Teaching light reflection and refraction to the blind

A. C. de Azevedo[1], L. P. Vieira[2], C. E. Aguiar[2], A. C. F. Santos[2*]

[1]*Colégio Pedro II, Unidade Escolar Realengo 2, Rua Bernardo Vasconcelos, 941,CEP 21710-261, Rio de Janeiro, RJ, Brazil*
[2]*Instituto de Física, Universidade Federal do Rio de Janeiro, PO 68528, 21941-972 Rio de Janeiro,RJ,Brazil*

Abstract

The late trends in special education policy aim to maintain in the same school system students with and without special needs. In the case of students with visual impairment, one of the main problems they face, particularly in physics, is the lack of instructional materials adapted to the experimental laboratory. In this paper we present strategies, activities and resources for instructional use by the physics teacher in a classroom with students with visual impairment, using tactile sensations produced by laser light to teach optics concepts. For best results, we suggest that teachers use resources from a perspective of building models in order to stimulate interest and active involvement of the student.

Keywords: inclusion, visually impaired, optics, laser.

* Corresponding author: toni@if.ufrj.br

Introduction

Traditionally, specialized schools have been responsible for the education of students with special needs. However, this trend in special education has been modified. The current view is that students with special needs should be educated together with their peers in regular education situations. Notwithstanding, this new school system should be prepared to receive this student. Regarding students with visual impairments, they need strategic teaching, adapted instructional materials and modifications in the regular curriculum to emphasize skills of touch, hearing and communication.

One of difficulties encountered by the visually impaired student is to perform experiments, and in the particular case of optics, to construct a mental representation about light. In a previous work [1], we focused on the difficulties that visually impaired students have when dealing with graphics and diagrams in their study of geometrical optics. In this article, we establish practical alternatives for experimental work as well as a contribution to building a conceptual representation of light. It is based on the assumption that our information on nature originates via our senses. Much of our knowledge on the nature of many physics concepts relies on the various senses we employ in our inquiry about it. For the blind, the sense of sight is replaced by the senses of hearing and touch. Teaching optics to students with visual impairment has usually been addressed by presenting tactile-visual artifacts [1-3]. However, the information that can be received by the visually impaired becomes limited by its lack of vision. To overcome this difficulty it is necessary to use practical methods of instruction as close as possible to a real experience. Most of the experiments in optics which have sensorial meaning must be visually observed. Thus, the experiments must be adapted to convert light signals into signals perceived by the blind student. One of the main senses used by the blind is touch, and in this work we discuss how the tactile sensation created by light can be explored in optics experiments. For best results, we suggest that teachers use resources from a perspective of building models, in order to stimulate an active involvement of students and facilitate the development of reasoning skills and a deeper understanding of concepts.

As will be described below, this article suggests using lasers in an unconventional way. It must be stressed that there are standards that describe procedures for the safe use of lasers in order to minimize the risk of accidents, especially those involving eye injuries. Even a relatively low intensity of laser light can cause a permanent damage to the eye. Lasers of moderate and high powers are potentially dangerous because they can burn the eye retina or even the skin. To minimize the risk of injury, regulations were created such as the ANSI Z136 [5] in the United States and the international standard IEC 60825 [6] that define "classes" of lasers depending on their power and wavelength. These regulations also describe necessary safety measures, such as labeling lasers with specific warnings, and the use of safety goggles when operating the laser. The latter are necessary even when low power laser pointers are used, as the visually impaired person usually does not present the reflex response of rapidly closing the eyes when exposed to strong light.

Methodology

The present methodology is based on the premise that teaching physical phenomena must be subsidized by the construction of conceptual models [1, 4]. As the theory of modeling involves a procedural knowledge, it is best learned in the context of specific activities of modeling, where the theory is developed gradually in order to monitor and guide these activities. An active learning, using the construction of a model, demands the coordination and integration of the observed events with the scientific method, rather than a mere collection of facts and formulas. Principles of modeling organize the information in a scientific theory for application in actual physical situations and practical problems. Hence, a physics teaching focused on developing models adjusts itself to the physical reality and is believed to be efficacious in germinating the physical intuition of the pupils.

To introduce the concepts of light, initially the students are exposed, for example, to sunlight. Alternatively, the teacher can bring the student’s hand to a lamp or a candle, so that she or he could sense the heat. Both sun exposure, and the approach of the hand to a lamp or candle should occur within a short time to avoid accidents. Touch is one of the main forms in which the blind student interacts with the world [7]. The teacher may also use a laser of reasonable power (Figs. 1 and 2) in order to sensitize the skin, with due attention to the safety measures outlined above. Then, based on the specific experiences in the previous stage, the teacher might introduce a new concept: that light intermediates the interaction between a source (the lamp or the laser pointer) and the receiver (the skin of the student). Here, the operational definition for light as "*the radiation detected by the human eye*" does not make sense for the blind student. So we propose a new definition: "*Light is a radiant energy that strikes ones' skin by termoception* (perceived temperature)".

Fig. 1 – A red laser beam from a "pointer". The blind student is able to pinpoint the area on his skin where the laser focuses (photo taken with permission of the responsible for the student).

Fig. 2 - The student shows in his arm the area where the incidence is felt.

Again with due attention to the necessary security measures, the linear propagation of light can be easily taught with the aid of a laser device. The student is able to identify the point at which the laser light sensitizes her/his skin (Fig. 3). On the bench, the teacher can put a styrofoam sheet on which the student sticks pins marking the points where he felt the light incidence. Repeating this process several times he can trace the path of light and verify that the pins are aligned on a straight line (Fig. 3).

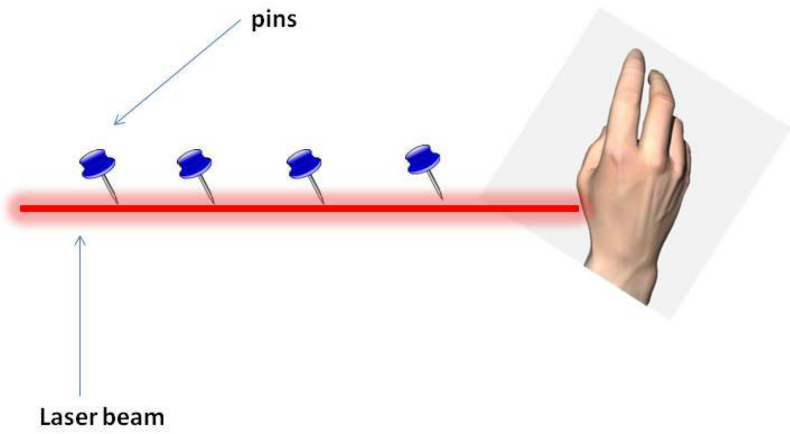

Fig. 3 – With the aid of pins to mark the light path, one can demonstrate the concept of linear propagation of light.

The laws of reflection and refraction can also be easily determined through the use of pins as markers on the styrofoam sheet, as shown in Figs. 4 and 5. During the activities, the students are stimulated to develop relationships that generalize their experiences. The teacher acts as a facilitator helping students to formulate these relationships in order to be consistent with the goals of instruction.

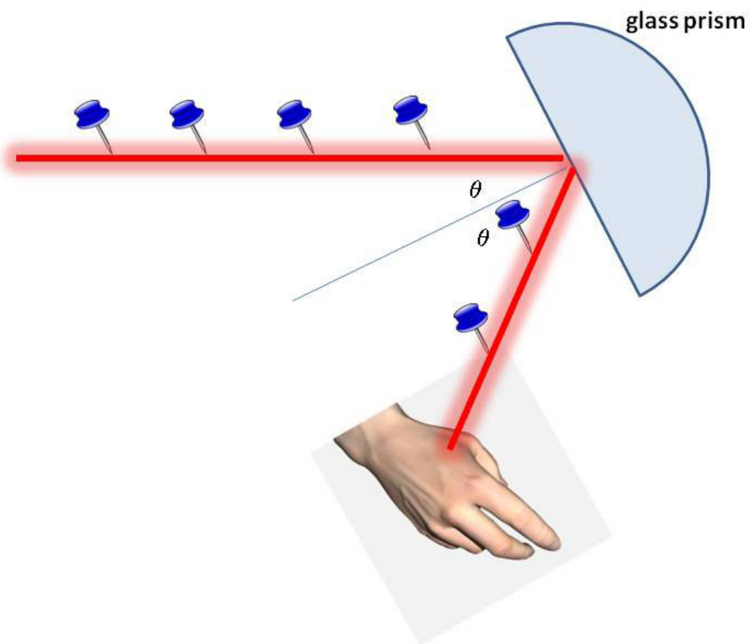

Fig. 4 – Demonstrating the law of reflection.

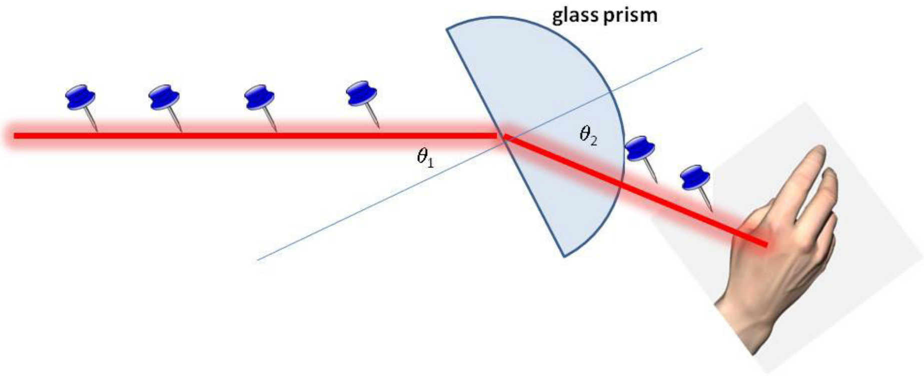

Fig. 5- Demonstrating Snell's law.

Conclusion

This paper presents a methodology for teaching light propagation, reflection, and refraction to the visually impaired using laser light. It is based on the premise that teaching physical phenomena must be subsidized by the construction of conceptual models. Since the theoretical frame of modeling involves a procedural knowledge, it is best learned in the context of specific activities of modeling, where the theory is developed gradually in order to monitor and guide these activities. Thus, hands-on activities that aim at building models of the physical reality should be effective in developing students' physical intuition.

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