the cardboard discs or plates as an axis of rotation. They could also use a thread bobbin. On one end of the pencil, they tie a string with weight on it, which they have previously weighed on a scale.

Note: If the classroom does not have a sink, a water reservoir can be used (e.g., camping water receptacle) to simulate a waterfall. Soft drink bottles filled with water and poured over a large plastic tub could also be used.

EXPERIMENTAL FACTORS

To ensure scientific rigor, the students should evaluate the experimental factors that might influence the experimental results.

- Size of wheel
- Solidity of machine
- Force of stream
- Orientation of blades
- Width of blades
- Weight of blades
- Freedom of axle to turn

DISCUSSION: SUGGESTED INTEGRATION ACTIVITIES (CONSOLIDATION)

After the experiment, each team makes a poster showing the steps taken to build their water wheel and presents its results to the other teams. The teacher could give the students a period to review the construction of their machine in preparation for a contest. The machine that lifts the heaviest weight wins.

SUGGESTED ACTIVITIES FOR APPLYING KNOWLEDGE (APPLICATION)

The students do research on the first water mills or on other uses of rotational motion to produce energy, such as turbines. They try to understand how, in another context, humans used (or still use) technologies based on water power to carry out difficult tasks.

SCIENTIFIC CONCEPTUAL CONTENT

Types of waterwheels
A vertically oriented wheel turning on a horizontal rotational axis is called a "waterwheel." A horizontally oriented wheel with a vertical rotational axis is called a "turbine" Turbines produce more energy than water wheels, but they kill large fish that come near them, while water wheels do not harm them.

Waterwheel
This simple machine is made up of blades or buckets that transfer energy from the linear motion of a fluid (water) into rotational energy turning around a central axis. Water can feed into the upper, lower or middle part of a water wheel. Consult the *Éclairs de sciences* website for diagrams.

Blades
Flat blades are older technology and relatively more fragile than curved blades, and they turn the wheel more slowly. The blade angle determines the speed of the wheel's rotation.

Winch
Part of a machine that can raise or lower an object by winding a thread around a horizontal axis.

Water
Water's energy is a product of its initial speed, its pressure and its weight. This energy is transferred to any simple mechanism (e.g., a waterwheel) with which the water comes into contact. This energy can be used to produce other types of energy, such as electricity, or to do physical work, such as grinding grain or hoisting a load.

CULTURAL REFERENCES

History
The wheel was invented in ancient Mesopotamia about 3,500 years BCE. The first waterwheel was built in Asia Minor about 100 BCE, while in Europe, the first water mills were not built until the Middle Ages. Waterwheels were very popular until the 19th century, but they were eventually replaced by steam power and then by electricity.

Technology
Waterwheels were used for a variety of purposes such as milling grain, sawing wood, weaving wool or making paper pulp. Today, they are often classified as historical monuments.

FOR MORE CULTURAL REFERENCES, VISIT THE ÉCLAIRS DE SCIENCES WEBSITE:
www.eclairsdesciences.qc.ca

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PROCESS OF ACTIVE DISCOVERY

GENERAL LEARNING PROCESS IN SCIENCE AND TECHNOLOGY (IN ELEMENTARY SCHOOL)

Context related to everyday life

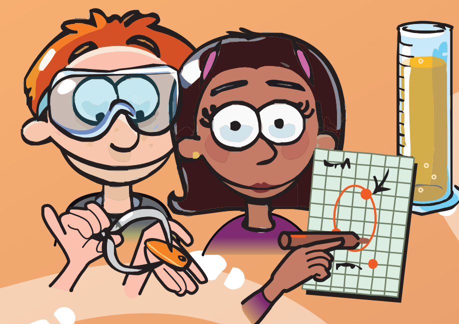
- **Situation problem** or
- **Discovery question** or
- **Need to be fulfilled**
- **Question related to the operation of an object** (how does it work?)

Initial ideas and hypothesis

My initial ideas:
- I share my own ideas.

My hypothesis:
- I predict that...
  I think that because…
- I imagine my prototype.
- I think it works like this…

Planning and carrying out



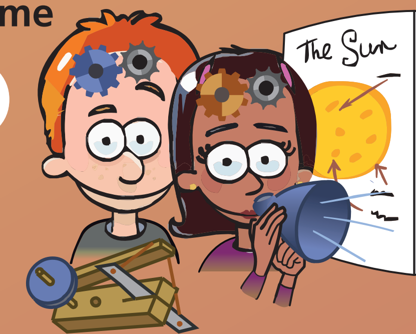
My equipment:
- I observe and handle the equipment.
- How could this equipment be useful to me?
- I choose my equipment and my materials.

Carrying out my process:
- What will the steps be?
- What precautions should I take?

My actions:
- I carry out the steps of my protocol.
- I note or draw what I observe, what I do and what I discover.

My results:
- What is my answer to the problem, question or need?

Outcome



My outcome:
- Do my results confirm my hypothesis or not?
- Are my results similar to those of the other teams?
- Can the other teams' results help me to find answers to my problem, my question or my initial need?
- What could I communicate concerning my discoveries?

New question?

What I learned:
- What do I retain from this activity?
- What could I communicate concerning my results or my discoveries?

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