

Development of biological literacy through drawing representing organisms.

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Abstract

This chapter is about how children's drawings convey their level of conceptual understanding of organisms. Drawings is a useful pedagogical tool as a window to investigate children's conceptual knowledge and meaning they give to this form of art.. We intend to show how children represent by means of drawings their concepts and ideas of the natural world. Our methodology was to analyze the drawings collected from pupils living in rural areas, towns and suburbam areas in Brazil will be discussed.

Introduction

Young children aged 4 to 6 years and also those a little older in every culture notice and find out about living things around them. They are innately interested in living organisms such as plants, insects, birds which they identify, classify and seek for patterns either invertebrates, but also animals in general (Bartoszeck et al., 2011; Bartoszeck et al., 2014; Rybska et al., 2014). Additionally, primary and secondary school students show positive attitudes towards animals such as spiders, toads (Prokop et al., 2010; Tomazic, 2011). When children deal with living organisms offers countless opportunities for understanding the natural world and contribute to their science learning (Zoldosova & Prokop, 2006).

Children see live animals at home backyard or visits to zoos and plants (shrubs, trees, flowers) at home and its immediate surroundings or when going on trips to botanical gardens (Sanders, 2007). Therefore, they are able to identify striking features of their structure and sometimes behaviour having environment as a background of natural world (Patrick & Tunnicliffe, 2011). Thus, the concept of animal and plant are fundamental ontological categories that allow children in every culture to organize the perception of the world in which they live (Angus, 1981; Wee, 2012).

However, most children entering preschool have a early biology acquired intuitively from observing what happens in the world around them (Inagaki & Hatano, 2002; Legare et al., 2013). It is mostly in the preschool level that the conceptual learning of sciences by children aims to help give meaning to the natural world around them (Vieira et al., 1968; Bartoszeck, 2014). Therefore, children's drawings are significant tools that may be used to evaluate their knowledge and concepts for the ecosystem and diversity of flora and fauna, as for example in the Atlantic rain forest (Schwartz et al., 2007).

Contemporary children's drawings of system of symbols, numbers and letters and real objects recalled from associations gathered in memory or in action in the working memory are less accurate in detail but are able to depict the many aspects of the object to other people to recognize (Potter, 1976; Hitch & Halliday, 1988; Morse, 1999; Pike et al., 2012; Dunning et al., 2013). A child's drawing is a way children may choose to represent their inner mind representation (Van Driel, 1999; Schnotz, 2002). According to Rapp (2007) "mental models" are representations of information and experiences from the outside world. Moreover, drawings (the expressed model) channel graphic information and communicate children's ideas or development of concepts, sometimes in an alternative and confused way (Hopperstad, 2008).

The basic hypothesis of Luquet (1927/1979) is that the aim of drawings is a translation of visual properties of objects into graphics. Thus, when a child is using symbols she is reflecting her knowledge (expressed model) she means to express, either from the point of view of her psychological or in the course of her cognitive development her view of the world (Jung, 1962; Johnson-Laird 1988; Plotkin, 1997). On the other hand, from very early on, boys (3-4 years old) when attracted by trains will draw rudimentary railways more frequently than other boys. Girls (4-6 years old) will tend to draw princesses with crown and long pretty dresses most of the time, perhaps due to how boys and girls are raised (Langevin, 2014).

It is claimed that there are some similarities between the first children's drawings and those produced by primates and earlier *Homo sapiens sapiens* in prehistory or in more recent proliferate oral societies, recapitulating Haeckel's law but on cognitive development (Diamond, 1992; Manqueriapa & Darinquebe, 2009).

Animals and plants in the drawings of children

Prehistorical drawings dated to be about 30,000 to 11,000 years old representing specially animals such as horses, stags and oxen were found painted by primitive inhabitants, on the walls of Lascaux and Altamira caves, mainly in Southern France and Spain in Europe where they are better documented, but also in other sites worldwide (Chauvet et al., 1996; Spivey, 2005; Kleiner, 2011). The meaning of those paintings seems to be related to preparation for spiritual ceremonies, for successful hunting as food represented a survival item for the primitive populations or either man's urge to express creatively his imagination, reflections or dreamings (Boas, 1955; Day, 1970; Leakey, 1981).

Prehistoric rock art and specially animals paintings (jaguar, deer, vulture) and geometric traces found on the walls of caves, were described in sites close to the towns of Pirai do Sul, Tibagi, Sengés and Jaguariaíva, Paraná State (Southern Brazil). Such paintings are presumed to be carried out by hunter-gatherer Indian tribes in the last 12,000- 5,000 years. It is interpreted to be representations depicting spiritual ceremonies or images derived from everyday activities, reflections or dreamings from this populations (Cardoso & Westphalen, 1986; Parellada, 2009; Oliveira, 2014; Parellada et

al., 2014). The first report of animals and plants known by Brazilian indian tribes was done by Hans Staden, around 1576 (Staden, 2008).

It is believed that these rough ancient art created by our primate antecessors will reappear as mental models in contemporary children's mind and manifest as drawings (expressed model) which begins with the scribbling of the shape of animals (Luquet, 1923, 1927/1979; Cox, 2005). It seems that children tend to spontaneously draw people, animals because they are active and make sounds, but show less interest for plants (Dempsey & Betz, 2001; Villarroel & Infante, 2014; Anderson et al., 2014; Ballas & Momsen, 2014).

Children usually have in their mind an image of a composite flower and of a "lollipop" tree which they draw to what they are more used to as represented in Figure 1. Older children and adolescents notice differences that characterize other kinds of trees (Figure 2)

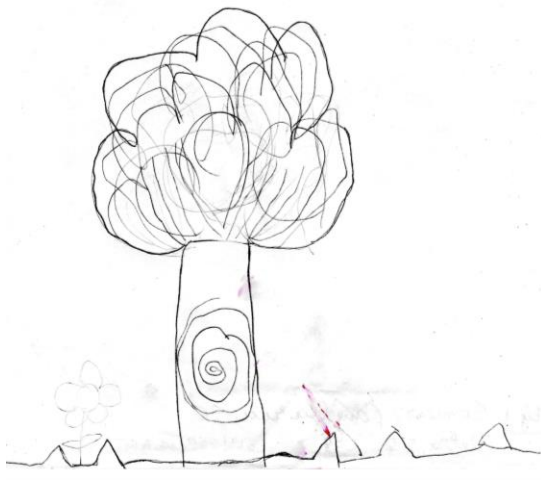


Figure 1. Drawing from a five years old girl depicting her representation of a tree (Camboriú town, urban area).

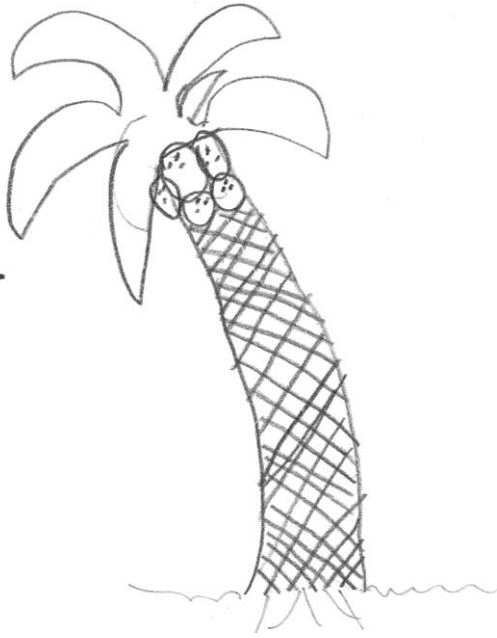


Figure 2. Drawing from a eight years old boy depicting a coconut tree (Dorizon town, rural area).

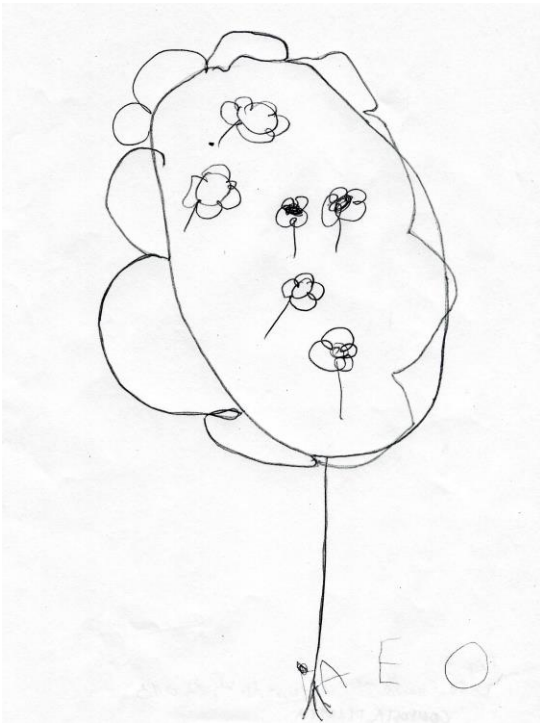


Figure 3. Drawing from a four years old boy depicting a compositae plant (Piraquara Town, rural área).

However, children are attracted by the colour of flowers and fruits, some of which they have to learn are edible, from trees and shrubs in the home backyard (Figure 4).

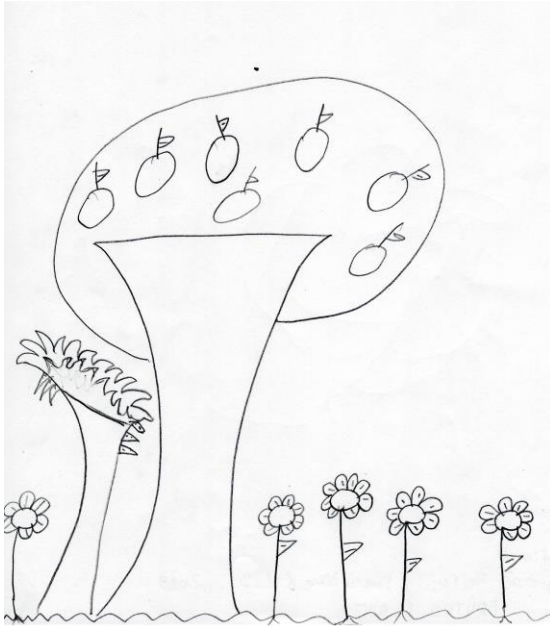


Figure 4. Drawing from a six years old girl depicting a tree with apples and environ elements (Piraquara town, rural area).

Taking into consideration which topics children aged 5-13 year olds prefer to draw spontaneously, an outline of animals are more frequently drawn by the youngest children (Waehner, 1946). A similar procedure was carried out when pupils were asked to draw what they thought was inside creatures when they were alive. Pupils were not examined under formal examination conditions but were told to draw on their own (Bartoszeck et al., 2011). However, some children say that they do not have an ability to draw. Therefore researchers also included interviews as a way for children explain their drawings.

Relatively little is known on how the structuring process of biological concepts take place. Probing pupils' thinking by means of drawings is the starting point for more effective teaching in the classroom. As a consequence, science teachers even on the stage of preschool years would be able to elicit ways to add new knowledge to the existing biological knowlwdge stucture pupils gleaned for instance from visits to science museums. Children in different cultures either in underdeveloped countries as Zimbabwe and Brazil and developed ones such as England already knew there were a

few internal organs and roughly know KNEW were WHERE they are located in specimens bodies (Tunncliffe & Reiss, 1999 a, b; Manokore & Reiss, 2003; Bartoszeck et al., 2008).

The first author on separate occasions presented the pupils with a single dead specimen of a Wistar rat, (*Rattus norvegicus*) taxidermic, a bird, a woodpecker (*Chrysophilus melanochlorus*), taxidermic, and a salt water fish corbina (*Sciaena aquila*) fresh. On each occasion, the pupils were asked to draw what they thought was inside these creatures, (the intention was that they drew specially bones as well other organs) when they were alive as presented on the set-up brought by the author. Many pupils labelled the internal structures in their drawings and the supply teachers wrote labels for children who where not able to write properly as the drawings shown in Figure 5, Figure 6, Figure 7 and Figure 8.

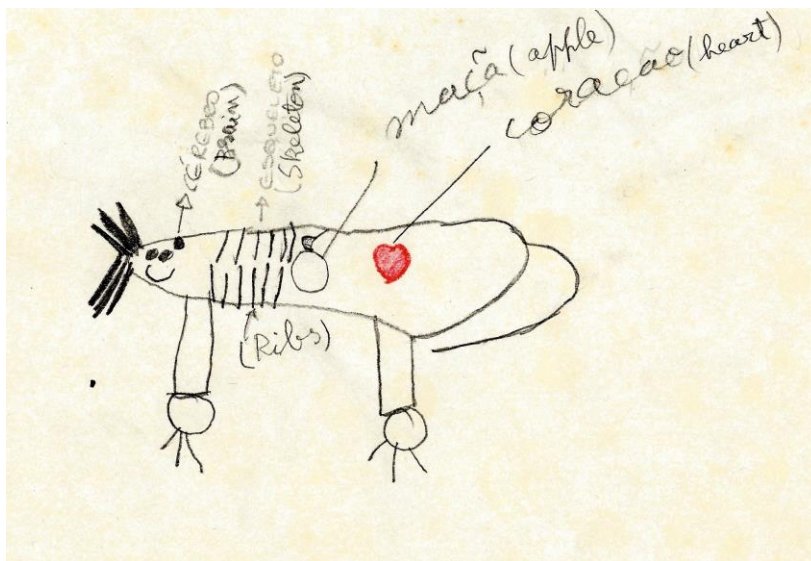


Figure 5. Drawing from a four years old girl representing what she thinks is the internal organs of a rat (Curitiba town, suburban area).

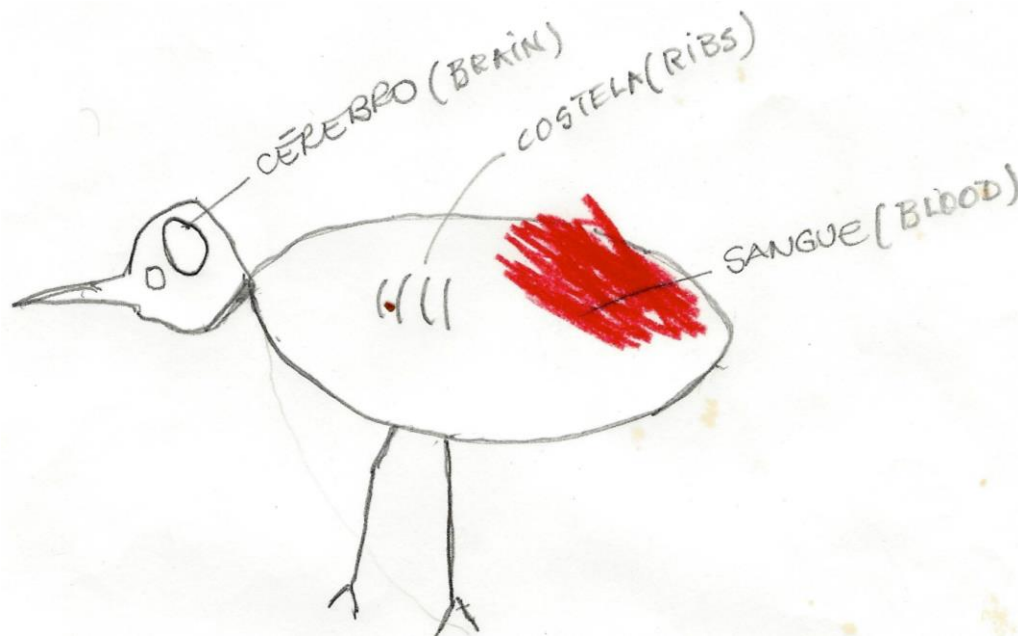


Figure 6. Drawing of a four years old boy representing what he thinks is inside a bird (Curitiba town, urban area).

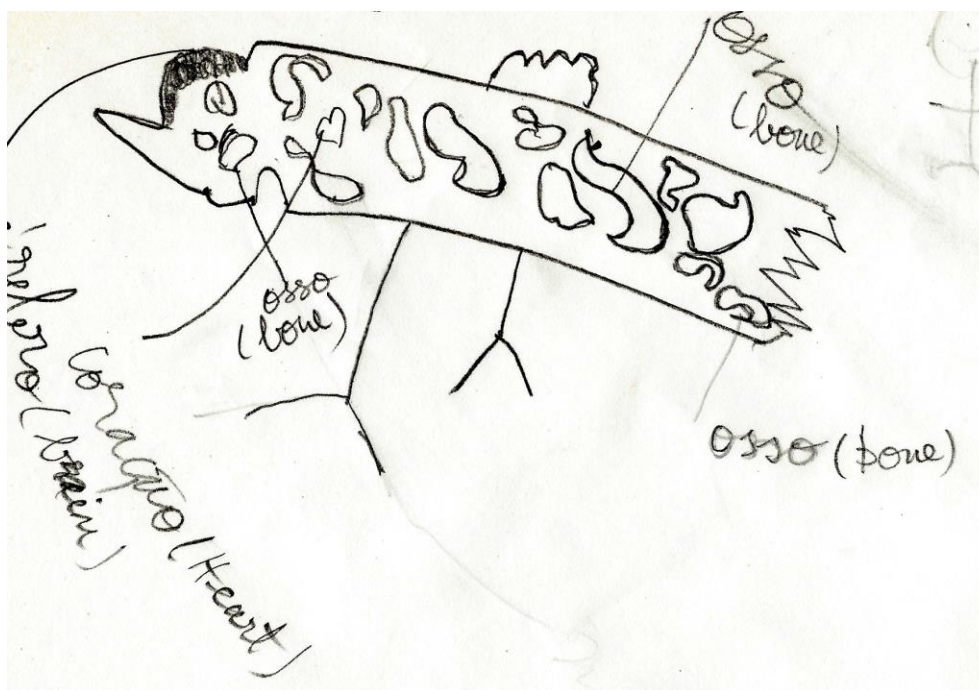


Figure 7. Drawing of a four years old boy depicting what he thinks are the inner structures of a bird (Curitiba town, suburban area) .

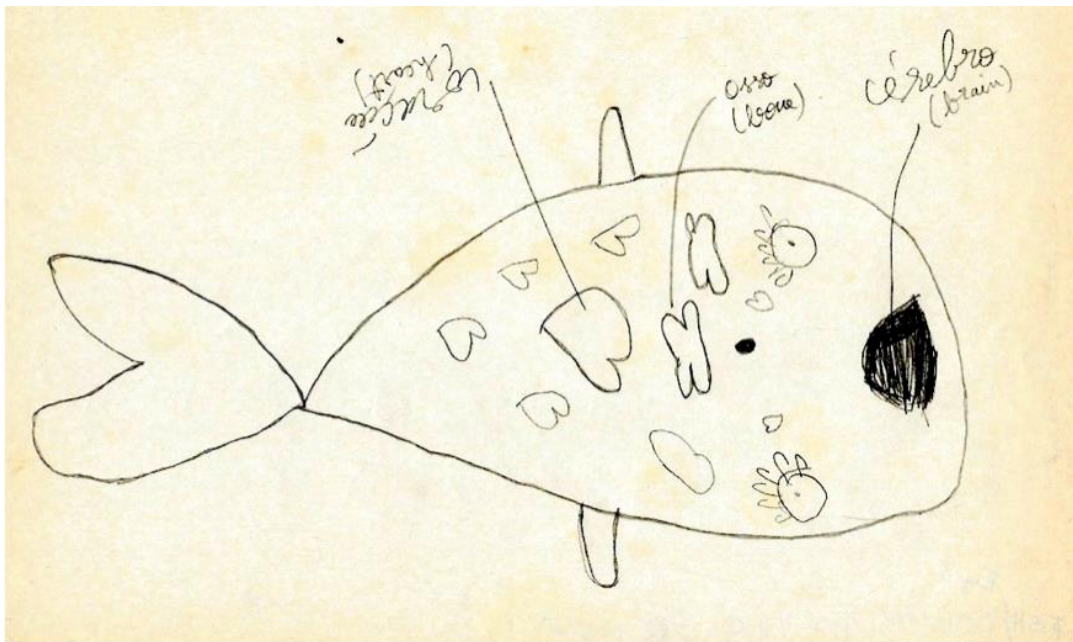


Figure 8. Drawing of a four years old girl representing what she thinks is the internal structures of a fish (Curitiba town, urban area).

Previous studies had shown that boys tend to draw more domestic animals (horses, oxen, cow) but also pet animals (dogs, cat, fish, invertebrates, than girls (Bender & Rapaport, 1944; Rioux, 1951). Children's understanding how birds behave, fly and live perching on the bough of trees or swim on ponds and rivers was evaluated by concept maps and interviews with kindergarten American children, and accessing their mental model through drawings (Buchholz, 2000; Tunnicliffe, 2012). On the other hand, domestic fowl (hen, cock, ducks) and other wild birds were largely represented in Brazilian

children's drawings (Bartoszeck et al., 2011; Bartoszeck & Tunnicliffe, 2011, Lourenção van Kolck, 1981).

Importance of children's drawing as a tool for learning.

Activities such as drawing, painting and sculpting are part of human nature and historically human beings wish to communicate their experiences, dreams and thoughts to other people. On the other hand, dealing with infants, children's drawings change according to their development and bring to school their socio-cultural backgrounds which may manifest in the shape of symbolic representations (Kendrick & McKay, 2002). Drawings produced by children evolve as the child's cognitive and motor skills expand a fact observed in many cultures. As a start point, scribbles are the first purposeful marks left by children when they are about 2 years of age (Fig. 9). They reveal the child's capacity to form an intention and put it into practice. It changes from purposeless pencillings to a purposive and may be given a name to it (Burt, 1922).



Figure 9. A drawing representing an insect by a four years old boy which scored as level 0 (zero) according to grades in Table 2.

Noticibly, scribbles evolve into shapes when the child is about 3 years of age. As children have increasing control and co-ordination of movements (fine and gross motor skills) and can manage the pencil in a better way, they start making their first shapes (Eliot, 1999). The child seeks to produce circles, crosses and next rectangles and triangles (Yang & Noel, 2006). Between 4 to 5 years of age children develop a progressive visual control. The human figure becomes the favourite subject but also plants and animals (Figure 10.). They begin to draw suns and clouds illustrating a scene in the environment (Figure 11.).



Figure 10 . A drawing by a 4 year old boy representing a picture of a human being with the characteristics of a “tadpole man”.

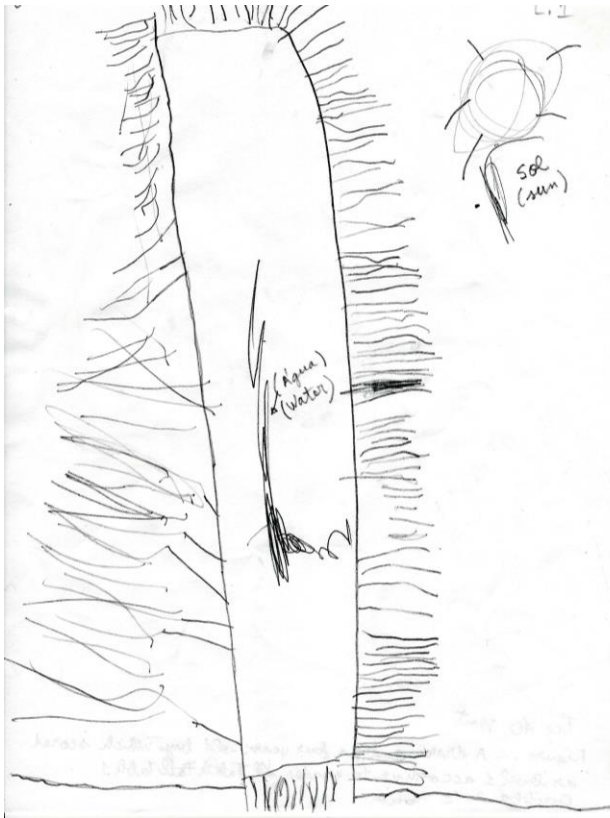


Figure 11. A drawing of the concept of plant by a four years old boy which scored as level 1 according to grades in Table 3.

By 5 to 6 years of age children reach the so to say “early pictorial stage”. Flowers, leaves and fruit may be added when representing trees and shrubs. By 7 years old children create a more elaborate scene, a narrative and begin to reveal how they perceive and attach meaning to the world around them, a kind of descriptive symbolism (Bourssa, 1997; Hopperstad, 2010). However, although drawing activity is common during elementary science lessons, there is a scarcity of studies concerning the natural world (Symington et al., 1981).

Hayes & Symington (1988) stated based in previous studies, 3 labelled stages: “symbolism” where the human figure depicted is reproduced with certain accuracy; “intellectual realism” (around 7 to 8 years old children) where the child jot down what she knows instead of what she sees. She is trying to communicate a lot of details that she remembers from a topic. The next stage, the third (around 9 to 10 years old) the child begins drawing from memory and imagination to the stage of drawing to what she perceives from nature, called “visual realism” (Hayes & Symington, 1994; Hayes et al., 1994).

Biological drawings performed by pupils allow them to create their own visual representations aiming to have a conceptual understanding of the subject they are working on (Ballew, 1930; Chang, 2012). Drawings aid the pupil in remembering details to what he has observed as is the case of dissecting an exemplar of the earthworm or a grasshopper under the extereo-microscope and identify the parts which form the rudimentar nervous system of these invertebrates (Freeman & Bracegirdle, 1976; Righi, 1966).

Bird drawings

It is often said that young children are out of touch with wildlife at least in developed countries (Louv, 2008). However, in every culture children are annately INNATELY interested in living things, identifying, classifying and seeking patterns, especially on animals (Tompkins & Tunnicliffe, 2007). Bird observation only recently has been adopted in preschool and elementary school as a strategy to improve environmental and preservation education, as it stimulates pupils observations of organisms in the natural world and develops respect for environments they live in (Figure 12, Figure 13 and Figure 14).

One advantageous approach is to ask children to identify morphological features related to feed habits (e. g. beak shape) and at the same time the concept of birds by means of drawings (Bartoszeck & Tunnicliffe, 2011; Bartoszeck et al., 2011).



Figure 12. Drawing of a bird by a five years old boy which scored as level 1 according to grades in Table 3.

Analysis of the drawings collected intend to elicit the mental model pupils may have of a bird on the perspective of Luquet's (1927/1979) through this drawn expressed model.

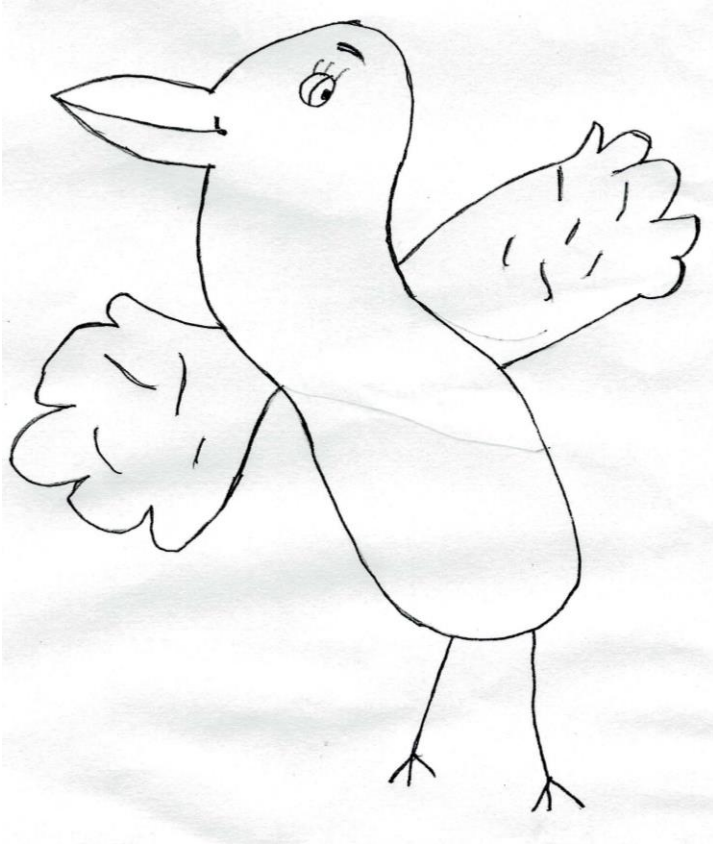


Figure 13. A drawing of a bird by a nine years old girl which scored as level 2 according to grades in Table 3.

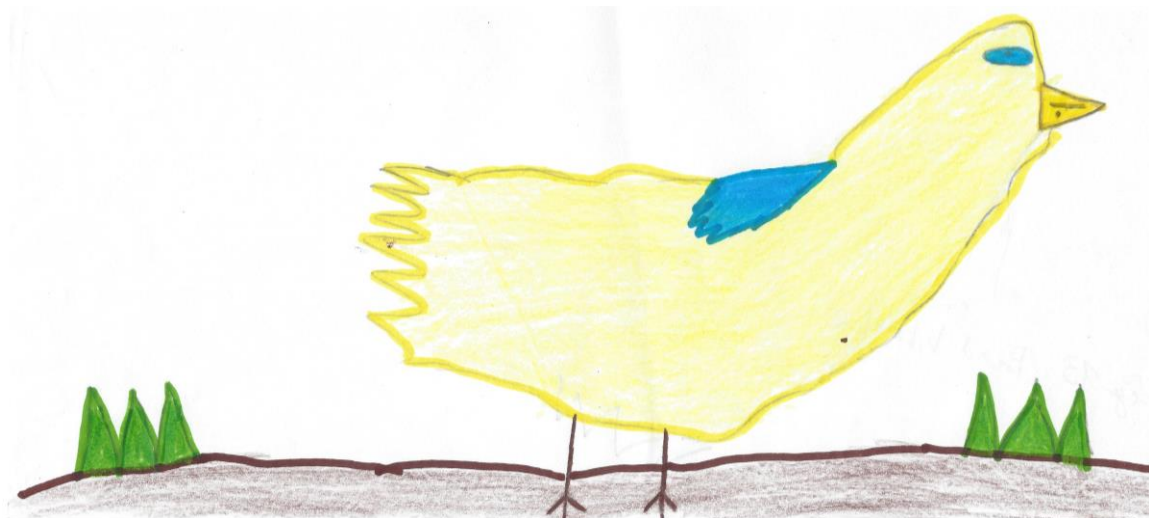


Figure 14. A drawing of a bird by a 11 years old girl which scored as level 2 according to grades in Table 3.

The authors after examining the drawings created a simple rubric scheme for assessing the morphological attributes of bird to be scored by raters (Table 3).

Table 3. Bird rubric scheme used to allocating a grade to drawings.

Level	Bird characteristics
0	Nothing recognizable
1	Scribble (resemblance of a bird).
2	3 parts body, legs, wings, beak.
3	3 parts body, 2 legs on thorax, feathers, wings, tail, beak (e. g. insect catcher).
4	3 parts body, 2 legs on thorax, feathers wings, tail, beak (e.g. seed breaker).
5	3 parts body, 2 legs on thorax, feathers, wings, tail, beak long (like humming birds).

Learning about birds endemic to the culture children live in is part of their learning about emergent science in the everyday world and birds are very much a part of this world.

Insect drawings

Children notice insects in their lives to differing extent and sources according to the culture they are immersed (Figure 15, Figure 16). Drawings together with other educational tools (for instance interviews) are useful strategies to elicit children's mental model of insect and to evaluate their understanding of the natural world manifested by pictorial representations (Cinici, 2013).

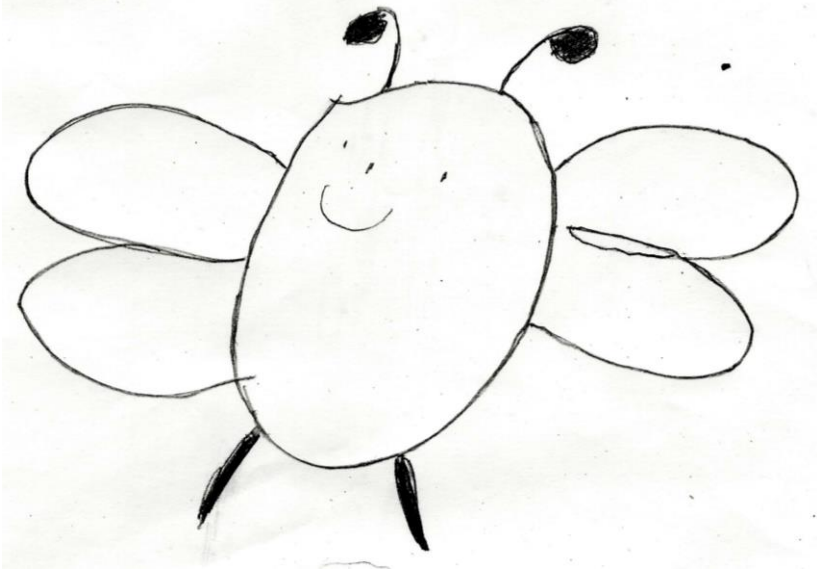


Figure 15. A drawing by a five years old girl depicting what she thinks is an insect which scored as level 5 according to grades in Table 2 .

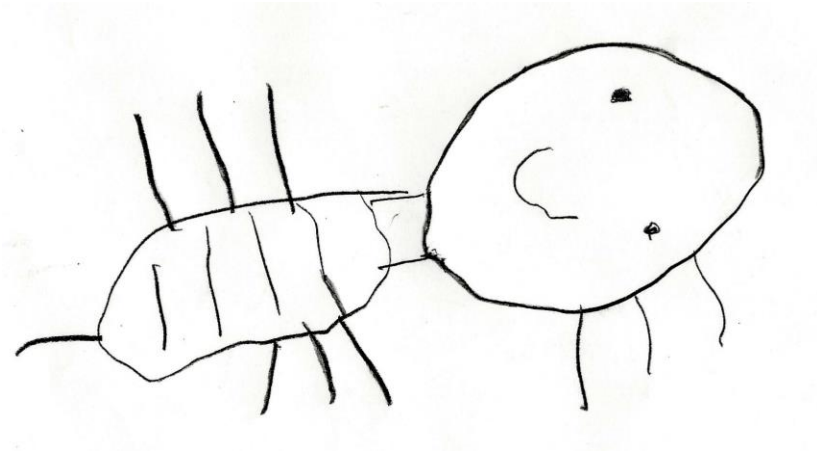


Figure 16. A drawing by a 5 years old girl depicting what she thinks is an insect which scored as level 3 according to grades in Table 2.

The sample of drawings were collected in schools located in urban, suburban and rural areas as to reflect the social and cultural strata of the population in southern (Curitiba town, Paraná) and northern (Rio Branco town, Acre), Brazil (Bartoszeck et al., 2011; Bartoszeck & Tunnicliffe, 2012). The key objectives of this study was to investigate the mental model children may have by means of an insect drawing, score the drawings to allocate a grade to the drawings according to a rubric scheme of levles (Andrade, 2000; Moskal, 2000; Malini, 2007).

Table 2. The rubric scale used to allocating a grade to insect drawings.

Level	Insect characteristics
0	Nothing recognizable
1	Scribble I
2	Scribble II with resemblance to body and appendages.
3	Has resemblance to an organism with legs and or antennae.
4	Has resemblance to a caterpillar (head/body/appendages).
5	Single body, wings representations, often as a single structure with 2 lobes and/or antennae.
6	3 parts of body and/or antennae or wings.
7	6 legs and wings or antennae.
8	3 parts body, 6 legs on thorax, 1 or 2 pairs of wings , antennae.

Inside trees drawings

Research about plants and young children in their early years as well their understanding of the concept o plant and trees is limited(Tunncliffe & Reiss, 2000; Bianchi, 2000; Patrick & Tunncliffe, 2011; Nyberg & Sanders, 2014). Children from the earlies years notice plants in their everyday lives and build a memory bank of knowlwdge gradually acquiring an understanding of adaptation to habitats as depicted in Figure 17 .

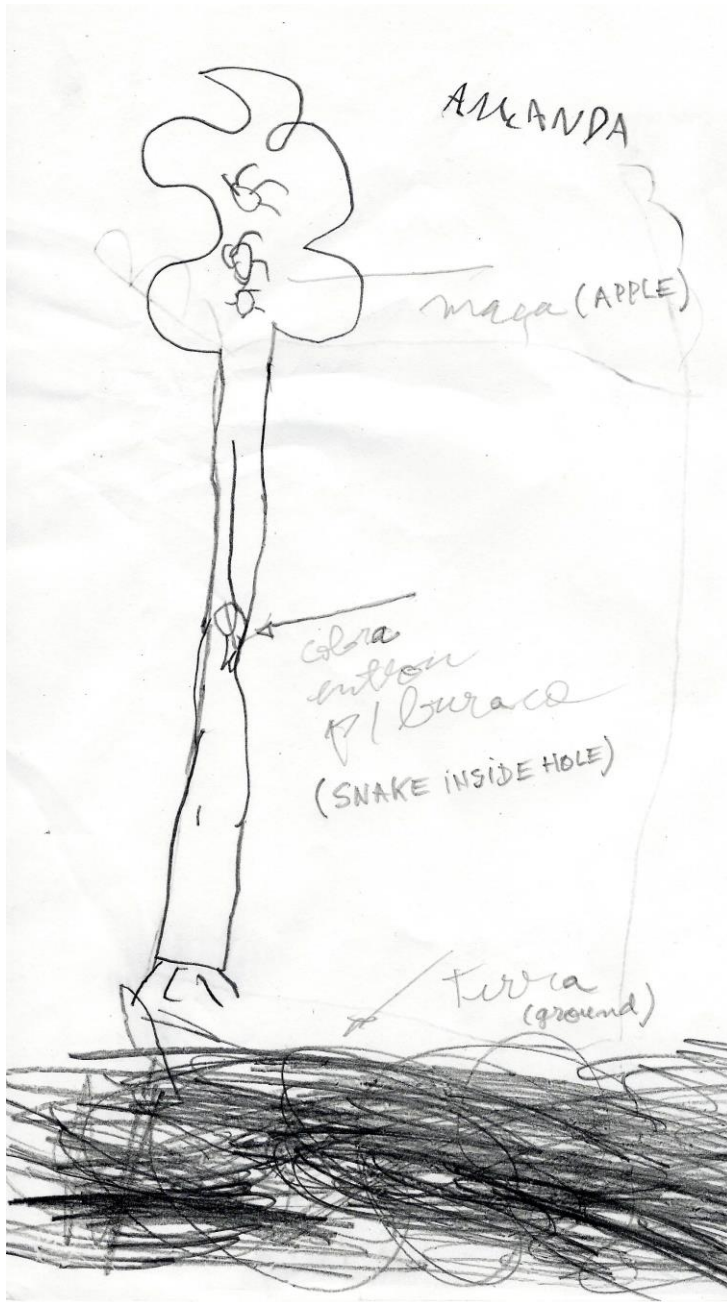


Figure 17. A drawing by a five years old girl depicting what she thinks is inside a tree which scored as level 4 according to grades in Table 3.

It is well establish by previous studies that children have a developed theory about the natural world before they experience any formal teaching in pre-school. Out of school experiences, in particular informal education, are important sources of science literacy for all gender and age groups (Knight, 2009). When children are asked to draw what they think is inside a tree they are familiar with either at the school grounds or park or home

orchard, they seem to transfer the knowlwdge of bones, which are peculiar to vertebrates to trees using themselves as their templates (Carey, 1995; Tunnicliffe, 1999; Bartoszeck & Tunnicliffe, 2013; Tunnicliffe, 1999).

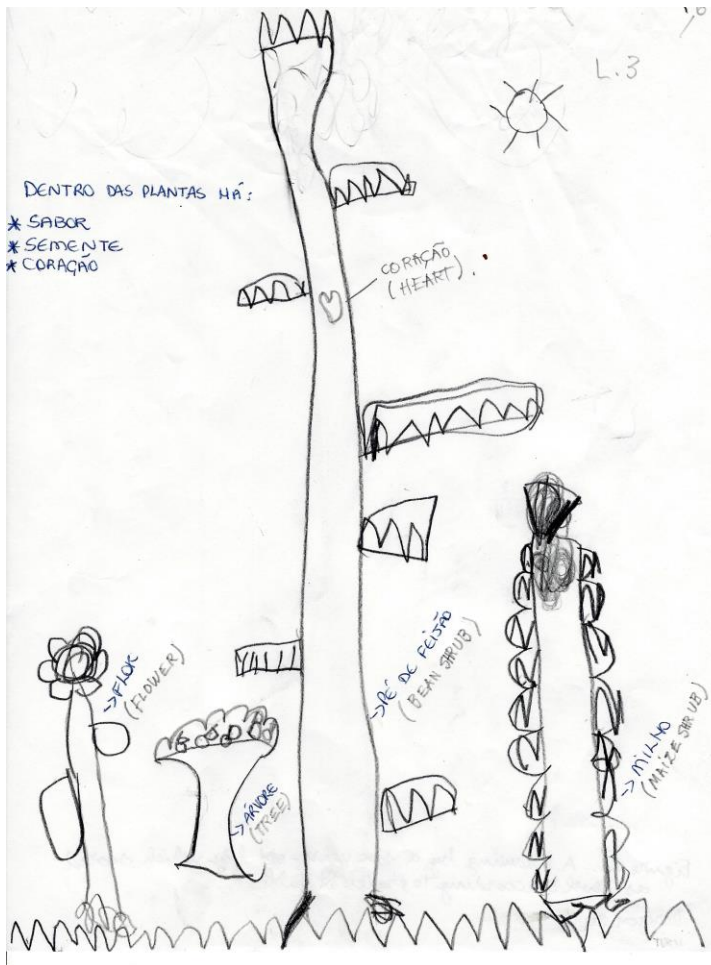


Figure 18. A drawing by a six years old boy representing what he thinks is inside a plant which scored as level 3 according to grades in Table 3.

The key objectives of the research carried out in the towns of Mallet, Rio Claro, Dorizon (rural area) and Curitiba (urban and suburban areas) Brazil, it is to evaluate what children know about the internal organization of trees through drawings and ecological views and habitats associated with trees (Lorenzi & Souza, 2001; Haene & Aparicio, 2007; Lorenzi & Souza, 2001). A rubric scale of levels was compiled based on researchers previous experiences in other biological fields to score drawings collected from children are shown at Table 3.

Table 3. The rubric scale used to allocating a grade to the inside trees drawings.

Level	Source of knowledge
0	Scribble (nothing recognizable).
1	First hand observation remembered (resemblance of a tree).
2	Internal parts of a tree (water tubes, veins, heart, lungs).
3	External parts of a tree (roots, branches, leaves, fruit, bark).
4	Ecological & habitats views associated with trees (birds, ants, butterflies, nest, grass, sun, clouds).

Exemplars of drawings depicting what children thought was inside trees and grades allocated to the pictures are shown in Figure 17, Figure18. Additionally, some children chosen randomly, were interviewed and prompted to explain what they thought is inside a tree depicted in their drawing. For example, during the interview a 4 years old girl, after performing her drawing, said the inside the trunk is timber, the roots make the tree grow and leaves are outside the plant on the branches. A 5 years old boy said that the roots hold the tree on the ground preventing it from falling, the trunk is inside the plant, and that the apple is an inner part of the plant. A 3 years old boy from a Mallet nursery school represented the tree with structural elements and the pine fruit (pinhão in Portuguese) inside a hole in the trunk revealing his precocious natural world observation.

Although the botanical information supplied by pupils in the range of 4 to 6 years old, from this study, was not totally accurate, they provide their conceptions of the environment and trees from their own observations, and additionally the basic anatomical features of trees and that trees may be a shelter for invertebrates and reptiles and water for trees to survive and produce eatable fruit and timber (Anderson et al., 2014). It seems that as children grew older they rearranged the representations of trees and environs, showing a progressive complexity reflecting a better grasp of internal and external parts of trees. Younger children seem to interpret “inside” as within the branches whereas older children interpret inside as actually internal to the outside to the tree, inside the trunk and branches reflecting Symington’s perspective varying from scribbling to realism (Symington et al., 1981).

Discussion

The work commented in this chapter indicates how much knowledge about the natural world children may learn in the everyday. The authors are aware and recognize that collecting drawings plus holding an interview with pupils would certainly clarify, as for example, to what inner animals' structures they are referring to or to the main features of birds, insects and the inside trees. Interviews would be an opportunity to avoid ambiguities in the interpretation of drawings. However, interviews to be fully valuable in eliciting the understanding of the interviewee should have to be carried out soon after the pupil handed their drawing as s/he would still have it fresh in their mind what s/he intended to depict on the sheet.

Capturing the expressed models, i. e. representations of phenomena illustrated on drawings placed in public domain should be a collaborative goal in itself and expand through other educational settings and should be a collaborative endeavour and the subject of cross-cultural investigations worldwide. Probing pupils thinking in biological issues is the starting point for more effective teaching in the classroom. As a consequence Science teachers starting in pre-school would be able to elicit ways to add new knowledge to the existing biological knowledge structure of pupils.

Thus, educators working with early years children eliciting their representations of the natural world could assist pupils to construct further understanding of the living organisms. Therefore, more emphasis should be added in pre-service and in-service teacher training, exploring the use of readily observable organisms such as snails, earthworms, insects, birds, common local plants and trees, particularly in developing observational science learning.

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