8-9 year old pupils’ mental representations of light: teaching perspectives

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ABSTRACT
In several researches focused on representations of light that are children from 5 to 15 years found that these representations are often incompatible with the scientific model. 110 children participated in this research where we studied representations of children 8-9 years on the light. As a technique of research we chose the directive individual interview. The results of the research show that children of 8-9 years use different categories of representations for the light and they rarely recognize the light as a separate entity in the area, independent sources that produce it and the effects it causes during its spread.

Indexing terms/Keywords
Mental representations, light, primary education.
THEORETICAL FRAMEWORK

Pupil’s mental representations in science and especially in the field of physics have been reported in number of concept areas such as mechanics, heat, electricity etc. A large part of contemporary research focuses on the study of spontaneous representations or alternative ideas of students of different ages for various concepts and phenomena (Driver, Guesne & Tiberghien, 1985; Driver, Squires, Rushworth & Wood-Robinson, 1994). During the last thirty years, in several researches we can see that, children are approaching the physical world, formulate and reformulate certain ideas, solve problems and gradually acquire knowledge of physical world. Based on the assumption that each individual in a given situation mobilizes personal explanatory systems, it is often noted that their own representation can be an obstacle to the appropriation of scientific concepts. This underlines the need for organizing suitable teaching for achieving overshooting of obstacles (Dedes & Ravanis, 2009a, 2009b).

Mental representations, being the product of the individual and social history of the child, are in continuous interaction with the socio-cultural and educational environment and as such, present a dynamic, developmental and evolutionary nature. Thus, insofar as the representations through which the child interprets the phenomena of the physical world are remote or in contradiction with certain elements of scientific models currents dominant of Science Education research, aim at the construction of educational interventions, teaching situations and curricula that may foster the crossing designs and the explanatory mental forms of naive representation implied, local and non-conscious concepts or phenomena (Ravanis, 1998).

The analysis of a certain number of researches focused on light conceptions is expounded with the aim of showing that several “mental representations” of this subject matter are present in the children’s thought. These investigations exposed that children aged 5-15 years, amid a series of difficulties on the propagation and interaction of this physical entity with different objects, the main obstacle to the recognition of light as being a separate and autonomous, independent entity from sources that produce it and the effects it causes exist in a certain region of space. According to the authors who have studied this subject, this difficulty stems from the tendency of the subjects to associate the light exclusively to its source or visible effects it causes (Tiberghien, Delacote, Ghiglione & Matalon, 1980; Stead & Osborne, 1980; Andersson & Kärrqvist, 1983; Guesne, 1984, 1985; Osborne, Black, Meadows & Smith, 1993; Kok-Aun & Hong-Kwen, 1999; Ravanis & Boilevin, 2009; Ravanis, 2012). It is in this perspective that we studied children’s representations of light.

The model of school science geometrical optics provides the framework for discussing these representations. The main characteristic of this model, are the hypothesis of the point light sources, the straight propagation of the light rays and the light as an entity in space that is independent from sources and its respective results (Ravanis, Zacharos & Vellopoulou, 2010).

A starting point of our study is the research results about light representations of 5-15 year-old students. Indeed, understanding light as an entity in space has previously been identified in a series of studies. Research based on various experimental procedures had ruled out the possibility of children comprehending the concept of light in space. For the children’s thought light may be conceived as something static and is not connected with movement and transition of an entity. Thus it seems that pupils’ thought concentrates more on light sources or bright areas where light bounces (Tiberghien, Delacote, Ghiglione & Matalon, 1980; Stead & Osborne, 1980; Andersson & Kärrqvist, 1983; Guesne, 1985; Rice & Feher, 1987; Ravanis & Papamichael, 1995; Selley, 1996; Langley, Ronen & Eylon, 1997; Galili & Hazan, 2000; Ravanis, Papamichael & Koulaidis, 2002; Castro, 2013).

According related research (Ravanis & Boilevin, 2009) for a child from 5 to 12 year-old, the approach to light as an entity centres on light sources (LS) and visible lighted areas (VLA) or their combination via a thought of direct transition of the following form: LS → VLA. As a result, children ignore the space in which light bundles propagate, that is to say, the space of light’s propagation (SPL). In contrast, a particular form of elementary optic model acquisition presupposes a reasoning of type: LS → SPL and SPL → VLA → LS → VLA. Therefore, the correlation among the elements of the problem of light existence and propagation operates as a general model of representation about light. This light representation is important because, as a two-step procedure, it imposes identifying the presence of light in space. The acceptance of light as an entity transmitted independently from the light source to the final receiver constitutes a necessary convention and the beginning in constructing other associated phenomena of light. For example, without the identifying light as an entity it would be impossible to understand the notion of a straight path of light.

This study was set out 8-9 years old children’s representations on the concept of light. From the results we are trying to develop and schematise the principal axes of a model educational intervention aimed at exceeding of the cognitive obstacles created by the own representations of students

METHODOLOGY

Procedure and Subjects

The identification of the representations of children was also conducted through interviews. Each interview lasted approximately ten minutes. Four situations have been proposed to the children. The questions concern the recognition of light as a separate entity in space. The conversation took place in a dimly-lit room specially prepared to that procedure in a special site of the schools. We present tasks, devices and features excerpts from responses of children. We also propose a categorization of answers and present the frequencies of the responses of subjects (Table).

110 (54 boys and 56 girls) 8-9 years of age coming from 5 different school classes, took part in this study. The students were in the third grade of a primary school. None of the children had yet received any formal or informal instruction
concerning the light. Each socio-economic level (low, moderate, high) and all levels of students’ performance (low, moderate, high) are represented equivalently in the sample.

**TASKS AND RESULTS**

Four types of tasks were used to obtain different kinds of information.

Task 1. At every child, we ask the question: "What is the light for you?". With this question we seek to know if children spontaneously distinguish light as a separate entity of the light sources. This first question we got the answers that we have classified into three categories:

a) Responses that recognize the existence of light like entity in space. For example, "Light is like the air ..... are everywhere ....", "... light fills the whole space".

b) Responses focused on the visible effects produced by light. E.g. "The light ..... brighten the room ..... all things .....", "Is a white thing on the floor, on the wall......".

c) Responses focused on light sources. E.g. "Is an object that enlightens us...", "Is a lamp ..... a torch....", "Is the Sun... the Moon....the stars.....".

Task 2. We ask every child the question: "What does the light?". With this question we want to know if the children focus on light sources, their operating characteristics, and some directly sensitive phenomena such as heating and lighting or if they recognize other more general phenomena like life, the development of the plants etc. The responses to this question were classified into four categories:

a) Responses that recognize more general effects caused by light as entity. For example, "... warms and dries clothes","... it makes the day".

b) Responses focused on the sensitive effects produced by light. E.g., "Lights the thinks and the walls, the floor....", "Light enlightens us...".

c) Responses focused on the presence and function of light sources. E.g., "... we turn on the lamp and it lights up the room...", "Light is in the candles, in the lamps, on TV... ".

Task 3. We ask children to show us a few locations in the room "where there are light". When children show us exclusively light sources in operation and/or illuminated or strongly illuminated surfaces we ask them to show other places to check if they evoke the light in the space. The responses of children have been categorized as follows:

a) Recognition of light as an autonomous entity in space or in the dimly lit surfaces. For example, "The light is everywhere all around and... fills the air....", "... it is also on the wall...." "Here where we are sitting...almost in the whole room....".

b) Focus on strongly illuminated surfaces. E.g. "I can see the light on the window, on the floor...", "Light is everywhere... on the ground... on the table...,

c) Focus exclusively on light sources. E.g. "It’s the Sun and incandescent electric lamps", "As we light this electric lamp... it has light (touch the lamp)... ".In the following table we present the frequency of the subjects’ answers in the three tasks that were introduced.

Task 4. Turning on a flashlight we produce on the wall a bright spot and we ask each child: "Where there - it of the light from the flashlight?". If the children recognize the existence of the light in the lamp and on the wall we ask them, pointing to the somewhere between the lamp and the wall: "what is there between the lamp and the wall light?". This situation gives the opportunity to the children recognize the light outside sources, on a bright spot or in space, in a familiar situation. The responses were classified into three categories:

a) Recognition of light in space. E.g. "There is in the air... to the wall... could not always see".

b) Focus on the bright spot on the wall. E.g. "The round mark made on the wall", "There... on the white wall", "Light is in the color on the wall.... at this point"

c) Focus exclusively on the light sources. E.g. "The light is the flashlight you hold".

The table shows the frequencies of responses of children to four tasks.

| Task | Task 1 | Task 2 | Task 3 | Task 4 |
|------|--------|--------|--------|--------|
| Light as entity in space | 6      | 8      | 12     | 14     |
| Light as sensitive effects | 52     | 52     | 49     | 64     |
DISCUSSION

The analysis of the responses of the children showed the difficulties of 8-9 years old students. Based on these difficulties we formulate categories of representations of subjects on the concept of light. The results obtained in the first three tasks indicate that light is associated with light sources. This corresponds to a common social understanding centered on perceptual aspects. The focus on light sources and/or effects is an obstacle to a design of light as entity in the space between a source and a reflective surface.

The results obtained in the fourth task - experimental situation confirm the results obtained in the first three tasks - open questions. The light remains, for children, strictly linked to the light sources with the exception of the circumstances where it produces intense bright spots, as for example, in the situation where we used a powerful flashlight. The essential obstacle to the age of 8-9 relates to the difficulty of that light and light sources are entities not having the same status. This raises several important issues for the teaching plan of optical phenomena in the primary school, since the change of primitive conceptions of the student may occur spontaneously. However the clear knowledge of different types of representations allows the construction of didactic procedures which would facilitate the transition to the new representations, compatible with the scientific model of the school geometric optics.

Indeed, if light is strictly attached to the light sources, it is impossible to understand any problem pertaining to phenomena involving spread straight light in all directions like, for example, the formation of shadows, the phenomena of diffusion, the formation of images by mirrors or lenses (Rice & Feher, 1987; Feher & Rice, 1988; Resta-Schweitzer & Weil-Barais, 2007; Gallegos-Cázares, Flores-Camacho & Calderón-Canales, 2009). Therefore, the recognition of the light as a separate entity from the source is a prerequisite for any educational activity for teaching about the concept of light. So, the questions raised by the researchers are related to the possibility of developing innovative teaching interventions based at the mental representations that students form regarding the light concept.

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