Lesson 1. Scientific inquiry: investigating parachutes

Goals

Questions and concepts to be addressed

- What is science?
- What is the basic process of science?
- How does science "move forward"?
- What are some characteristics of a "scientific" question?

Skills

- ► You will be introduced to these skills during this lesson, but they are skills you will be practicing throughout the semester—both during class activities and in your inquiry projects.
- ► Pose a question that can be answered by a systematic investigation
- ► Given a vague question about a scientific topic, revise the question to make a more specific question.
- ► Identify, isolate, and measure variables in an experiment.

Context

A. Overview and scenario

Lesson 1 involves investigating the performance of a parachute. The main learning goal of this lesson is to give you the opportunity to experience doing science while investigating a question about the "designed world." In the process you will be discuss some important tenants of scientific inquiry and the way scientific understanding is formulated, as well as the limitations of that understanding.

For this lesson, your group is an R&D team at the local parachute factory. Your task will be to work with your team to design and test a parachute that will stay in the air for as long as possible while falling straight enough to fall in a designated landing zone.

The CEO of your company will show up on the second day of your work on the project and lead the testing of your parachutes. The performance test will take place outside (weather permitting). The team that has the parachute that stays in the air the longest and successfully lands in the landing zone after being dropped from a height specified by the CEO will win a special bonus prize. Your "ticket" into the final competition will be a brief report on your work and a graph of the way the flight time changed as you changed one parachute variable.

B. Discussion questions about scientific investigations

The point of this section is to get you thinking about and discussing "what makes an investigation an investigation" and "what makes a scientific investigation scientific." When answering and discussing the questions in your teams, keep in mind your understanding of what some people refer to as the "scientific method" as well as other ideas you've learned about science over the years.

1. Discuss the following questions in your group and then write your answer, in your own words, in your lab book. We will have a class discussion on these questions, pulling together the class knowledge on this topic of investigation.
    - What are some of the different parts of the "life cycle" of an investigation? Try to name and explain at least three or four different parts or key concepts.
    - What about an investigation makes it "scientific"?
    - Imagine that you are doing a design experiment with paper airplanes. You change the length of your 11" airplane by ¼" and ½", but it doesn't change how far the plane flies. Does this mean that length doesn't influence how far the plane flies? What would you do next in your experiment?

- What is “experimental error”? What are some ways you can minimize error in your final results?

- What characteristics of a question make it “testable” scientifically?

Investigation

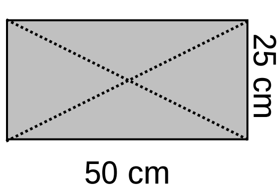
C. Look before your parachutist leaps—Collecting preliminary data

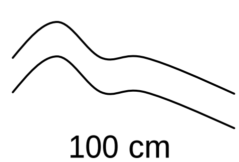
This investigation is about using basic science to think about the design and performance of an object or collection of objects (what we will learn to call a “system”) in the designed world. In this case the system is a toy parachute. The first part of this investigative process we sometimes refer to as “messing around with” or “exploring” the system to see how it performs and to build insight into what influences its behavior.

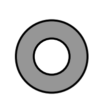
Design projects often start with a prototype—a sample design that has already been built—and then try to improve it. Using words that we commonly associate with scientific investigations, that prototype is the “control” that you will compare the performance of all your new designs to.

1. Use the specifications below to build your original prototype parachute. While you’re building the prototype, think about and discuss in your group what you could change about the components of the parachute to make it “better.”

   a. Specifications/procedure for building the prototype parachute







   b. Cut a 50 cm × 25 cm rectangle from your white plastic trash bag.

   c. Cut two 100 cm lengths of string.

d. Tie one side of each string to neighboring corners of the rectangle.

e. Place both strings through the washer.

- Tie the free ends of each string to the diagonal corner of the rectangle, so that the strings cross to form an "X".

- Try it out by dropping it from the ceiling and observing it as it falls to the floor. Record your observations and any initial measurements.

D. Variables roundup—Identifying variables that affect performance

1. Complete the variables chart below. List the parts of the parachute that you will put together as well as any other parts that you might add. List the different properties of the parts that you could change, and list possible effects of changing that property.

   - For example, for the "canopy" (column 1), you could change the variable "color" (column 2), and that would probably make "no difference" in the rate at which the parachute falls (column 3).
   - Your CEO has made lots of different materials and supplies available to your group, so use your imagination when you are thinking about what you could change about the prototype parachute to address the design goals of longest time to the ground and straightness of fall.

Parachute part	Variable you could change	Possible effects

2. Now use the variables table you just made to devise a plan to develop an optimum parachute to meet the CEO's requirements. Do not build any parachutes until you have received approval from your instructor (an official representative of the CEO) for the plan you develop in this part of the lesson. For your research plan:

   a. First decide which variable you feel will have the greatest positive effect towards meeting the design requirements. You will measure the effect that changing this variable has on your parachute's behavior.

   b. Make a table that you will use to collect your data for the prototype and at least two additional parachutes that you will build. Follow the example tables below (which uses color of the canopy as the variable being changed). Make your table clear, legible, and include the units of what you will be measuring. Remember that you can change only <u>one</u> variable.

	Time to fall (s)			**Straightness (How will you measure this?)**		
Color	Trial 1	Trial 2	Trial 3	Trial 1	Trial 3	Trial 3
White						
Green						
Gold						
...						

Variables held constant	
For example:	
Payload weight	10 g
String length	25 cm
...	

3. Make sure you have a plan to collect the data necessary to complete your table. Before moving to the next part, you must have your second table and plan checked and signed off by your instructor.

E. Testing, designing, and reporting your optimum parachute

Your CEO (or their official representative) will let you know how much time you have for building and testing your parachutes. To get into the final contest, <u>each member of your group</u> must have the following:

(i) a completed data table

(ii) a graph of how the descent time changed with the variable you changed

(iii) a 3-sentence report of your results based on the format given below.

1. Build at least two additional parachutes with the modifications you proposed in your data table. (Including your prototype, you will then have a total of at least three parachutes). Time the descent of the parachute from the same height. Record your results in the data table.

2. Use the following report to summarize your investigation:
   a. We studied how the time of flight changed with ___________ .
   b. We varied ____________ and held __________ , _________ , _________ , …. constant.
   c. We found that as ____________ increased, the time of flight increased/decreased.
3. After you have completed steps 1 and 2 above for one variable, you can, <u>if you have time</u>, try another variable to change and build and test two or three parachutes modifying that variable. Make sure you have your instructor check your work for steps 1 and 2 before you do this. (That will ensure that you have fulfilled all your obligations for entering the final contest!)

F. The CEO arrives…

1. When you drop your parachute in the final testing, you will be asked to give a brief report to the class about your investigation. Depending on the CEO's schedule, this could mean reading your 3-sentence report or a more open discussion of your group's thinking and design criteria for your parachute. Everybody in your group should have notes and written comments and add to the discussion. Be prepared to take questions.
2. Weather permitting, the final testing will take place outside, from a height of about 5 m. Each team will have to designate a "dropper," a "timer," and a "recorder" for the final testing. The parachute that takes the longest time to strike the ground while falling straight enough (as explained by your CEO) will win the contest and a special prize.

Assessment and wrap-up

A1. Reflection. Based on your observation of the performance of all of the parachutes write out some comments on the design variable(s) that seemed to have the best performance. Also make a few on your group's process in developing knowledge about parachutes.

A2. Reflection. Do you think the constraints the CEO imposed on you (namely, that you had to build a prototype first and then change only one variable at a time) reflects the way design engineers really work? Answer this question in a paragraph or two.

Appendix—Science and knowledge

This appendix presents two definitions of knowledge and science for you to think about.

1. Knowledge.

« Knowledge is the understanding gained by actual experience, clear perception to the truth, something learned and kept in the mind. »

2. Statement on "What is science?"

   From the American Physical Society
   (adopted by the Council, 14 November 1999)

« Science extends and enriches our lives, expands our imagination and liberates us from the bonds of ignorance and superstition. The American Physical Society affirms the precepts of modern science that are responsible for its success.

Science is the systematic enterprise of gathering knowledge about the universe and organizing and condensing that knowledge into testable laws and theories.

The success and credibility of science are anchored in the willingness of scientists to:

1. Expose their ideas and results to independent testing and replication by others. This requires the open exchange of data, procedures and materials.
2. Abandon or modify previously accepted conclusions when confronted with more complete or reliable experimental or observational evidence.

Adherence to these principles provides a mechanism for self-correction that is the foundation of the credibility of science.