Force and Motion: Ramp It Up

Grade Level: 4-5

Time: 3 class periods

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Overview

After watching an engaging video on Olympic alpine skiers, students then participate in a teacher-modeled "think-aloud" about generating questions. These activities prompt students to explore aspects of motion using a variety of materials with the goal of generating questions about the properties of motion. The students' questions are considered as to whether they can be answered experimentally in the classroom, and then students, working in groups, will design a method to test their questions and record their data. Students will use their data as evidence to answer the question under investigation before presenting their findings to the class.

This lesson offers students' the opportunity to develop a greater understanding of creating a testable question, controlling the experiment for fairness, and devising a way to collect data. Graphs and photos of the students' investigations and results will be displayed on a shared bulletin board in the hall. This lesson follows an *open inquiry* approach: the students will decide what the question under investigation will be, the students will decide on a method to collect the relevant data, the students will analyze the data, and the students will use their data as evidence to answer the question under investigation.

This lesson was developed through the "Introduction to Inquiry: A Professional Development Model to Reform Teacher Practices" project directed by *Science by Inquiry at Sweet Briar College* and funded by the *Virginia Department of Education Math Science Partnership Grant (MSP) 2012-2013*.

Objectives

Know

- Students will know what friction is and how it affects a moving object
- Students will know that speed and distance are ways to measure how an object moves.

Understand

- Changing the surface and angle of an inclined plane can affect an object moving down the incline plane.

Do

- Create a testable question.
- Design and implement an investigation around that question.
- Measure length using metric measurements.
- Record, analyze, and graph data.
- Use data analysis as evidence to answer the question under investigation.

Standards

Virginia Standards

Science 4.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

a) distinctions are made among observations, conclusions, inferences, and predictions;
c) appropriate instruments are selected and used to measure length, mass, volume, and temperature in metric units;
f) independent and dependent variables are identified;
g) constants in an experimental situation are identified;
h) hypotheses are developed as cause and effect relationships;
i) data are collected, recorded, analyzed, and displayed using bar and basic line graphs;
j) numerical data that are contradictory or unusual in experimental results are recognized;
k) data are communicated with simple graphs, pictures, written statements, and numbers;

Science 4.2 The student will investigate and understand characteristics and interactions of moving objects. Key concepts include:

a) motion is described by an object's direction and speed;
c) friction is a force that opposes motion; and
d) moving objects have kinetic energy.

Science 5.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

b) estimates are made and accurate measurements of length, mass, volume, and temperature are made in metric units using proper tools;
d) hypotheses are formed from testable questions;
e) independent and dependent variables are identified;
f) constants in an experimental situation are identified;
g) data are collected, recorded, analyzed, and communicated using proper graphical representations and metric measurements;
h) predictions are made using patterns from data collected, and simple graphical data are generated;
i) inferences are made and conclusions are drawn;

Context and Background Information

This lesson was written as a review activity; however, it could be easily modified for placement within a unit on motion. It addresses several fourth grade standards, providing a valuable refresher for fifth grade students who are required to test on fourth grade content.

The students have already learned about simple machines and motion. They have also covered speed, basic measurement, and friction. This knowledge provides background for the students to build upon as they focus on investigation skills while extending their knowledge of these topics.

This lesson uses an open inquiry approach, as the students will derive both the question and the methods of the investigation. In this investigation, the teacher is vital as a questioner and collaborator.

"I loved this activity. The use of an open lesson format for a review of prior skills was perfect. It allowed me and the students to focus more on the structure of the experiment and the measurement piece. The three groups each came up with a different question and all were easily expanded into future discussions about speed and velocity.... The students also left with a reinforced understanding of averaging along with scientific inquiry!"

~Carrie Perry

What You Need

- ☐ Tracks or ramps made of sturdy materials
- ☐ Dictionaries or other standard set of books to use as blocks
- ☐ Variety of balls
- ☐ Matchbox cars (one per team)
- ☐ Meter sticks
- ☐ Measuring tapes
- ☐ Variety of paper and graph paper
- ☐ Variety of pens, crayons, colored pencils, etc.
- ☐ Access to the NCES "Create -a- Graph" website

Materials available to students to cover tracks or ramps. Include much of the following:

- ☐ Foil
- ☐ Carpet scraps of various naps, profiles, or piles (different types of carpet)
- ☐ Towels
- ☐ Sand paper or textured wall paper samples
- ☐ Heavy-duty scissors to cut materials, if needed

Getting Ready

Two-weeks to ten days before the inquiry lesson

Copy and distribute the pretest (see handouts in the Appendix). The students began by taking a short pretest about scientific inquiry and including items about simple machines, friction and measurement.

After scoring the pretests group the students into homogeneous teams of 3.

Assess and remediate the students' understanding of metric measurement and their ability to make measurements of distance. See pre-lesson assessment section.

At least one week before the inquiry lesson

Make sure that you have a large area of space available (like the hall or cafeteria) for the lesson because some items roll QUITE far.

Check access to the video clip of the Olympic ski competition found at:
http://www.olympic.org/alpine-skiing

Check access to the web-based program: NCES Create -a- Graph found at:
http://nces.ed.gov/nceskids/createagraph/default.aspx

Day One: Planning the Investigation

Engagement

Engage students with a short video clip of an Olympic ski competition found on the olympic.org website. Ask the students to comment about the results and the slope and surface. Questions for the students may include: What impacts these athletes' end times? Can we build an inclined plane in our room and use it to produce motion that can be measured? How would you design your ramp? Draw a simple plan.

Present a variety of materials for students to use including: tracks or ramps, books to use as blocks, carpet pieces, linoleum pieces, sand paper, meter sticks and measuring tapes, matchbox cars, various balls, and other materials listed on the What You Need page.

Split students into groups based upon their pre-assessments. Allow students to take a selection of materials to their areas for exploration. Tell the students that their job is to play with the materials briefly, and then work in small groups to create a testable question, per team, that could be examined using the given materials.

Defining the Question for Investigation

As the groups are working, move around the room and listen for groups that may need to refine their question. Hand out note cards to every student and ask them to write a testable question on the concepts of motion discussed earlier. If necessary, the questions may be displayed to the whole group for open discussion about whether the question is ready to test or if it needs revising.

Have the students share their questions with their team and choose the one question that they want to investigate.

Planning the Investigation

Once a question is ready, the group then has to plan their experiment. One team member will keep notes on the steps the group will follow. The steps should be edited as the group tests their plan.

The steps should include a plan for measuring the data as well as multiple trials. The groups will need to have a way to record the data. They should be collecting data that they can then graph.

Emphasize with students that they should frequently come back to the question that is under investigation to assure that they stay focused on collecting the data needed to answer that question.

Day Two: The Investigation

Begin the Investigation

Allow the students to continue planning, if needed.

Tell students that they will be presenting their investigations to the school by displaying their graphs and their process on a shared bulletin board in the hall. To help with this, one group member will be assigned an iPod and will be the photographer to visually record what the group is investigating.

As plans are coming together, prompt students to begin testing and recording data. The students will be asked to consider how to record data that can be graphed and shared.

As students are working, the teacher should monitor their progress ensuring that they are following their recorded plan, doing multiple trials, and are on target to finish in a timely manner. It is sometimes difficult to manage multiple groups in a large space. It is helpful to call time-outs at set intervals (15 minutes is good) and let the students know how much time is left. While they are in this time-out, visit each team and see if they are working at a good pace, too fast or two slow. Help them decide what to do next and make suggestions if they are not on schedule. (Be aware of traffic in your building, as well. If you are using a hallway, you may have to do one step then move out of the hall for traffic and come back.)

Days Three: Data Analysis

Making Meaning of the Investigation Experience

After students have completed their experiments, they will work on organizing and analyzing their data.

Students will have access to the Create-a-Graph website and will be prompted to make a graph from their data. Through this process, student may need varying levels of assistance. Some may be able to derive an average without any help, while others may need teacher guidance. Some students may connect that inches can be converted in to feet or centimeters into meters, while others may need a calculator and a conversion rule. Be aware of which group(s) may require prompting to set the graph up using appropriate titles and graph intervals. If these skills have not been covered in the mathematics classroom, it may be necessary to do this portion of the lesson as a class.

Students will next create a display for the school bulletin board. The display should have their question for investigation, pictures and words to explain their methods, and a graph of their results. The display should also have a summarizing conclusion statement that answers the question for investigation with reference to the data and graph.

An envelope, where other students and teachers can make comments or ask questions addressed to the teams, will accompany each display board.

Wrap Up – on a later date

The teams will meet one final time to wrap up any questions that were placed in the envelope using a poster. They will discuss the question, come up with a possible answer, and share that answer. You can decide as a class if the students want to respond to the questions in a public format such as the morning announcements, posting the responses on the same bulletin board or even giving a presentation in a class or if the responses will be shared only within the class that completed the lesson.
A post assessment will then be given in the computer lab.

Assessment

Objectives

The overall learning objective of this lesson (The Big Idea) is for students to learn about motion through the development and design of their own scientific investigation. Learning goals also include: control of experimental variables; graphing and analyzing data to answer an investigation question; and collaboration and communication skills that lead to a deeper understanding of the nature of science.

Assessment Plan

A pre-lesson assessment is given two-weeks to ten days before the inquiry lesson begins. The information from the pre-assessment is used to evaluate students' abilities to use the metric measurements (a readiness issue that needs to be addressed prior to the lesson) and uncovers students' prior conceptions about scientific inquiry. It also serves to review and prompt students on concepts related to motion, in anticipation of the investigation.

During the inquiry the teacher uses formative assessment to monitor students' skills and to provide feedback to the students as needed during the investigation.

At the end of the inquiry, students' graphs and displays will be used as a summative assessment. As students have an opportunity to engage in discussion through the bulletin-board, these communications will also be used as a summative assessment.

Pre-lesson Assessment

The students begin by taking a short pretest about scientific inquiry which includes items about metric measurement, friction, ability to define a testable question, and graphing. (see Appendix 1) Using these results, students will be grouped based on their comfort level with the investigation process.

Formative Assessments:

During the inquiry lesson, the teacher will use an informal checklist (see Appendix 2) to record which students created a testable question independently and also to record measurement skills demonstrated by all students in a group. Teacher will intervene to help with measurement if necessary.

Summative Assessments:

After the investigation, students will complete their graphs. The teacher will assess students' graphs using a rubric. As questions and comments come in from the bulletin board displays, the students will be asked to respond to their new audience. These responses will also be collected by the teacher and used as part of the summative assessment. (The teacher may evaluate these responses based on a rubric or a checklist as preferred.) Additionally, the students may take a post test, similar to the pretest for comparison of scores, or the skills can be included in a unit test.

Acknowledgements

My initial idea was a combination of an investigation that another Inquiry student shared at a previous class meeting and a science fair experiment that my regular science teacher has used for past science fairs. I have always thought that this hands on activity was fun, but lacked the investigation that would allow students to learn through experience. I wanted to open up the options to cover more than just changing the surface of the ramp. In addition, I was glad that another teacher tested marbles and shared how impossible they were!

Credits to Amanda Ergenbright and Maryanna Soult, teachers in Bedford County Schools

"Inquire Within" by Douglas Llewellyn

Ski Video Link:
http://www.olympic.org/alpine-skiing

NCES Create -a- Graph link:
http://nces.ed.gov/nceskids/createagraph/default.aspx

Appendices: Handouts

1. Pre Assessment

2. Informal Checklist Sample

Appendix 1

NAME_____DATE_____HR_____

Sort the following questions into the correct category.

Testable	Needs Revision

A. Do ramps affect the speed of the ball?

B. How long does a basket ball bounce?

C. What effect can different textures of soil have on the amount of water held?

D. How many trees will grow in one acre?

E. How can the weight of a toy car affect the distance it will roll?

What is **friction**?_____

_____

Circle the correct answers.

1) A bike that is rolling down a paved hill will...

a. need a lot of pedaling b. roll easily c. come to a sudden stop

2) On a flat, grassy surface a bike will...

a. roll without pedaling b. not roll at all c. need a lot of pedaling

3) In a scientific experiment it is very important to...

a. test several things

b. keep everything the same except the thing being tested

c. keep data and notes

d. start over if one thing isn't coming out exactly like we planned

e. repeat the trials

Match:

___height of a door **a. centimeters**

___length of a road **b. meters**

___width of a toothpick **c. kilometers**

___length of a pencil **d. millimeters**

Cut out the pictures to the right and sort them into the correct area. Glue them when you are done.

SCREW	INCLINED PLANE	WEDGE

Appendix 2

Student Name	Target 1: understands friction (adjusts height/ surface)		Target 2: demonstrates "fairness" with constants		Target 3: uses appropriate measures for distance		Target 4: graphs the data correctly	
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N
	Y	N	Y	N	Y	N	Y	N