Exploring Optics: A kit and curriculum for teaching eighth graders about light waves and their applications

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Abstract: Created with support from an SPIE Outreach Grant, the "Exploring Optics" kit, curriculum, and teacher training was developed with the aim of increasing awareness of and interest in optics and photonics in Arkansas by targeting pre-high school students and science teachers.

1. Introduction

The "Exploring Optics" kit, curriculum, and teacher training workshop was created with the primary goal of increasing awareness of and interest in optics and photonics for pre-high school students and teachers in Arkansas. To ensure that the largest number of students and teachers could be reached, the curriculum is aligned with the Arkansas science standards. Optics and photonics concepts fit naturally in the grade eight standards so the curriculum is aligned to eighth grade Arkansas science standards. Alignment with the standards also ensured teachers could use the kit and curriculum with little additional preparation time. The kit was made low-cost and consist of easily available materials to maximize accessibility.

2. Exploring Optics: The kit and curriculum

The curriculum consists of three activities, each aimed at increasing interest in optics and photonics while meeting the Arkansas Education Standards for eighth grade science - Waves and Electromagnetic Radiation (8-PS4) [1]. A photograph of the complete kit and booklet is shown in Figure 1. The concepts in each activity build on each other, culminating with the final activity where students build an optical communicator. The complete activity guide and other related resources are available at [2]. The first section in the booklet addresses safety concerns associated with the electronics and lasers in the kit. The second section introduces general properties of waves then moves on to light waves. The remaining sections of the booklet are activities. Each set of activities introduces the concepts required for investigations and introduces guided-inquiry type questions to prepare the students before performing the investigations.

Fig. 1. The complete Exploring Optics kit and booklet.

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2.1. *Activity 1: Index of refraction*

This activity introduces refraction and how the speed of light in different materials is related to the index of refraction of the material. This activity consists of two parts, one where students use white light from a flashlight and a glass container filled with water to create a rainbow. In the second investigation, the students use a laser pointer and a protractor to investigate how light bends more as the index of refraction of a sugar water mixture is increased (by adding more sugar).

2.2. *Activity 2: About optical fibers*

This activity applies refraction to investigate guiding light using total internal reflection. Students observe total internal reflection in a container of water then use a bent acrylic rod to see how the laser light can be guided from one end of the rod to the other.

2.3. *Activity 3: Build an optical communicator*

In the final activity, students learn how data can be encoded to a laser beam then transmitted through an optical fiber or free space, received, and then decoded. This activity utilizes an earpiece as part of the receiving device, but some teachers preferred to set up a demonstration and replace the earpiece with a speaker and amplifier. Plans for the speaker and amplifier setup is available at [2].

3. Teacher Training

3.1. *Pilot cohort selection*

A cohort of ten eighth grade science teachers in Arkansas were chosen from over 50 applications. The applications required teachers to answer questions that allowed for determination of the need for support and equipment in their classrooms. The cohort has and will continue to receive support implementing the Exploring Optics curriculum in their classroom. When each teacher completed the training, they received ten complete Exploring Optics kits to be used in their classroom.

3.2. *Virtual workshop*

With initial research, it was recognized that teachers wanted assistance with planning material and activities required to meet state standards and additional optics content education to increase comfort teaching the material to their students. The original plan for the workshop was a two-day in-person workshop to train teachers on the use of the kit and help increase teacher confidence in teaching optics and photonics. Due to pandemic restrictions, the workshop was converted to a completely virtual experience. The self-paced workshop was broken into four units that correspond to the four main sections in the booklet. Each unit consists of instructional videos that introduce the concepts required to understand the activities followed by assessment and demonstrations for how to perform the activities. Teachers were asked to earn at least 80% on each assessment before moving on the the next module.

3.3. *Future plans*

The virtual workshop received positive feedback from the participants but an in-person workshop would be beneficial. The Authors plan to offer the teacher training as an in-person summer workshop in the near future. Additionally, state approval will be sought for official professional development credit for the teachers that participate in the workshop. At the completion of the pilot program and receiving feedback from the first cohort, the full content of the curriculum will be available to the public. Finally, in partnership with the Arkansas Tech University STEM institute, 20 Exploring Optics kits (consisting of only the non-consumable components) are available to be checked out to Arkansas teachers.

4. Acknowledgements

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