LESSON PLAN: GETTING INTO INQUIRY-BASED LEARNING WITH INCLINED PLANES

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Curriculum Connections

The activities in this resource complement the Ontario Science and Technology Curriculum, 2022, Grade 2

Teacher Resource:
Inquiry-Based Learning

ONTARIO SCIENCE CENTRE
An agency of the Government of Ontario

STEP 1:
STRUCTURED INQUIRY

QUESTION + PROCEDURE + ~~SOLUTION~~

This image shows that the solution is not identified in a structured inquiry.

The structured inquiry process provides students with a question and a procedure to follow but allows them to discover the solution.

TEACHING BASIC CONCEPTS

Use words, pictures, and objects to introduce different types of simple machines:

Materials:

1. **Levers:** Scissors, seasaws, tongs, bottle openers, nutcrackers, light switches and lower jaws are all examples of levers.
2. **Inclined Planes:** Ramps and slides are inclined planes. Stairs are a modified type.
3. **Pulleys:** Flagpoles and some clotheslines have pulleys, as do cranes.
4. **Wheels and Axles:** Cars, skateboards and pizza cutters include wheels and axles.
5. **Gears**: Examples of gears include bicycle gears, hand beaters and wind-up toys.
6. **Screws:** Jar lids, bolts, drill bits and corkscrews are all screws. Corkscrews also contain levers and gears.

Note: The Ontario Curriculum categorizes simple machines as follows: levers, inclined planes, pulleys, wheel and axles, screws and wedges. Feel free to use the categorization you feel most comfortable with.

Procedure:

Introduce students to the six types of simple machines. Simple machines make work easier by changing the magnitude (amount) and/or direction of a force. Examples:

1. **Changing the magnitude of a force:** It would be difficult to crush a hard-shelled nut with your bare hands. A nutcracker (a lever) makes the work easier by reducing the amount of effort (input force) required. The tradeoff is that the force must be applied over a longer distance.
2. **Changing the direction of a force:** A single fixed pulley makes work easier by changing the direction of the force. Instead of working against gravity by lifting a weight up directly, you can work with gravity by pulling down on a rope.
3. **Introduction to Inclined Planes:** Another word for an inclined plane is a "ramp." Ask students where they might find examples of ramps in or around their school and who might use them (e.g., a caregiver pushing a stroller, a person pushing a grocery cart, a wheelchair user, etc.).

A nutcracker reduces the amount of effort (input force) required on a load (the nut).

This pulley system changes the direction of a force. To lift the weight up, you must pull down.

STEP 1:
STRUCTURED INQUIRY

STRUCTURED INQUIRY ACTIVITY

Students will learn more about inclined planes by collecting and analyzing data.

Materials:

Students work in groups (groups of three are ideal). Each group needs:

- A long rectangular piece of cardboard
- A ball (lightweight foam balls can be purchased from many dollar stores)
- Three large similar sized books (textbooks are ideal)
- Masking tape
- A measuring tape
- A whiteboard or worksheet with writing materials

Procedure:

- **Outlining the experiment:** Students work on a long table or on the floor. Have each group tape the top of their cardboard to the edge of a book, creating a small ramp or inclined plane. Next, have students place the ball at the top of the cardboard ramp and let it roll down until it stops. Have students measure how far the ball has rolled.
- Have each group measure (in centimetres) how far the ball rolled, starting from the end (the bottom) of the inclined plane and measuring to the middle of the ball. Students should keep track of their measurements by recording them on a worksheet or whiteboard (see Appendix for example recording sheet). Scientists often repeat the same experiment more than once: students will repeat the ball roll two more times and record their results for each try.

Procedure continued:

- After three tests with one book, students will repeat the experiment with two books and, finally, with a stack of three books, recording the results for each test. Before beginning the experiment, you may ask your students to predict the results. Consider asking: How will changing the height of the book stack affect the distance that the ball rolls, and what is the reason behind your prediction?
- **Arriving at a conclusion:** After students have completed their experiments, debrief the results in small groups or as a class. Here are some questions to consider:
- What can the students conclude from the distances they have recorded? (The steeper the plane is, the farther the ball travels.)
    - How does the steepness of the plane affect the ball's rolling speed?
    - What would it feel like to walk up a very steep slope? For example, what if students were as small as an ant and had to walk up the ramps they created?
    - Is there a way to create a gentler (less steep) slope that goes all the way up to the top of the three stacked books? (Make a longer ramp, e.g., by connecting multiple pieces of cardboard with masking tape.)

STEP 2:
GUIDED INQUIRY

This image shows that the procedure and solution are not identified in a guided inquiry.

Guided inquiry presents students with a question or a problem to solve. By combining their prior knowledge with experimentation, students will determine a procedure and arrive at a solution.

Materials:

- Pictures or videos depicting St. Bernard rescue dogs and Swiss and Italian Alps
- Students work in groups (groups of three are ideal). Each group needs:
  - A model of "Barry" and his sled (made with an eraser, two paperclips, a Styrofoam ball and a disc magnet)

    Note: You may have to experiment with finding a disc magnet with just the right amount of strength. It needs to be able to hold the "sled," but not so well that it can be lifted up directly without the use of an inclined plane. We used magnets purchased from a dollar store.
  - Several pieces of cardboard, cut into rectangles
  - Cardboard rolls (from toilet paper or paper towel), cut lengthwise to form two shallow channels per tube
  - Scissors
  - Masking tape
  - A bench, table or chair (to represent the mountain)

Procedure:

Problem #1:
Getting Barry up the mountain

- Introduce Barry, the St. Bernard dog, and ask students if they have ever seen a dog like this before. Some St. Bernard dogs rescue people from the Swiss and Italian Alps, which are very tall and cold mountains in Europe.
- Next, introduce the scenario. The magnet represents Barry the dog, and the eraser is Barry's sled. There is an injured hiker on the other side of the mountain (represented by a bench, table or chair), and Barry needs to bring them medicine (represented by the foam ball) on his sled.
- Finally, introduce the problem. Barry needs to be very careful when pulling the sled. Ask your students: What will happen if he pulls too hard? Then, demonstrate how the magnet sticks to the paperclip attached to the sled but easily detaches on a steep slope. Barry needs to get up the mountain, but the mountain is too steep. Luckily, Barry is a very smart dog. Ask the students what they can build to help Barry get over the mountain (an inclined plane). Point out that since the height of the mountain can't be changed, something else needs to be adjusted (the length of the inclined plane). Students may use the cardboard to build an inclined plane any way that they want (there is more than one possible solution to the problem). They can use tape to attach the pieces together and to attach the inclined plane to the top of the mountain.
- **Criteria for success:** Barry needs to get to the top of the mountain as easily as possible. What does "easy" mean? He has to stay attached to the sled the entire way up (i.e., the magnet must not detach from the paperclip). A gentle slope is required for the solution, but do not tell students this explicitly.
- All students in the group must collaborate to find a solution through discussion, planning and experimentation.

STEP 2:
GUIDED INQUIRY

Problem #2:
Getting the medicine down the mountain

- Gather students together and encourage them to discuss their observations from the first activity.
- Now that Barry has gotten to the top of the mountain with his sled, there is a second problem. The hiker is on the other side of the mountain, and Barry needs to drop the medicine down to the hiker. Ask your students: Instead of making a very long inclined plane like before, is there a way we can build one that takes up less space? (Build it on the side of the mountain, using paper rolls this time.)
- The medicine is in fragile glass bottles inside the ball, so the ball must travel down the inclined planes as slowly as possible, otherwise the bottles will break. Ask the students to discuss among their group members how they should do this before they start building (adjust the steepness and the number of inclined planes).
- When the groups have a design they are satisfied with, they can time how long it takes for the ball to travel from the top of the mountain to the bottom. Add the times for all the groups together; the goal is to have the longest class time possible.

STEP 3:
OPEN INQUIRY

This image shows that the question, procedure and solution are not identified in an open inquiry.

Students will come up with questions about inclined planes that can be answered with experimentation.

Materials:

Students work in groups (groups of three are ideal). You may wish to incorporate:

- Small whiteboards and dry erase markers for students to plan their experiments (in the absence of whiteboards, paper, pencils and erasers work too)
- Many pieces of cardboard, cut into rectangles
- Toilet paper and paper towel rolls (some intact, some cut into channels)
- Foam balls and other lightweight materials to travel up or down the inclined planes
- Timers
- Scissors
- Masking tape
- Benches, tables or chairs
- "Barry" models from previous step (optional)

Procedure:

Now that the students are inclined plane experts, they can begin planning their own experiments. Each group should come up with a question about inclined planes. They should also formulate a prediction (what they think will happen and why) and a plan for how to answer their question.

These Smarter Science resources may help you and your students with the inquiry process.

RELATING SCIENCE AND TECHNOLOGY TO SOCIETY AND THE ENVIRONMENT

ESCALATOR VS. STAIRS

Have you ever walked up an escalator that is out of service? Why does it feel so much harder than walking up the stairs? Develop a hypothesis and plan an investigation.

RAMPS AND ACCESSIBILITY

Many buildings use ramps for increased accessibility. Think about who might prefer to use a ramp instead of stairs. Consider why ramps are often so long. What problems might a shorter, steeper ramp cause? Finally, how might a ramp be modified to accommodate a person with a visual impairment?

Conduct an accessibility investigation at your school or another building in your neighbourhood (library, transit station, etc.). Ask people who used the ramp why they chose to do so, how easy it was to navigate and whether they have any ideas on how to improve accessibility. Develop a hypothesis before you begin. Are there any things you think will be easy or difficult? Record and share your observations.

Extension: Based on your observations, do you have any recommendations to increase accessibility in your school or neighbourhood? Write a letter to your principal or a community leader describing your recommendations.

Design a building (a library, community centre, school or even your own dream house) that is accessible to as many people as possible. Draw a floor plan or construct a diorama of your design.

FRICTION RAMPS

Will it slide? Investigate friction by creating a cardboard ramp. Find a variety of objects made from different materials (you may wish to cover wooden or LEGO blocks in fabric, foil, plastic wrap, paper, etc.), and predict whether they will slide quickly, slowly or not at all. Test your predictions. Use a stack of books to adjust the steepness of the ramp. Repeat the experiment with a different level of steepness. Have any of your predictions changed?

Extension: Cover the ramp in a different material and repeat your tests. Compare and contrast your results with your previous investigation.

SIMPLE MACHINES IN ANCIENT CONSTRUCTION

How did the ancient Egyptians assemble the pyramids? There are a number of different hypotheses, and they all use simple machines in some capacity. Use books or the internet to conduct your own research, and build a model of a device you think would do the job.

POTATO HOLES: A SIMPLE MACHINE INQUIRY

What's the best way to poke a potato? A simple machine makes it easy! This Science Buddies investigation guides you through a surprising experiment using different types of wedges.

Research Opportunity: How does a pneumatic nail gun combine a wedge with the power of compressed air?

APPENDIX

SIMPLE MACHINES VOCABULARY

Effort: Input force applied to a simple machine that produces an output force on the load.

Force: A push or pull by one body on another; these forces can change the speed or direction of an object.

Fulcrum: The pivot point about which a lever turns.

Gear: A toothed wheel that engages another toothed mechanism in order to change the speed or direction of transmitted motion.

Inclined Plane: A ramp that reduces the force necessary to lift a weight.

Lever: A rigid bar that pivots about a point (fulcrum) and is used to move or lift a load at one end by applying force to the other end.

Load: A force that resists movement.

Pulley: A simple machine consisting of a wheel with a groove in which a rope can run.

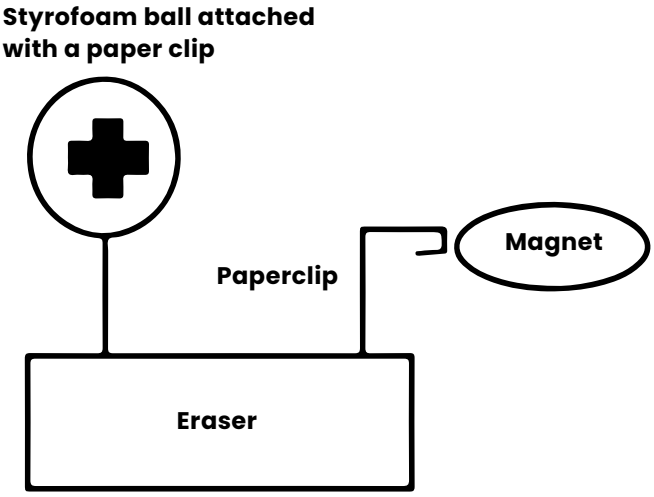
Screw: An inclined plane threaded spirally around a cylinder.

Simple Machine: A device that only requires the application of a single force to work.

Wedge: Any shape that is triangular in cross section and is usable as an inclined plane that can be pushed between two things.

HOW TO CONSTRUCT BARRY'S SLED

Note: You will need to find a magnet with just the right amount of strength. It needs to stick to the paperclip on the "sled," but not so well that the sled can be lifted off the ground without an inlined plane. A disc magnet from the dollar store should work well. A rare earth magnet (with a reflective surface) will likely be too strong.



INCLINED PLANES - EXPERIMENT WORKSHEET

How does the height of the inclined plane affect how far the ball rolls? Measure the length in centimetres (cm).

	TRY 1	TRY 2	TRY 3
1 BOOK			
2 BOOKS			
3 BOOKS			