

Art, science and technology in early childhood education: constructing an in-service training program about the notion of color

*Dimitris Koliopoulos, University of Patras, dkoliop@upatras.gr
Xenia Arapaki, University of Thessaly, parap@uth.gr*

ABSTRACT

In this study we will present the principles and the structure of a trans-disciplinary in-service training program concerning the notion of color, which is addressed to early childhood educators. More specifically, we will describe a methodological framework for analysis and designing training programs influenced by the constructivist approach of teaching and learning. This framework is organized on three levels: (a) the analysis level, (b) the planning level and (c) the application and evaluation level. In this study, we will refer only to the first two levels.

With regard to the analysis level, we will emphasize the conceptions early childhood educators have about color. We will present certain results of empirical research regarding these conceptions and we will show that the majority of these educators have unclear ideas about the notion of color, due to an indiscriminate use of two different conceptual frameworks: that of science and that of the visual arts.

Concerning the planning level, we will refer to the structure of a sequence of teaching units. This sequence is based on an educational environment where the educators could (a) explore the limits of the validity of their unclear ideas when solving color problems and (b) construct and use new operational ideas about color, based on both the discrimination and the relationship between the conceptual frameworks of science and the visual arts.

A. INTRODUCTION

Early childhood curricula are by nature multi-disciplinary or trans-disciplinary. Their content is often structured based on multi-disciplinary or trans-disciplinary groups of activities (as, for example, the French study program -<http://www.education.gouv.fr>). As a result, it becomes necessary for the early childhood education teachers to train and educate themselves in multi-disciplinary and/or trans-disciplinary fields.

However, when it comes to training and education in issues of art and science, then it is not simply two different groups of activities that have to be brought closer, but two totally different cultures (Snow 1959). Despite efforts to show epistemological similarities between art and the natural sciences (Miller 1996), these two branches of human activity developed autonomously, having different goals and leading to different cultural results (Levy-Leblond 1996). Therefore, any trans-disciplinary intervention concerning art and science on the level of training and educating early childhood teachers should take into account this peculiarity, in addition to everything else.

In this study we will describe the planning principles and the content of a trans-disciplinary program on art and science, which is addressed to in-service teachers in early childhood education in Greece. This program focuses on a preeminently trans-disciplinary field, as is that of the notion of color. It is a field in which the visual arts, the natural sciences (physics, chemistry and biology), as well as various technological applications can all come together. The notion of color is also fundamental to early childhood education, since it appears in basic groups of activities, such as the study of the environment or artistic expression. The aim of this study is to highlight the problem of, on the one hand, the peculiarity of a trans-disciplinary approach to art and science, and, on the other, the transformation of this peculiarity into a topic for teacher education.

B. A TRANS-DISCIPLINARY TRAINING MODEL: THE ANALYSIS LEVEL

Figure 1 shows a schematic presentation of the model we used as a tool for the analysis and planning of the proposed training program. The model is structured and functions on three levels: a) the analysis level, b) the planning level, and c) the application and evaluation level (Koliopoulos, 1997). In this study we will be presenting only the first two levels.

FIGURE 1 ABOUT HERE

The analysis level contains three elements which function as *information entries* for the planning level. The first element refers to the analysis of knowledge and social practices which are related to the notion of color; the second element refers to the exploration and the interpretation of educators' conceptions of issues which are related to the notion of color; while the third element refers to the analysis of the educational framework within which the training program is called upon to function, i.e. the analysis of the traditions and/or the demands of the specific early childhood education curriculum which the educators are called upon to serve. Each element of the analysis level contributes in its own way to the process of stating the cognitive objectives and the content of the training program.

- *Analyzing knowledge and social practices regarding color.* The notion of color takes on a different meaning when it functions within different conceptual frameworks. In physics, for example, color is directly linked to the concept of light, and especially within the conceptual framework of the transmission of electromagnetic radiation. This means that the concept of "light" takes on its meaning through its relation to a series of other concepts, such as "frequency and wavelength of electromagnetic radiation", "speed of light", "absorption", etc. This systemic meaning (Baltas, 1990) is completely different to the meaning we give to color when we talk about it in everyday life or in the visual arts. In chemistry, color is linked to the macroscopic qualities and the microscopic structure of various materials, while in biology the conceptual network to which color belongs includes concepts such as "cell", "optic nerve" and "cone cell". On the other hand, in the visual arts, while the conceptual networks that apply are not as strict as in the sciences, color centers on the artwork itself, while special significance is given to the notions of a "warm/cold color" or the "value of color" (Itten 1961). Finally, in the field of color technology, we come across notions such as "RVB", which do not appear in any of the other aforementioned frameworks. We would like to point out, however, that in a trans-disciplinary field such as color, both the analysis of each different framework within which the notion of color takes on a different meaning and the highlighting of the similarities and the differences between the different frameworks are of special significance. Such a process would include, for example, discrimination between notions which are common to various frameworks (e.g. the notions of "color intensity", "primary color" or "complementary color") or are used in a non-differentiating way, such as the notions of "additive color mixing" and "subtractive color mixing".

- *Exploring educators' conceptions about color.* One of the main processes of the analysis level is to define the conceptions of the educators who will be participating

in the training program regarding the notion of color. Defining these conceptions contributes to the highlighting of the differences between reference knowledge and the cognitive profile of the educators regarding color. Not having access to data from other empirical research regarding the cognitive distance between the conceptions of early childhood educators and knowledge regarding color, we used the results of a pilot study in which 101 Greek early childhood educators took part. These were in-service trainee educators with significant kindergarten experience. The study used a questionnaire comprising six questions, some of which were used in a similar study in France, but which was aimed at different populations (Chauvet 1994 ; Chauvet, 1996).

In this paper we will present indicative results of this research in order to form a basic hypothesis regarding the conceptions of Greek early childhood educators, and that is that: the majority of these educators have unclear ideas about the notion of color that are due to an indiscriminate use of two different conceptual frameworks: that of science and that of the visual arts. More specifically, we will present the results of three out of the six questions (Table 1). In the first question, we see that the majority of the educators choose the correct answer, thus activating a conceptual framework which is related to the visual arts. In the second question, they activate the same conceptual framework, but the result is that they choose one of the wrong answers. The correct answer to this question requires the activation of a conceptual framework which is related to the natural sciences. Of course, this does not mean that several of the educators do not use elements of this latter framework in the correct way, as can be seen from the results of the third question. The results mentioned above tend to confirm our initial hypothesis and to reinforce the opinion that the proposed training program will have to aim at the discrimination, on the part of early childhood educators, between the various conceptual frameworks within which color takes on a different meaning. However, in order to precisely define these frameworks we must gather complementary information from the analysis of the educational framework.

TABLE 1 ABOUT HERE

- *Analyzing the educational framework.* As basic elements of that which we refer to as the educational framework, we may consider the nature and the characteristics of the kindergarten curriculum. However, we cannot ignore the innovative research trends concerning learning and teaching in early childhood education (among which the leading trend of the “constructivist” approach to learning and teaching), which are included in the contemporary training and education programs, or the limited presence of the natural sciences and their teaching compared to the presence of the visual arts and their teaching. The new Greek curriculum (www.pi-schools.gr) expressly introduces the trans-disciplinary teaching, either as the teaching of a notion which is of a trans-disciplinary nature (as, for example, “dimension”, “change”, etc.), or as the teaching of a subject or problem, the study of which requires the recall and processing of knowledge from various fields (e.g. studying a technological object which requires a knowledge of technology, geography, history, etc.). The notion of color is encountered mainly in two basic sectors of the curriculum: in the “Study of the Environment” (mainly in the sub-sector of the natural sciences – e.g. light and color) and in the “Development of Artistic Activities (color as a constituent component of artistic composition)”. From the aforementioned, it is inferred that: a) the nature of the new Greek curriculum legitimizes the planning of a trans-disciplinary program on the topic of color for early childhood

educators, b) the main corpus of the content of the proposed training program must comprise conceptual frameworks related to the sectors “Study of the Environment” and “Development of Artistic Activities”, and, c) an attempt can be made towards a synthesis (as opposed to a juxtaposition) of these frameworks which will serve the trans-disciplinary characteristics of the curriculum which we mentioned earlier. At the same time, the proposed program must contain elements of the “constructivist” approach to learning and teaching. For example, a “simulation” of this approach can be achieved with the use of the educators’ conceptions of color as the program progresses. Finally, attention should be paid to the approach of natural science elements, given the insufficient instruction of Greek early childhood educators in this field.

C. A TRANS-DISCIPLINARY TRAINING MODEL: THE PLANNING LEVEL

The planning level consists of two parts: stating the cognitive objectives and forming the “hard core” of the training program’s content.

- *The cognitive objectives of the program.* This is where the results of the analyses of the previous level come together. The aims of the proposed program, for early childhood educators, are the following:

i. To realize that the notion of color takes on a different meaning when it is used in everyday life and a different meaning when it is used within the conceptual frameworks of the natural sciences and the visual arts,

ii. to understand the significance of a trans-disciplinary training program regarding color in the teaching of the natural sciences and the visual arts in early childhood education, and,

iii. to construct a synthetic conceptual model regarding color in order to be able to analyze, to interpret and to create the appropriate teaching activities on the level of early childhood education.

Based on the aforementioned aims, we formed the “hard core” of the content of the training program, the units of which are presented in Table 2. In Unit 1, a discussion will be held regarding the phenomenological and cultural dimension of color (color as it is encountered in nature and in society, the characterization of different colors, etc.) and comments will be made on the conceptions of early childhood educators regarding color (e.g. comments will be made on the questionnaire presented in the present study). Special emphasis will be given to the epistemological differences between the natural sciences and the visual arts, as well as to the efforts made to correlate the two fields on an epistemological, educational and technological level.

TABLE 2 ABOUT HERE

In unit 2, a discussion will be held on the multi-disciplinary and trans-disciplinary aspects of the early childhood education curriculum and evidence will be given for the need of a trans-disciplinary program regarding color. Specific examples of curricula will be presented in which the notion of color appears in the same way as in the new Greek curriculum. Furthermore, a discussion will be held on the conceptions of pre-school children regarding color and the respective teaching interventions in the field of the visual arts (Arapaki 2000 ; Arapaki & Zafrana, 2004) as well as in that of the natural sciences (Charalambopoulou 2001).

Unit 3 is the program's basic unit. Figure 2 shows a schematic description of the composite model which educators will be called upon to build, while at the same time becoming aware of the fragmentariness and the partial functionality of their own conceptions. This is a simplified model for the emission, transmission and reception of light, which is considered to be electromagnetic radiation (Zuppiroli & Bussac, 2003). The specific structural form of the model allows the main discrimination between the area of "absorption/emission of light" (a natural object, a work of art, etc.), where color appears as *color-material*, and the area of "transmission of light", where color appears as *color-radiation*. In our opinion, this discrimination further allows for the discussion and construction of the differences and the similarities of the different conceptual frameworks of the natural sciences and the visual arts (or of various other technological applications). In fact, this discrimination is attempted not only on a conceptual but also on a symbolic level, in order to differentiate even further between the characteristics of these conceptual frameworks. As an example, we would like to mention the issue of additive and subtractive color mixing which is usually presented using color circles or color squares (Itten 1961). In order to avoid the confusion usually caused by the same symbolic representation of the two forms of color composition (Woolf 1999), in the proposed model we have substituted the circle of the subtractive composition with a simplified color spectrum, which refers us to the conceptual framework of the natural sciences (Hewitt 1992). In this unit, we have the option of enriching our model with other conceptual frameworks such as that of the chemical explanation of colors-materials on the level of the light receiver/transmitter (by discussing, e.g., how colors-materials are produced) or that of the function of vision (by discussing, e.g., various vision dysfunctions) on the level of the light receiver.

FIGURE 2 ABOUT HERE

Finally, in Unit 4, depending on the wishes of the participants and the demands of the curriculum, we can emphasize either the scientific, technological or artistic applications of the "Light and Color" model, or its pedagogical applications, such as the planning of teaching activities on the subject of color, on the level of early childhood education.

D. EPILOGUE

We consider this study to be a small contribution to the rationalization of the way in which a training program aimed at early childhood educators should be structured. The principles of analysis and planning presented here ensure the cohesiveness of the program by preventing its conversion into a sum of disconnected activities (activism). The principles of analysis and planning can also function as the guiding principles and criteria for a systematic evaluation of the program's application, unlike the empirical methods normally used for the structuring of such programs. The systematic evaluation of the program's application presented in this study constitutes the next step for the completion of this empirical study.

REFERENCES

1. Arapaki X. (2000). The planning, application and evaluation of a teaching model leading pre-school children to a creative expression in their artwork. *Doctoral dissertation*. Department of Early Childhood Education. Aristotle University of Thessaloniki. Thessaloniki [in Greek].
2. Arapaki X. & Zafrana M. (2004). The artistic expression of kindergarten children after a 'guided' teaching approach. *European Early Childhood Education Research Journal*, 12, 2, 43-58.
3. Baltas A. (1990). Once again on the meaning of physical concepts. In Nikolakopoulos P. (ed.) *Greek Studies in the Philosophy and History of Science*, Kluwer Academic Publishers, 293-313.
4. Chauvet F. (1994). Construction d'une compréhension de couleur intégrant sciences, techniques et perception. *Thèse de doctorat*. Université Paris 7. Paris.
5. Chauvet F. (1996). Teaching color: designing and evaluation of a sequence. *European Journal of Teacher Education*, 19, 2, 121-136.
6. Itten J. (1961). *Kunst der Farbe*. Ravensburger Buchverlag. Ravensburg.
7. Koliopoulos, D. (1997), Epistemological and teaching dimensions of the curriculum construction processes: the case of the teaching transposition and learning of the energy concept, *Doctoral dissertation*, University of Patras, Patras [in Greek].
8. Snow C.P. (1956). *The Two Cultures*. Cambridge University Press. Cambridge.
9. Levy-Leblond J.M. (1996). *La pierre de touche. La science à l'épreuve ...*. Gallimard. Paris.
10. Miller A. (1996). *Insights of genius. Imagery and Creativity in Science and Art*. Springer-Verlag. New York.
11. Charalambopoulou X. (2001). The tones of colors in the mind of pre-schoolers: a teaching approach. *Master's thesis*. Department of Early Childhood Education, University of Patras [in Greek].
12. Woolf L. (1999). Confusing color concepts clarified. *The Physics Teacher*. 37, 4, 204-206.
13. Zuppiroli L. & Bussac M.-N. (2003). *Traité des couleurs*. Presses polytechniques et universitaires romandes.
14. www.pi-schools.gr
15. www.education.gouv.fr

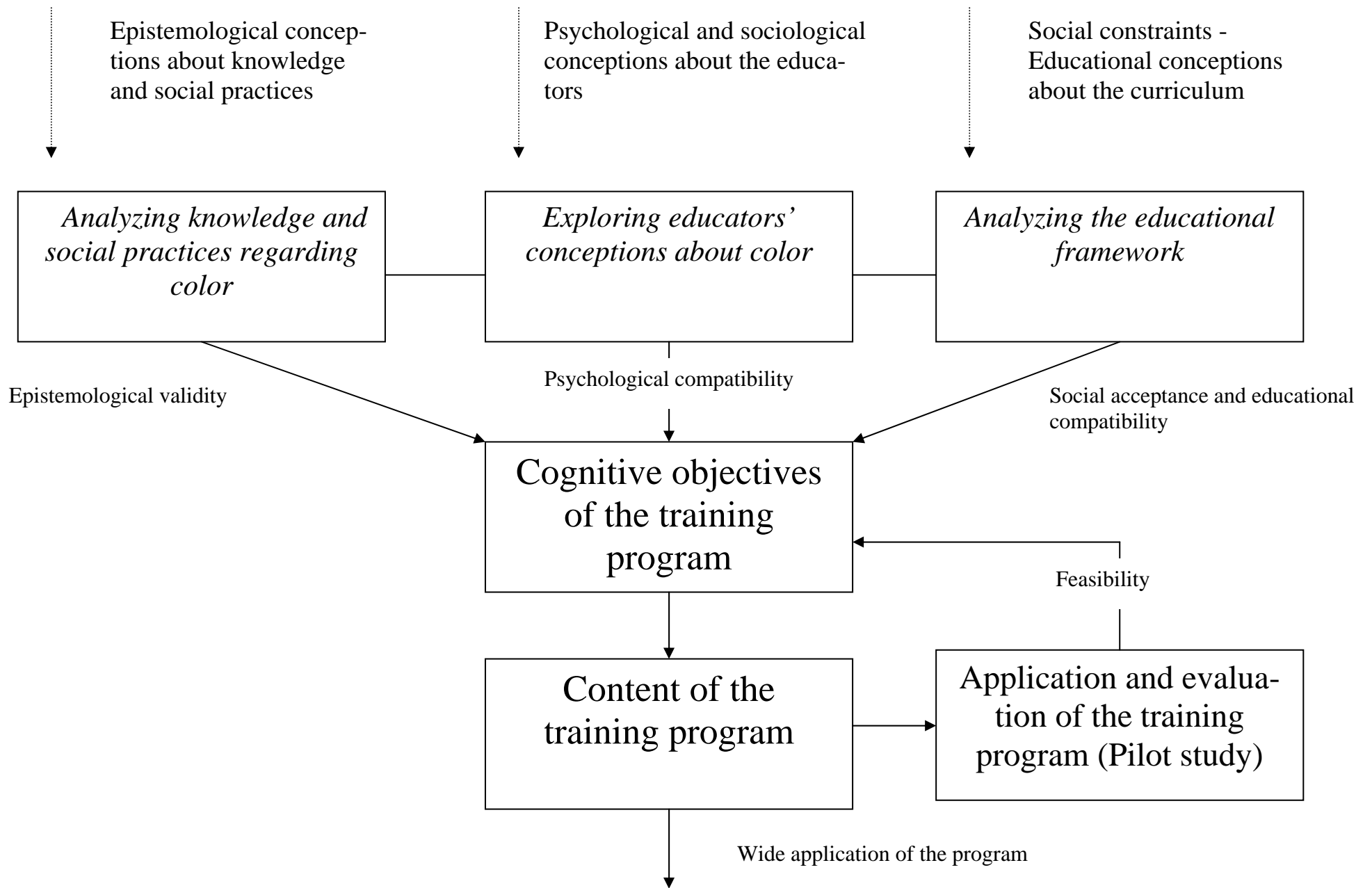


FIGURE 1 A model for the analysis and planning of the proposed “Light and color” training program

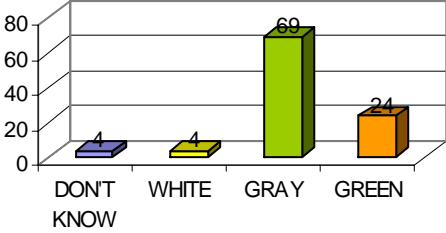
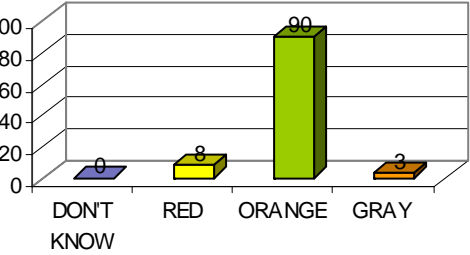
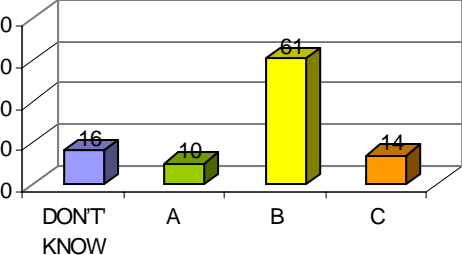
<p>QUESTION 2 Which color would result, if on a palette you mixed color pigments which correspond to the three basic colors of painting (red, yellow, and blue)?</p> <p><input type="checkbox"/> WHITE <input checked="" type="checkbox"/> GRAY <input type="checkbox"/> GREEN <input type="checkbox"/> I DON'T KNOW</p>	<p>QUESTION 2</p>  <table border="1"> <thead> <tr> <th>Option</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>DONT KNOW</td> <td>4</td> </tr> <tr> <td>WHITE</td> <td>4</td> </tr> <tr> <td>GRAY</td> <td>69</td> </tr> <tr> <td>GREEN</td> <td>24</td> </tr> </tbody> </table>	Option	Count	DONT KNOW	4	WHITE	4	GRAY	69	GREEN	24
Option	Count										
DONT KNOW	4										
WHITE	4										
GRAY	69										
GREEN	24										
<p>QUESTION 5 If a beam of red light (for example, light from a laser projector) is projected on a yellow transparency, which color would appear on a white surface behind the transparency?</p> <p><input checked="" type="checkbox"/> RED <input type="checkbox"/> ORANGE <input type="checkbox"/> GRAY <input type="checkbox"/> I DON'T KNOW</p>	<p>QUESTION 5</p>  <table border="1"> <thead> <tr> <th>Option</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>DONT KNOW</td> <td>0</td> </tr> <tr> <td>RED</td> <td>8</td> </tr> <tr> <td>ORANGE</td> <td>90</td> </tr> <tr> <td>GRAY</td> <td>3</td> </tr> </tbody> </table>	Option	Count	DONT KNOW	0	RED	8	ORANGE	90	GRAY	3
Option	Count										
DONT KNOW	0										
RED	8										
ORANGE	90										
GRAY	3										
<p>QUESTION 3 What do you think causes the impression of black on a TV screen?</p> <p><input type="checkbox"/> I don't know <input type="checkbox"/> Mixing the three basic colors of the painting (A) <input checked="" type="checkbox"/> Absence of light (B) <input type="checkbox"/> Black color is projected (C)</p>	<p>QUESTION 3</p>  <table border="1"> <thead> <tr> <th>Option</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>DONT KNOW</td> <td>16</td> </tr> <tr> <td>A</td> <td>10</td> </tr> <tr> <td>B</td> <td>61</td> </tr> <tr> <td>C</td> <td>14</td> </tr> </tbody> </table>	Option	Count	DONT KNOW	16	A	10	B	61	C	14
Option	Count										
DONT KNOW	16										
A	10										
B	61										
C	14										

TABLE 1 Answers of Greek early childhood educators to a questionnaire which show that the majority of these educators have unclear ideas about the concept of color

UNIT 1	Knowledge and social practices about color
1a	Color in nature and in society
1b	Color in the visual arts, in the natural sciences and in technology
UNIT 2	Color and Education
2a	Color, curriculum and trans-disciplinary fields
2b	Color and the child of early childhood education
UNIT 3	The “Light and color” model
3a	Emission and transmission of light (color-radiation)
3b	Transmission and reception / emission of light (color-material)
UNIT 4	Applications of the “Light and color” model
4a	Scientific, artistic or technological applications
4b	Pedagogical applications

TABLE 2 *The “hard core” of the content of the proposed training program regarding color*

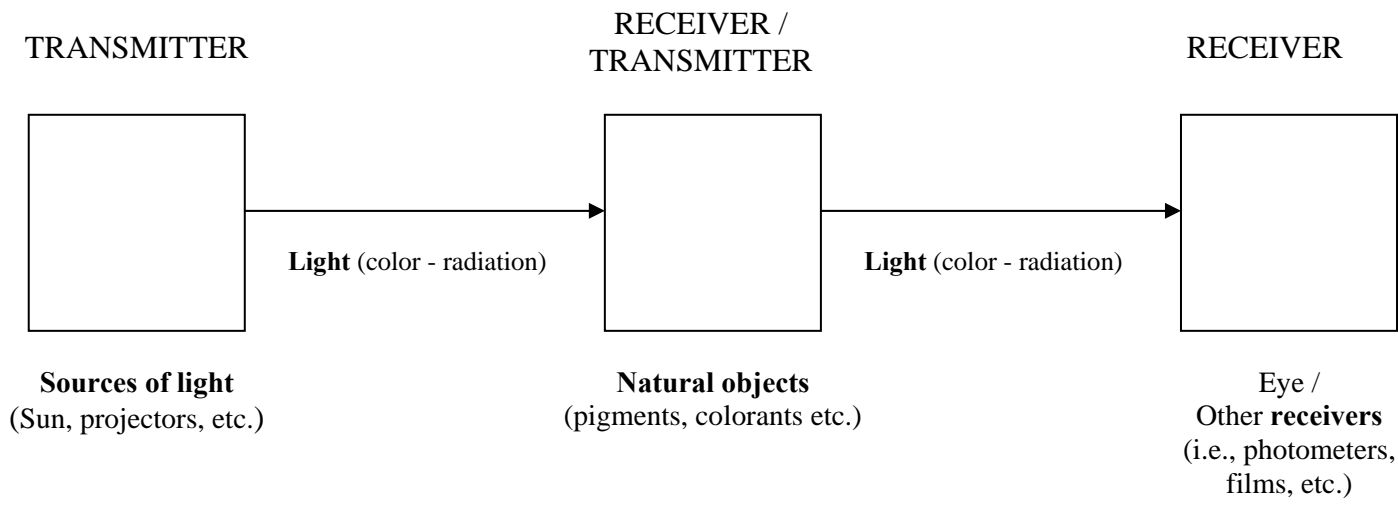


FIGURE 2 *Schematic presentation of a conceptual model regarding color*