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Popularization and Teaching of the Relationship Between Visual Arts and Natural Sciences: Historical, Philosophical and Didactical Dimensions of the Problem

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Abstract The need for a convergence of the visual arts and the natural sciences within the framework of both formal (schools, universities) and non -formal education (museum) at the level of dissemination and popularization of this knowledge is something that has preoccupied the communities of artists, scientists and educators. In the present work we aim to present in a concise way certain positions with regard to the historical, philosophical and didactical dimensions of the problem of popularizing and teaching the relation between the visual arts and the natural sciences. More precisely, we intent to show the existence of this relation throughout history and within the society by reference to certain typical examples of how scientific ideas about nature and the propagation of light influenced the practices of the neo-impressionists or the early abstract painters in relation to the use of colour or the way the visual arts aid in the representation of scientific objects and/or ideas. At the epistemological level, we are going to put forth Levy-Leblond's idea that the relation between the visual arts and the natural sciences is a relation of meeting, controversy or even conflict but definitely not a relation of confusion or fusion. Furthermore, at the didactical level we aim to present the popularization and the teaching of the relation between the visual arts and the natural sciences as a problem of the didactic transformation of knowledge and reference practices and not as a clearly pedagogical construct.

1 Introduction

Bringing into closer contact the visual arts and the natural sciences, and popularizing the benefits of interaction, has been of concern to the artistic and scientific communities in

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recent years. The exhibitions "Aux origines de l'abstraction" (Musée d'Orsay 2003) and "Signatures of the Invisible" (http://www.arts.ac.uk/infinite) on the part of the visual arts and the exhibitions "La Lumière au siècle des Lumières & aujourd'hui—Art et Science" (Changeux 2005) and "Lumière, Couleur—Dialogues entre art et sciences" (Lafait et al. 2005) on the part of the natural sciences are typical examples of the fruitful dialogue that is developing between the artistic and scientific communities concerning the nature and the characteristics of the relationship that has evolved historically and continues to evolve between the fields of the visual arts and natural sciences. The following are just some of the issues discussed in this dialogue: How scientists' ideas about the nature and propagation of light influenced the ideas of the Neo-Impressionists (e.g., Signac, Seurrat) or the early abstractionists (e.g., Klee, Kandinski) in their use of color; in what ways do the natural sciences contribute to the analysis and conservation of paintings or other works of art; how the visual arts help in the pictorial representation of plants or animals shown in Natural History Museums; and the pictorial representation in general of scientific objects, events or ideas.

In parallel to the development of popularizing conceptions regarding the relationship between the visual arts and the natural sciences (most of which, in fact, include an educational dimension), over the past few years, a similar dialogue has developed within the context of the formal (school, university) and non-formal (museum and school) forms of education. One such example is the "Science, Art and Technology" educational program of the Art Institute of Chicago (http://www.artic.edu) in terms of the visual arts, and the "Physics and Art" special feature in *Physics Education* magazine (2004) as well as other related studies (Galili and Zinn 2007) in terms of the natural sciences. A typical example of a curriculum in which the visual arts and the natural sciences co-exist in an autonomous manner and cooperate on equal terms to achieve special didactical goals is the "Sciences et Arts" curriculum of the Cité des Sciences et de l'Industrie scientific center, known as "La Villette" (Caillet 1989).

Besides the discourse taking place within the framework of the above mentioned activities, there is also another discourse unfolding. It is mainly of a post-cognitive nature and is related to the highlighting of the meaning that can be taken on by the relationship between the visual arts and the natural sciences, on both a popularizing and an educational level. We believe that the forming of clear positions regarding the historical, philosophical and didactical dimensions of this meaning can lead to the elucidation of the nature and the characteristic results of educational proposals, whether they come from the area of popularization (informal or non-formal types of education), or from the area of teaching (formal types of education). In this paper, we will be presenting certain positions regarding the historico-philosophical and didactical dimensions of the relationship between the visual arts and the natural sciences, and how they influence specific educational proposals in Greece, and especially in preschool and primary teachers education.

2 The Historico-Philosophical Dimensions of the Relationship Between the Visual Arts and the Natural Sciences in Education

In the history of the natural sciences as well as in the history of the visual arts, there emerge elements of a formal or informal dialogue between the two fields. A typical example is the *introduction of the concept of light and color* during the 18th and 19th centuries. The debate between Newton and Goethe regarding the nature of light and color, and the work of the French chemist Chevreul that influenced the Neo-Impressionists and early abstract

painters certify the effect that one field had on the other. A lesser known case related to this issue is that of the French painter Charles Bourgeois, who tried, unsuccessfully, to identify the "color of the physicist" with the "color of the painter", thus calling into question Newton's theory (Mertens 2007).

The history of ideas and practices in both fields contains many other cases of their coming together. The *analysis of art works* in the light of scientific concepts constitutes such a case. For example, the exploration of the secret structures of works of art is based on the principles of geometry (Bouleau 1963). The color analysis attempted by the painters themselves or by art historians in the works of early abstract painters (e.g. Kupka, Delaunay or artists of the Russian avant-garde such as Kliun) introduces elements of the natural sciences regarding the nature of light and the interaction between light and matter (Rousseau 2003; Douglas 2005). At the same time, the view is put forward that a fuller understanding of spectroscopy in Physics can derive from the application of spectroscopic methods on works of art (Caillet 1989; Lafait et al. 2005).

Finally, the *depiction* or the *pictorial approach to elements of the natural sciences* (e.g., texts, collections of plant and animal samples, scientific instruments or modern scientific concepts) is an activity in which the visual arts contribute to the "visualization" or even the conceptual understanding of natural science phenomena. The theoretical physicist and philosopher Levy-Leblond (1996), underscores this relationship between the visual arts and the natural sciences by stating that "*seeing* ideas and concepts in a way other than through the mathematical formalism of the physicist … teaches me, empirically, that the conceptual is not limited to the theoretical."

The above analysis shows that the relationship between the visual arts and the natural sciences is an actual social activity. The question that arises is whether this relationship and the influence of each field on the other are generalized or constitute merely coincidental encounters, each one of which has its own peculiarities. In answer to this, there are two schools of thought. One claims that there are *epistemological similarities* between art and the natural sciences (Shlain 1991; Miller 1996). Here strong similarities are acknowledged as existing between artistic creativity and creative scientific thought. Also emphasized is the aesthetic perfection of science (the "elegance" and "beauty" of science). The creative dualism in Leonardo da Vinci between art and science (Grammatikakis 2005; Atalay 2006), the case of the influence Einstein's ideas had on the work of Picasso (Miller 2001) as well as the strong relationship between projective geometry and visual arts found in the work of Dürer (Panofsky 2005) constitute typical cases that support this view.

The effect this school of thought has on popularization and education is to support the idea that, given that there is no fundamental distinction between art and science and that both fields belong to a single culture, it is possible for the planning of school curricula to be redirected towards common curricula for the teaching of the arts and sciences (Zubrowski 1982; Samson and Weininger 1995; Wenham 1998).

One may criticize this school of thought by pointing out that the argument "science contains beauty" sounds more like a *belief* than an argument for bringing together art and science. Levy-Leblond (2008) deconstructs this concept by claiming that those (scientists mainly) who invoke this argument are referring to models of classical beauty that were developed during antiquity and the Renaissance. He also holds that the aesthetic upheaval that modern art brought about does not have a corresponding phenomenon in science. Moreover, at times, the common ground between art and science seems to emerge more as an *ideological construct* that aims to combat the marginalization of art vis-à-vis science in the educational system (Wenham 1998).

The other school of thought holds that the visual arts and the natural sciences constitute sectors of human creativity that developed autonomously throughout history, having different goals and leading to different cultural results. According to Levy-Leblond (1996), the relationship between the visual arts and the natural sciences cannot be conceived as anything but "brief encounters", precisely because he does not accept the methodological equivalence of aesthetics and science ("The most beautiful theories have collapsed in the face of a pitiful fact"). On the other hand, this school of thought claims that art can restore, to a certain degree, the relationship between the abstract concepts invented by modern science and the daily human experience.

This conception could be perceived as an obstacle to popularizing the dialogue between the arts and the natural sciences. Nevertheless, it can constitute the basis for overcoming, at least in principle, the lack of communication between the two fields which is rooted in the preservation of their *autonomy*, as well as in the need to create *complementary* relationships (rather than relationships of equivalence) wherever that is needed (Caillet 1989; Levy-Leblond 1996; Author 2007).

3 The Didactical Dimensions of the Relationship Between the Visual Arts and the Natural Sciences in Education

Another question that is of great interest to researchers of the Didactics of the Natural Sciences and the Didactics of the Visual Arts[1] is what could be the form and characteristics of the relationship between the natural sciences and the visual arts in education. We have already mentioned that the two epistemological schools of thought that have taken shape lead, among other things, to decisions of an educational nature. But that is not in itself sufficient, since the objectives and the knowledge that popularization and teaching entail often manifest their own autonomous characteristics with regard to social objectives, knowledge and reference practices. Depending on the degree of autonomy of the educational process, we can discern two schools of thought that can answer the question we have posed.

The first school of thought views the relationship between the visual arts and the natural sciences in education as a purely *pedagogical artifact*. According to this school, the inner objectives of the educational system guide the nature and the characteristics of the form which the relationship between the visual arts and the natural sciences will take on when popularized and taught. For example, certain educational systems (such as the Greek one) or certain curricula (e.g., Tolley 1994) promote the so-called interdisciplinary approach as the general principle in organizing the curriculum or the educational program. According to this principle, various school subjects that were taught separately must now be unified. Another typical example of this concept is the use of works of art in the teaching of Physics. Thus, Duchamps's *Nude Descending a Staircase* can be used in the teaching of kinematics (Herklots 2004), and works by Giotto in the teaching of optics (Galili and Zinn 2007). But is there a true dialog taking place between the visual arts and the natural sciences in all the previous cases, or does this coming together merely constitute a juxtaposition of elements of the two fields that are not fundamentally connected? Could the

[1] In this paper, the terms "Didactics of the Natural Sciences" and "Didactics of the Visual Arts" take their meaning from the European continental tradition (Izquierdo-Aumerich and Aduriz-Bravo 2003; Gaillot 1997).

absence of a cohesive epistemological framework invalidate the meaning of this encounter?

A second school of thought considers the relationship between the visual arts and natural sciences in education as an interdisciplinary concept which is based on the notion of *didactical transposition* (Izquierdo-Aumerich and Aduriz-Bravo 2003; Author 2009). Didactical transposition is the sum of the modifications undergone by the content of knowledge and reference practices when they become teaching subjects. A basic feature of this didactical transposition is the *reframing* of knowledge and the related social practices of reference. This reframing is related to the demands and the restrictions set by the educational framework, such as, for example, the demand to determine within the year a sequence of units regarding a specific teaching subject. However, at the same time, *authentic elements* of the activities that appear in society or in the reference education (e.g., tertiary education) are preserved. According, therefore, to the above notion, interdisciplinary activities will appear in the process of popularization and teaching only as the transposition of forms of interdisciplinariness which appear as knowledge or as social practices of reference as they have functioned throughout history or continue to function within certain social environments. Thus, the epistemological validity of these activities will be ensured (Maingain and Dufour 2002), a fact which does not apply to interdisciplinary approaches, as they considered purely pedagogical artifacts.

A typical example of this notion is the teaching of the concepts of "light" and "color" to pre-service or in-service educators of preschool or primary education, i.e. to teachers who are not specialists in matters of art and science but are called upon to teach them. In this case, we adopt the approach of interdisciplinariness as the didactical transposition of a *conceptual model* which combines elements of the natural sciences and the visual arts in regard to the concepts of "light" and "color" (Author 2004). The specific syntactical form of this conceptual model (Zuppiroli and Bussac 2003) offers, among other things, a) a classification of the various color phenomena either during the diffusion of light (e.g., colors that are produced either by the interference or the diffraction of light), or during the interaction of light and matter (e.g. color phenomena that are produced by the absorption and diffusion of light); b) the distinction between color-radiation and color-pigment, which allows the discussion of topics such as chromatometry and the mixing of colors; and c) the distinction between the natural/physiological basis (color-perception) and the intellectual basis (color-interpretation) of the color that allows the understanding of topics such as harmony and the correlation of colors. This conceptual model is fully compatible with historical and philosophical elements that express true encounters between art and science in the field of "light and color". Another example of the same concept is the education of teachers and preschoolers in topics of the visual arts and the natural sciences through the *analysis of works of art*.

4 Epilogue

Even though "two cultures" (Snow 1998) continue to coexist and clash, the dialog between the visual arts and the natural sciences is also present and is being carried out on different levels in society and in education. In this paper, we have commented on the historical, philosophical and didactical dimensions of this dialog in the light of the Didactics of the Visual Arts and the Didactics of the Natural Sciences. On an epistemological level, we have supported the idea that the relationship between the visual arts and the natural sciences is one of "meeting, controversy or even conflict but definitely not a relation of

confusion or fusion" (Levy-Leblond 1996). On a level of didactic theory and practice, we held that the idea of the popularization and teaching of the relationship between the visual arts and the natural sciences solely as a problem of a didactical transposition of knowledge and social practices of reference can be understood if we wish to render true meaning to this relationship.

Of course, forming a clear conception regarding the meaning of the relationship between the visual arts and the natural sciences constitutes a necessary but insufficient condition for the planning of effective educational interventions. The peculiarities of each educational system, as well as knowledge of the cognitive abilities of the populations at which these interventions are aimed constitute two more fundamental factors that can influence them. The further exploration of the relationship between these three factors is the main object of the research currently being carried out by our team.

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