Mental representations of sixth graders in Greece for the mechanism of vision in conditions of day and night

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ABSTRACT
This research studied the mental representations of 11-year-old Greek students concerning the mechanisms for vision in day and night condition. The aim was to examine the prevalent mental representations that students hold in order to explain the way a person is able to see an object during the day and during nighttime, to recognize possible differentiations among the representations of the two conditions and compare them.

General Terms
Vision, Science, Education, Psychology

Keywords
Students' Mental Representations, Vision at day, Vision at night.

1. THEORETICAL BACKGROUND

1.1 Introduction
It is well known that every day, in classrooms across the world, teachers make efforts to transfer a part of knowledge to young pupils. This type of knowledge is differentiated, as it is actually transformed scientific knowledge that students have to acquire via the educational procedure. However students already have their own constructed knowledge, a personal construction of consistent ideas, based primarily on experience, concerning a particular phenomenon or situation that is not always identical to the scientific explanation [1]. It is thus obvious that those preexisting ideas are significantly important in education and should be taken into consideration by schoolteachers.

1.2 Children's mental representations
The ideas that children have on different matters have been extensively studied. Those ideas, otherwise called mental representations, can be regarded as contexts, through which the world is explained and on which the perceived information is embodied; specific rules of functioning are applied on them [2] [3].

The origins of mental representations can be either sensory perception or personal experiences. They seem to be very persistent due to the fact that they present a rational, causal and sometimes quantitative explanation of a situation, making apparent the qualitative difference between this kind of ideas and the conceptual contexts of scientific knowledge [4].

Along with their deviation from the scientific explanations, the persistence that characterizes them should also be taken seriously into account, before planning an educational act.

1.3 Scientific model for human vision
At this point, a conflict emerges. Since there are the ideas of children on one part and the scientific ideas on the other, what happens when it comes to teaching Science at school?

Science as a school course is filled with new and complex concepts, natural phenomena, theories, models, symbols and specific terms used for certain fields of Science. Unfortunately, not all content of school Science is easily comprehended by students, due to its complexity as well as the fact that not every natural phenomenon can be directly perceived through experience [5].

The concept studied in this paper is vision. From ancient times to present, this field of Optics curriculum has been profusely studied. On the 13th century AD, Al-Hasan ibn al-Haytham, proposed what we today know as the modern theory of vision. The light travels directly from the light source towards the object, where a part of it is retransmitted in all directions. Kepler later refined this theory by adding the creation of a reversed image of the object in the retina, once the retransmitted light reaches the human eye [6]. Consequently, the process of vision involves two areas: the first lies outside the human being, between the object and the human eye, and the second is a psychophysical area placed between the human retina and the cortex of human brain [7]. Primary school knowledge relates to the first type of vision area, thus some basic features of light should be described. Light is both a wave and a particle. When it is being emitted by a light source, it reaches an object and, depending on its type of surface and according to the object' s properties, light of a certain frequency is absorbed and reflected back in all directions. The reflected light reaches the eye of the observer and is responsible for the colour of the object that we see [8]. A reaction is caused in the eye retina and it is then "translated" by the human brain [9]. The scientific model for human vision is summarized in the following essential principles [7] [9]:

- Light is transmitted in a straight line almost instantly.

- An illuminated object retransmits light in all directions, including towards the eye of an observer, as that is necessary so as to see an object.

- The trajectory of the light from the object to the eye, is identical to the straight line in which the eye sees the object.

Same rules apply to the way we see an object when it' s night, only that in this case, vision is accomplished with the use of minimal light reflected from the moon and stars towards objects and then back to the observer' s eye.

1.4 Student's mental representations for human vision

As vision is a complex procedure it would be interesting to gain insight on children's ideas about this subject. Selley was one of the first to study their mental representations. The participants were in class 4 (8 years of age) and the development of their ideas was followed for 3 consecutive years [9]. The data of this quantitative research revealed nine different types of children' s interpretations for vision and light:

1. Cooperative Emission: Both the eye and the light source emit light towards the object.

2. Stimulated Emission: The light reaches the eye and is then retransmitted or causes the emission of a light beam towards the object.

3. Simple Emission: The eye sends light to the object.

4. Stimulated Emission with Reflection: The light leaves the light sources, reaches the eye, is then retransmitted or provokes a secondary emission towards the object. The object then retransmits the light, which returns to the eye.

5. Primary Reception: The light source lights the eye – this model involves primary light sources.

6. Secondary Reception: The light travels from the light source first to the object, then to the eye – this model involves objects retransmitting light from a primary light source.

7. Secondary Recepto-Emission: The light travels from the light source to the object, it then "bounces" towards the eye, the eye then emits something towards the object.

8. Sea of Light: The light source generally lights the space and this is the reason we can see.

9. Dual Illumination: The light source lights both the eye and the object at the same time.

The dominant mechanisms on children' s thinking are Mechanisms 2 and 8 that evolve into Mechanisms 1, 4, 6 and 7 as the grow up [9]. Amongst them, some also appear in Dedes' s research on Greek students along with a new Mechanism where the light starts from the light source and simply reaches the object, with no further detail provided [6]. Emission models are easier to be adopted by children than reception models, as light is less often perceived as an entity on the one hand and the eye is often given an energetic role [9] [10], a characteristic so persistent that is even noted in the ideas of 15 year old students [11] [12].

However, the energetic role of the eye was not dominant in Ravanis's findings on 12 and 13 year old Greek students' mental representations [13]. The findings of this research also deviate from the perspective findings of other researches as an acceptable number of subjects have a satisfactory idea about the mechanism for vision and also a different interpretative mechanism similar to Dedes's introduced mechanism was mentioned.

1.5 Research scope

It is evident that students do hold specific ideas on science matters, ideas that emerge during any educational attempt. Vision is a field of Optics that presents a certain complexity, which lead researchers to investigate on students' ideas for vision. Findings of the scientific community are in some cases diverse. This ascertainment leads us to reflect on the way students in Greece perceive the procedure of vision. The published bibliography is centered solely on children's ideas, during daytime. What mechanisms for vision would subjects' answers reflect if they were asked to give their opinion about vision during nighttime? Which factors would be referred as important and would those factors be identical to those mentioned for vision at daylight? Would their own mechanism for vision remain intact for vision in both daylight and nighttime? These questions present the baseline of our study.

2. METHODOLOGY

2.1 The participants

In this qualitative study thirty 11-year-old Greek students were involved, among who 14 boys and 16 girls, from three different primary schools located in rural and semi-urban areas in the county of Elia in Greece. None of them had previously been taught about vision at school.

2.2 The research material

Semi-structured interviews were used. Each participant was given a blue piece of A4 paper and a white piece (so as to investigate whether colour would differentiate an answer) and then asked the following questions:

1. "Would you be able to see this blue and this white piece of paper if you were outside in the school yard, in daylight?"

2. If answer to Question 1 is affirmative – "What would help you see them?"

3. "Can you describe specifically the way in which the factors you mentioned would help us see them?"

4. "Would you be able to see this blue and this white piece of paper if you were outside in the school yard at nighttime, with no street lights or any other sord of artificial light around you?"

5. If answer to Question 4 is affirmative – "What would help you see them?"

6. "Can you describe specifically the way in which the factors you mentioned would help us see them?"

2.3 The research procedure

The research procedure involved two phases, and was implemented in a separate class in each school, individually with each participant and within the school time schedule:

- Phase 1: test interviews
- Phase 2: interview process

Test interviews were conducted with fourth graders in order to eliminate possible defects in interview design and procedure. Phase 2 lasted 22 days (from 21 March 2011 to 12 April 2011). In the interview process, the participant would sit in a room with the interviewer and the interview would commence with the six questions referred to above in an order that would fit each child.

3. FINDINGS

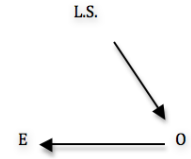
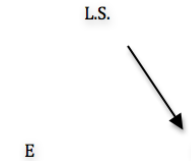
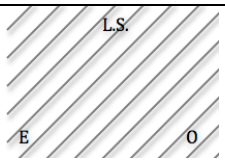
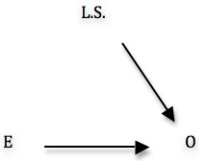
3.1 Data analysis

Interviews were qualitatively analysed and categories were created for children' s interpretative mechanisms (paper colour factor did not present significant differences in students' answers and was, consequently, not further refered in our data analysis). Those categories were placed in hierarchical structure depending on the factor that appears to be most active and on their relevance to the scientific model for vision. Table 1 shows the interpretative mechanisms that were mentioned by students. L. S. stands for light source, O for object and E for eye of the observer.

Mechanisms 1,2 and 3 involve a light source that sends something to the eye. To be more specific, interpretative Mechanism 1 or "Secondary Reception" represents the scientific model. Mechanism 2 or "Illumination of the Object" is approximate to the scientific model as the light source sends light to the object. In "Sea of Light" Mechanism, the light source generally lightens the space and the object is seen. This must not be confused with Mechanism 2, as there is neither a specific procedure that is described, nor a specific direction towards which the light is headed. In the last mechanism ("Cooperative Emission"), it is the eye that sends something in order to see an object. The light source emits light towards the eye.

The mechanisms presented in Table1, were mentioned both for vision during day and nighttime, although in the last case not all of them were evoked.

Table 1. Students' interpretative mechanisms for vision

	Interpretative Mechanisms	Name
1		Secondary Reception
2		Illumination of the Object
3		Sea of Light
4		Cooperative Emission

Examples of answers for each mechanism are provided below:

1. Secondary Reception. Subject 20 explains: "It (the sun) transmits light to the objects around us. Sometimes they (the objects) retransmit that light. The eyes send this image to the brain".

2. Illumination of the object. Subject 9 mentions that: " It (the sun) sends sunbeams to the object. Then the eyes focus, they function and we see."

3. Sea of Light. Subject 11 explains that: "The sun illuminates and the eyes see". Subject 10 explains that: "The moon and stars lighten up the night a little. That' s why I see (this paper)".

4. Cooperative Emission. Subject 8 believed that in order to see in the natural light condition: "The eyes (help). The light from the sun (also helps) (…) the sunlight, the sun rays. They (the eyes) send rays".

Table 2 presents students' interpretative mechanisms for daylight condition.

According to table 2, children's mental representations are identical to Selley' s Mechanisms 6 ("Secondary Reception"), 8 ("Sea of Light") and 1 ("Cooperative Emission") [9]. Additionally, another mechanism for vision emerged in

comparison to Selley' s findings: the object receives light from the light source and then the eye sees the object, with no further detail provided concerning the space between the eye and the object. We named this mechanism "Illumination of the Object".

In more detail, the majority of students adopt "Sea of Light" mechanism (19/30 students) and "Illumination of the object" (8/30 students). The scientific mechanism of "Secondary Reception" was more rarely mentioned (2/30 students). It was the same case for "Cooperative Emission" (1/30 students). It is worth noting that all participants mentioned an interpretative mechanism for vision.

Table 2. Students' interpretative mechanisms for vision at daylight

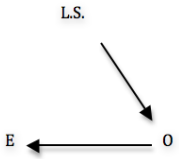
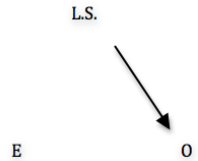
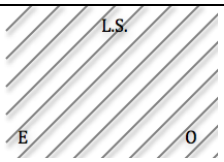
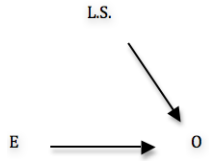
	Interpretative Mechanisms	Subjects	f
1		20,24	**2**
2		4,6,7,9,10,17,26,29	**8**
3		1,2,3,5,11,12,13,14, 15,16,18,19,21,22,23, 25,27,28,30	**19**
4		8	**1**
5	No interpretative mechanism mentioned		**0**

Table 3 presents students' interpretative mechanisms for nighttime condition.

Children's answers reveal that they present a smaller range of interpretative mechanisms for vision during nighttime. One subject out of 30 refers to "Secondary Reception" and almost half of the participants (f=12) mention "Sea of Light" to interpret the way one sees an object at night. The majority of students (f=17) do not answer adequately enough to embody their idea to a certain mechanism.

Table 3. Students' interpretative mechanisms for vision at night

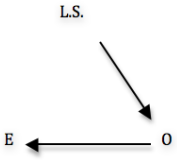
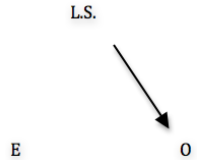
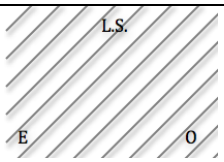
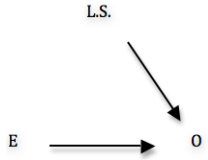
	Interpretative Mechanisms	Subjects	f
1		20	**1**
2			**0**
3		10,14,15,18,22,23,24, 25,27,28,29,30	**12**
4			**0**
5	No interpretative mechanism mentioned	1,2,3,4,5,6,7,8,9,11, 12,13,16,17,19,21,26	**17**

Table 4 represents a comparison of subjects' answers in the given conditions, that is, daylight and nighttime.

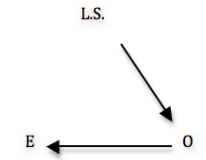
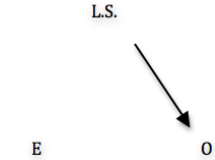
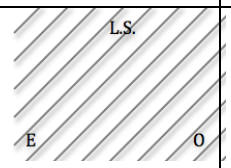
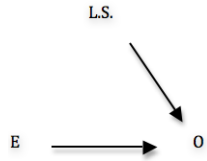
By comparing the answers given for those two light conditions we conclude to the following:

- In general, the factors that are implicated in vision are more obvious and concrete in daylight condition: the light source, the object, as well as the observer' s eye, play a specific role. In nighttime condition, the factors are apparent in children's answers, yet their role or the way they interact with one another is blurry and not specified.
- Different mechanisms are adopted in each condition (according to Table' s 1 mechanisms): Mechanisms 1, 2, 5 and 6 are adopted for daylight and mechanisms 1 and 5 for nighttime.
- Although all students have a certain mechanism in mind for daylight condition, when it comes to vision at night, the absence of an interpretative mechanism is apparent in the majority of students' answers.
- However, amongst students who did hold a certain mental representation for vision at night, the

majority mentioned the mechanism "Sea of Light" which is also the prevalent mechanism for vision at daylight.

- As far as the persistence of students' ideas is concerned, we observe that one third of the participants (subjects 14, 15, 18, 20, 22, 23, 25, 27, 28 and 30) preserve an intact interpretative mechanism for both conditions. In that case, the mechanisms that present solidity are "Secondary Reception" mechanisms (Subject 1) and "Sea of Light" mechanism (Subjects 14, 15, 18, 22, 23, 25, 27, 28 and 30). Three subjects (Subjects 10, 24 and 29) refer to a mechanism that is less evolved when explaining vision at night, compared to their proposed mechanism for vision at day. Finally, the majority of students (Subject 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 16, 17, 19, 21 and 26), after having mentioned a certain mechanism for the first condition of day, then move to inexistence of a mechanism for the second condition of vision at night.

Table 4. Interpretative mechanisms for vision at day and night

	Interpretative Mechanisms	Vision at day		Vision at night	
		Subjects	f	Subjects	f
1		20,24	**2**	20	**1**
2		4,6,7,9,10, 17,26,29	**8**		**0**
3		1,2,3,5,11, 12,13,14, 15,16,18, 19,21,22, 23,25,27, 28,30	**19**	10,14,15, 18,22,23, 24,25,27, 28,29,30	**12**
4		8	**1**		**0**
5	No interpretative mechanism mentioned		**0**	1,2,3,4,5, 6,7,8,9,11, 12,13,16, 17,19,21, 26	**17**

3.2 Results - discussion

According to the findings of this study, the interpretative mechanisms for vision at day and at night are the following:

1. Secondary Reception
2. Illumination of the Object
3. Sea of Light
4. Cooperative Emission

The above also appear in published bibliography [6] [9]. Moreover, a new mechanism is introduced (mechanism 2) that reinforces Ravanis' and Dedes' findings about explanations that concerns primarily the illumination of an object [6] [13]. Although, most of Selley' s mechanisms do not appear here (Stimulated Emission, Simple Emission, Primary Reception, Stimulated Emission with Reflection, Secondary Recepto-Emission and Dual-Illumination mechanisms), the mentioned factors that contribute to the process of vision both at day and night are the same and consist of a light source, an object and the observer' s eye. In general, in juxtaposition to published literature, the participants do not attribute an energetic role to the eye in their explanations [10] [11] [12].

As far as natural light condition is concerned (vision at daylight), most students adopt a mental representation that is a little abstract and generalized, something that confirms published studies' findings according to which, students perceive light as a general situation of illumination [1]. The prevailing mechanism here is Sea of Light.

As expected, when asked to express their opinion about vision at daylight, all subjects answered with some sord of interpretative mechanism. This finding enforces the belief that students do hold on to certain ideas for science matters, even if they have never received official information about them through the educational process.

The prevailing mechanism for vision at night is also Sea of Light. Almost no other mechanism is mentioned. The latter, along with the fact that the majority of subjects did not appear to adopt a specific mechanism to explain the way an observer can see an object at night, make it obvious that vision at night condition presents a certain difficulty for them. This can be due to the fact that there is an evident confusion in the way we think vision works at night, since there is no apparent natural light source such as the sun and not all students refer to light sources such as the stars and the moon that reflect the sun' s light. Consequently an expected answer would concern generally the existence of illumination.

Comparing the mentioned mechanisms for day and night it is evident that students can express themselves more easily in the first condition than in the second. This could be attributed to their personal experiences as sunlight helps them see better and receive more information about the objects around them, whereas this is harder to happen at night. This could explain the absence of an adequate mechanism in the latter case.

Last but not least it is worth commenting on the findings on persistence of students' mechanisms through the two conditions. The majority of students shift to either a less evolved mechanism or to absence of an adequate answer, when it comes to explaining the way we see an object at night. This could mean that children believe there is a different process taking place when seeing an object at night, that is,

that vision works in a different way if there is no direct light source.

3.3 Applications on teaching

Those findings point us to the importance of introducing the investigation of mental representations that students hold for a certain matter in Science or in another school subject, before teaching process takes place. This way, we could spot the explanations they give as well as their weaknesses, thus plan our lesson according to those, starting from that point and achieving better educational results.

Specifically when intending to teach Vision, it is strongly advised to investigate on the mechanism students hold so as to determine the starting point of our teaching process [14]. It is helpful to know how mechanisms evolve so as to be able to spot an evolution in a student's representation during the teaching process. This also offers flexibility to the teacher, who will also have information on how close or far to the scientific model for vision a particular student' s ideas are.

Finally, as interpretative mechanisms are not always persistent when initial conditions change, teachers should be careful when trying to investigate applications of a certain model in different conditions and take in mind that it is not always easy for students to transfer the accepted knowledge in different conditions. The teacher could at that point analyze different conditions and bring up the similarities between what students have already been taught and the new situation that is introduced.

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5. REFERENCES

[1] Driver, R., Squires, A., Rushworth, P. and Wood-Robinson, V. 1994. Making sense of secondary science research into children's ideas. London & New York: Routledge.

[2] Ravanis, K. 1996. Stratégies d'interventions didactiques pour l'initiation des enfants de l'école maternelle en sciences physiques. Revue de Recherches en Éducation: Spirale, 17, 161-176.

[3] Ravanis, K., Zacharos, K. and Vellopoulou, A. 2010. The formation of shadows: The case of the position of a light source in relevance to the shadow. Acta Didactica Napocensia, 3, 1-6.

[4] Weil-Barais, A. 2001. Constructivist approaches and the teaching of science. Prospects, 3, 187-196.

[5] Ravanis K., Koliopoulos, D. and Boilevin, J.-M. 2008. Construction of a precursor model for the concept of rolling friction in the thought of preschool age children: A socio-cognitive teaching intervention. Research in Science Education, 38, 421–434.

[6] Dedes, C. 2005. The mechanism of vision: Conceptual similarities between historical models and children's representations. Science & Education, 14, 699-712.

[7] Hosson, (de) C. and Kaminski, W. 2002. Les yeux des enfants sont-ils de "porte-lumière"? Bulletin de l'Union des Physiciens, 96, 143-160.

[8] Hewitt, P. G. 2004. The notions of Science. Iraklio: University of Crete Publications.

[9] Selley, N. J. 1996. Children's ideas on light and vision. International Journal of Science Education, 18, 713-723.

[10] Anderson, C. and Smith, E. 1982. Student conceptions of light, colour and seeing. In Proceedings of the National Association for Research in Science Teaching Annual Convention.

[11] Hosson, (de) C. and Kaminski, W. 2007. Historical controversy as an educational tool: Evaluating elements of teaching-learning sequence conducted with the text "Dialogue on the ways that vision operates". International Journal of Science Education, 29, 617-642.

[12] Ramadas, J. and Driver, R. 1989. Aspects of secondary students' ideas about light. University of Leeds, Centre for Studies in Science and Mathematics Education.

[13] Ravanis, K. 2000. How do we see objects that reflect light? Experiential mental representations of students of 12-13 years old, about vision. In N. Valanides (ed.), Second Panhellenic Conference on Teaching of Science and Application of New Technologies in Education, I, 214-221.

[14] Kokologiannaki, V. and Ravanis, K. (2011). Representations of sixth graders in Greece for the vision in condition of night. Teaching of Science: Research and Practice, (38/39), 5-15.