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How Peruvian Secondary Students View Scientists and their Works: Ready, Set, and Draw!

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Abstract

The investigation of students' images of scientists and their work is of interest to researchers due to the widely held belief that the students' perceptions are important preliminary indications for the future academic and professional choices. This study explored the images of 218 Peruvian high school students about scientists and their work (convenience sampling). Specifically, 'Draw–A–Scientist Test' (DAST) was administered, while the analysis framework included an enriched version of 'Draw–A– Scientist Test–Checklist' (DAST–C). Several descriptive and inferential analyses were performed in order to address the research questions. The results showed that Peruvian students hold common images of the scientists. The majority of the students depicted scientists as men, working indoors, wearing lab coats, surrounded by research symbols and involved in chemistry. In addition, the results showed, to a significant degree, that girls more frequently draw symbols of knowledge than boys. On the other hand, boys drew, on average, more stereotypical images than girls regarding the alternative stereotypical image subscale for scientists. No statistically significant gender differences were found in the remaining indicators and scales. Finally, it is noteworthy that Peruvian students' drawings included, on average, less stereotypical indicators than students of similar age from South Korea, Turkey, the United States of America, India, Greece, Bolivia, and Colombia.

Introduction

Today, science and technology are present in almost every aspect of modern life and, as a result, it is considered essential to be able to understand and use scientific and technologic information (Karisan & Zeidler, 2017; National Academies of Sciences, Engineering, and Medicine, 2017). Recently, several institutions including the European Parliament (see Siarova, Sternadel, & Szőnyi, 2019), UNESCO (see UNESCO, 2016) and Los Organismos Nacionales de Ciencia y Tecnología (see Fernández Polcuch, Bello, & Massarani, 2016) set as main goals the promotion of scientific literacy and the development of scientific culture of citizens, in order to avoid disinformation and reject theories that can be harmful to themselves and the environment (Metin & Ertepinar, 2016; Sen & Yesilyurt, 2014).

Pupils' perceptions of science, scientists and scientific work are considered crucial for the development of scientific literacy (Akerson, Pongsanon, Park Rogers, Carter, & Galindo, 2017; Allchin, 2014; Lederman, Abd–El–Khalick, Bell, & Schwartz, 2002; Lederman, Lederman, & Antink, 2013) and have been systematically investigated by researchers (see Eurobarometer, European Social Survey, Pew Research Center's Survey, World Values Survey) (Siarova, Sternadel, & Szőnyi, 2019). In addition, researchers have also focused on students' images of scientists and their work in the context of whether the existence of stereotypical images may affect their attitudes towards scientists and science (Emvalotis & Koutsianou, 2018). The concept of images is used in psychology to describe the internal cognitive representations of a revived earlier sensory experience recalled from memory without external simulation (Bhatia, 2009). The term "stereotypical images" includes the set of cognitive generalisations about the characteristics and qualities of the members of a group (VandenBos, 2015). Stereotypes are easily spread because they allow people to quickly explain the world around them (Blagdanic, Kadijevic, & Kovacevic, 2019). Stereotypes fill the gap when a person does not have enough information, that is, add to the missing information and build a sense of certainty and clarification. As a result, stereotypes influence the behavior and perception of a person (Müller & Rothermund, 2012).

In order to investigate students' images of scientists and their work, researchers have used the 'Draw–A–Scientist Test' (DAST) instrument (Chambers, 1983); a test that captures students' images of scientists by asking them to draw a scientist during his/her working time on a blank sheet. The results of international studies using DAST are common: students hold common images for scientists, regardless of students' origin. In particular, scientists are usually designed by students as middle–aged men, with facial hair, using test tubes, wearing laboratory coats and carrying out dangerous experiments (Christidou, Hatzinikita, & Samaras, 2012; Emvalotis & Koutsianou, 2018; Koren & Bar, 2009; Mead & Metraux, 1957; Newton & Newton, 1998). Researchers are also interested in investigating the possible relationship between students' gender and their images of scientists (Medina–Jerez, Middleton, & Orihuela–Rabaza, 2011). It is believed that if these images reflect self-images, they can provide us with evidence about the possibility of pursuing a scientific career in the future (Laubach, Crofford, & Marek, 2012). While many countries from Europe, as well as the United States of America, Latin America, Australia and Canada have been involved in research on the aforementioned subject, Peru have not (Medina–Jerez, Middleton, & Orihuela–Rabaza, 2011).

Theoretical Framework

One of the reasons why there is a continuing research interest in students' images of scientists is because these images are closely related to students' future educational and professional career choices (Farland–Smith, 2019; National Science Board, 2016). The results from worldwide research show that there is a lack of students who choose to be educated or work in the field of sciences, and this shortage is partly related to the stereotypes students have developed at younger ages for scientists and their work (Shin et al., 2015). An additional reason supporting the aforementioned intense research activity lies in the fact that these perceptions are related to students' willingness (when they become adults) to support the policies and actions adopted and communicated by scientists. At the same time, these perceptions also seem to determine students' level of understanding of "who is a scientist" and "how a scientist works" (Tintori, 2017).In this context, for more than fifty years, students' images of scientists have been collected with a variety of research instruments and techniques such as questionnaires (Kind, Jones, & Barmby, 2007; Krajkovich & Smith, 1982; Pell & Jarvis, 2001; Reis & Galvao, 2004; Sala de Gomezgil, 1975; Silver & Rushton, 2008), drawings (Chambers, 1983; El Takach & Yacoubian, 2020; Finson, Beaver, & Cramond, 1995; Tan, Jocz, & Zhai, 2017; Yang & Zhou, 2017), illustrations (Boylan, Hill, Wallace, & Wheeler, 1992), and interviews (Buck, Leslie–Pelecky, & Kirby, 2002; Erten, Kiray, & Sen–Gumus, 2013; Samaras, Bonoti, & Christidou, 2012; Schibeci & Sorensen, 1983).

Of the above research instruments and techniques, the written questionnaire presented in Mead & Metraux's (1957) study was innovative for its time and influenced subsequent literature. In the previously mentioned study, thirty–five thousand American high school students were asked to fill in open–ended questions related to scientists ("When I think about a scientist, I think of …," "If I were going to be a scientist, I should like to be a scientist who…"). The results of their research revealed that students described, either positively or negatively, scientists in a common way, stereotyping them for example as shrewd and intelligent persons, but also antisocial and lonely. Despite the enlightening results of this study, the demanding data analysis and the difficulties faced by young students in completing the questions were the main reasons why the use of that instrument was severely restricted (Finson et al., 1995; Özgelen, 2017; Schibeci & Sorensen 1983).

The above limitations of Mead & Metraux's (1957) written questionnaire were resolved through the introduction of Chambers (1983) drawing technique called DAST several years later. In order to capture students' images of scientists, Chambers (1983) administered DAST to students over a period of eleven years, and coded their drawings on the basis of seven indicators (lab coat; eyeglasses; facial hair; symbols of research and knowledge; technology; relevant captions) that appeared to indicate the standard scientist's image. During this test, participants were asked to draw a scientist during his/her work on a blank sheet. The benefits of such a test were many: (a) it offered the ability to capture students' images, regardless of age, (b) it had low time requirements for completion, (c) it was not restrictive in speaking language, and (d) it was easily and pleasantly administered (Chambers, 1983; Losh, Wilke, & Pop, 2008; Schibecci & Sorensen, 1983).

A few years later the aforementioned DAST analysis framework was enriched by Finson and colleagues (1995) with eight additional indicators (male gender; Caucasian indications of danger; presence of light bulbs; mythical stereotypes; indications of secrecy; scientist doing work indoors; and middle–aged or elderly scientist) and this new version of analysis was called the 'Draw–A–Scientist Test–Checklist' (DAST–C). It was an objective and quantitative method to code and evaluate the degree of stereotypes by analyzing students' drawings and filling in that checklist. To date, DAST and DAST–C have been used as the research instruments of many studies worldwide (Akçay, 2011; Emvalotis & Koutsianou, 2018; Miller, Nolla, Eagly, & Uttal, 2018; Steinke, et al., 2007; Tan et al., 2017). The results of these surveys show that students hold stereotypical images of scientists with differences in the frequency of each indicator by country of origin (Finson, 2002; Koren & Bar, 2009; Türkmen, 2008).

The scientist is mainly portrayed as a middle–aged, bald man who works in a laboratory equipped with test tubes, has little or no interest in non–scientific subjects, works isolated and specialises in the natural rather than the social sciences (Kaya, Doğan, & Öcal, 2008; Koren & Bar, 2009; Miller et al., 2018; Minogue, 2010; Newton & Newton, 1998; Sjøberg, 2000). Researchers are also investigating the possible relationship between students' gender and ethnicity and their images of scientists. Concerning gender, research results show that there are no statistically significant gender differences in DAST–C subscales and in DAST–C total scores (Laubach, Crofford, & Marek, 2012; Middleton & Orihuela– Rabaza, 2011). Nonetheless, there are surveys that capture a trend of girls to draw less alternative and traditional stereotypical images of scientists than boys (Laubach et al., 2012), while other studies show that boys tend to draw, on average, more stereotypical images than girls (DAST–C lower subscale; DAST–C total score) (Emvalotis & Koutsianou, 2018). Concerning students' ethnicity, differences have been identified in students' drawings regarding the frequency of each indicator (Laubach et al., 2012; Narayan, Park, Peker, & Suh, 2013; Türkmen 2008).

Significant research is also carried out on the gender differences in the DAST–C "male scientist" indicator, with the general consensus being that male scientists are most frequently depicted in student drawings of both sexes, while the small number of drawings in which female scientists are depicted mainly come from girls (Cheryan, Plaut, Handron, & Hudson, 2013; Fung, 2002; Thomson, Zakaria, & Radut–Taciu, 2019; She, 1998). However, recent research reveals a growing trend, especially among girls (but also boys), of depiction of women scientists (Farland–Smith, 2009, 2019; Ruiz–Mallén & Escalas, 2012). Recently, the meta–analysis published by Miller and his colleagues (2018) also reported that students, regardless of their gender, are now drawing male scientists less frequently than in the past.

Specifically, in Peru as in many developing countries science education is a major concern (Cueto, 2005). Although education plays a key role in policy-making, the Peruvian curriculum does not meet the contemporary needs of the state (Alvarado, 2010). Regarding science education it is shown that students from Peru perform below students from most other countries on international standardised tests in science (Ministerio de Educación del Perú, 2019). The low scores of Peruvian students and the poor quality of education in science in Peru are troubling in view of the growing demand for a more scientifically literate workforce and country's strong economic growth (Näslund-Hadley, Thompson, & Norsworthy, 2010). An extra problem added to the existing problematic situation is the lack of Peruvian students pursuing a scientific career. In a recent study, it was published that Peruvian students are facing a number of barriers that prevent them from following a career in science: they have scarce "scientific culture"; they are misinformed of what a science career is; they have teachers who are not informed about the variety of science professional careers and work opportunities (CONCYTEC, 2015).

As it was mentioned earlier, this lack of students is partly related to the images for scientists and their work that students have developed at younger ages (Shin et al., 2015). Researchers believe that these images are partly affected by the science school textbooks contents (Türkmen, 2008). Recently UNICEF (2008) has investigated the stereotypes that emerge in Peruvian elementary and high school science textbooks. In the aforementioned report it was shown that science textbooks reproduce ethnic, geographic, social and gender stereotypes. For instance, the indigenous people are associated with dirt, poverty, sadness, physical ugliness, restricted access to science and barbarism. Stereotypes of character and personality according to the origin were also presented (the people from the coast are happy and fun; the serranos are sad and melancholic). Finally, social and appearance stereotypes were demonstrated. In respect to scientists they were mainly depicted as being white (Caucasian), middle-aged and wearing eyeglasses.

In this context, Avolio Alleci et al. (2018) have investigated the perceptions of Peruvian female high school students about science and scientists. In their study it was shown that female students have difficulties in defining what science is. Furthermore, a number of common images about science and women involved in science were highlighted: (a) science tends to be a masculine activity (b) science is a reclusive and demanding work (c) women in science are emotionally cold, serious, less interested in having a family and with little social life (d) men are better with "numbers" and in engineering. Supporting these results, The National Council of Science, Technology and Technological Innovation report (CONCYTEC, 2016) highlighted that the percentage of professional women dedicated to science, technology and innovation in Peru reaches 34% of the total number of professionals registered in the National Directory of Researchers and Innovators (DYNE). As it was reflected in this research male predominance was evident in scientific areas and this probably indicates the traditional role assigned to Peruvian women, which is that of primary caregiver and responsible for household tasks (Pautrat, 2015).

Despite the intense research activity on images of students for more than half a century, it is noteworthy that Latin American countries have not followed the above trend and few studies have investigated images of scientists of Latin American male and female students (Aguilar, Rosas, Rosas, & Romo–Vázquez, 2016). In the few exceptions (Medina–Jerez et al., 2011; Sala de Gómezgil, 1975; Valderrama, Vernal–Vilicic, & Méndez–Caro, 2016), Peru is not included. The authors of the present study systematically searched for studies that investigated male and female Peruvian students' images of scientists in various databases (ERIC, Web of Science, Google Scholar, JSTOR, ProQuest Dissertations & Theses Global, ScienceDirect, Scopus) using a variety of keywords (Peru, Peruvian, images / ideas / perceptions about scientists, Draw–A–Scientist Test). Our search returned very few results (only one study was found see Avolio Alecci et al., 2018).

In view of the above, it is considered extremely important to investigate the images of Peruvian students about scientists as they have not been studied in the past. The results of our study will be used to shed light on the field of scientific education in Peru and will enrich the current scholarship by adding students' perception of scientist in Latin American context. In particular, our results will allow those in charge of Peruvian science education to know how students perceive scientists and what needs to be done to provide them with images that will make scientific work an attractive field of study.

Research Aim and Questions

The present study attempted to investigate the Peruvian high school students' images of scientists and their work. Specifically, DAST was administered to high school Peruvian students, while the analysis framework included a modified version of DAST–C and additional categories based on previous studies (i.e. Chambers, 1983; Christidou et al., 2012; Emvalotis & Koutsianou, 2018; Finson et al., 1995; Fung, 2002; Lee & Kwon, 2018; Schummer & Spector, 2007). The research questions that were attempted to be answered through this study were:

(1) What are the images of Peruvian high school students about scientists and their work?

(2) Do these images differ significantly according to students' gender?

Method

Participants

The participants in the present study were 218 twelve years old students (102 boys and 116 girls) from three Peruvian high schools. Thirty–two of them were enrolled in a public high school located in Chumbivilcas which is a rural area (12 boys and 20 girls), 78 in a private high school located in Lima which is an urban area (33 boys and 45 girls) and 108 in a public school located in Cusco which is an urban–tourist area (57 boys and 51 girls). Convenience sampling strategy was adopted since the aim of the study was to answer the research questions rather than generalise the results. After the consent of the school directors, the students who wished to participate in the study were selected. All students attending the first grade of the selected high schools had the right to participate in the research, without discrimination on the basis of religion, academic performance or other independent variables that were not in the aim of the study.

Instrument

Students' images of scientists and their work were evaluated using the DAST. During this test, participants were asked to draw a scientist during his/her work on a blank sheet. Specifically, participants were asked to answer the following question "Dibuja un cientifico hacienda su trabajo" which means *"Draw a scientist while he is working".* The drawings of students were coded using the DAST–C, which includes the seven DAST indicators and eight additional indicators (Finson et al., 1995) as mentioned above. The administration of DAST–C allowed the extraction of three total scores for each student drawing (Finson, 2003): (a) the score of the first seven indicators, reflecting traditional stereotypical images of scientists (ranging from 0 to 7), (b) the score of the last eight indicators, which reflects the alternative stereotypical images of scientists (ranging from 0 to 7), and (c) the total score from all fifteen DAST–C indicators (ranging from 0 to 15). The DAST–C inter–rater reliability in the Finson and colleagues (1995) study, was found to be between .94 and .98.

Data analysis

The present study's framework for analysis of students' drawings (see Figure 1) was based on the synthesis of analysis frameworks of previous studies (Chambers, 1983; Christidou et al., 2012; Finson et al., 1995; Fung, 2002; Lee & Kwon, 2018; Schummer & Spector, 2007). Specifically, the DAST–C (Finson et al., 1995) was used as the basic analysis framework. However, in line with the studies of Emvalotis and Koutsianou (2018), Meyer, Guenther, and Joubert (2019) and Steinke with colleagues (2007) the "Caucasian" indicator was excluded, as the students' drawings did not provide sufficient information on the scientist's ethnicity.

In the present study "research symbols" and "technology products" indicators were defined as follows. In line with Lee and Kwon's (2018) study, the presence of the "research symbols" indicator in students' drawings depended on whether one or more of the following science–related experimental tools (alcohol lamp, dropper, microscope) or making–related experimental tools (driver, saw, scissors) were expressed in their sheet. The "technology" indicator incorporated images symbolizing home appliances (such as the telephone and television), computers, robots, rockets, telescopes, and all sorts of fantastic products, such as Fung's (2002) study.

The aforementioned DAST–C analysis framework was enriched with three additional categories of analysis, (a) the scientist's gender (Fung, 2002), (b) the scientist's workplace and (c) the scientist's field of specialisation (Christidou et al., 2012) (see Figure 1). Specifically, in order to identify the field of specialisation of the scientist, specific emblematic objects of scientific disciplines were sought, based on Schummer and Spector's (2007) categorisation. In particular, (a) test tubes, flasks, beakers indicated the scientific field of chemistry, (b) microscopes, biomedical sciences, (c) telescopes, astronomy, (d) rockets and spaceships, space science, (e) magnifying lenses, earth science – geography, (f) algebraic formulas and pair of compasses, mathematics.

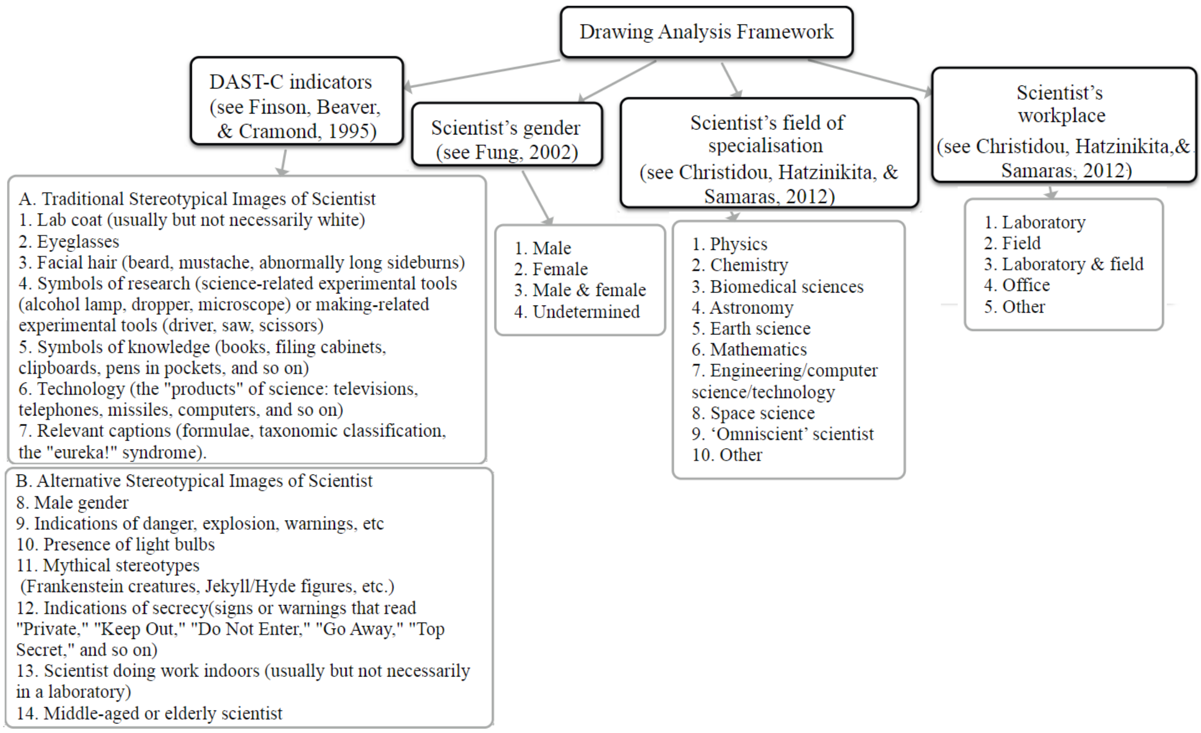

Figure 1. Analysis Framework of Students' Drawings

With regard to the field of physics, it is claimed that there are not any relevant emblematic objects (Schummer & Spector, 2007). As a result, images of unspecified experimental settings or drawings that containing captions that provided information about the field of physics (for example Stephen Hawking, Albert Einstein etc.) were considered to indicate the field of physics. As far as the analysis procedure is concerned, the two authors worked together as coders for a small number of drawings in order to become more familiar with the analysis framework. Then, the rest of the drawings were coded separately by the first author through *NVivo v.12* software and checked by the second. The inter–rater reliability was considered to be acceptable if the agreed ratio exceeded .90 (Chaturvedi & Shweta, 2015). The inter– rater reliability estimate was computed to be .90. When an indicator was present in a drawing, code 1 was assigned, while when the indicator was absent, code 0 was assigned. The existence of an indicator was counted once per drawing, although it may have been present two, three or more times. For example, if six test tubes were depicted in the drawing of student, were counted as only one symbol of research.

Then, three new variables were calculated, as suggested by Finson (2003): (a) the traditional stereotypical image subscale for scientists (high stereotyping subscale), which was calculated from the sum of the first seven DAST–C indicators and ranged from 0 to 7, (b) the alternative stereotypical image subscale for scientists (low stereotyping subscale), which was calculated from the sum of the remaining seven DAST–C indicators with values ranging from 0 to 7, and (c) the DAST–C total score, which was calculated from the sum of the 14 DAST–C indicators with values ranging from 0 to 14. The results from *NVivo v.12* (see Figure 2) were exported to *SPSS v.25* to quantitatively answer the research questions through descriptive and inferential statistics. More specifically, non–parametric tests were performed, since the data did not follow the normal distribution. In more detail, the non–parametric Mann Whitney U (Daren & Mallery, 2019) criterion was selected to identify potential gender differences in the DAST–C subscales and DAST–C total score. Also, a series of tests were conducted through the non–parametric criterion chi square (χ^2) (Ho, 2017), to examine potential gender differences for each DAST–C indicator.

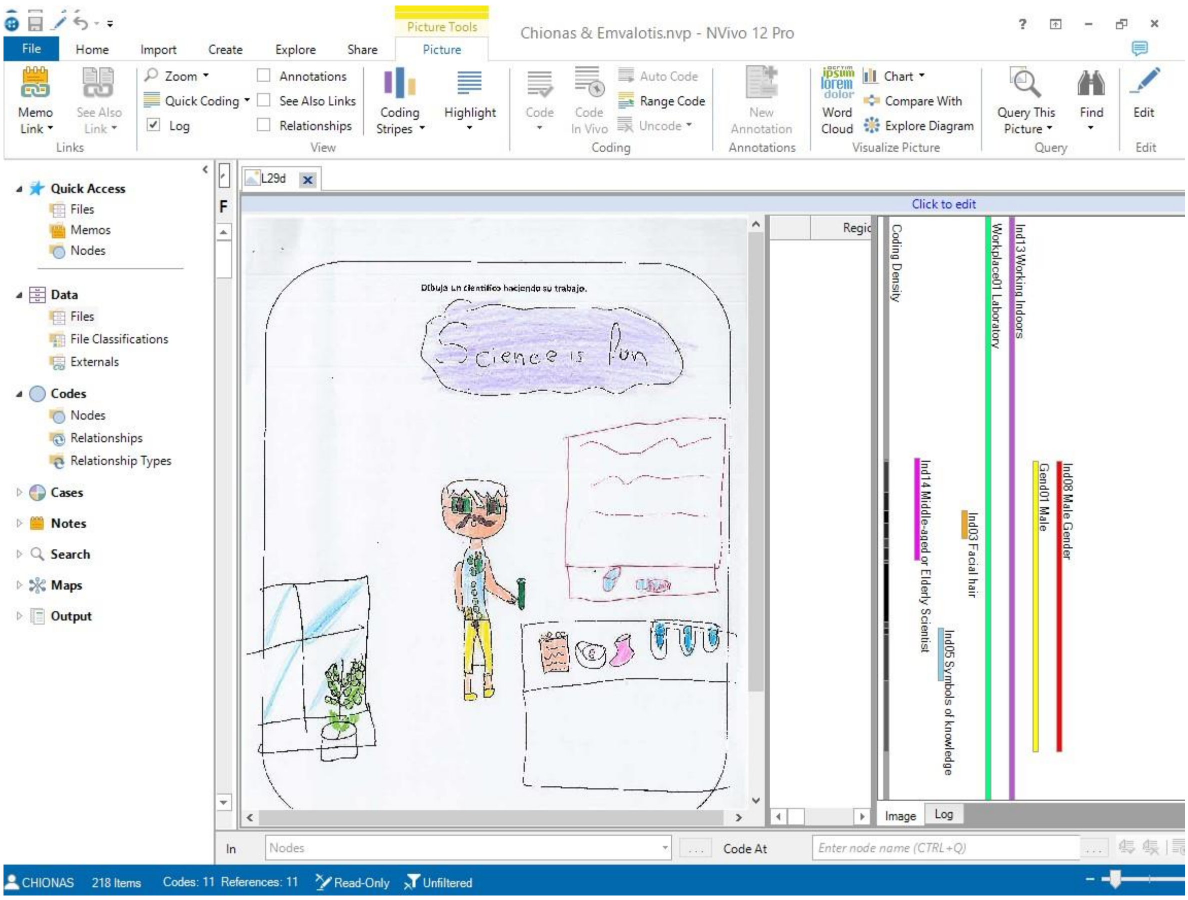

Figure 2. An Example of Drawing Analysis using the *NVivo* Software

Results

DAST–C Indicators

The analysis of the drawings of the Peruvian students who participated in this study showed that they hold stereotypical images of scientists and their work. Specifically, students represented scientists as males (72%), working indoors (79.4%), wearing lab coats (54.1%) and surrounded by research symbols (85.8%), such as test tubes and bottles. The remaining DAST–C stereotypical indicators that appeared less frequently in students' drawings were (in descending order): eyeglasses (29.4%), symbols of knowledge (24.3%), middle–aged or elderly scientist (17.9%), technology (products of science) (13.8%), facial hair (12.8%), indications of danger (4.5%), light bulbs (2.8%), relevant captions (2.3%) and mythical stereotypes (1.8%). There were no indications of secrecy in the students' drawings (see Table 1).

Table 1. Frequencies (and Percentages) of DAST–C Indicators and Other Elements in Students' Drawings according to Student Gender

	Drawing Elements	Groups by gender: Boys (*n* = 102)	Girls (*n* = 116)	Total (*n* = 218)
Indicators of traditional and alternative stereotypical images of scientists (DAST–C)	lab coat	50 (49)	68 (58.6)	118 (54.1)
	eyeglasses	30 (29.4)	34 (29.3)	64 (29.4)
	facial hair	13 (12.7)	15 (12.9)	28 (12.8)
	symbols of research	86 (84.3)	101 (87.1)	187 (85.8)
	symbols of knowledge	17 (16.7)	36 (31)	53 (24.3)
	technology	13 (12.7)	17 (14.7)	30 (13.8)
	relevant captions	3 (2.9)	2 (1.7)	5 (2.3)
	male gender	88 (86.3)	69 (59.5)	157 (72.0)
	indications of danger	5 (4.9)	5 (4.3)	10 (4.5)
	presence of light bulbs	3 (2.9)	3 (2.6)	6 (2.8)
	mythical stereotypes	3 (2.9)	1 (0.9)	4 (1.8)
	indications of secrecy	0 (0.0)	0 (0.0)	0 (0.0)
	scientist doing work indoors	79 (77.5)	94 (81)	173 (79.4)
	middle–aged or elderly scientist	22 (21.6)	17 (14.7)	39 (17.9)
Scientist's gender	male	88 (86.3)	69 (59.5)	157 (72.0)
	female	2 (2)	31 (26.7)	33 (15.1)
	male & female	1 (1)	0 (0)	1 (0.5)
	undetermined	11 (10.8)	16 (13.8)	27 (12.4)
Scientist's workplace	laboratory	70 (68.6)	85 (73.3)	155 (71.1)
	field	0 (0)	4 (3.4)	4 (1.8)
	laboratory & field	0 (0)	4 (3.4)	4 (1.8)
	office	1 (1)	0 (0)	1 (0.5)
	other	31 (30.4)	23 (19.8)	54 (24.8)
Scientist's field of specialization	physics	0 (3)	3 (2.6)	3 (1.4)
	chemistry	53 (52)	79 (68.1)	132 (60.6)
	biomedical sciences	17 (16.7)	12 (10.3)	29 (13.3)
	astronomy	0 (0.0)	2 (1.7)	2 (0.9)
	earth science	0 (0.0)	2 (1.7)	2 (0.9)
	mathematics	2 (2)	1 (0.9)	3 (1.4)
	engineering/computer science/technology	5 (4.9)	1 (0.9)	6 (2.8)
	space science	0 (0)	2 (1.7)	2 (0.9)
	'omniscient' scientist	1 (1)	2 (1.7)	3 (1.4)
	other	24 (23.5)	12 (10.3)	36 (16.5)

The mean for the traditional stereotypical subscale of DAST–C was 2.22 (*SD* = 1.23) and the mean for the alternative stereotypical subscale of DAST–C was 1.78 (*SD* =.86). In addition, the total DAST–C mean score was 4.00 (*SD* = 1.79), showing that, on average, 4 stereotypical indicators were present in each drawing (see Table 2).

Table 2. Means (and standard deviations) of DAST–C subscales and total score according to student gender

groups by gender	traditional stereotypical subscale		alternative stereotypical subscale		DAST–C total scale	
	Mean	SD	Mean	SD	Mean	SD
boys (*n* =102)	2.07	1.19	1.96	0.83	4.03	1.77
girls (*n* = 116)	2.35	1.25	1.62	0.87	3.98	1.81
total (*n* = 218)	2.22	1.23	1.78	0.86	4.00	1.79

Scientist's Gender

The results show that the majority of students (72%) imagined the scientist as male, while female scientists were depicted in about one–fifth of students' drawings (15.1%). The percentage of students who drew an undetermined gender scientist was 12.4%. Finally, only one student drew (in the same drawing) both a male and a female scientist (0.5%) (see Table 1).

Scientist's Workplace

As mentioned above, about four–fifths of Peruvian students depicted scientists who generally worked indoors. Further analysis of the students' drawings showed that the vast majority of them drew that research is performed by scientists in laboratories (71.1%) using specialised equipment. A small portion of students depicted scientists doing fieldwork, observing plants or stars (1.8%), or working in the laboratory and field (1.8%). Only one participant perceived that scientific research may involve offices (0.5%). Finally, one in four students designed "other" settings that did not belong to any of the above categories (24.8%) (see Table 1).

Scientist's Field of Specialization

Peruvian students portrayed scientists working in various disciplines. Specifically, the fields of specialisation most frequently depicted were chemistry (60.6%), biomedical sciences (13.3%), and engineering, computer science and technology (2.8%). Physics, mathematics and the "omniscient scientist" appeared less frequently (1.4%). Astronomy, earth science and space science appeared at the same percentage (0.9%). Thirty–six students (16.5%) drew scientists specializing in "other" fields (see Table 1).

Gender Differences in DAST–C Subscales and DAST–C Total Scores

For exploring the possible gender differences of students in (a) the traditional stereotypical image subscale for scientists, (b) the alternative stereotypical image subscale for scientists and (c) the DAST–C total score, Mann Whitney U tests were conducted since the data did not follow the normal distribution (see Table 3). Significance level was set at $\boldsymbol{p} <.05$.

Table 3. Kolmogorov–Smirnov Normality Test Results

Kolmogorov–Smirnov	Statistic	df	Sig.
Traditional stereotypical image subscale for scientists	.187	218	.000
Alternative stereotypical image subscale for scientists	.254	218	.000
DAST–C total score	.140	218	.000

The results of the Mann Whitney U criterion (see Table 4) showed that there were no statistically significant differences between boys and girls for the traditional stereotypical image subscale for scientists, $U = 5232.5$, $z = -1.517$, $p = .129$, and for the DAST–C total score, $U = 5752.5$, $z = -.358$, $p = .720$.

Table 4. Independent Samples Mann–Whitney U Test Results

Test	Null hypothesis	Sig.	Decision
Mann–Whitney U independent samples	The distribution of traditional stereotypical image subscale for scientists is the same across category of gender.	.129	Retain the null hypothesis
	The distribution of alternative stereotypical image subscale for scientists is the same across category of gender.	.003	Reject the null hypothesis
	The distribution of DAST–C total score is the same across category of gender.	.720	Retain the null hypothesis

On the contrary, statistically significant differences between boys and girls were found in the alternative stereotypical image subscale for scientists. Boys produced significantly more stereotypical images of scientists (lower subscale) (*M Rank* = 122.33), than girls (*M Rank* = 98.22), $U = 4607.5$, $z = -3.015$, $p = .003$. Table 5 shows the mean ranks of DAST–C subscales and DAST–C total scores, regarding student gender.

Table 5. Mean ranks of DAS T–C subscales and total score in different groups according to student gender

Groups by gender	Traditional stereotypical image subscale for scientists	Alternative stereotypical image subscale for scientists	DAST–C total score
Boys (n =102)	102.80	122.33	111.10
Girls (n = 116)	115.39	98.22	108.09

Gender Differences in the Presence of DAST–C Indicators

Furthermore, in order to detect potential gender differences in the fourteen DAST–C indicators, chi–square tests were employed. Chi square test is conducted when (a) the variables under study are each categorical, (b) the collected data are displayed in frequencies and (c) the study groups are independent (Stockemer, 2019). The level of statistical significance was set at p <.05. The results of the analyses showed significant differences between boys and girls for two of the DAST–C indicators. Specifically, girls more frequently included symbols of knowledge (31%) in their drawings than boys (16.7%), $\chi^2(1)$ = 6.089, p = .014, whereas boys more frequently drew male scientists (86.3%) than girls (59.5%), $\chi^2(1)$ = 19.332, p = .000011 (see Table 6).

Table 6. Chi–square Tests Results

Drawing Elements	χ^2	sig.
lab coat	2.015	.156
eyeglasses	0.000	.987
facial hair	0.002	.967
symbols of research	0.038	.561
symbols of knowledge	0.089	.014
technology	0.167	.683
relevant captions	0.359	.549
male gender	19.332	.000
indications of danger	0.043	.835
presence of light bulbs	0.026	.873
mythical stereotypes	1.303	.254
indications of secrecy	–	–
scientist doing work indoors	0.425	.514
middle–aged or elderly scientist	1.766	.184

Discussion

The present study aimed to identify essential aspects of the image of scientists and their work as reflected in drawings produced by Peruvian secondary school students. In order to analyze students' drawings an enriched version of DAST–C drawing analysis framework was applied. The results showed that Peruvian secondary students hold stereotypical images of scientists and their work. More specifically, the majority of students in this study depicted scientists as males, who work indoors, wear a lab coat and are surrounded by research symbols, reinforcing the results of existing studies (Barman, 1999; Emvalotis & Koutsianou, 2018; Finson et al., 1995; Huber & Burton, 1995; Medina–Jerez et al., 2011; Narayan et al., 2013; Türkmen, 2008). As it is shown in earlier studies, Peruvian students believe that women are less likely to pursue a career as scientists which means that science is perceived as a male domain (Darcourt, Ramos, Moreano, & Hernández, 2019). This belief was reflected in our results. In addition, there is evidence that the Peruvian national curriculum is reproducing, at least to some extent, gender stereotypes reinforcing traditional female roles as caregivers and housewives (Ames, 2013; Espinoza, 2004; Mena, 2018). Moreover, female professionals are rarely featured in Peruvian television programs, which are generally claimed to influence viewers' perceptions to some degree (Ardito, 2014). As a consequence, the students' drawings that depicted women scientists were few compared to those of male scientists.

Furthermore, scientists have been depicted working in laboratories as chemists, in concordance with other recent studies (Emvalotis & Koutsianou, 2018; Türkmen, 2008). It has been postulated that these trends may result from the influence of the mass media on students' ideas, since the media typically portrays scientists in a way that reproduces the aforementioned stereotypes (Tintori, 2017; Ruiz–Mallén, Gallois, & Heras, 2018). Moreover, Peruvian students are generally considered to be misinformed about what scientific work involves (Avolio, Chávez, & Vílchez Román, 2020) resulting in reinforcing these stereotypes.

On the other hand, a smaller proportion of students, compared to the aforementioned indicators (about twenty–five percent), included eyeglasses in their drawings, in line with previous studies (Huber & Burton, 1995; Medina–Jerez et al., 2011; Narayan et al., 2013; Song & Kim, 1999; Thomson et al., 2019; Türkmen, 2008). However, the above result differs from the surveys of Barman (1999), Finson and colleagues (1995), and Fung (2002), in which the frequency of the "eyeglasses" indicator was more than forty– five percent and could be considered high.The percentage of drawings depicting middle–aged/elderly scientists was even lower than the eyeglasses percentage. The current trend, given the limitations of the present research, is in line with recent literature (Emvalotis & Koutsianou, 2018; Hillman, Bloodsworth, Tilburg, Zeeman, & List, 2014; Narayan et al., 2013; Yontar Toğrol, 2013). However, our results differ when compared to those of past studies (Barman, 1999; Mead & Metraux, 1957; Song & Kim, 1999; Türkmen, 2008).

Drawings depicting scientists with facial hair were even less than all the aforementioned indicators, a finding that has also been reported by other researchers (Emvalotis & Koutsianou, 2018; Fung, 2002; Narayan et al., 2013; Song & Kim, 1999; Türkmen, 2008). The above results may reflect the tendency of students to identify scientists as young people who have no beard or mustache and do not wear glasses (Emvalotis & Koutsianou, 2018). The "symbols of knowledge" indicator appeared in the students' drawings at a similar frequency (about one in five students) to those found in the students' drawings from South Korea, India, Turkey, United States of America, China and Hong Kong (Hillman et al., 2014; Medina–Jerez et al., 2011; Narayan et al., 2013). On the other hand, the results differed in frequency with other recent studies (Barman, 1999; Emvalotis & Koutsianou, 2018; Finson et al., 1995; Türkmen, 2008).

As regards to technology, Peruvian students did not often include technological and/or scientific products in their drawings, a finding which aligns with previous studies (Barman, 1999; Finson et al., 1995; Fung, 2002; Huber & Burton, 1995; Medina–Jerez et al., 2011; Narayan et al., 2013; Yontar Toğrol, 2013). In addition, the frequency of "mythical stereotypes" and "relevant captions" indicators were among the smallest identified in similar surveys (Barman et al., 1999; Emvalotis & Koutsianou, 2018; Finson et al., 1995; Fung, 2002; Hillman et al., 2014; Medina–Jerez et al., 2011; Narayan et al., 2013; Türkmen, 2008). Concerning the frequencies of "indications of danger", "indications of secrecy" and "presence of light bulbs" indicators in Peruvian students' drawings, these were low, a finding which has also been highlighted by other researchers (Medina–Jerez et al., 2011; Narayan et al., 2013). An explanation of the aforementioned trends could be sought in the increasing number of students who recognise that scientists are real people working on projects that are not mysterious and harmful to humans and society (Barman, 1999).

A further trend which is aligned with current research (Emvalotis & Koutsianou, 2018; Samaras et al., 2012), is that girls more frequently depicted symbols of knowledge in their drawings than boys. On the other hand, boys tended more often to draw male scientists than girls (Hubber & Burton, 1995; Miller et al., 2018), while no statistically significant gender differences were found in the remaining indicators. Finally, it was interesting that approximately one in four girls drew a female scientist, in line with the findings of other recent research efforts (Emvalotis & Koutsianou, 2018; Laubach et al., 2012; Ruiz–Mallén & Escalas, 2012). However, the above results cannot be generalized given the limitations of the sample size and sampling strategy of the present study.

DAST–C Subscales and DAST–C Total Score

In the present study, taking into account the limitations on sample representativeness, it has been shown that fewer DAST–C indicators were included, on average, in Peruvian students' drawings than students of same age from South Korea, Turkey, the United States of America, India, Greece, Bolivia and Colombia (Emvalotis & Koutsianou, 2018; Medina–Jerez et al., 2011; Narayan et al., 2013). Furthermore, Peruvian students depicted, on average, fewer DAST–C traditional indicators (traditional stereotypical image subscale for scientists) than the earlier studies in this field (Chambers, 1983; Schibeci & Sorensen, 1983) and an approximately equal number of DAST–C traditional indicators compared to recent research that showed similar trends (Emvalotis & Koutsianou, 2018; Fung, 2002). The similarity between this and previous studies in the perceptions of scientists confirms the fact that stereotypes are particularly resistant to change (Narayan et al., 2013).

On the other hand, the aforementioned country–based differences in stereotypes can be traced to the way in which stereotypes are formed, which have a collective and cultural background (Markus & Zajonc, 1985; Tajfel, 1981). Stereotypes are shaped by parents, peers and other factors that influence students' socialization, like mass media and the internet (Tintori, 2017). It is possible that differences in stereotypes may be due to different media penetration rates and hence the exposure to media by the students in different countries. Although the Government of Peru has invested in students' access to information and communication technologies (ICTs), such as computers, internet connectivity, software, and online resources (Kho, Lakdawala, & Nakasone, 2019), this goal, finally, was not met (Mateus & Quiroz, 2017; Trucano, 2016). It is worth noting that only 26% of homes (and only 1.2% of rural homes) have access to the Internet (OECD Development Center, 2017) and as follows, students' generally have poor internet access. As a result, the influence of stereotypical media stories may not be very strong and may not take Peruvian students away from the real image of science and scientists.

Regarding the alternative stereotypical image subscale for scientists, comparison of the results of this study with other similar studies has proved limited. Almost all previous studies have focused on the total DAST–C scale or the traditional stereotypical image subscale for scientists. In terms of gender differences, the present study found that boys drew, on average, more stereotypical images than girls regarding the alternative stereotypical image subscale for scientists, in agreement with Emvalotis and Koutsianou (2018) who identified similar trends and in contrast to Medina–Jerez and colleagues (2011) who did not find statistically significant differences in the aforementioned subscale. On the total scale of DAST–C, no gender differences were found, on average, between boys and girls from Peru, a finding consistent with previous research (Laubach et al., 2012; Medina–

Jerez et al., 2011; Narayan et al., 2013).

Conclusions

Taking into account Peru's limited relevant research focusing on students of this age, this study adds to the current body of knowledge by offering a more comprehensive overview of how Peruvian secondary school students view scientists and their work. However, we aware that our research has two limitations. Initially, the selection of school units, departments, and students participated in the study was not representative, so the results and conclusions need to be limited to this population, and their application to other groups is not suggested.

An additional limitation is found in the data collection tool, which has received a lot of criticism from researchers, despite its positive contribution as mentioned in a previous section of this paper. Specifically, students' drawings may have represented only a part of their overall perceptions of scientists (Boylan et al., 1992). The absence of additional text from the drawings sometimes does not allow the researchers to understand exactly what the student is trying to communicate (Rennie & Jarvis, 1995). To overcome this limitation, it is recommended to use the DAST with other techniques such as interviews or questionnaires (Bernard & Dudek–Różycki, 2017). Moreover, the way the research question was formulated ("*Dibuja un cientifico hacienda su trabajo*") may have reinforced gender stereotypes. It is suggested that future researchers should formulate their question with gender-fair language (Sczesny, Formanowicz, & Moser, 2016) that will treat women and men symmetrically (for example *"Dibuja una persona que haga ciencia"*) (Valderrama, Vernal-Vilicic, & Méndez-Caro, 2016).

Educational Implications

The findings of this study highlight the need to design and implement interventions that could modify the stereotypical images of Peruvian students, mainly as regards to the image of a male scientist working indoors, wearing a lab coat, working in chemistry and surrounded by research symbols. Knowledge of how Peruvian students' conceptualise scientists provides a starting point towards understanding how students can be practically supported in formal, non–formal and informal learning settings. Specifically, in the context of formal learning, it is proposed that teachers, with the economic and organizational support of the state, promote a variety of school activities towards overcoming these stereotypes (e.g. get students to meet female scientists by bringing them into their classroom, provide students with various instructional modes like active or inquiry–based etc.) (Farland–Smith, 2019).

As it was mentioned earlier, a recent study has shown that Peruvian teachers are not informed about the variety of science professional careers and work opportunities (CONCYTEC, 2015) and this fact may prevent students from expanding their views about scientists and science. We believe that it is very important to improve science teacher training because they are the keys in exposing the students to realistic images of scientists (Emvalotis & Koutsianou, 2018). It is also suggested that parents (and teachers) should provide out–of–school, informal learning experiences to students, such as visits to science museums, zoos and botanical gardens, where they can meet real scientists (Ruiz–Mallén et al., 2018; Thomson et al., 2019). These experiences will enhance their views about the nature of science and will facilitate their understanding about scientists' work. In the context of non–formal learning, it is proposed to create educational programs that will be promoted by the mass media and will have scientific content. Visual (photos, videos) (Fossard & Riber, 2005), print (magazines, newspapers, comics) (Roy, Baker & Hamilton, 2015) and digital media (Pride & Ferrell, 2017), are sources of information for young people (Biagi, 2016; Medoff & Kaye, 2017; Dittmar & Eilks, 2019) and through such sources a more realistic and less stereotyped image of scientists can be developed. This could also be facilitated by increased use of Social Media by scientists, whereby they can increase the visibility of their research and interact with broad audiences in a way that expresses warmth and not just scientific competence (Jarreau et al., 2019).

Suggestions for Future Research

Future research needs to further investigate and compare these initial findings with the images of students from other countries and cultures, justifying and interpreting any differences. In addition, it is proposed to investigate the potential influence of various factors on students' images of scientists. Finally, it is suggested the application of various educational techniques that may facilitate the development of more positive, inclusive images, while evaluating their effectiveness through experimental designs is also essential.

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