Journal of Modern Education Review, ISSN 2155-7993, USA
August 2021, Volume 11, No. 8, pp. 853–860
Doi: 10.15341/jmer(2155-7993)/08.11.2021/006

http://www.academicstar.us

Perceptions of Primary Education Teachers About Visible Light

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Abstract: This paper presents the results of a research that investigated the perceptions of primary school teachers concerning the notion of visible light that is required to be taught in the last two classes of Primary School. The survey was conducted in autumn 2009 and primary school teachers of the four prefectures of the Epirus region participated in it. The survey results showed that primary school teachers hold misconceptions in the scientific field of Physics and, more specifically, implement different approaches to optical physics which is included in the primary school curriculum. These misconceptions are similar to those of students, according to the bibliography.

Key words: perceptions, concepts, visible light, refraction, reflection, dispersion

1. Introduction

Systematic research has been carried out in recent years related to teachers' knowledge, what is its nature, in which way it is built and rebuilt and how it affects their teaching practice. Especially in the field of Natural Sciences, research on students' ideas seems to lead and influence research on teachers' ideas and perceptions (Cochran & Jones, 1998). It is even argued that many corrective changes that have been attempted in the past in education have failed because the existing teachers' knowledge and beliefs were not taken into account (Van Driel et al., 2001; Molochidis, 2005).

Some of the reasons why teachers have a superficial knowledge and opinion as opposed to the scientific one is (Pardhan & Bano, 2001), the way they have been taught, the educational books, the intuitive/direct observations of everyday life events, the use of terms in everyday language (energy, force, electricity) and the lack of relevant tangible and conceptual experiences that can be deductively connected to construct conceptual shapes (Novak, 2004).

Arons (1992), has repeatedly found out, both in research and as a result of many years of experience in teacher education and training that teachers have little understanding of the concepts and material that was going to be taught. The development of concepts in teachers' thinking was almost at the same level as the students they had to teach. He also considers that this fact is one of the most important reasons why ambitious curricula and new educational materials failed in their implementation. It should also be noted that what constitutes an obstacle is not only the teachers' perceptions of the content of the concepts, but also their views on the role of their students' prior perceptions (Spyrtou et al., 1995).

The teacher is the determining factor for the success or failure of teaching. A basic condition is sufficient knowledge of the subject. In order for the teacher to be able to answer questions and other queries of his students,

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to simplify complex concepts, to present in an alternative way something that the students find difficult to understand, he himself must possess the subject matter in a substantial and multidimensional way. Among other things, scientific competence gives the teacher the necessary self-confidence, which often leads to successful teaching. Teachers need to feel the security of actually owning the object taught, that they are able to satisfactorily answer students' questions, simplifying concepts without spoiling their logic (Frensham, 2001). The completeness of scientific training gives the teacher the confidence necessary for teaching (Harlen, 2000).

This paper aims to contribute to this very field. It focuses on exploring the perceptions of teachers in Physics concepts contained in textbooks E and F Primary School Classes, i.e., in the curriculum of compulsory education. The concepts under consideration come from the field of Optics and especially of visible light.

Palacios et al. (1989) record education department students' opinions in Spain regarding a number of optical phenomena, before and after the completion of teaching Optics. From the results of the research the authors find out that significant percentages of subjects still retain their alternative ideas, as they consider that: a) the speed of light depends on the speed of the source from which it is emitted b) the phenomena of reflection and refraction evolve in each case independently c) the flat mirrors are perfect reflectors and create real images d) the lenses increase the energy of light, i.e., they are generators of light energy and heat e) the optical prisms are exclusively triangular in shape and analyze the light of any pure spectrum color.

F. Chauvet (1994 & 1996), after recording through questionnaires and interviews the perceptions of first-year students of the School of Fine Arts in France about the nature and origin of colors, designs and carries out, in a constructive approach, a series of experimental activities with the aim is to understand a) the dependence of the color of heteroluminous bodies on the color of the incident radiation (absorption — re-emission) b) the results of the synthesis of light rays of different colors (additive — abstract mixing). The positive learning outcomes of the intervention lead the researcher to proposals for the implementation of similar activities in the level of secondary education.

Colin & Viennot (2001) in their study: "*Using two models in Optics: Student difficulties and teaching suggestions*" on the one hand point out the difficulty of pupils and students to determine the direction of rays when they fall on a separating surface of transparent media, on the other hand the small number of assignments available in connection with the teaching of refraction and the use of models.

As reported by Fyttas (2010), in research held in students and teachers of physics using open questions, it was found that students and teachers have the same misconceptions about refraction and find it difficult to implement its principles on the various visual phenomena.

Similar useful teaching suggestions have recently been made for DPE (Department of Primary Education) students (Michas & Yamousakis, 2009) for teaching concepts of Optics.

2. Research

The questionnaires were designed with appropriate questions concerning concepts of Physics that are negotiated in the textbooks of the E&F the Primary School Class.

This paper presents the results of the empirical research carried out on Primary Education teachers who teach in schools in the four Prefectures of the Epirus region.

The research population is 102 teachers. In terms of gender, 51% were women and 49% were men. Years of service: from 1–10 years 32.4%, from 11–15 24.5%, from 16–20 years 11.8%, from 21–25 16.8% and over 25 years 14.5%. The sampling method used is simple random sampling. The collection of data was carried out using closed-type questionnaires and the data analysis was performed using the SPSS16.0 program.

The questions asked to teachers are mostly related to simple phenomena and situations of daily life and not questions that would sterilely check teachers' knowledge.

The first question investigates the perception of teachers about the phenomenon of scattering of visible radiation by atmospheric molecules, while the second question if the different wavelengths that make up white light, undergo different deflections of the prism. The next question explores teachers' perceptions of refraction, essentially the propagation of radiation in different materials at different speeds. The rest of the questions examine the teachers' view of body colors and whether they relate them to the radiation they are illuminated with each time.

3. Results

The results of the research are presented per unit in the form of bar graphs with students' answers. For each question, the answers are analyzed and commented:

Then the perceptions of teachers on Optics are explored. The first question investigates the phenomenon of white light scattering:

Question 1: When Neil Armstrong, the first man to set foot on the surface of the Moon, turned his gaze upward, he saw a black sky as opposed to the deep blue of the Earth. This is because:

A very large percentage of 83.2% of teachers (Figure 1) answer correctly that the black sky of the Moon is due to the lack of atmosphere while 15.8% believe that the lack of oceans results in the black colour of the sky. They obviously confuse the phenomenon of the scattering of visible radiation of sunlight by the gas molecules of the Earth's atmosphere. The rays of visible light scattered more are those corresponding to violet colour and rays corresponding to the other colors of the spectrum follow successively. The blue color light is scattered less than that of violet but our eyes are more sensitive to the blue rather than the violet colour, so our sky looks blue. Instead of this interpretation they believe that the blue of the sky is due to the reflection effect in ocean waters.

Question (2) investigates the phenomenon of white light dispersion.

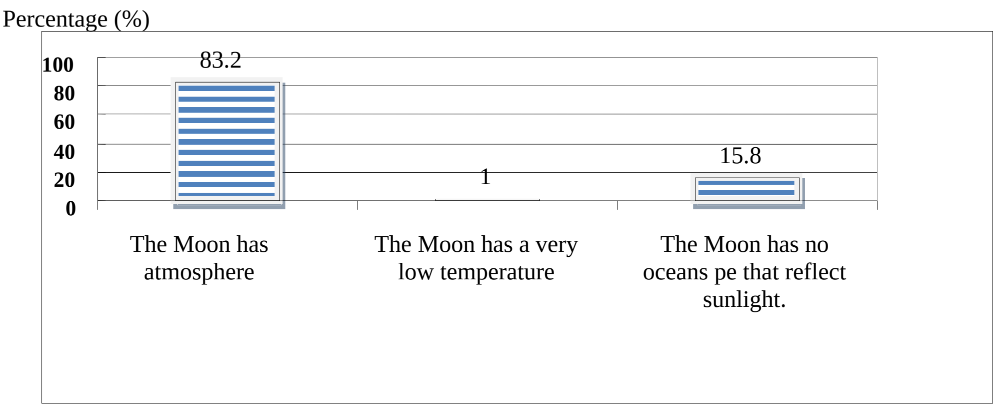

Figure 1 Distribution of Teachers' Answers to Question 1

Question 2: The white light in each of its refractions is analyzed:

Based on the answers (Figure 2) 73.5% of teachers believe that the white light in each refraction is analyzed while 26.5% believe the opposite.

Anderson & Smith (1982), in the same study, find that most children perceive white light as the absence of color and not as a combination of other colors.

The next question explores the phenomenon of refraction:

Question 3: "The monochromatic light coming from the air when it falls on glass is refracted, spreads in the glass at a lower speed and then refracted again and travels in the air…"

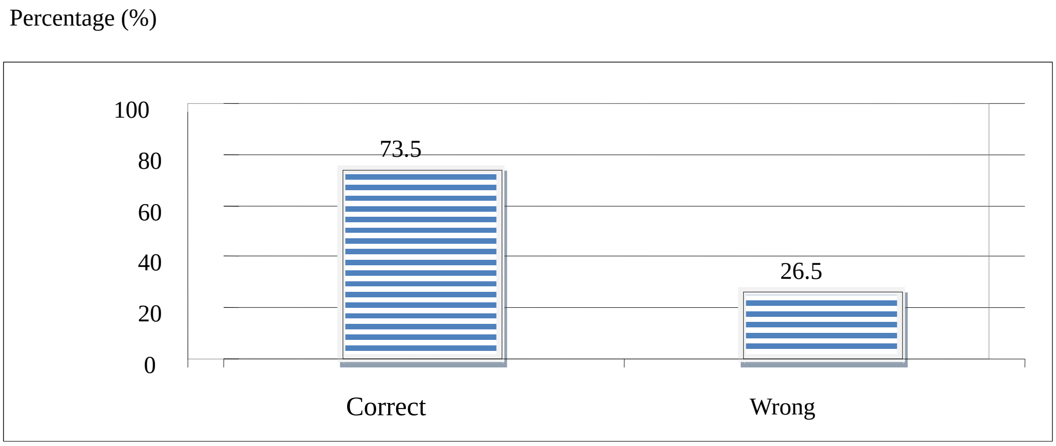

Figure 2 Distribution of Teachers' Answers to Question 2

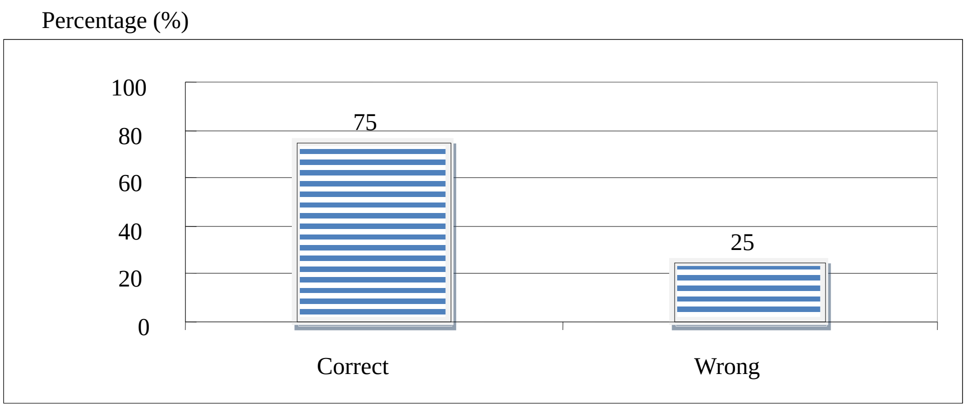

Figure 3 Distribution of Teachers' Answers to Question 3

75% of teachers (Figure 3) agrees that the monochromatic light in the air path in the glass is refracted and moves at a slower speed while 25% of respondents disagrees because teachers have not understood the principle of least time (Fermat principle), according to which the light speed, during its propagation from one material to another, is different in the second material in relation to the first, so the propagation time depends not only on the length of the path but also on the speed. In this case, the light moving between two points does not propagate in a straight line, it follows a zigzag path passing a longer path in the material whose velocity is greater, so that it reaches its destination in the shortest time.

The following questions highlight teachers' difficulty in understanding how body colors appear:

Question 4: The poppy only shows red when the light falling on it is white or red**:**

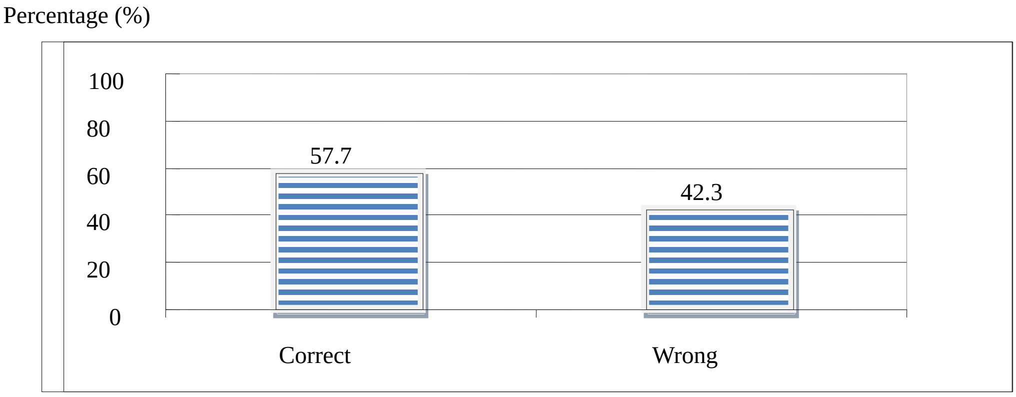

Figure 4 Distribution of Teachers' Answers to Question

A percentage of 57.7% of the teachers (Figure 4) answers correctly that when white or red light falls on the poppy it will show red but a very large percentage of 42.3% disagrees.

In this case the poppy as an opaque body absorbs all the light rays of all colors and reflects only those that correspond to the red color and therefore look red. Also, the vast majority of students believe that color is bound to the bodies and that light just helps us to distinguish it. In other words, they believe that with our eyes we see the color of an object and not the color of the reflected light (Dedes, 2005).

In the same field, C. Prat (1989), in his research with students aged 12–15 in France on the nature of colors and their relationship to light, finds clear similarities between student representations and early historic models, as well as in the two areas of research interest focus:

a) colors are perceived as properties of bodies,

b) the role attributed to light in terms of the sensory perception of colors is that of a "vehicle" transporting them from objects to the eye as a fluid substance (a substance which the author calls "photogenic" by analogy with the corresponding "calorific value" from the region of heat dissipation phenomena).

In the same section the question arises whether:

Question 5: When white light falls on a lemon, it shows yellow because its surface absorbs the yellow colour contained in the white light:

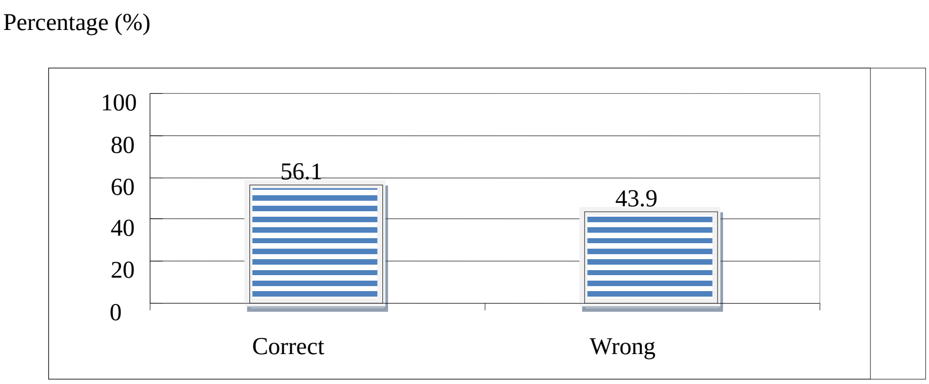

Figure 5 Distribution of Teachers' Answers to Question 5

The teachers as shown in Figure 5 agree in a percentage of 56.1% that the statement "when white light falls on a lemon, it shows yellow because it absorbs the yellow colour contained in the light" is wrong. 43.9% answer correctly because the color, as mentioned above, is determined by the rays of the reflected color.

Question 6: In white light, a tomato looks red while a pepper looks green. If we illuminate them with monochrome green light, circle which of the following happens:

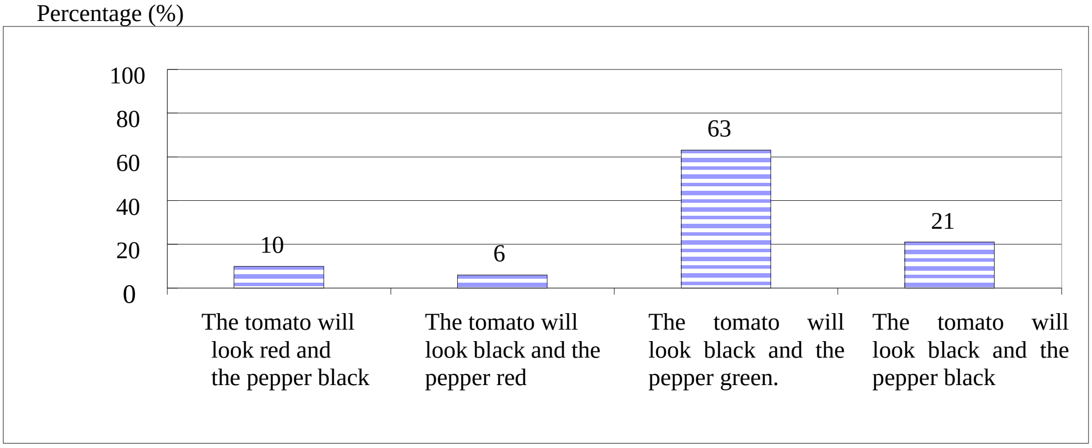

Figure 6 Distribution of Teachers' Answers to Question 6

From the distribution of the answers presented in Figure 6, 63% of the respondents correctly answer that if we illuminate the tomato with green light it will look black and the pepper green. 10% predict that the tomato will look red and the pepper black, 6% believe that the tomato will look black and the pepper red and finally 21% answer that the tomato will look black and the pepper black. In other words, teachers believe that color is bound to the bodies and that light just helps us to distinguish it.

4. Conclusions

Studying the results of the research we find that the current primary school teachers have shortcomings in terms of the knowledge they are called to manage in the classroom. The shortcomings that appear are many and negatively affect the learning process. The view of Hashweh (1987) that many of the misconceptions that have been established for students, may derive from similar misconceptions educators themselves have, is rather reinforced by the findings of this investigation.

More specifically, some teachers do not perceive the phenomenon of sunlight scattering by the molecules of the atmosphere and do not connect the lack of atmosphere on the moon with the black sky.

Moreover, they do not take into account that white light is a mixture of all colors and due to the phenomenon of dispersion, each color is deflected at a different angle during refraction and when the shape of the incident body allows them to separate, then the wave/light is broken down into its various frequencies/colors.

They also believe that light only helps us to distinguish bodies and that color is bound to bodies and that it is with our eyes that we see the color of an object and not the color of reflected light, that is, color is a property of bodies.

Finally, many educators have not understood the cause of the refraction of light, which is nothing more than a change in the speed of light when passing from one transparent medium to another, which is interpreted with Fermat principle.

For teachers' misconceptions on Optical phenomena (diffusion of light in optical media, body color) we have to observe that a training intervention is required in order for the teachers to be able to argue and interpret the Optical phenomena based on the interaction of light radiation with matter (quantum theory) but also with models for light, specifically that of rays and the wave model at first and the particle and the model of photons afterwards (Knight, 2006).

The particle model is used to explain specific phenomena, such as energy transfer or photoelectric effect. With the wave model they approach more abstract phenomena, such as the propagation of light in vacuum, the change of velocity of propagation in different material media or the interactions with matter. However, these models are often challenged and overshadowed by the representation of light rays, which is more familiar to them, both at the level of perception and at the level of teaching (Dedes, 2005).

Consequently, teaching objective of the intervention is understanding a) the apparent body color when illuminated by white light b) the color dependence of hetero-luminous bodies on the color of the incident radiation (absorbance — retransmission) c) the results of composing light radiation of different color (additive — subtractive mixing) d) the differentiation of chromatic composition illumination light and pigments and the results of subtractive mixing monochromatic radiation and e) the phenomenon of reflection and refraction which evolve in each case simultaneously.

As a result, teachers will perceive white light as a combination of other colors and not as one colour. Also, they will believe that light only helps us to distinguish bodies and not that color is bound to bodies. That is, they will consider that with our eyes we do not see the color of an object but the color of the reflected light. Furthermore, they will be able to interpret that the color of an opaque body is determined by the color corresponding to the light rays it reflects, (opaque bodies that absorb part of the light rays falling on them), while reflecting the remainder. On the contrary, the colour of a transparent body is determined by the colour corresponding to the light rays the passage of which it allows.

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