EDUCATOR'S GUIDE

discover science

Discover how much fun science can be!

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About the *Discover Science* series

Lights, camera, science! This new series features unique experiments and challenges that explore a wide range of topics in science. Follow the intrepid "Experiment Rangers" as they lead audiences through 26 episodes (of approximately 13 minutes in length), conducting real trial-and-error experiments—no CGI here! With humour and a great sense of adventure, this series engages and entertains viewers, from elementary school students to adults, plunging them into the fun and fascinating world of science.

About the guide

This National Film Board of Canada (NFB) educator's guide explores the various scientific concepts presented in the unique ***Discover Science*** series. The generic activity detailed in this guide is designed for higher-level elementary students (Grades 5 and 6) and focuses on deconstructing and critiquing experiments, as well as designing new experiments based on the concepts presented in ***Discover Science*** episodes. In the discipline of science, experiments are performed to test ideas, and students using this guide will have the opportunity to explore concepts that relate to their everyday world, to formulate questions, problems and hypotheses, and to problem-solve. The short episodes in this series are used as springboards to discussions aimed at developing scientific literacy inspired by outcomes recommended in the reform of science education.

Introduction

In recent years, there has been an international movement towards educational reform, including reform of science education. Our new understanding of the human brain and its learning processes, coupled with a growing awareness of the need to rethink our technological and global world in order to build a sustainable future, are two of the factors driving this reform. In order for our youth to develop the competencies and the knowledge to participate in the creation of an innovative and sustainable world, in other words, to be scientifically literate, we need to focus our efforts on specific outcomes for science education. These outcomes include:

- Developing inquiry-based research skills;
- Developing critical-thinking skills;
- Engaging students in creative problem-solving;
- Promoting a constructivist approach to learning;
- Cultivating a sense of wonder and curiosity in learners of all ages;
- Nurturing a lifelong view of learning;
- Contextualizing the relationships between science, technology, society, and environment;
- Making real-world connections that focus on personal lives, community, careers and the future, to encourage responsible action and choices.

Most science education programs are not constructed around such a rigorous approach. Research has shown that science education tends to be popularized, stereotyped and lacking in rigour in order to make it accessible to all. Content and facts are taught over complex and transferrable thinking processes. Simple experiments and activities are designed around set desired results rather than complex investigations anchored in current events or students' interest in scientific phenomena and discoveries.

The importance of having students 1) explore a real problem; 2) come up with different hypotheses; and 3) create a design for an experiment to confirm or infirm these hypotheses, is undervalued. Students must become the leaders of their own scientific explorations with teachers mentoring and guiding them as they develop the thinking habits of people working in this discipline. For the development of scientific literacy, mistakes are learning opportunities, false hypotheses lead to more problem-solving, and *conceptualizing* experiments is more important than carrying them out.

The activity described in this guide is suitable for all episodes of the ***Discover Science*** series. The episodes available for viewing and the scientific concepts they explore are outlined in the table below:

EPISODE	TITLE	SCIENTIFIC CONCEPTS
#2	"Under Pressure"	○ Under water, pressure is exerted from all directions ○ The deeper the column of water, the greater the pressure exerted ○ Pressure has different effects on an object (compression, displacement, increase in temperature)
#4	"Flying Whale"	○ The sun is a natural source of energy ○ As air is heated, its relative density decreases, causing it to rise; air that is heated up can exert a lifting force
#5	"A Salty Wedding"	○ Salt (sodium chloride) is soluble in water ○ Crystals of sodium chloride form when a saturated solution is cooled or evaporates
#9	"The Rescue! Leverage Plan"	○ Levers make work easier ○ The same amount of force applied to a lever can lift different weights, depending on the position of the fulcrum

Activity

This activity consists of two parts:

1. Deconstructing and critiquing the experiment;
2. Designing an experiment based on the scientific concept presented in the episode.

Although each of these tasks can be performed independently of the other, it is recommended that educators ask students to deconstruct and critique the experiment before they attempt to design a new experiment based on the concept presented. This learning sequence ensures that students have had the chance to research, discuss and explore the concept before they begin to imagine, conceptualize and possibly carry out their own experiment.

Previewing the episode

Whether students are challenged to complete one or both tasks in this activity, it is essential that educators preview the episode in preparation for their classroom presentation. While previewing, note the following:

- What, and how, are the scientific concepts presented?
- When would be appropriate times to stop the presentation to ask and answer questions?
- What part of the episode should be watched a second time to promote a deeper understanding of the information?

Part 1: Deconstructing and critiquing the experiment

Explain to students that they will be watching an episode of ***Discover Science***. Their task is to deconstruct and critique the scientific approach and process presented in the episode. The goal of this task is to develop one's critical- and scientific-thinking skills, in other words, to learn to think like a scientist, while trying to answer this key question:

- What are the strengths and weaknesses of the scientific process carried out during the experiment or challenge presented in the film?

Following is a list of criteria for a rigorous scientific investigation. This list can be posted in class and referred to during the critiquing process. It should also be discussed with the students so that they become familiar with a thorough experimental approach:

- The problem or challenge is clearly stated.
- The scientific concepts involved in the investigation are clearly defined and illustrated.
- Hypotheses are clearly stated.
- The experiment is designed to effectively test hypotheses.
- The method is revised when problems are encountered as the experiment is being carried out.
- The possible sources of error are identified.
- The results of the experiment are analyzed and the conclusion is used to verify the validity of hypotheses.
- The experiment tests only one variable at a time.
- The experiment can be reproduced.
- The experiment contributes to the development of a scientific culture.

Review all the sub-questions in the table on page 3 with your students. Create seven teams and assign one question to each team. This is an opportunity to differentiate your approach by a) creating teams that are homogeneous in terms of student readiness and b) assigning each team a question according to its level of complexity. This allows ALL students to tackle an equally challenging assignment that engages them fully in the collaborative aspect of this task.

Ask all students to focus on finding the answers to their respective sub-question during the viewing. After watching the episode, they will come together as a team and discuss their findings. All students must then update their notes based on the contribution of their peers.

While watching the film, students can also collect information and answers to other questions, if they wish. These notes will be useful in the class discussion that will follow.

Present the episode of your choice to your class, stopping and reviewing as necessary to allow the students time to develop both their own questions and their understanding while answering their respective sub-questions.

What are the strengths and weaknesses of the scientific process carried out during the experiment or challenge presented in the episode?

SUB-QUESTIONS	NOTES
1 What is the problem being investigated or the challenge being tackled?	
2 What scientific concept(s) is/are related to the experiment being carried out?	
3 What questions do we need to ask and research in order to better understand this scientific concept? Note: It is often necessary to engage students in research to improve their understanding of the scientific concept. Demonstrations and simulations can be useful to deepen their comprehension.	
4 What is/are the hypothesis(es) being tested?	
5 What is the procedure used during this experiment or challenge?	
6 What problems did the team of ***Discover Science*** encounter during the experiment? **a** How did they overcome those issues? **b** What did they learn from their mistakes or experiment revisions?	
7 What real-world connections can you make to this science concept?	

Facilitate a class discussion so that each team can present its answers to the question it was assigned. Note all responses and create a summary document for students.

After shuffling your teams so that you have at least one member from each of the seven original teams in each of the new groups (jigsaw approach), ask students to discuss and respond to the original question: What are the strengths and weaknesses of the scientific process carried out during the experiment or challenge presented in the episode?

Demonstrate how each of the items in the list of criteria for a rigorous scientific investigation can be checked against the list of answers in the summary document.

After this group discussion has been completed, ask each student to prepare a "3-2-1"document that lists at least three strengths and two weaknesses they have identified in this experiment, as well as one question they still have with regard to this investigation.

Part 2: Designing an experiment based on the scientific concept presented in the film

As a follow-up to the deconstruction and critique of the experiment or challenge presented in the film, students are asked to imagine, conceptualize and, if possible, carry out their own experiment.

Organize students in groups of four or five members. The questions in the table on page 4 are designed to guide students through the steps necessary to create their own experiment. Review the procedure and the questions as well as the model of an experiment provided on page 4 and 5. It may be necessary to take one section at a time and guide the students through their work gradually, always going back to the sequence of steps for this task and the desired outcome. Over time, as students become more skilled in designing their own experiments, they will master the use of this checklist.

Having students keep an experiment journal is a great idea. Students can use it to record all the steps of their design process: answers to questions and reflections, brainstorming, observations, research notes, etc.

Once their experiment is designed and approved, students can test their hypothesis by performing the experiment. Once again, observations, results, analysis and conclusions can be logged in the experiment journal. Students can present their experiments and findings to the rest of the class.

After this group discussion has been completed, ask each student to prepare another "3-2-1"document (see above for details).

STEPS TO DESIGNING YOUR OWN EXPERIMENT
Designing your own experiment is a creative and challenging project that allows you to think and work like a scientist. Use the questions and steps in this table to guide you and your team in designing your experiment.
1 What is the scientific concept presented in the film?
2 What real-world connections can you make to this concept?
3 What do you need to inquire about before you design the details of the procedure for your experiment?
4 Based on that scientific concept and its real-world connections, what is the problem or related challenge for which you would like to design an experiment?
5 What is/are your hypothesis(es) with regards to this experiment?
6 How would you test your hypothesis(es)? **a** Create and design an experiment to test your hypothesis(es) **b** List material required and procedure; include appropriate sketches and photos and videos **c** Include at least two references to support your research and ideas for this experiment
7 What problem(s) do you anticipate in your experiment? **a** How could you solve this/these potential problem(s)?

Model of an experiment, based on the "Flying Whale" episode

STEPS TO DESIGNING YOUR OWN EXPERIMENT
Designing your own experiment is a creative and challenging project that allows you to think and work like a scientist. Use the questions and steps presented in this table to guide you and your team in designing your experiment.
1 What is the scientific concept presented in the film? *Hot air is less dense or heavy than cooler air.*
2 What real-world connections can you make to this scientific concept? *Heated air is used to lift hot-air balloons. Hot-air balloons rise when the air inside the balloon is heated with a propane burner. To make the balloon come down, there is a flap at the top of the balloon that can be opened to release the hot air.* eballoon.org/balloon/how-it-works.html
3 What do you need to inquire about before you design the details of the procedure for your experiment? *I want to learn what happens to the molecules of air when they are heated.* scienceforkids.kidipede.com/chemistry/atoms/heat.htm ehow.com/how-does_5220405_warm-air-rise-cool-expands_.html

4 Based on that scientific concept and its real-world connections, what is the problem or related challenge for which you would like to design an experiment?

If hot air takes more space and the molecules move faster, can heated air cause a balloon to expand and rise?

5 What is/are your hypothesis(es) with regards to this experiment?

I think that if I transfer the heat from hot water to air in a bottle, the air will expand and cause the balloon to expand and rise.

6 How would you test your hypothesis(es)?

- **a** Create and design an experiment to test your hypothesis(es)
- **b** List material required and procedure; include appropriate sketches, photos or videos
- **c** Include at least two references to support your research and ideas for this experiment

I will perform the following experiment: turtlediary.com/kids-science-experiments/hot-air-balloon-experiment.html

I will need:

- *1 small empty bottle (500 ml) and one large bottle (1000 ml)*
- *10 deflated balloons of identical size*
- *A pot of hot water (not boiling)*
- *A thermometer*

These other two experiment models have helped me understand how to set up my experiment:

acs.org/content/dam/acsorg/education/whatischemistry/science-forkids/planetearth/air/heat-energy-extraordinaire.pdf

sciencekids.co.nz/experiments/heavyair.html

7 What problem(s) do you anticipate in your experiment?
How could you solve this/these potential problem(s)?

I think that if my balloon is too big and my bottle too small, there will not be enough hot air to expand and lift the balloon. The same problem may occur if the water is not hot enough to warm up the air in the bottle. I will try my experiment with bottles of different sizes but will keep the same balloon size and the same water temperature for each test. I will always leave the bottles in the hot water for the same amount of time. I have to try variations of this experiment to determine how much time is required to best achieve the results I am expecting.

Assessment options

- Collect anecdotes about students' participation and contributions during class or group discussions.
- Ask each student to prepare a table with the names of their teammates and the responsibilities assumed by each person in the team (including themselves) in order to complete a given task.
- Evaluate each team's work (process, 3-2-1 assignment, experiment journal, experiment presentation).

References

Monkman, D. (2001). *Science Curriculum Review Report*, British Columbia Ministry of Education. bced.gov.bc.ca/irp/reports/scireview.pdf

Chinn, C. A., and Malhotra, B. A. (2002). "Epistemologically Authentic Inquiry in Schools: A Theoretical Framework for Evaluating Inquiry Tasks," *Science Education*, 86(2), 175-218.