Teaching optics to blind pupils

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Abstract

We focus on the difficulties that visually impaired students have when dealing with graphics and diagrams in their study of geometrical optics. This case study suggests practices that use low cost materials, easy to find and to handle, and that provide a tactile perception for visually impaired students. The activities employ light and easy to carry magnetic boards and different types of magnets, mainly shaped rubber magnet strips. A student-centered learning method, namely Karplus's learning circles, is adopted.

1. Introduction

Blindness is a condition of the eyes, not of the mind [1]. The visually impaired have the same ability to learn and curiosity of the non blind. Though she or he cannot see the world around us, the blind want to know and understand it as well. Thus, the teaching of Physics should be held in appropriate conditions, considering the needs of an individual. Besides the difficulty in reading the written material, the visually impaired also confronts diagrams and charts that are not easily understood only by oral transmission. As the blind person 'sees' the world usually by touching, experiments must be developed to use the student's tactile sense.

There are studies about the difficulties faced by people with physical disabilities when learning science [1–11] although the issue of teaching physics for visually impaired students is still scarcely researched. A common mistake is the use of teaching models for blind persons based largely on the physical sense of sight.

Lack of understanding is always an obstacle in the teaching of physics for the visually impaired within the ordinary classroom, this being partly due to his/her lack of vision. There is a high chance that the information received can lead to misconceptions, unless an objective method of thinking is employed. The authors understand that the use of models should play a central role in teaching optics for the visually impaired. This means that the teaching of physical phenomena must always be subsidized by the construction of conceptual models. In this sense, it is necessary that there are well-trained instructors for the practice of inclusive education, in particular for visually impaired students [1].

While electronic devices which help these students in activities such as reading have been developed for decades [8], a significant number of students in the world do not have access to this kind of assistance. Various alternative materials have been reported in the literature [8]. Some authors, for example, have suggested the use of frames with a high rim and filled with wax, on which students can write or draw with the aid of a pointed tool [8].

In the present case study, we focus mainly on the difficulties that the visually impaired have in reading when dealing with graphics and diagrams. We suggest practices that use low-cost

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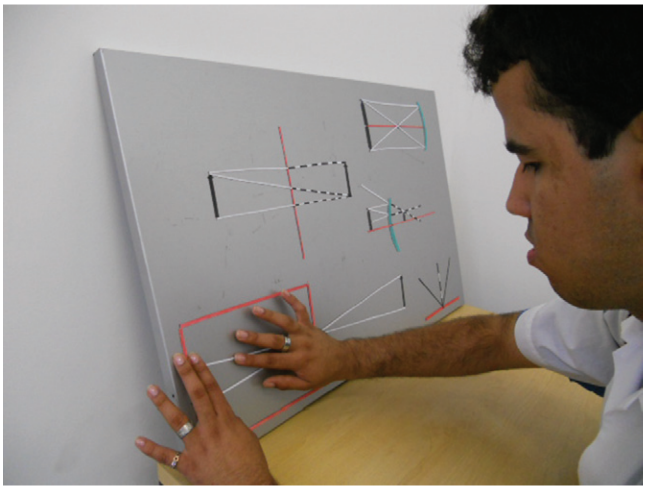

Figure 1. Pupil using the magnetic board and magnetic ribbons representing the ray model of light.

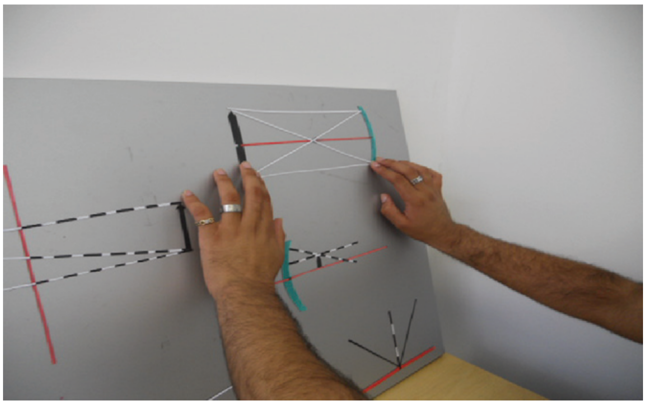

Figure 2. Student using a representation of spherical mirrors using a magnetic board.

materials which are easy to find and handle, and provide tactile perception for visually impaired students.

2. Presentation

The case was performed at a Brazilian public School, Colégio Pedro II, between March 2007 and February 2012. We included eleven high-school students (boys and girls; age range 15–20) with partial or total visual disabilities.

A typical physics class, especially in geometrical optics usually requires the use of charts and graphs. But, how can we make drawings and diagrams that visually impaired people can follow? Some criteria must be followed: the material should be easily obtained, the rows may be easily removed or erased and enable rapid replication. The lines should be raised so that the disabled student can easily distinguish them from the background. Magnets and magnetic boards meet these criteria.

The material consists of a $80 \times 50\,\mathrm{cm}^2$ light and easy-to-carry magnetic board and different types of magnets, mainly shaped rubber magnet strips (1.0 cm wide and 3 mm thick) which are of great practical use when forming both the Cartesian axes, as well as straight lines: an example would be the linear propagation of light, as shown in figure 1. These dimensions make tactile recognition of drawing forms easy for blind students. Other magnet types—such as mats and

Figure 3. Student using a representation of spherical mirrors using a magnetic board.

shaped discs, all with reasonable thickness—can be used to make drawings of curved lines and to mark points on the graphs.

As opposed to a sighted student, who can visualize a picture at a glance, the blind pupil ‘reads’ the picture step by step. To do so, they used both hands to follow the raised lines in the board, as seen in figures 1–3.

Initially, students have some trouble interpreting the picture on the board. The discernment of pictures demands a learning process in which the pupil is taught to associate the elements of a picture with real objects [11].

The simplest representation of light is something that travels in a straight line as rays. For the non-blind, rays are easily perceived as the transmission of a beam of light in a medium containing particles in suspension. But, how can we convey this concept to a blind person? One solution is to think of an abstract description, a mathematical line, as illustrated in figures 1–3.

To represent the refraction of the light, broken and curved lines can be easily drawn using the magnetic strips. The drawings are sufficiently stable, so that the students can easily follow the broken lines by using their fingers.

One should point out that the frame magnets and objects only establish similarities—the common properties of real objects: so-called object-models—which constitute the conceptual images (and are therefore abstract) of the elements belonging to the real system intended for interpretation.

3. Discussion

Models are important resources for science teachers in general, because modeling is intrinsic to science [12]. A physical model is an analogous representation, simplified and objective, of a physical phenomenon that contributes to our understanding of the content. In the case of the blind, modeling serves as a substitute for direct observation and experimentation, which, in the case of traditional teaching of geometric optics, makes use of imaging with the aid of lenses to study the refraction and reflection of a beam of light on a dioptric surface. Models, in the form of diagrams, can be used when it is impossible or impractical to create experimental conditions in which students can directly measure the results due to their physical limitations. The instructor should keep in mind that a true and complete representation to the student is almost always impossible. We can build models, mockups or diagrams that act as simplified simulations of reality, made to describe the phenomenon they represent. However, analog models always have their limitations. For example, light is sometimes modeled as a wave, sometimes as a particle. Some authors argue [1] that, because the world is invisible to the blind person, she or he would have no difficulties bridging the gap between the concrete and the abstract.

Present-day learning methods call for student-centered teaching, recognizing the significance of pupils' previous knowledge state in the learning process. We have adapted learning circles [12], which are based on the framework of Piaget's theory of intellectual development. These are composed of three learning phases: exploration, concept introduction and concept application.

In the exploration phase, pupils explore an unfamiliar situation in ways which generate questions that cannot be solved with their patterns of reasoning. For instance, in this phase the student is invited to approximate his/her hand to the flame of a candle or sunlight. Although he or she cannot see the light, it can be sensed through his/her skin. The teacher then raises questions such as 'What is light?', 'How does it propagate?', 'Does it bend?'. Teacher interaction is minimized, though still present, in this phase.

The concept of light is introduced in the second phase. Teacher interaction is more necessary at this stage. The conventional definition of light as 'a kind of electromagnetic radiation visible to the human eye, responsible for the sense of sight, and which can sometimes be represented by light rays', is true but makes no sense to the blind student, who neither has a sense of vision nor can see the representation of light rays on a board. A new representation of light rays, mirrors, lenses and other optical objects is necessary. We define a ray of light as a kind of radiation that sensitizes the skin. The student is then introduced to the magnetic board and is invited to explore it with his/her fingers.

In the concept application phase, the pupils apply the new concept to additional situations. In this phase, physical experience, with the materials and social interactions with teacher and peers, is important.

The positive results obtained in this work suggest that the students are able to realize and to understand in detail the figures and graphics presented to them. As a consequence, they feel encouraged to continue the study, so that the teaching–learning process is successfully completed.

4. Conclusion

Unintelligibility is a permanent barrier in the teaching of physics for the visually impaired student, as is the lack of adequate teaching resources and the absence of adapted experiments. Student-centered active learning, using model building, requires the coordination and integration of facts with the scientific method, rather than the mere collection of facts and formulas.

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