Outreach Activity Box for Engineering Education: Optics Lab

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Introduction

What do engineers do? Although direct in its inquisitiveness, the question is a simple one that many young minds may find difficult to answer. But intuition about what engineers do is vital for generating interest in engineering and the applied sciences. So how do you teach children what engineers do? Have them solve an engineering problem. The small number of activities that do this adequately limit university professors that participate in outreach programs such as the one just described. With limited tools, professors have limited ability to convey engineering principles that make engineering fun.

We propose to design an activity that engages students in engineering problem solving that teaches them about the properties of light.

Problem

At Carnegie Mellon there are a number of professors that participate in outreach activities. These professors visit local elementary or junior high schools to teach childeren something about engineering. We will design an activity which the professor can take to a classroom to teach the students something about engineering. The activity must meet the following criteria.

- engage the students in an engineering activity
- teach them something about what engineers do
- appeal to all types of children
- engage about 30 children simultaneously
- be safe, durable, and suitable for an indoor classroom

- be transportable in a compact car

Objectives

The objective of our project is to help children learn basic optics and properties of light by building simple experiments. Students aged 12 to 13 usually do not have much exposure to this field, and we believe that light and the effects of light can be one of the most captivating and interesting aspects of science and engineering.

We believe that students will be eager to learn and experiment on their own with the tools given to them. Having witnessed a number of in class activities in which children were asked to build their own experiments, we noticed that the children's interest was sparked by the hands-on approach rather than the theory explained on the blackboard.Many of the projects that we have seen or heard about that are used to instruct children in the classroom do not give them a lot of freedom with both the experimental setup and the outcome of the experiment, and we think that this approach might discourage the children by not letting them fully express their creativity. In our case, we wanted to give the students a modular kit that can be used in many different ways so that each group could have a unique experimental setup with interesting results. The optics experiments could also be used to show how the same optical effect can be obtained in different ways.

By providing the groups with the tools necessary to setup an optical experiment we will enable them to learn empirically.

Solution

We propose to build and distribute a number of optical kits that will allow students to experiment with different optical effects. Each kit will be composed of the following material :

- A wood base board, 18 inches x 24 inches, covered in a black matte plastic sheeting
- 1 triple and 1 single slit plate for mounting on the ray box
- 1 hollow acrylic prism
- 1 double concave lens
- 1 convex lens
- 2 plane mirror
- 1 concave mirror
- 5 different colored filters
- 3 pairs of mirror holders (manufactured with fused deposition)

The ray box will be provided in the activity box, but we will provide only one because of the high cost of this piece of hardware. The instructor will demonstrate the usage and effects of each component to the students and then assign the groups a task to complete in a certain time frame. An instruction manual will be supplied with the activity box to aid the teacher in setup and will contain relevant background information on optics. Each group's task should be different, thus allowing for each group to learn from other groups after the experiment is complete.

As the groups design their experiment, the instructor will bring the ray box to a table and test the group's proposed solution. If the solution meets the objectives, then they have completed their task will work on a second project while the other groups complete thier first task. If the test produces unexpected results the group will have a chance to redesign their experiment. Once all groups have reached their objective, or time has elapsed, the instructor will demonstrate each solution so that other groups can see and learn from other experiments.

Our group will write all documentation for the activity. In it, we will outline a series of possible experiments that the instructor can draw upon for group tasks. Each outline of the experiment will describe the effects produced and the setup of optical tools that will produce the result. We estimate that there will be 4-6 different experiments documented. In addition to the experiment tasks, the instructions will help the instructor explain the function of each of the optical components as well as some basic theory on light.

Costing

Costing for the material is as follows - prices are from 1998 Boreal catalog :

Ray Box includes prism, 1 convex lens, 2 slit plates 1 plane mirror, 1 convex mirror, filters, bulb	$75.00 part #69360
Alkaline batteries	$3.50

In addition, for each kit past the first (most of which comes with the ray box) we will require the following :

1 plane mirror	$3.95	part #66522-00

1 concave mirror	$2.95	part #62596-50
1 double concave lens	$13.95	part #69884
1 double convex lens	$14.95	part #69885
Total for each kit after first	**$35.80**	
Total for 1 ray box and three kits	**$146.60**	

We have attached the completed order form from Boreal with this information.

This pricing does not include the cost of wood and plastic laminate, which we believe will be approximately $10 for 5 kits.

Plan

Our plan for the completion of the project is as follows :

Task	**Assigned To**	**Due**
Proposal	All	Now
Order parts	Molinari	Apr 10
Table build for prototype	Cho	Apr 14
CAD design of mirror mounts	Lam	Apr 14
Assemble Prototype	All	Apr 16
Obtain mirror mount via LaserCamm	Lam	Apr 20
Table build for all kits	Cho	Apr 24
Assemble all kits	All	Apr 26
Experiment Design Instructions	All	Apr 24
Light/Optics Background	Molinari	Apr 24
Final Report	All	Apr 26