Exploring the world of optical devices: Learning about lenses & building a telescope

Overview: To demonstrate how the knowledge and the skills gained through studying Math can be applied in building a real optical device.

Objectives: Students will: 1) learn the basics of ray optics; and 2) build a simple version of a telescope.

Key Concepts: Convex Lens, Thin Lens Equation, Focal Plane, Light Propagation, Refracting telescope (Recommended grades 7-8)
Subjects: Math, Physics
Duration: 1.5 class period (50 min+20 min)
Setting: Classroom with desks and windows
Indiana State Mathematics Standards: Measurement (7.5.2, 7.5.3)

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Introduction (background): The Science of Light plays important role for the society by bringing essentials such as light bulbs, photo cameras, and displays, as well as providing other sciences with tools for further research like microscopes, telescopes, lasers, etc. The basic element of almost every optical device is a lens. And studying lenses is the main objective of the two-part lesson. During the first part of the lesson we are going to cover simple mathematical model describing propagation of light through the lens and experimentally prove the derived formulas. The second part of the lesson will be devoted to building simple versions of telescopes.

Materials:

- Meter stick with support
- Double concave and convex lenses with lens holders
- Light source with holder
- Card board (it will be used as a screen)
- Cardboard frame with holder

Before starting the lesson divide students into groups. Each group will be given later the optical experimental kit. Number of the groups depends on the amount of the available kits.

Engagement: This is a warm-up part of the lesson. At the very beginning tell students that today they are going to explore the field of Optics and their first task is to guess 8 names of well-known optical devices which start from the letters shown on a board (use the power point file *Optical Devices*). If a student gives the right answer show the slide illustrating the guessed device. You can go back to the main slide by clicking the 'Pi' button in the left corner. The devices included into the game are telescope, binoculars, microscope, camera, eye, glasses or contact lenses, and projector. Rewarding the students for giving the right answers can help in awakening the spirit of competition.
[*5 mins*]

At the end of this part, mention that in all of the optical devices involved into this game lenses play the key role and now you are going to uncover the principle of lens operation.

Explanation: After the warm-up activity, distribute the blank report documents (*student_doc_1a*) and ask the students to fill in on page 1 *Name*, *Date* and *Hour*. Then, give a short lecture on the theory of thin convex lens. The major concepts to be discussed here are lens functionality, thin lens equation and ray diagrams. Paragraphs under the same number in Explanation and Exploration & Elaborations are connected to each other.

1. Lens has the property that as light passes through it, the light is refracted. In particular case of convex lens, incident parallel light, i. e. the light coming from far away, focuses to a single point, which is called a focal point. The distance between the lens and a focal point is called a focal length.
   [*2 min*]

   Here you can ask them additional questions to refresh what they studied in Science classes:
   What is light? Where does it come from?

2. "Let us try to understand what happens with the light passing through the lens and why the image of the window is upside down." Ask the students to follow your explanation (*Lecture*) by drawing on their graph paper (*Lecture_student*).
   [*10 min*]

Exploration & Elaboration:

1. Allow the student to build an optics bench consisting of a supported meter stick, a double-convex lens with 30 cm focal length, a screen, an object and a lamp.
   [*2 min*]

   Give them a task to measure a focal length of the lens by focusing the light coming from the windows behind onto a screen. They should observe a sharp image of the windows. Draw their attention to the fact that the picture is inverted and that you will explain them later why it is so. If they move the lens away from a certain position the image will become blurred. The focal distance depends on the shape and material of a lens. In our particular case the correct focal length should be about 6 cm. Ask students to write the result of the measurements in their report documents. The measurement of the focal length is very important for further tasks, therefore make sure that students do the measurements in a very accurate manner.
   [*3 min*]

2. After the short lecture, students will practice in solving the problems (file *student doc_1a*). "Now we are going to play with light by making some predictions: where should we place an object, a screen and a lens in order to get the image magnified certain number of times."
   Right answers to the problems are in file *student doc_1a_teacher edit*. Ask the students to solve optional tasks in case of extra time. If you are out of time, it is recommended to let them solve just one magnification case.
   [*20 min*]

Evaluation: Save some time before the end of the lesson, so that students have time to write a conclusion "what they have learnt today in class" (part 6 of *student doc_1a_teacher edit*)
[*5 min*]