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CHILDREN'S CONCEPTIONS ABOUT RESPIRATION BEFORE AND AFTER FORMAL TEACHING: IDENTIFICATION OF LEARNING OBSTACLES

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Abstract

In general, Portuguese primary school teachers impose content knowledge on pupils without having any idea about pupils' alternative conceptions constructed in their daily life. Using drawing technique, we carried out a systematic investigation on primary school pupils' conceptions about air breathing and smoking (tobacco and hashish smoking) either before their first formal learning or after it, in order to identify their alternative conceptions, to monitor the conceptual change and to identify learning obstacles. Results showed no significant differences ($p > 0.05$, χ^2 test) between boys and girls. Significant differences ($p < 0.05$) were found between before and after teaching. Children's drawings before formal teaching showed large variety of alternative conceptions (one or two lungs with no links; one lung with one tube; two lungs with two tubes). One week and one year after formal teaching pupils' drawings were mostly correct and precise (98% and 95%, respectively), but pupils made no links with circulatory system. In all grades, children differentiated the tobacco and hashish smoking effects from the air breathing effects by representing the lungs in dark colour. Teachers should give more emphasis to the interactions between the respiratory and circulatory systems. This study also suggests that teachers may be more efficient in their teaching process if being aware of the patterns of children's alternative conceptions.

Keywords: Primary school; Children's conceptions; Respiratory System, Smoking.

1. Introduction

There is increasing concern in Portuguese society that students are becoming less well prepared in scientific knowledge and skills (CNE, 2012). At each level of the education system, blame is placed upon the previous one for the lack of students' achievement: university lecturers assume that their freshmen have acquired a certain level of knowledge from secondary school (16/17–18/19 years-old); similarly, secondary school teachers expect their students have acquired the upper basic school level of attainment (12/13–15/16 yrs); the upper basic school teachers expect the same from students coming from the lower basic school (9/10–11/12yrs) and the lower basic school teachers expect their pupils have acquired the primary school levels of attainment (6/7–9/10 yrs). Thus, the key question is: what do the primary school teachers expect from their very young pupils before their first formal learning?

In general, Portuguese primary school teachers impose new content knowledge on their pupils without having any idea about their conceptions prior to their first formal learning. Therefore, teachers are usually not aware of pupils' scientifically incorrect conceptions (alternative conceptions, earlier conceptions or misconceptions) that they have constructed in their daily life when trying to make sense of common events and situations (Byrne & Grace, 2010; Byrne, Grace, & Hanley, 2009; Driver, Guesne, & Tiberghien, 1985). These alternative conceptions can turn to be epistemological obstacles (Bachelard, 1938; Carvalho, Silva, Lima, Coquet, & Clément, 2004) and teachers unawareness of their pupils' alternative conceptions can be didactical obstacles (Carvalho et al., 2004; Clément, 2002; Giordan, 1999), both leading to barriers in conceptual change and productive learning. Having this in mind, our research questions are formulated as follows:

- What are the children's alternative conceptions (before their first formal learning) about breathing and smoking?
- What are children's difficulties (if any) in their conceptual change after their first formal learning about breathing and smoking?

Identification of children's conceptions about the content and functioning of their body has been a matter of some investigation in earlier studies (Gellert, 1962; Mintzes, 1984) as well as in more recent ones (Carvalho et al., 2004; Reiss & Tunnicliffe, 2001; Reiss et al., 2002; Teixeira, 2000). However, most of these works addresses general questions about what is in the children's body (Gellert, 1962; Mintzes, 1984; Reiss & Tunnicliffe, 2001; Reiss et al., 2002) or focuses on the digestive system (Carvalho et al., 2004; Teixeira, 2000). These studies on human biology have been using children's drawings, which is a very convenient method since (i) it is an excellent mean of communication that transfer personal representations to the public domain (Buckley, Boulter, & Gilbert, 1997), (ii) it helps children having difficulties in expressing themselves verbally (Rennie & Jarvis, 1995), especially those that are in their earlier school years with low writing skills, (iii) it avoids the constraints pupils may have by giving the 'wrong answer' in text writing (White & Gunstone, 1992), and (iv) it makes children motivated to participate in the research work because they enjoy drawing in science activities (Hayes, Symington, & Martin, 1994).

By applying the drawing technique, in the present study we carried out a systematic investigation on primary school pupils' conceptions about air breathing and smoking (tobacco and hashish smoking), either before having their first formal learning (grades 1 and 2; 5/6 and 6/7 years old, respectively) or after it (grades 3 and 4; 7/8 and 8/9 years old) in order to monitor the conceptual change and to identify learning obstacles.

2. Methodology of Research

2.1- Sample

In the Portuguese school curriculum (ME, 2004), the human systems formal teaching, particularly the respiratory tract, occurs at the first term (September to December) of grade 3 (7/8 years old pupils). Therefore, pupils of grades 1 and 2 (5/6 and 6/7 years old, respectively) have no formal teaching whereas those of grade 3 had the formal teaching one week before data collection and the grade 4 pupils (8/9 years old) had had their teaching the year before.

A minimum of 40 pupils of each of the four grades primary school (of either urban or rural schools) participated in this study. The total sample was composed of 392 pupils, being 191 from schools of the centre of Braga town and 201 from schools of the rural area of the Braga district. The sample is well balanced between subsamples by school type (urban/rural), gender (girls/boys) and grades (grade 1 to grade 4) as shown in Table 1.

Table 1. Primary school pupils' sample characterisation

| | | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Total |
|--------------|--------------|---------|---------|---------|---------|-------|
| Urban | Girls | 23 | 18 | 23 | 30 | 94 |
| | Boys | 17 | 32 | 26 | 22 | 97 |
| | <i>Total</i> | 40 | 50 | 49 | 52 | 191 |
| Rural | Girls | 23 | 23 | 31 | 25 | 102 |
| | Boys | 19 | 25 | 28 | 27 | 99 |
| | <i>Total</i> | 42 | 48 | 59 | 52 | 201 |
| <i>Total</i> | | 82 | 98 | 108 | 104 | 392 |

2.2- Data collection

One A4 sheet of paper with three human body outlines printed on it (for normal breathing and for tobacco and hashish smoking drawings) and six questions was given to every pupil. The six questions were:

For the normal breathing body outline:

- i) *Draw where the breathing air goes in your body.*
- ii) *Look at your drawing and explain where the air goes in your body.*

For the tobacco cigarette smoker body outline:

- iii) *Draw where the tobacco products go in the body of a smoker.*
- iv) *Look at your drawing and explain where the tobacco products go in the smoker's body.*

For the hashish cigarette smoker body outline:

- v) *An addicted hashish cigarette smoker is having hallucinations. Draw where the hashish products go in the body of the hashish smoker.*
- vi) *Look at your drawing and explain where the hashish products go in the hashish smoker's body.*

The drawing technique was applied to all the 392 pupils. Complementary short texts (5 lines maximum) were also asked to grade 3 and grade 4 pupils. Younger children of grades 1 and 2 were helped by the researcher in writing down their short explanations about their drawings. Some individual interviews were carried out with pupils whose drawings were difficult to understand.

2.3- Data collection and data analysis

In a first step, pupils' drawings were analysed carefully in order to identify patterns for the creation of categories (Carvalho et al., 2004). The aim was to systematize the answers of respondents in a format that summarises and organises pupils' conceptions, making them understandable and significant. Categories emerged from the drawings analysis were coded as shown in Results.

Subsequently, pupils' drawings, and corresponding text, were allocated to the appropriate category. Each category frequency for every grade in either type of school (urban and rural) was estimated and data were statistically analysed by using the Qui-square method at the significance of 95%. The Statistical Package for the Social Sciences (SPSS) program was used.

3. Results of Research

3.1- Categories of pupils' conceptions about air breathing and smoking

In this transversal study, data collection was carried out one week after grade 3 formal learning, which for grade 4 corresponded to one year after formal learning and for grades 1 and 2 it was before their formal learning. Therefore, the drawings showed a variety of conceptions about breathing and about tobacco and hashish smoking. After analysing several drawings of all grades it was possible to create four large categories, which examples are shown in Figure 1:

- a) **WB – Whole body:** representation of the air way in trough mouth/nose, circulating freely throughout the body, but ignoring the lungs (Fig. 1a);
- b) **OO – Other organs:** representation of the air going to the stomach, liver, heart or head, but ignoring the lungs (Fig. 1b);
- c) **L – Lungs:** Lungs representation, but not given the complete general structure (Fig. 1c);
- d) **L/WB – Lungs/Whole body:** representation of the lungs and passage of the oxygen to the blood to go through the whole body (Fig 1d).

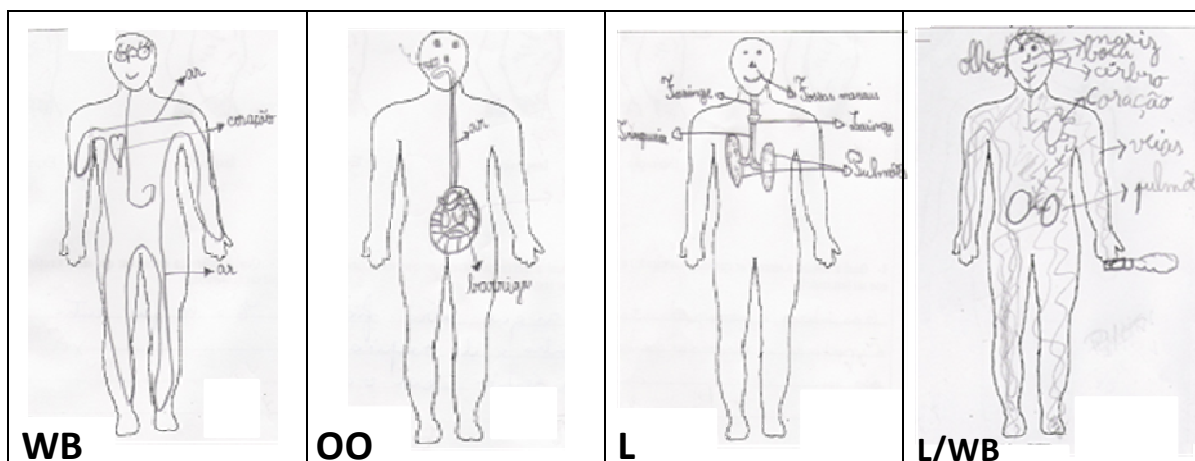



Figure 1. Categories defined by the iconic representation.
WB: Whole body; OO: Other organs; L: Lungs; L/WB: Lungs/Whole body.

For the large categories of *Lungs* and *Lungs/Whole body*, several subcategories were defined as shown in Table 2 and drawings in Figure 2.

Table 2. Subcategories of drawing referring the lungs.

| Organ | Kind of link | Colour | Subcategory |
|----------------|----------------------|-----------|-------------|
| One lung (L1) | With no links | Light | L1 |
| | | Dark* (d) | L1d |
| | Link to 1 tube (t) | Light | L1t1 |
| | | Dark (d) | L1t1d |
| Two lungs (L2) | With no links | Light | L2 |
| | | Dark (d) | L2d |
| | Link to 2 tubes (t2) | Light | L2t2 |
| | | Dark (d) | L2t2d |
| | Link to 1 tube (t1) | Light | L2t1 |
| | | Dark (d) | L2t1d |

* Dark (d) is related to smoking, according to pupils' interviews.

 The only scientifically correct drawings.

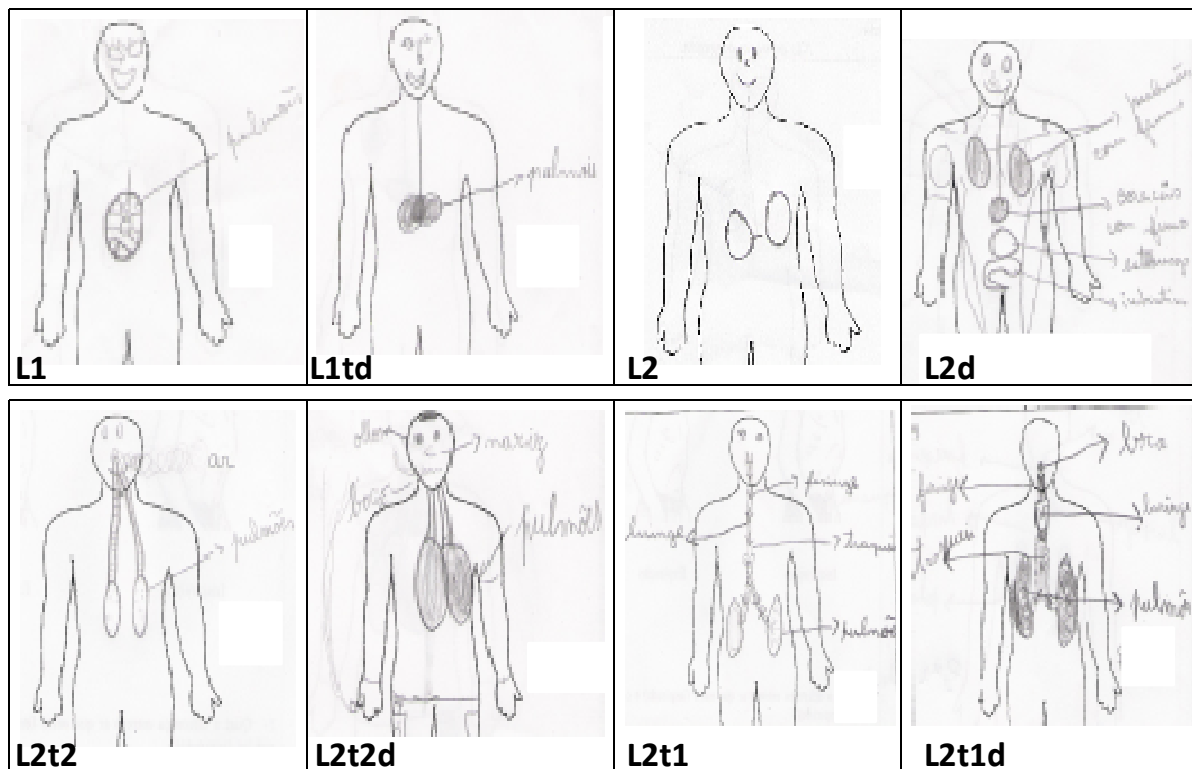


Figure 2: Examples of subcategories from children drawings.

L1: one lung, with no links; **L1td**: one lung, with one tube and dark; **L2**: two lungs with no links;

L2d: two lungs with no links, dark;

L2t2: two lungs with 2 tubes; **L2t2d**: two lungs with 2 tubes and dark; **L2t1**: two lungs with one tube;

L2t1d: two lungs with one tubes and dark.

3.2- Pupils' representations of air breathing and smoking before and after their first formal learning

Applying the above subcategories to drawings, it was possible to characterise each grade pupils' conceptions about the way air breathing (Figure 3a), tobacco smoking (Figure 3b) and hashish smoking (Figure 3c) go into the body, as answering to the three questions:

- (i) "Draw where the breathing air goes in your body";
- (iii) "Draw where the tobacco goes in the body of a smoker";
- (v) "Draw where the hashish products go in the body of the hashish smoker".

Results showed no significant differences ($p > 0.05$, using χ^2 test) between urban and rural schools nor between boys and girls. However, as expected, significant differences were found in each question between grades, especially between grades 1 and 2 together and grades 3 and 4 together ($p < 0.05$) (Figure 3 a, b and c).

Comparing to grades 3 and 4, both grades 1 and 2 pupils expressed a larger variety of subcategories, which are clearly alternative conceptions to the air breathing process, such as one or two lungs with no links (L1 and L2, respectively), one lung with one tube (L1t1) or two lungs with two tubes (L2t2). For example, in air breathing (Figure 3a) 70% of grade 1 urban pupils expressed alternative conceptions: 41% L2, 9% L1t1 and 8% L2T2.

A clear higher proportion of correct 2 lungs and one tube (L2t1) or this plus the indication of the whole body (L2t1/WB) are expressed by grades 3 and 4 pupils (Figure 3). For example, in air breathing (Figure 3a) 98% of grade 3 and 95% grade 4 urban pupils drew the correct respiratory system. In general, these drawings were more precise and were enriched by correct captions identifying the organs as shown on Figure 2 – L2t1 and Figure 2 – L2t2d.

This showed that the majority of pupils (*e.g.* 98% at grade 3 and 94% at grade 4 urban school) made a correct conceptual change. Only a small percentage (*e.g.* 2% in grade 3 and 6 % in grade 4) maintained the original alternative conceptions of 2 lungs with no links (L2) or with two links (L2t2), being one week after teaching only 2% in grade 3 (urban school) and a little higher proportion of 6 % after one year of formal learning, *i.e.* grade 4 (Figure 3).

In addition to the above subcategories, in the case of either tobacco smoking (Figure 3b) or hashish smoking (Figure 3c) also dark (d) indication were present in subcategories L1d, L2d, L1t1d, L2t2d and L2t1d, which did not appear in the air breathing (Figure 3a). It is rather interesting to highlight that the total percentage of L2t1 in air breathing (Figure 3a) was similar to the sum of L2t1 and L2t2d in tobacco or in hashish smoking. For example, for urban grade 3 it was found: 98% L2T1 in air breathing (Figure 3a); 78% L2t1 plus 20% L2t1d in tobacco smoking (Figure 3b); and 63% L2t1 plus 30% L2t1d plus 5% L2t1/WB in hashish smoking (Figure 3c).

No significant differences ($p > 0.05$) could be found between tobacco smoking (Figure 3b) and hashish smoking (Figure 3c) categories proportions.

Besides the questions asking the pupils to draw the air breathing, tobacco and hashish smoking through the body (questions (i), (iii), and (v)), it was also asked them to look at their drawings and explain in few lines text:

- (ii) "Where the air goes in your body",
- (iv) "Where the tobacco products go in the smoker's body"
- (vi) "Where the hashish products go in the hashish smoker's body".

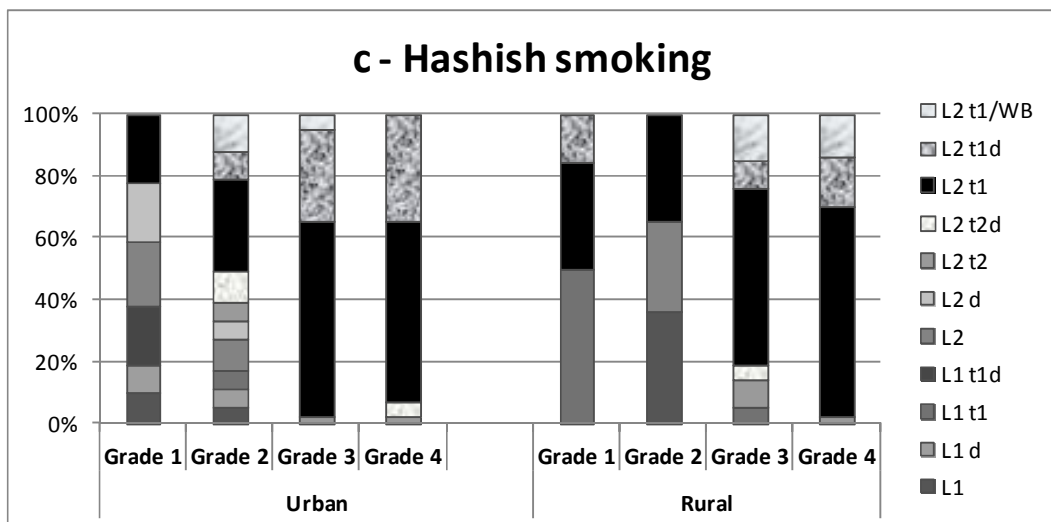
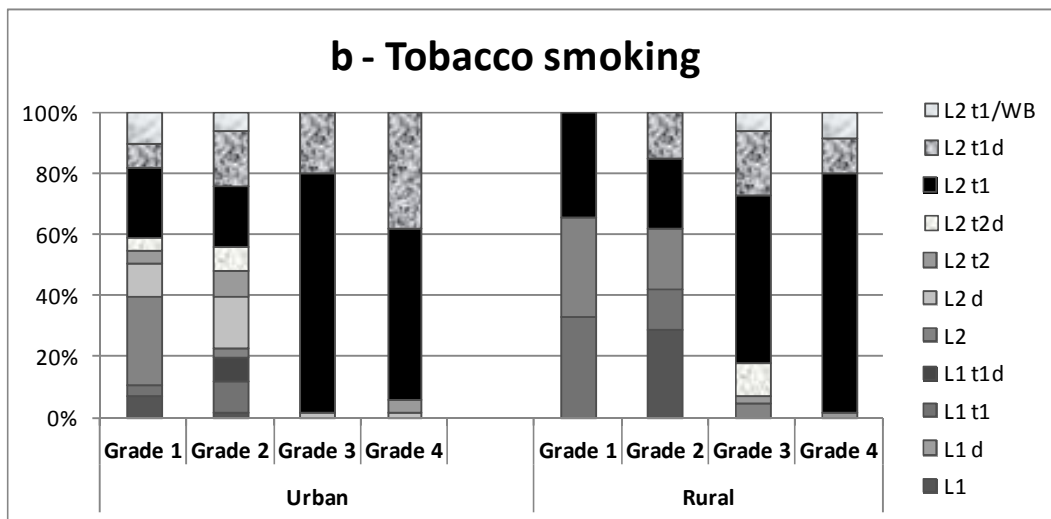
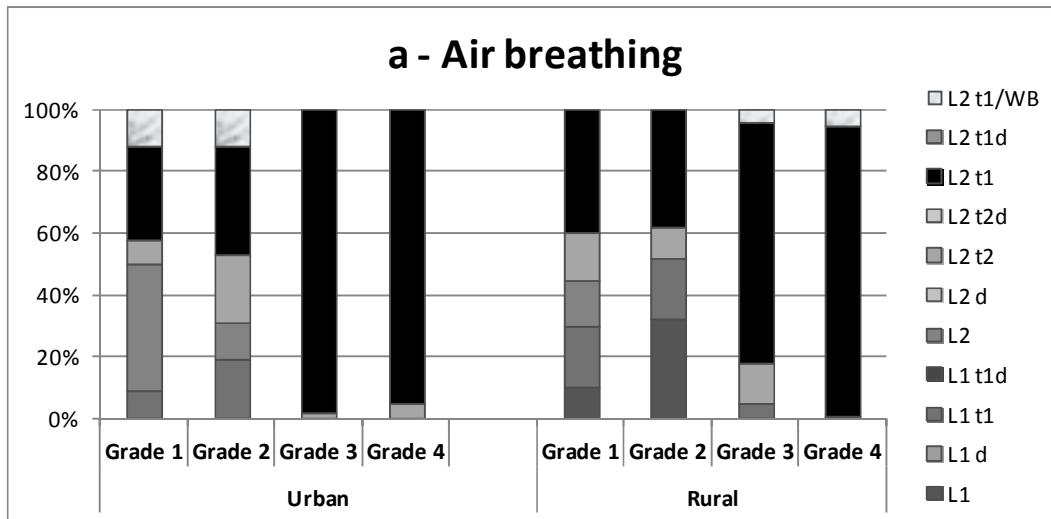


Figure 3: Distribution of the sub-categories related to the iconic representation of the passage of air in the lungs. (See Table 2 for legend coding)

Lungs were the most common organs referred by pupils of all grades, in both urban and rural schools. Some of the grades 1 and 2 pupils said “*the air enter through the nose and spreads through the all body*”, “*the air enter in the mouth and goes to the belly*”, “*the smoke goes through the mouth and neck and then goes out through the mouth*”.

In the case of the hashish smoker, pupils wrote in text other organs, particularly the brain, maybe in association to the question saying “*An addicted hashish cigarette smoker is having hallucinations. Draw where...*” (see 2.Methodology). Like in the text, also the drawings concerning the hashish question (see Figure 3c) showed a considerable high proportion of 15% and 14% in grades 3 and 4 rural school, respectively, as compared to 6% and 8% in tobacco question (Figure 3b) and 4% and 5% in air breathing (Figure 3a).

4. Discussion, Conclusions and perspectives

When children enter in primary school they have already their own conceptions that they constructed from their daily life in trying to make sense of everyday experiences (Byrne & Grace, 2010; Byrne, Grace, & Hanley, 2009; Driver, Squires, Rushworth, & Wood-Robinson, 1994; Newton, Driver, & Osborne, 1999; Shepardson, 2002; Tobin, 1998). This personal learning is built within their families, in the kindergarten, children’s books, TV and other media. However, such children’s earlier conceptions may not coincide to established scientific conceptions, being therefore known as a misconceptions or alternative conception (Driver, 1989; Osborne, Wadsworth, & Black, 1992). A major goal of primary school is to make children learn scientific contents. In the framework of the constructivist view of learning science, children construct their own knowledge by structuring their previous ideas (Bentley, 1998; Selley, 1999). Thus, to have success in science learning, teachers must be aware of their pupils’ previous ideas in order to achieve effective conceptual changes (De Vecchi & Giordan, 2002; Rosalind Driver, 1989; Giordan, 1999; Pozo & Crespo, 1998).

Previous reports have investigated pupils’ conceptions on digestion by analysing their drawings (Carvalho, Silva, & Clément, 2007; Carvalho et al., 2004; De Vecchi & Giordan, 2002; Giordan, 1999), but little has been investigated on air breathing. In addition to the biological process of breathing we also intended to identify pupils’ conceptions about tobacco and hashish smoking as a complementary health perspective.

By drawing, pupils represent schematically what they know and what they feel through analogical situations with the reality. According to several authors (Coquet, 2000; Lowenfeld, 1977; Mèridieu, 1974) pupils at this age (5 to 9 years old) are at the stage of visual realism, which is the phase where they represent the objects by the knowledge they have of them and the manner they conceive them. Moreover, the way they draw cannot be dissociated from their age, which is the “development stage”, period that Piaget called pre-operatory or intuitive thought, where the children have already in their mental schema a representation of the exterior world (Pozo & Crespo, 1998; Sprinthall & Sprinthall, 1993).

The children’s drawings before formal teaching (grades 1 and 2) showed a large variety of alternative conceptions (see Table 1 and Figure 1) expressing one or two lungs with no links; one lung with one tube; or two lungs with two tubes. One week (grade 3) and one year (grade 4) after the formal teaching the pupils’ drawings were mostly correct and precise (98% and 95%, respectively), including captions identifying the organs and a clear short text explaining the drawings. In all grades children were able to differentiate the tobacco and hashish smoking effects from the air breathing effects by representing the lungs in dark colour.

Before teaching, some drawings represented the whole body in a general disperse way (see Figure 1-WB). After teaching there was a greater decrease in this whole body representation, probably because they were focused on the respiratory system, making no connection with the

circulatory system. The passage of air (oxygen) to the blood and of carbon dioxide from blood to the lungs air is not referred at all, although it is a content matter of the primary school programme and is present in grade 3 textbooks, even if in a simple way. Similarly, previous studies have shown children do not make interactions between the digestive and the circulatory systems (Carvalho et al., 2004) and the respective textbooks present these systems in a separate way, contributing for this learning obstacle (Carvalho & Clément, 2007; Carvalho et al., 2007; Carvalho et al., 2004).

In the case of the hashish smoking, there is some higher expression of the whole blood, most probably due to the way the question was asked, referring the smoker was having hallucinations (see 2.Methodology), inducing the idea of hashish products circulating through the body up to the brain.

In short, this study showed that: (i) it was possible to construct a pattern of children's early or alternative conceptions, as exhibited in Table 1 and Figures 1 and 2; (ii) a conceptual change to correct respiratory system was effectively achieved after grade 3 and maintained at year 4; (iii) however, these pupils do not make links between the respiratory and the circulatory system.

The results indicate that teachers should give more emphasis in their teaching practice to the interactions between the respiratory and the circulatory systems. This study further suggests that teachers can be more efficient in their teaching process if being aware of the patterns of children's early or alternative conceptions.

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