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Brazilian Primary and Secondary School Pupils´ Perception of Science and Scientists

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Abstract: The purpose of this study is to understand in an exploratory way pupils´ perception of science and the image of scientists at primary and secondary school levels. Data was collected by means of a survey questionnaire and a drawing representing pupils´ depiction what scientists do during their working hours. A questionnaire anchored on a Likert scale was filled by 204 primary and 229 secondary school children. Pupils from this sample considered science classes enjoyable, helped to understand issues covered by media, that science is a body of knowledge whose goal is to make life more comfortable to people. A total of 433 drawings were collected at 3 urban and 1 rural schools. Drawings illustrated scientists in scientific activity, mainly working alone, wearing lab coat and eyeglasses. Scientific specialization included chemists, biologists and a few technologist and astronomers. Educational implications are discussed.

Keywords: *Scientist image, science, questionnaire, drawings, pupils.*

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Introduction

Life quality both in industrial and in developing countries improved worldwide in the last few years. It is mainly due to advances in science and technology and application of new knowledge to society towards sustainable development and the welfare of the common citizen (Meis and Leta, 1997). However, there is some concern related to worn off of natural resources, environmental pollution, child poverty and cognitive development and the negative results of science and the lack of role models of scientists to be followed by pupils (Piccolo et al., 2016). A better understanding of science education aims in primary and secondary schools may contribute to reduce the human technology conflict faced by pupils (Meis, 2002; Sjoberg, 2000, 2002).

Brazilian education

Brazilian education system comprises pre-kindergarten (nursery), kindergarten, primary school and secondary school before undergraduate courses at university level similar to other countries in South America. Nursery school pupils (aged 2 to 3 years) learn toilet and washing procedures beside language acquisition as learning to point and to name objects, learning of live organisms, natural phenomena such as stones, plants and actions as walking, holding objects (Tunnicliffe, 2013).

Early years education in the kindergarten (aged 4 to 6 years) children learn the rudiments of reading and writing, arithmetics, weights of objects, volume of solids and liquids, heights and periods of time and principles of science curricula such as parts of human body, animals, plants, vegetables, fruit (Bartoszeck et al., 2014, 2015).

The primary school comprises Grade 1, (for children aged 6 to 10) to Grade 9 (for children aged 11 to 14). The curriculum covers basic concepts of Physics (electrical currents, forces,), Chemistry (acids and bases) Biology (vertebrate and invertebrate animals, plants). Grade 1 to grade 4 is taught by primary school teachers (“normalistas”) to pupils 7 to 10 year olds (Lannes, et al., 2002). These teachers attended only a secondary pre-service course (“Escola Normal”, period of 4 years, which is being discontinued) not an undergraduate Education college course (Brasil, 1997).

On the other hand, grade 5 to grade 9 the second part of primary school “Physics and Biological Sciences are covered with more details to pupils aged 11 to 14 year olds. These preparatory courses are followed by secondary school where

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Biology, Physics, Chemistry and Mathematics are taught with plenty of details to student 15 to 17 year olds (Marandino et al., 2005). The secondary school teacher sat for a four years undergraduate course at a College or University (Schwartzman, 2016). Textbooks are extensively used by teachers and provided to students free of charge to public schools by the Brazilian Ministry of Education (Brasil, 2015). The subjects for this study had been in school for a total of 12 years (8th grade) and 15 years (2nd grade of secondary school). Usually pupils start formal schooling at nursery aged 3, followed to entrance to pre-school aged 4 and primary school aged 6. Science community resources include a Natural History Museum, City Planetarium, a Botanical Garden, Anthropological Museum and a Zoological Garden. These public institutions do not charge entrance fees. TV offers large number of programs on science and technology and publications for children " Revista Ciência Hoje para crianças" (science for children) and " Revista Ciência Hoje" (science for primary and secondary schools). " Revista Nova Escola" (New School) which publish science articles and other issues for teachers (Meis et al. 1994; Herculano-Houzel, 2012).

Science as an area of knowledge is strongly linked to the image of the scientist and what he does during his working hours at the laboratory or in the environment (Freire-Maia, 1997; Cross, 1999; Bizzo, 2002; Curi, 2004; Ardigó, 2011). However, a stereotypical image of the scientist developed along the years indicating social and psychological attitudes towards science and technology especially by pupils (Chambers, 1983). The interest of studying school science and the image of the scientist among pupils attending primary and secondary school in Brazil, may be traced back to the pioneering investigation in US (Mead & Metraux, 1957; Meis et al., 1993; Barman, 1996; Kosminsky & Giordan, 2002). On the other hand, there is a decline in the pursuit of science careers internationally (Jarvis, et al., 2003; Dewitt et al., 2012). Previous studies reported school students´ attitudes and perception towards science, images of scientists respectively in UK, Korea, Hong Kong, Turkey, Portugal, Israel, Brazil, Greece, US (Newton & Newton, 1992; Matthews, 1996; Choi & Cho, 2002; Fung, 2002; Buldu, 2006; Ozgelen, 2017; Reis et al., 2006; Konflanz & Scheid, 2011; Samaras, 2012; Price, 2017) Other studies referred to pre-service teachers´ perception of science and scientists in Israel (Rubin et al., 2003; Koren & Bar, 2009). The goal of the present investigation is to study by means of a questionnaire and a drawing, how primary and secondary school pupils perceive science and what scientists do during their workings hours. The sample was collected from public and private schools in Southern Brazil.

Methodology

This study sought to elicit the understanding pupils aged 14 (N=204), 8th grade of primary school and aged 16 (N=229), 2nd grade of secondary school, when representing scientists from drawings made by each pupil in the study. Such knowledge being elicited through the drawings made by the pupils from their mental models of what they think is a scientist. These data were collected during the class period at selected schools (3 urban and 1 rural schools, in Paraná State, Brazil) which agreed to participate in this study. In the first day of the study the pupils drew what they thought is a scientist and in the second they filled a questionnaire (14 statements) about their perception of science and characteristics of scientists.

The main goal of this study was approved by the headmasters and teachers from the four participating schools. All data were collected subject to the full consent of parents.

The research methodology used to carry out this exploratory study was a mix of qualitative and quantitative approach in this survey. This study aims to analyze whether there is a bias among students concerning their views about thescientific work as a whole and what characterizes the performance of scientists in the laboratory and in the field.

Students were asked to draw what they presume a scientist does during his/hers working hours. This methodology was thought to reduce any language constraints from an interview that could afflict the subjects (Cox, 1997). According to previous study three stages are involved in the ability of pupils to produce pictures: scribbling where pictures bear very little resemblance to the person represented; symbolism pictures are used of a symbol of the pupil idea what a scientist is really like; and visual realism when the illustration of the scientist resemble the real person (Symington at al., 1981).

The quantitative approach used 14 questions anchored in a Likert scale (1=totally disagree) to 5=totally agree). The questions range into the following matters: a) how students enjoy science classes, questions 1 to 3; b) perception of students how science classes are useful for their every day lives, questions 4 to 6; c) perception of students towards the practical fulfillment of scientific knowledge, questions 7 to 9; d) scientists as particular persons, questions 10 to 12; positive and negative bias towards science & technology, questions 13 to 14. The questionnaire was adapted from those of Choi & Cho (2002).

The drawings were collected in the classroom during a class period. Students were asked to draw on an A4 sheet of blank paper what they thought is a scientist and given 20 minutes to perform it. Afterwards drawings were analyzed by both authors independently and the following categories emerged: drawings representing a scientific activity or not; a

kind of activity (chemist, biologist, sex of the scientist, scientists working in a group or alone, dressing a white coat (lab coat) with a pair of spectacles, scientific specialization). Evaluation of the images of scientists was adapted from previous investigation (Chambers, 1983).

The analysis of the drawings used the rubric protocol for scoring drawings based on the scientific equipment, reagents and symbols of knowledge, and symbols of space and outdoor exploration displayed on the drawings are shown in Table 6 (Reis et al., 2006).

Participants

A total as 433 subjects participated in this study. Two groups from every school were randomly selected from the 8th grade of primary schools participating in the study (N= 204, aged 14 years, 97 boys and 107 girls) which have had some learning experiences towards sciences. This stage is for many Brazilians citizens the ending point of formal education before entering the working force of the nation. It was also randomly selected two groups (N= 229, aged 16 years, 98 boys 131 girls) from the secondary school (12th grade) equivalent to American high school. At this stage, here is a deeper commitment to hard sciences (STEM) as many students intend to sit for University admission examination similar to the "SAT, US.

Findings

The completed surveys from the participants were combined into a single data set. Table 1 depicts the number of participants (8th grade primary school) and their ratings of each of the 14 questions. Table 2 depicts the number of participants for the 2nd grade secondary school as well their ratings for the questions. The mean score for each question is reported with standard deviation and mean standard error. Reported are the raw scores for each participant across the 14 questions. In this way, it has archival value and can be readily compared in other studies in other regions in Brazil and elsewhere.

A questionnaire was handed to pupils with fourteen questions (QI to QXIV) and answered. The first question asked pupils if they considered science classes enjoyable. Results indicated that 55.86% (8th grade) and 71.64% (2^{nd} grade) pupils agreed or strongly agreed with the statement. The second question asked if pupils wait with enthusiasm for science classes. Results showed that 53.30 % (8^{th} grade) and 50.78% (2^{nd} grade) pupils disagreed or strongly disagreed with the statement. The third question enquired if they thought science classes boring due to any reason. Results indicated that 57.63 % (8^{th} grade) and 65.10% (2^{nd} grade) pupils disagreed or strongly disagreed with the sentence. The fourth question asked pupils if topics studied during science classes helped to have a better understanding on issues covered by media. Results indicated that 77.33% (8^{th} grade) and 80.0% (2^{nd} grade) respectively agreed or strongly agreed with the statement. The fifth question asked if a great deal what pupils learned in the classroom will be useful tor them in the future. Results showed that 80.78% (8^{th} grade and 72.39% (2^{nd} grade) pupils agreed or strongly agreed with the statement. The sixth question stated that most of what pupils learned during science classes was useless for every day life. Results indicated that only 65.02% (8^{th} grade and 72.39% (2^{nd} grade) pupils strongly disagreed or disagreed with the statement. The seventh question stated that science is a universal body of knowledge. Results indicated that 81.77% (8^{th} grade) and 83.85% (2^{nd} grade) pupils respectively agreed or strongly agreed with the statement. The eighth question stated that science foresaw the invention of very useful technology devices. Results indicated that 75.36% (8^{th} grade) and 58.33% (2^{nd} grade) pupils respectively agreed or strongly agreed to the statement. The ninth question proposed that science mission is to produce knowledge to turn this world a better place for people to live in. Results indicated that 93.59% (8^{th} grade) and 92.85% (2^{nd} grade) pupils respectively agreed or strongly agreed with the statement. The tenth question asked pupils how they view the scientific qualities and behavior of scientists. Results indicated that 53.20% (8^{th} grade) and 45.31% (2^{nd} grade) pupils respectively agreed or strongly agreed to the statement. The eleventh question asked pupils how they view the scientists´ personality. Results indicated that 77.83% (8^{th} grade) and 68.75% (2^{nd} grade) pupils respectively disagree or strongly disagree with the statement. The twelfth question inquired pupils´ view if scientists are addicted to lab work and nothing else matters. Results indicated that 62.56% (8^{th} grade) and 68.74% (2^{nd} grade) pupils respectively disagree or strongly disagree with the statement. The thirteenth question stated that they main goal of science is to make life more comfortable to people. Results indicated that 66.50% (8^{th} grade) and 65.59% (2^{nd} grade) pupils respectively agree or strongly agree with the statement. The fourteenth and last question of the questionnaire stated that science and technology are to be blamed for environmental degradation and global war conflicts. Results indicated that 34.97% (8^{th} grade) and 42.18% (2^{nd} grade) pupils respectively agreed or strongly agreed to the statement.

Analyzing the drawings depicting what the scientist does and where during the working hours, it looked like some students are not sure what exactly is a scientist or what he does. Incorrect perception included gardening (although it could be a botanist!), a football player, a teacher, a car´s race pilot, someone in a reading room, a robot illustration

(could be robotics!), a laboratory without a researcher. Alternatively, other drawings depicted graphic representations of what scientists are suppose to do, as for example figures 1, figures 2, and figure 3.

Figure 1. Drawing by a girl aged 14 years old where in the left top box she referred to presumably a psychologist. Other frames clockwise seemed to represent a chemist (level 2), a botanist, and a biologist (level 3) according to the scale rubric in Table 6.

Figure 2. Drawing by a boy aged 17 years old where a scientist was speculating about physics, sexual diseases and environment issues (level 4) according to the scale rubric in Table 6.

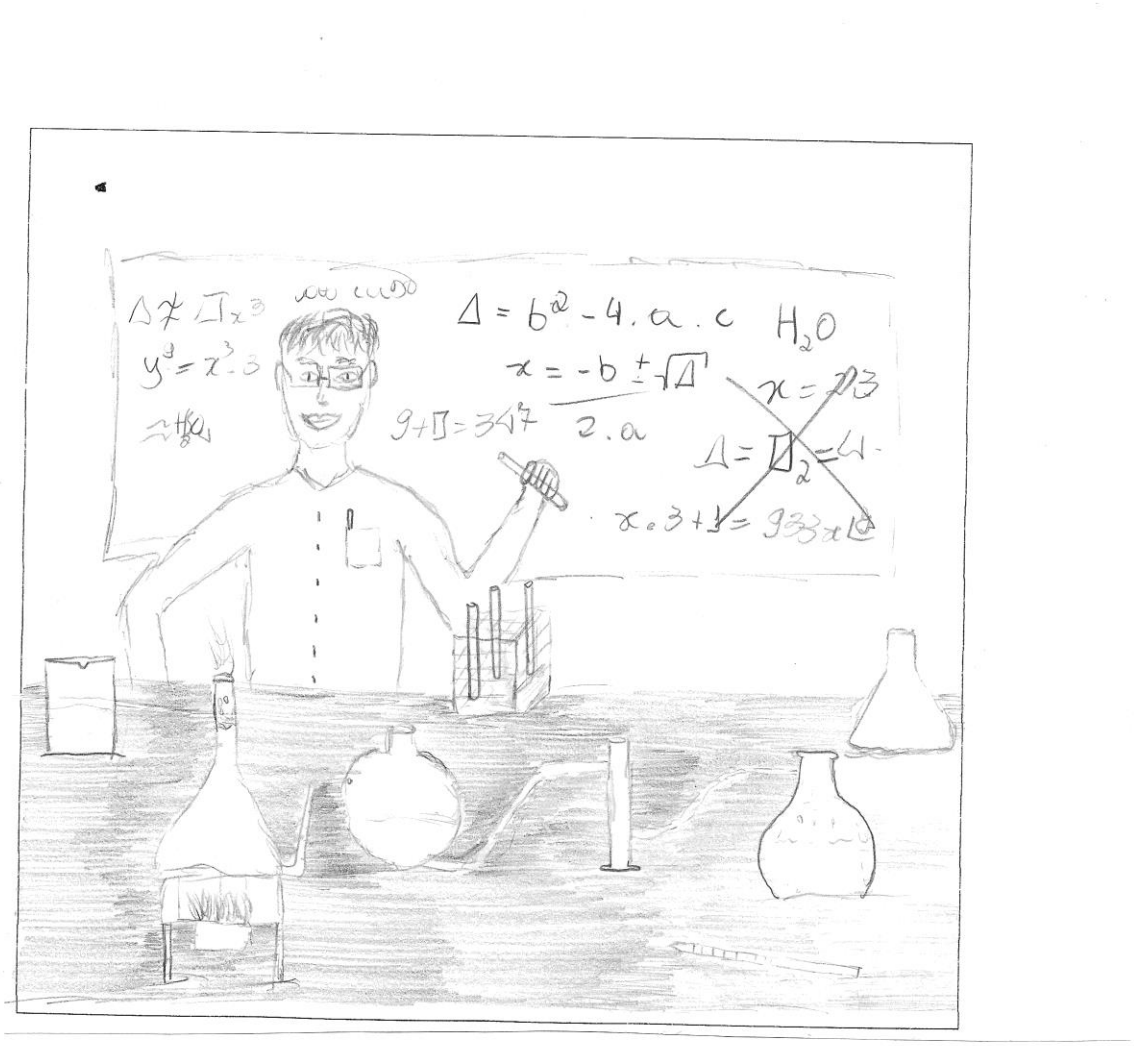

Figure 3. Drawing by a girl aged 13 where a scientist seemed to be a chemist (level 2) according to the scale rubric in Table 6.

Table 3 shows people engaged in "non scientific activities" and in "scientific activities" according to their age range, considering that, Brazilian pupils countrywide are not attending classes in grades according to their ages.

Table 1. Ratings for pupils´ perception (8th grade primary school) of science and scientists.

Item/rating	1	2	3	4	5	M	SD	MSE
1	20	39	35	82	37	3.53	1.17	0.08
2	39	68	39	41	13	2.60	1.17	0.08
3	38	79	41	29	16	2.51	1.20	0.08
4	10	16	20	97	60	3.86	1.07	0.07
5	6	13	20	92	72	4.03	0.98	0.06
6	65	67	21	35	15	2.34	1.26	0.08
7	4	4	29	108	58	4.23	0.73	0.05
8	4	12	34	109	44	3.86	0.89	0.06
9	2	6	5	68	122	4.55	0.69	0.04
10	11	33	51	90	18	3.39	1.00	0.07
11	68	82	42	9	2	2.01	0.93	0.06
12	63	64	57	10	9	2.16	1.03	0.07
13	8	13	47	97	38	3.71	0.97	0.07
14	36	56	40	56	15	2.80	1.20	0.10

Table 2. Ratings for pupils´ perception (2nd grade secondary school) of science and scientists.

Item/rating	1	2	3	4	5	M	SD	MSE
1	3	38	14	97	42	3.71	0.98	0.07
2	12	85	30	53	11	2.75	0.98	0.07
3	32	93	31	34	2	2.36	0.95	0.06
4	8	6	25	88	68	4.03	0.84	0.06
5	4	25	24	80	59	3.94	1.04	0.08
6	67	72	8	31	14	2.18	1.18	0.09
7	2	6	23	90	71	4.15	0.77	0.06
8	11	20	49	74	38	3.63	1.00	0.07
9	1	6	7	71	111	4.51	0.70	0.05
10	12	49	44	72	15	3.13	1.06	0.08
11	56	76	50	9	1	2.05	0.84	0.06
12	46	86	46	10	4	1.95	0.81	0.06
13	4	24	36	76	46	3.78	0.94	0.07
14	23	45	43	66	15	2.75	1.21	0.08

Table 3. Drawings indicating non scientific activities and scientific activities according to age range.

Age range	*Non scientific activity*	*Boys*	*Girls*	*Scientific activity*	*Boys*	*Girls*	*Total*
13 to 14 years old	8th grade	5 (5.5%)	6 (5.45%)	8th grade	96 (45%)	97 (55%)	204
15 to 20 years old	2nd grade	24 (25.8%)	24 (20.43%)	2nd grade	90 (40.43%)	91 (59.56%)	229

Either primary (8th grade) and secondary school (2nd grade) pupils view that scientists work alone in the laboratory or elsewhere and boys (both grades) mostly think they are males and the stereotypical images such as wearing lab coat and spectacles still persists for both sexes as expressed on the drawings collected (Table 4).

Table 4. Male scientist working alone, wearing lab coat, eyeglasses according to drawings by boys and girls of different ages.

Age range	*Works alone*	*Boys*	*Girls*	*Male scientist*	*Lab coat*	*Boys*	*Girls*	*Eye glasses*	*Boys*	*Girls*
13-14 years old	8th grade	40 (41.6 %)	48 (41.0%)	boys=39 (40.6%) girls=34 (29.0%)	8th grade	11 (11.4%)	19 (16.2%)	8th grade	6 (6.2%)	16 (13.6%)
15-20 years old	2nd grade	40 (23.3 %)	148 (62.7%)	boys=103 (60.2%) girls=40 (16.9)	2nd grade	13 (7.6%)	24 (10.1%)	2nd grade	15 (8.7%)	24 (10.1%)

Evaluating the characters depicted on the drawings collected from the 8th grade and 2nd grade pupils, the following image of scientists could be distinguished: a chemist, a biologist, a technologist, an astronomer and other specializations such as a geographer, physicists, a mathematician. The most selected specializations were the chemist and the biologist (fewer) for both sexes (Table 5, Table 6). Previous work in UK identified similar specializations represented on the drawings (Matthews, 2003).

Table 5. Types of scientific specialization represented in the drawings by pupils from this sample.

Age range	*Chemist*	*Biologist*	*Technologist*	*Astronomer*	*Nothing recognizable*
13-14 years old	Boys=58(58.0%) Girls=70(70.0%)	Boys=23(23.0%) Girls=16(16.0%)	Boys=10(10.0%) Girls=5(5.0%)	Boys=7(7%) Girls=9(9.0%)	Boys=2(2.0) Girls=0
15 -20 years old	Boys=72(72.7%) Girls=86(64.6%)	Boys=15(15.1%) Girls=17(12.7%)	Boys=9(9.0%) Girls=5(3.7%)	Boys=3(3.0%) Girls=6(4.5%)	Boys=0 Girls=19(14.2%)

Table 6. Types of scientific specialization according to display of scientific equipment and symbols of knowledge.

Level	**Specialization and symbols of scientific knowledge**
Level 1	Nothing recognizable.
Level 2	Chemist, test tubes, beakers, burners.
Level 3	Biologist, laboratory animals, plants, dyes, microscopes.
Level 4	Technologist, robots, computers, oscilloscopes.
Level 5	Astronomer, telescopes.

Discussion

The present study aimed to explore in a preliminary way, pupils´ perceptions of science and image of scientists by means of a questionnaire and a drawing representing what a scientist does during his/hers working hours. The total sample was 433 pupils with an age range mainly of pupils´ aged 13 to 17 and a few aged 20. The group gender which answered the questionnaire and provided the drawings was composed of 195 boys and 238 girls. Considering the pupils affinity to science classes those of the 2nd grade, secondary school (71.64 %) enjoyed more than those of the 8th grade, primary school (55.86%). Thus, age has got an influence in this perception as found earlier (Konflanz & Scheid, 2011). However, neither grades (8th =53.30%) or (2nd =50.78%) showed great enthusiasm for the next week science classes, although considering that those classes are not boring (8th grade 57.63%; 2nd grade 65.10%). Therefore, the written questionnaire provided evidence that science classes are an activity pupils could happily engage in. Generally speaking pupils in this study had a positive attitude towards the usefulness of the contents of science classes for a better understanding of the coverage done by media. This fact might influence their daily lives and future career jobs as observed elsewhere (Okebukola & Jegede, 1990; Mordi, 1991; Cokadar & Kulce, 2008). Results indicated there is an almost full recognition on the quality of science and technology for the welfare of the world population once the scientific method is followed in the investigations and invention of new products (Alvarenga et al., 2005, Clegg & Beck et al., 2017). The two groups of pupils (8th and 2nd grades) expressed a mixed opinion related to how intelligent and open-minded scientists are compared to the whole population. Pupils did not see scientists as anti-social, selfish or boring as many enjoy sports and arts as previous study indicated (Bodzin & Gehringer, 2001). The above are good arguments in favour of following a scientific career, although teaching both undergraduate courses and carry out

research, scientists are badly paid in Brazil (Oliveira, 2004; Siqueira, 2005). In the last two questions, although pupils trusted the advances of science for the common good, they also blamed science and technology for environment degradation and improper uses in war conflicts (Soares, 1995; Tolentino et al., 1995; Razera, 2011). Science in Brazil began in the nineteenth century starting with mathematics, astronomy, physics, geology, paleontology, mineralogy and petrography and only later on with chemistry, zoology, and botany. This trend was still reflected in the answers to the questionnaire and kind of drawings illustration collected (Azevedo, 1955).

Drawings are representations or a piece of information how a person identifies herself/himself with science and perhaps reflected in this study what pupils thought is a scientist (Figures 1 to 3). Pupils both genders illustrated on their drawings that scientists most of the time are in scientific activities at the laboratory (Table 3). Scientists usually worked alone reproducing the expected stereotype (Table 4). Either boys or girls (8^{th} grade and 2^{nd} grade) drew mainly illustrations which looked like chemists and a few biologists (Table 5). Scientists were depicted mainly as males, wore lab coat, with a pair of spectacles and the benches and counters are full of glassware (pipets, jars, test tubes), suggesting that most were chemists or biochemists possibly imaging of an alchemist as pointed out previously (Meis, de et al., 1993). One of the limitations of the study was that due to school procedures, no interview was carried out where pupils could explain the meaning of their drawings. However, pupils and adults construct science knowledge in the context of social interaction and local culture. It was suggested that as pupils start school with different perceptions what is and what does a scientist, a rubric exploring attributes of "sensationalized/traditional/broader than traditional" could improve the value attributed to pupils´ scores described in Table 1 and Table 2 (Farland-Smith, 2017).

Educational implications

Many parents still nowadays have a rudimentary knowledge of science and scientific research and thus are not able to advise their children. Teachers during their undergraduate courses (pre-service, in service) seldom have opportunities to reflect on the nature of science and therefore and do not value the importance of science in classroom classes. The following strategies may be useful:

- Invite guests as speakers to talk about science that can be taken as role models in science;
- Make arrangements for fieldtrips with industrial partners;
- Plan more investigations and laboratory experiences during school semester;
- Encourage females and minorities towards careers in science;
- Plan guided tours to natural history museums, botanical garden and science centers;
- Plan guided tours to Biological Institutes at Universities or Colleges visiting selected departments where research is being carried out.

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