
# Enhancing Scientific Thinking in Children: Suggestions based on Studies about Creativity

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## Abstract

*If we consider science not only as a system of knowledge and theories, but also as a process of investigation, characterized by formulating and testing hypotheses, then we must recognize that this process may also be exercised as early on as infancy. The process of investigation, which coordinates evidence and theories, although not completely understood at preschool age, can find interesting similarities in activities of discovery, exploration and play, even when the context is not explicitly intended to provide the child's first naturalistic or scientific knowledge.*

*In preschools, activities such as building, exploring and pretend play, which on the surface may seem to be activities for free creativity, often hide logical thought processes and experimental testing typical of science education. Indeed it is precisely the current concept of creativity - defined as the ability to find original solutions that correspond to a given task – which closely links it to the scientist's problem-solving and investigation procedures (Sternberg & Lubart 2007, Feist 2011) . Both the scientific discovery and the creative processes are triggered when a problematic situation is perceived, and they require logical reasoning based on acquired data and knowledge as well as imagination to be resolved. Equally both make extensive use of combinatorial thinking, in other words the ability to connect ideas, facts and procedures belonging to diverse and remote areas of experience (Vygotskij 1973). The educational and teaching methods suggested by a lot of literature to stimulate creativity, which translate combinatorial thinking in practical terms, include analogy, metaphor, visualization and multiple associations, which are the exact same tools used by the creative scientist (Feist 2011, Kind & Kind 2007, Jalongo Hirsch 2012, Pramling 2010) .*

*A manifestation of the use of analogies and metaphors during the educational process, whether spontaneous or provoked, obtained both from literature and surveys carried out (the European project Creanet 2013), documents forms of scientific thinking in preschool children whilst also bringing to teachers attention the multiple opportunities in early education to promote it.*

## 1. Introduction

Studies on Creativity in science, like those designed to strengthen scientific teaching, stress the importance of removing a stereotypical representation of science as a mere system of enunciations and rules that explain classes of phenomena. Science is first and foremost a process of continual research, testing, construction and discovery. Such a process is fueled by the often routine, constant application of knowledge and rules, and of consolidated and convergent procedures, but certainly also of invention, continuous innovation and discovery, which require creative thinking. But it is exactly this noted and innovative dynamic that stresses that scientific discovery implies the adequacy of invention to problems and to the body of consolidated knowledge. It is obvious that the scientist has the solid and articulated knowledge of his field of knowledge, but also that he adopts a way of thinking which implies posing a problem, formulating hypotheses and making repeated tests. Moreover, this is the logic of enquiry [Feist 2011].

In other words the first analogy between creative activity of the child and that of the scientist lies in the common attitude of inquiry, or of research.

This investigative attitude animates the child not only when they explore objects or natural phenomena, contexts that are closer to the natural sciences, but in many activities: from constructive activities to artistic and play based activities, when he is dedicated to them in pursuing the solution to a problem, or the pursuit of a goal [Jalongo Hirsch 2012, p. 98].

If education and school can act effectively to foster creativity, such an action is, once again, promotes the contexts in which the processes which nurture creativity (or, in Guilford's words, divergent thinking) are favored. exactly in reference to scientists' creative thinking relevant indications emerge.
In preschools, activities such as building, exploring and pretend play, which on the surface may seem to be activities for free creativity, often hide logical thought processes and experimental testing typical of science education. Indeed it is precisely the current concept of creativity - defined as the ability to find original solutions that correspond to a given task – which closely links it to the scientist's problem-solving and investigation procedures [Sternberg & Lubart 2007, Feist 2011] . Both the scientific discovery and the creative processes are triggered when a problematic situation is perceived, and they require logical reasoning based on acquired data and knowledge as well as imagination to be resolved.

## 2. The processes: imagination and combined thinking

Certainly, imagination is the most widely included process in the definitions both of scientific and creative thinking, intended as the ability to represent fictional worlds guided by rules. Imagination is implicated in possibility thinking that is typically expressed in children's pretending games [Craft et al. 2012, p.49] if we intend it as the ability to figure out, that is to mentally anticipate, what is not yet there, or what does not exist [Craft et al., 2012].
Equally both make extensive use of combinatorial thinking, in other words the ability to connect ideas, facts and procedures belonging to diverse and remote areas of experience [Vygotskij 1973].
Even from the point of view of the imagination process that definition of 'combinatory art' of experiences that Vigotsky has already lucidly theorized, and which cognitive psychologists stress when they analyze mental production processes. For example, from Kind's definition, of imagination as a combination of multiple memories of external objects comes to us a significant step in recognizing the mental processes of creativity, which help us describe the conditions useful to its promotion [Ward 2007]. If the inclusive and eclectic model of Antonietti at al. is adopted [Antonietti et al., 2011] that is defined WCR, we can describe the three principle processes in action in creative behaviour and retrace the passages of imagination itself. In the first place a *widening* of the mental field is noted, which is even expressed as the production of numerous ideas, the fluidity of thought ( present in Guilford and Torrance) implies calling to mind (from long term memory) other fields or domains with respect to the present one. Secondly, the connection (*combining*) of knowledge coming from different explored fields, a translation of structures, concepts and configurations from one universe to another. and finally, their reorganization in a new set (*restructuring*), that can coincide, for the scientist, with the new solution. The three processes, typical of creative production, can be traced precisely in scientific discovery, from Darwin to Fleming, from Maxwell to Leonardo da Vinci (*ibid* p. 82 and 83). It is exactly this activation of these processes that brings together the scientist and the child.

## 3. Tools for thinking Creatively

The educational and teaching methods suggested by a lot of literature to stimulate creativity, which translate combinatorial thinking in practical terms, include *analogy, metaphor, visualization and multiple associations,* which are the exact same tools used by the creative scientist [Feist 2011, Kind & Kind 2007, Jalongo Hirsch 2012, Pramling 2010].
"Analogy has traditionally been viewed as a powerful engine of discovery, for the scientist, the mathematician, the artist, and the child" [Feist *ibid*, p.299].
A manifestation of the use of analogies and metaphors during the educational process, whether spontaneous or provoked, obtained both from literature and surveys carried out (the European project Creanet 2013), documents forms of scientific thinking in preschool children whilst also bringing to teachers attention the multiple opportunities in early education to promote it.

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