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Abstract

Several empirical studies reveal that students are poorly informed, and often hold stereotyped views of science and scientists. The present study aimed to investigate the Portuguese elementary school students' images of scientists and their work and the influence of gender and grade level on the development of these images. Two hundred and eighty-nine elementary school students enrolled in grades 1-5 in urban public schools participated in the study. Students were asked to draw a scientist and to answer questions about the drawing. The data collected were analyzed, considering three different features: stereotypical indicators, specialized research fields, and scientists' activity. Several descriptive and bivariate analyses were performed. Portuguese students tended to report the same stereotyped image of scientists described in other countries, and students' knowledge seems to be limited to a few fields of specialization and influenced by the pandemic context experienced during the DAST application. Moreover, the results showed differences according to the student's gender and grade level that may result, among other factors, from the influence of the atypical organization of the Portuguese education system in the first years of schooling.

Introduction

Several investigations have studied student conceptions about science, the work of scientists, and what type of person does science. In the pioneering study developed by Mead and Métraux (1957), a questionnaire was applied to 3500 students from 145 secondary schools in the United States of America to characterize their image of scientists. Although the results indicated that students perceived science positively, scientists were seen as boring people who neglect their families and have “no social life, no other intellectual interests, no hobbies or relaxations” (p.387). Other stereotyped images of scientists emerged, such as that of an old or middle-aged man, wearing a lab coat and glasses, who works in the laboratory carrying out experiments. These results were corroborated by other studies carried out between the 1950s and 1980s (Beardslee & O’Dowd, 1961; Krajkovich & Smith, 1982).

Later, Chambers (1983) developed the Draw a Scientist Test (DAST), where students are asked to draw a scientist and elaborate a short explanation. He used the DAST with 4807 children, from preschool to the 5th grade. Chambers (1983) analyzed the results based on the presence of seven indicators of the “standard image” of a scientist: laboratory coat; glasses; facial hair; symbols of research (scientific instruments and laboratory equipment); symbols of knowledge (such as books); symbols of technology; and relevant captions (taxonomic forms, expressions such as "eureka", among others). Alternative images were also detected, with scientists portrayed as magical or fictional characters, such as Frankenstein.

To facilitate the interpretation of drawings Finson et al. (1995) created the Draw a Scientist Test Checklist (DAST-C), adding eight new stereotyped indicators: male gender; Caucasian; indications of danger; light bulbs; mythical stereotypes; indications of secrecy; scientist doing work indoors; and middle age or old scientist. Other data collection methods have been developed, such as questionnaires with multiple-choice items, open-answer questionnaires, interviews, as well as the analysis and discussion of stories written by students. However, DAST is the most widely used instrument to investigate the image students have of scientists and their work, especially with children of young age with underdeveloped written skills, having been applied in many different countries (e.g. Dickson & McMinn, 2022; Emvalotis & Koutsianou 2018; Finson 2002; Rodari 2018; Türkmen 2008).

While stereotypes regarding scientists persist, evidence suggests that how children view scientists and their work is changing (Leavy & Hourigan, 2021; Miller et al., 2018; Quílez-Cervero et al., 2021). For example, the meta-analysis performed by Miller et al. (2018) demonstrated that, over the last 50 years, the likelihood of children representing female scientists has increased. This may reflect the increase of female research scientists in Western countries. Studies also reveal a decrease in the frequency of mythical stereotypes, light bulbs, as well as indicators of danger and secrecy, suggesting that these indicators no longer characterize the stereotype of the modern scientist (Ferguson & Lezotte, 2020; Finson, 2002; Türkmen, 2008). In addition, children seem to more frequently draw scientists that are young, casually dressed, and without facial hair or glasses (Emvalotis & Koutsianou, 2018).

The influence of different variables on the appearance of stereotypes in the DAST has been analyzed over the last few decades. Several studies suggest that the children's gender influences the stereotypes in the drawings. First, male children tend to draw more stereotyped elements than female children, particularly in Western countries (Bozzato et al., 2021; Emvalotis & Koutsianou, 2018; Martins et al., 2021; Ruiz-Mallén & Escalas, 2012). Furthermore, boys more often portray scientists with technology/science-related products, indicators of danger and mythical stereotypes, while girls portray scientists with symbols of knowledge (Emvalotis & Koutsianou, 2018). Although male figures predominate in drawings by both male and female students, differences are detected: while boys tend to draw, almost exclusively, male scientists, girls draw female scientists more frequently (Christidou et al., 2012; Emvalotis & Koutsianou, 2018). Finally, there also seem to be differences regarding the environment where scientists are represented: boys more often represent the scientist working outdoors while girls place them working indoors (Christidou et al., 2012).

The influence of grade level on the development and/or reinforcement of children's stereotyped images of scientists has received less attention in the literature. Some studies have detected a positive correlation between the number of stereotypes and grade level (Chambers, 1983; El Takach & Yacoubian, 2020; Özel, 2012), while others identified no differences (Emvalotis & Koutsianou, 2018) or significant differences between only some grade levels (Bozzato et al., 2021). Bozzato et al. (2021) suggested that the relationship between grade level and the image of scientific researchers and their activity may be mediated by the type of science activities performed in the school, which varies each year according to the local curriculum.

Cultural context also seems to influence children's perceptions of scientists (McCann & Marek, 2016). For example, compared to Western children, Turkish and Navajo children's drawings present less stereotyped images (Monhardt, 2003; Türkmen, 2008); Taiwanese and Navajo children tend to portray more female scientists and more female scientists in outdoor settings (Monhardt, 2003; She, 1998). Moreover, students incorporate elements of their own culture when portraying scientists (Farland-Smith, 2009; McCann & Marek, 2016).

Increasing our knowledge of how children see scientists is important, as it allows teachers and trainers to guide their intervention to reduce stereotyped ideas. The maintenance of stereotyped and inappropriate ideas of science and scientists is likely to lead children to lack interest in learning science and choosing a scientific career (Finson, 2002; Nguyen & Riegle-Crumb, 2021; She, 1998). For example, students who have a negative image of scientists are less likely to find science subjects interesting or a future career option to pursue in the future. Furthermore, more realistic conceptions of scientists are needed to understand the nature of science.

In Portugal, there was some research in this area, particularly with children in the first years of schooling (Martins et al., 2021; Reis et al., 2006). In a recent study using drawings about STEM professionals, students revealed a set of stereotyped ideas about the appearance and work of these professionals, including scientists (Martins et al., 2021). The study highlighted the need to change teaching practices to improve student views of these professionals. The study assessed differences between male and female students but did not analyze possible differences according to grade level, a relevant aspect considering the atypical organization of the Portuguese education system in the first years of schooling.

Contrary to many countries, the 1st cycle only covers 4 years in Portugal. In this first cycle, a single teacher is responsible for teaching all curricular areas. The Physical-Natural Sciences are taught together with History and Geography in the curricular area of Environmental Studies. The following cycle, the 2nd cycle, with only two years, is the first with a multi-teacher regime. For the first time, students have a subject – Natural Sciences – exclusively dedicated to the physical and natural sciences. The scarcity of data on the influence of grade level in the Portuguese context was one of the incentives for carrying out this study. This study aimed to analyze the images of scientists and their work drawn by 289 students from the 1st to the 5th grade, using DAST. For this purpose, the following research questions were defined: i) What are the students' conceptions about scientists and their work?; ii) Is there any relationship between the presence of stereotyped images about scientists and grade level?; iii) Is there any relationship between the presence of stereotyped images about scientists and the gender of students?

Method

Participants

A convenient sample of 289 Portuguese students, between 6 and 12 years old (M = 8.67 years; SD = 1.48 years) participated in this study. All participants were enrolled in public schools in the Lisbon metropolitan area. Consent was obtained from the school headmasters and class teachers where the study was carried out. Moreover, all participating children and their families were informed about the objectives and nature of the research and their consent was obtained.

One hundred and forty-four of these participants were male students (49.8%) and 145 were female (50.2%). Fifty-six participants were attending the first grade, 59 the second grade, 45 the third grade, 55 the fourth grade and 74 the fifth grade.

Data Collection

A modified version of the DAST (mDAST), created by Farland-Smith (2012), was employed in the present study. Following the instructions on mDAST administration, instead of just asking students to draw a scientist, participants were asked to draw a scientist busy doing their work. This provides more detail about the task and requires the drawings to incorporate not only aspects of the scientist's appearance, but also the location and nature of the scientific activity (Farland-Smith, 2012). Children were also told to answer questions about themselves (their age, grade level, and gender) and the drawing (scientist's gender, location, and activity). All data were collected between March and June 2021.

Data Analysis

The participants' drawings and responses to the open-ended questions were analyzed together, taking into consideration three different features: stereotypical indicators, specialized research fields, and scientists' activity. Regarding the first feature, 14 of the 15 DAST-C indicators were analyzed (Finson et al., 1995). As in other studies (e.g. Bozzato at al., 2021; Emvalotis & Koutsianou, 2018) the indicator "Caucasian" was not considered, as some drawings were not performed with coloured pencils, making a rigorous analysis of the indicator unfeasible. In each drawing, and for each indicator, a score of 1 or 0 points was given, depending on its presence or absence in the drawing.

After the analysis, three summary variables were created: the variable "DAST-C upper scale - standard image", corresponding to the sum of the scores in the first seven indicators of the DAST-C (lab coat; glasses; facial hair; symbols of research; symbols of knowledge; technology; relevant captions); the variable "DAST-C lower scale - alternative images", corresponding to the sum of the scores in the remaining indicators (male gender; indications of danger; light bulbs; mythical stereotypes; indications of secrecy; scientist doing work indoors; elderly/middle age scientist); and, finally, the variable "DAST-C total score" corresponding to the sum of the scores in all 14 indicators analyzed. Higher scores indicate highly stereotyped images of scientists, while lower scores indicate less stereotyped representations. In addition to the DAST-C indicators, the presence of scientists with crazy hair was also analyzed.

The area of specialization depicted in each drawing, as well as the type of activity performed by the scientist, was determined based on an adapted version of the coding scheme developed by Christidou et al. (2012) and by Fralick et al. (2009), respectively. Initially, the authors jointly scored 20 drawings and established clear criteria for the analysis of each item. Then, each drawing was independently analyzed by both authors. Lastly, the results of each analysis were compared. Inter-rater agreement ranged from 86% to 100% for each category. When codes differed, researchers discussed until a consensus was reached.

Data analysis was performed using SPSS Statistics® (IBM SPSS. version 27.0. Chicago. USA). Univariate and, then, bivariate descriptive statistics were performed to explore the relationship between the students' views about science and scientists (dependent variable) and gender and grade level (independent variables). To compare the scores obtained in the DAST-C between different grade levels, the one-way ANOVA was used, followed by multiple comparisons. To assess whether the distribution of scores obtained in the DAST-C varied according to the student's gender, the Mann-Whitney test was used. Finally, to examine potential differences between categorical variables, Pearson's chi-square and Fisher's exact test were used. Moreover, a cell-by-cell comparison of observed and estimated expected frequencies was used to understand the nature of the association. To identify those specific cells most contributing to the significance of the chi-square test, standardized residuals were calculated. When necessary, Cramer's V test was used to determine the strength of the relationship between the variables. The significance level of α=0.05 was used as a reference for all hypothesis testing.

Results

Stereotypical Indicators

The first seven indicators of the DAST-C, relative to the standard image, had a mean score of 2.62 (SD=1.25), while the remaining indicators had a mean score of 2.27 (SD=1.15). The mean total score was 4.89 (SD=1.94), indicating each drawing had, on average, almost five of the 14 indicators analyzed (see Table 1).

Table 1. Means (standard deviations) of DAST-C (subscales and total score)

				Mann-Whitney		
DAST-C	**Total**	**Boys**	**Girls**	*U*	Z	r
Upper scale	2.62 (1.25)	2.63 (1.35)	2.61 (1.15)	10365	-0.109	-0.006
Lower scale	2.27 (1.15)	2.61 (1.02)	1.92 (1.17)	**6755*****	-5.403	-0.318
Total Score	4.89 (1.94)	5.24 (1.95)	4.53 (1.87)	**8253****	-3.118	-0.183

**p*<0.05; ***p*<0.01; ****p*<0.001

Table 2 shows the frequency of the different stereotyped indicators analyzed. Symbols of research, such as test tubes and flasks, were the most frequent indicator (91.7%). In most drawings, the scientist was male (65.9%) and working indoors (86.2%), wore a lab coat (49.8%) and glasses (31.8%) and had crazy hair (43.6%) (Figure 1). In addition, the scientist was surrounded by symbols of knowledge in 45.3% of the drawings and by indicators of danger and relevant captions in 31.1% and 21.5% of the drawings, respectively. The remaining indicators analyzed were less frequent: light bulbs (18.7%); technology (13.8%); middle-aged or old scientist (10.7%); mythical stereotypes (10.4%); facial hair (7.6%); and indications of secrecy (3.8%).

Table 2. Frequencies of Stereotype Indicators According to Gender

	Total n=289	Boys n=144	Girls n=145	X^2 (gl=1)	V
Laboratory coat	49.8	49.3	50.3	0.031	
Eyeglasses	31.8	31.3	32.4	0.045	
Facial Hair	7.6	8.3	6.9	0.212	
Symbols of research	91.7	91.7	91.7	0.0003	
Symbols of knowledge	45.3	41.0	49.7	2.198	
Technology	13.8	17.4	10.3	2.983	
Relevant Captions	21.5	23.6	19.3	0.793	
Male gender	65.7	95.1	36.6	**110.114*** **	0.617
Indications of Danger	31.1	31.9	30.3	0.086	
Light bulbs	18.7	15.3	22.8	2.624	
Mythical stereotypes	10.4	14.6	6.2	**5.449***	0.137
Indications of Secrecy	3.8	2.1	5.5	2.327	
Working indoors	86.2	86.8	85.5	0.101	
Elderly/Middle aged	10.7	16.0	5.5	**8.247****	0.169
Crazy hair	43.6	59.0	28.3	**27.785*****	0.310

*p<0.05; **p<0.01; ***p<0.001

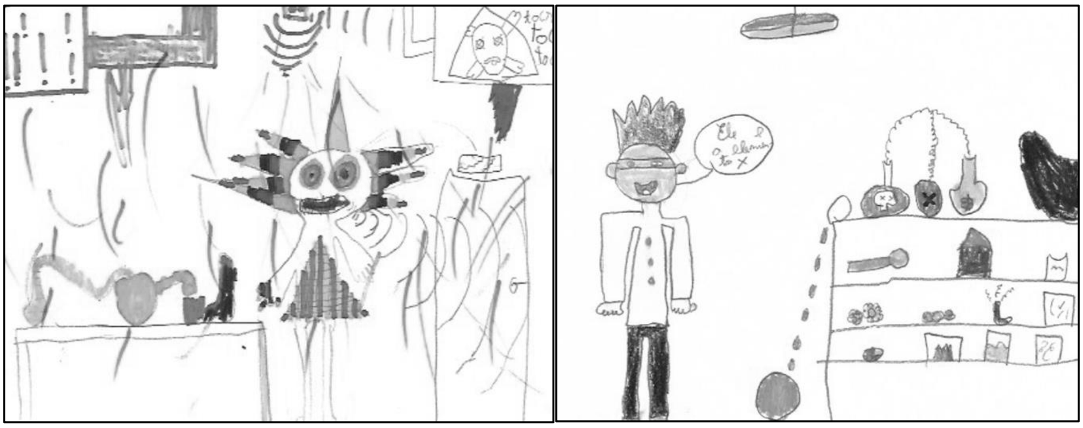

Figure 1. Stereotypical Images of Scientists Drawn by Boys Students (Grade 4)

Specialized Research Field

The drawings represented different areas of expertise (Table 3, Figure 2). A large group of drawings (74.4%) involved activities within the scope of STEM disciplines. Chemistry was the most frequently represented specialization (36.3%), closely associated with the idea of mixing liquids ("The scientist is putting two chemical solutions together"). Biomedical researchers were present in 15.2% of the drawings. Although some students stated that these scientists were studying and trying to find a cure for diseases, in general, most of them made explicit references to the discovery of a cure for COVID-19 ("I drew scientists trying to get a vaccine against COVID-19"). Biology was the third most frequent area of expertise, present in 11.1% of the drawings, covering different disciplines, like zoology ("The scientist I drew is studying a jellyfish, is observing it"), as well as botany ("He is doing an experiment with flowers"). Finally, while engineering was present in 5.2% of the drawings, areas such as physics, geology and mathematics were practically absent. In some cases, although the drawings included a volcano, they were coded as depicting chemistry, as the associated description underlined the chemical rather than geological elements, particularly the mixture of vinegar and sodium carbonate in a volcano experiment.

Table 3. Frequencies of Actions and Specialization of Research Field According to Gender

	Total n=189	Boys n=144	Girls n=145	X^2 (gl=1)
Research Field				
STEM	74.4	70.1	78.6	2.729
Chemist	36.3	47.5	50.0	0.131
Biomedical	15.2	22.8	18.4	0.623
Biology	11.1	17.8	14.9	0.333
Engineering	5.2	7.9	6.1	0.262
Other disciplines	5.5	4.0	10.5	3.352
Not determined	17.0	19.4	14.5	1.263
Science Fiction	6.2	8.3	4.1	2.177
Omniscient research	2.4	2.1	2.8	0.139
Action				
Experimenting/Testing	31.1	27.8	34.5	1.515
Making/Working with hands	29.1	33.3	24.8	2.535
Researching/Discovering	17.3	15.3	19.3	0.821
Designing/Inventing products	4.2	4.2	4.1	0.0001
Observating	3.8	4.2	3.4	0.102
Other actions	8.3	7.6	8.3	0.040
No action/not determined	6.2	7.6	5.5	0.529

*p<0.05; **p<0.01; ***p<0.001

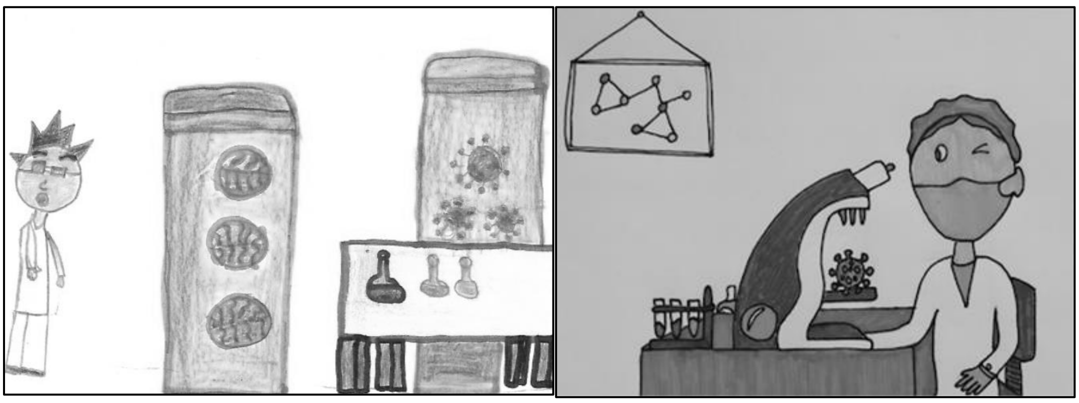

Figure 2. Biomedical Scientists Drawn by Girls Students (left - grade 3; right - grade 5)

In 17% of the drawings, no specialized research field could be determined. This was largely due to generic references to scientists doing experiments, without any further explanation. In 6.2% of the drawings, student descriptions indicated science fiction/magical activities ("My scientist is doing an experiment to build a blue frog with a dog face. This one is going to a strange animal contest"). Finally, a minority of the drawings (2.4%) were coded as “omniscient” research, with references to elements of different disciplines, from biology, astronomy, and biomedical sciences.

Some stereotypical indicators – such as lab coat ($X^2_{(4)}$=10.425; p=0.032), symbols of research ($X^2_{(4)}$=9.570; p=0.023), symbols of knowledge ($X^2_{(4)}$=11.545; p=0.020) and technology ($X^2_{(4)}$=21.231; p<0.001), male gender ($X^2_{(4)}$=11.175; p=0.023), indications of danger ($X^2_{(4)}$=22.524; p<0.001) and crazy hair ($X^2_{(4)}$=9.960; p=0.040) – were not uniformly distributed across drawings depicting different STEM-related subjects (see Table 4). Chemists tended to be surrounded by indications of danger more frequently than expected (48.6%); engineers tended to be male (93.3%) and were more often surrounded by technology (60%), although less surrounded by symbols of research (80%) and less likely to be wearing a lab coat (20%) and eyeglasses (13.3%); biomedical researchers tended to have less crazy hair (29.5%); and researchers of other STEM areas (e.g. physics, mathematics, geology) tended to be surrounded by symbols of knowledge more frequently (87.5%).

Table 4. Frequencies of Stereotype Indicators According to the STEM Disciplines

	Chem. n=105	Biom. n=44	Biol. n=35	Eng. n=15	Other n=16	X^2 (gl=4)	V
Laboratory coat	58.1	63.6	48.6	20.0	43.8	**10.425***	0.220
Eyeglasses	39.0	36.4	40.0	13.3	25.0	4.862	
Facial Hair	6.7	6.8	8.6	6.7	6.3	0.592	
Symbols of research	97.1	90.9	100.0	80.0	93.8	**9.570***	0.229
Symbols of knowledge	46.7	40.9	51.4	60.0	87.5	**11.545***	0.232
Technology	11.4	9.1	14.3	60.0	0	**21.231*****	0.377
Relevant Captions	17.1	31.8	31.4	33.3	37.5	7.754	
Male gender	70.5	56.8	65.7	93.3	43.8	**11.174****	0.228
Indications of Danger	48.6	13.6	34.3	20.0	12.5	**22.524*****	0.324
Light bulbs	23.8	13.6	8.6	33.3	25	7.056	
Mythical stereotypes	11.4	4.5	5.7	13.3	0	3.700	
Indications of Secrecy	4.8	0.0	8.6	0.0	0	3.975	
Working indoors	88.6	93.2	82.9	86.7	81.3	3.149	
Elderly/Middle aged	12.4	15.9	5.7	13.3	12.5	2.177	
Crazy hair	51.4	29.5	45.7	60.0	25.0	**9.960***	0.215

*p<0.05; **p<0.01; ***p<0.001

Action Developed by the Scientist

About 30% of the students indicated that the scientist was doing experiments/experimenting (Table 3). Students rarely described the experiment in detail, but when they did, the term experiment seemed to be used in a very vague way and not only for activities where scientists are controlling and manipulating variables. More technical actions, such as mixing liquids, producing solutions or tidying up laboratories, were mentioned by 29.1% of the students. In 17.3% of the drawings, students mentioned that the scientist was researching/discovering something, especially the solution for societal problems, like diseases. Although many drawings coded in this category also explicitly indicated products of the research/discovery process, like vaccines and medicines, the student descriptions alluded not only to the production of the product but also to the scientific knowledge necessary for its construction. However, in the drawings classified as designing/inventing products (4.2%), the focus was merely on inventing technology, such as a computer or robot, and not scientific knowledge. Additionally, 8.3% of the drawings indicated other activities, mostly unrelated to scientific activity (such as killing people and taking care of people, among others) and in 6.2% of the drawings the activity could not be identified because the drawing was not clear enough and the written description didn´t mention any activity. Finally, observation was mentioned only by 3.8% of the students.

Gender Differences

Stereotypical Indicators

The Mann-Whitney test was used to examine potential differences in DAST-C scores between male and female students. As shown in Table 1, there was no difference in the DAST-C upper scale, regarding the standard image, between boys and girls (U=10365; *p*=0.913). However, the distributions of the DAST-C lower scale (U=6755; *p*<0.001) and DAST-C total scale (U=8253; *p*=0.002) differed significantly between the two groups. Drawings by boys were more likely to present alternative images (lower scale), but there were no significant differences between genders in the use of standard stereotypes (upper scale). According to table 2, there were significant associations between a student's gender and the presence of the following stereotyped indicators: male scientists ($X^2_{(1)}$= 110.114; *p*<0.001), elderly ($X^2_{(1)}$=8.247; *p*=0.004) and crazy hair ($X^2_{(1)}$=27.785; *p*<0.001). Boy students drew scientists that were old (16%), male (95.1%) and had crazyhair (59%) more often than girls (5.5%, 36.6% and 28.3%, respectively).

Specialized Research Field and Action Developed by the Scientist

There was not enough evidence to suggest an association between gender and the specialized research field or the scientist's actions (see Table 3).

Grade Level Differences

Stereotypical Indicators

The analysis of variance showed that the mean scores for the DAST-C upper scale (F(4,289)= 9.499; *p*<0.001) and DAST-C lower scale (F(4,289)=2.883; *p*=0.039) were statistically different between grade levels. The results show that fifth-graders tend to draw more standard stereotyped indicators (3.23±1.20) than 1st (2.11±1.17), 2nd (2.27±1.22) and third- graders (2.47±0.97). Regarding alternative stereotyped images, significant differences were only found between two levels: fifth-graders (2.07±1.07) produced significantly fewer alternative stereotyped elements than fourth-graders (2.69±1.23) (Figure 3). However, results revealed no significant differences between grade levels in DAST-C total score.

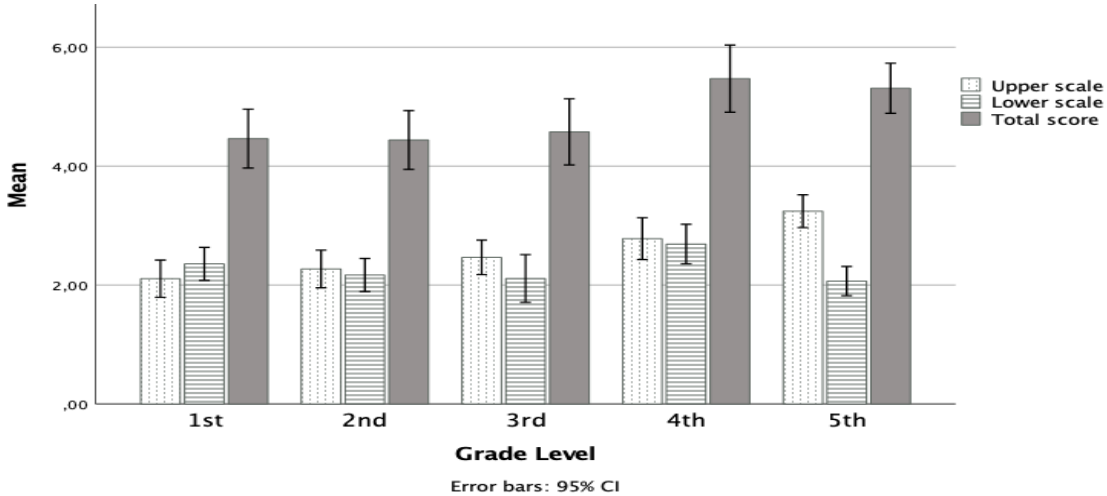

Figure 3. Means of DAST-C Subscales and Total Score by Grade Level

There was a significant association between grade level and the presence of the following stereotyped indicators: lab coat ($X^2_{(4)}$=30.614; p<0.001), eyeglasses ($X^2_{(4)}$=14.430; p=0.006), symbols of knowledge ($X^2_{(4)}$=13.153; p=0.011), relevant captions ($X^2_{(4)}$=15.710; p=0.003), male scientist ($X^2_{(4)}$=11.126; p=0.025), indications of secrecy ($X^2_{(4)}$=17.645; p=0.001), indoor location ($X^2_{(4)}$=14.000; p=0.007) and crazy hair ($X^2_{(4)}$=10.575; p=0.032). Students enrolled in fifth-grade drew scientists wearing lab coats (75.7%) and glasses (44.6%) and surrounded by symbols of knowledge (55.4%) more often than expected, but drew male scientists less frequently (56.8%). In turn, fourth-grade students drew male scientists (80%) and crazy hair (61.8%) more than expected. Furthermore, second and third-grade students depicted significantly fewer scientists with lab coats (30.5%) and working indoors (71.1%), respectively. Finally, children enrolled in the first-grade drew relevant captions (3.57%), symbols of knowledge (28.6%) and scientists with eyeglasses (14,3%) less frequently than expected (Table 5).

Table 5. Frequencies of Stereotype Indicators According to Grade Level

	1st n=56	2nd n=59	3rd n=45	4th n=55	5th n=74	X^2 (gl=4)	V
Laboratory coat	44.6	30.5	48.9	41.8	75.7	**30.614*****	0.325
Eyeglasses	14.3	33.9	35.6	27.3	44.6	**14.430****	0.223
Facial Hair	10.7	1.69	2.22	9.09	12.2	7.912	
Symbols of research	87.5	89.8	93.3	94.5	93.2	2.542	
Symbols of knowledge	28.6	44.1	37.8	56.4	55.4	**13.153***	0.213
Technology	21.4	6.78	6.67	18.2	14.9	8.047	
Relevant Captions	3.57	20.3	22.2	30.9	28.4	**15.710****	0.233
Male gender	73.2	64.4	55.6	80	56.8	**11.126***	0.196
Indications of Danger	30.4	37.3	40	34.5	18.9	8.155	
Light bulbs	21.8	12.7	16.4	27.3	21.8	5.008	
Mythical stereotypes	13.3	13.3	23.3	33.3	16.7	7.391	

	1st n=56	2nd n=59	3rd n=45	4th n=55	5th n=74	X^2 (gl=4)	V
Indications of Secrecy	0	10.2	0	9.1	0	**17.645****	0.247
Working indoors	91.1	81.4	71.1	92.7	90.5	**14.000****	0.220
Elderly/Middle aged	12.5	5.08	8.89	7.27	17.6	6.605	
Crazy hair	42.9	40.7	42.2	61.8	33.8	**10.575***	0.191

*p<0.05; **p<0.01; ***p<0.001

Specialized Research Field

Statistically significant differences were found between grade level and research fields among STEM disciplines ($X^2_{(4)}$=29.538; p<0.001). As shown in Table 6, students in fifth grade (91.9%) drew more researchers working in STEM areas while first (53.6%) and fourth-grade (63.6%) students drew them less frequently than expected. In addition, the representation of chemists ($X^2_{(4)}$=25.366; p<0.001) and biomedical researchers ($X^2_{(4)}$=19.396; p<0.001) was not uniformly distributed across grade levels: chemical researchers were depicted more often by fourth-grade students (77.1%) and less often by fifth graders (30.9%); biomedical researchers were depicted more frequently by fifth-grade students (32.4%) and less among first (0%) and fourth-grade students (5.7%).

Table 6. Frequencies of Action and Specialization of Research Field According to Grade Level

	1st n=56	2nd n=59	3rd n=45	4th n=55	5th n=74	X^2 (gl=4)	V
Research Field							
STEM	53.6	76.3	82.2	63.6	91.9	**29.538*****	0.320
Chemist	60.0	37.8	59.5	77.1	30.9	**25.366*****	0.343
Biomedical	0	26.7	21.6	5.7	32.4	**19.396****	0.300
Biology	20.0	26.7	10.8	2.9	17.6	9.399	
Engineering	13.3	6.7	2.7	8.6	5.9	3.114	
Other disciplines	6.7	2.2	5.4	5.7	13.2	4.714	
Not determined	39.3	13.6	6.7	21.8	5.4	**31.633*****	0.331
Science Fiction	5.4	6.8	8.9	10.9	1.4	6.262	
Omniscient research	1.8	3.4	2.2	3.6	1.4	1.039	
Action							
Experimenting/Testing	32.1	27.1	26.7	43.6	27.0	5.480	
Making/Working with hands	19.6	33.9	35.6	38.2	21.6	8.205	
Researching/Discovering	1.8	16.9	20.0	5.5	36.5	**34.088*****	0.343
Designing/Inventing products	7.1	1.7	8.9	1.8	2.7	5.123	
Observation	3.6	3.4	2.2	0.0	8.1	5.338	
Other actions	10.7	15.3	2.2	7.3	4.1	7.842	
No action/not determined	25.0	1.7	4.4.	3.6	0.0	**29.353*****	0.370

*p<0.05; **p<0.01; ***p<0.001

Action Developed by the Scientist

As shown in Table 6, differences were found between grade level and the following scientist activities: researching/discovering ($X^2_{(4)}$=34.088; p<0.001) and no action/not determined ($X^2_{(4)}$=29.353; p<0.001). Scientists doing research/discovery were mentioned more often than expected by fifth-grade students (36.5%) but less by first (1.8%) and fourth-grade students (5.5%). Drawings scored as no action/not determined were more frequent among first-grade students (25%) and less among fifth-grade students (0%).

Discussion

In this section, we try to discuss and respond in a systematic way to the three research questions that guided the study.

What are the students' conceptions about scientists and their work?

The results indicate that the drawings of the Portuguese students participating in this study include, on average, approximately the same number of DAST-C stereotyped elements as those reported in investigations with American and Greek children (Chambers, 1983; Emvalotis & Koutsianou, 2018), but more than in research with Italian students (Bozzato et al., 2021). The results also suggest that Portuguese students tend to report the same stereotyped images of scientists described in other countries (Bozzato et al., 2021; Chambers, 1983; Farland-Smith, 2012; Ferguson & Lezotte, 2020; Miller et al., 2018; Quílez-Cervero et al., 2021). Typically, students illustrated male scientists working in closed environments, namely laboratories, surrounded by symbols of research, suggesting that these students rarely associate scientific research with fieldwork. In addition, the scientist usually wore a lab coat and glasses and had crazy hair. Although the male gender was still the dominant stereotype, about 40% of the drawings represented female scientists. This is in line with recent studies that suggest the male stereotype is eroding, possibly as a reflection of a greater representation of women in science (Miller et al., 2018).

Finally, some stereotyped indicators, namely mythical stereotypes and indicators of secrecy, were rare in the sample analyzed. Therefore, the present study supports the idea that these indicators are becoming obsolete (Ferguson & Lezotte, 2020; Finson, 2002; Türkmen, 2008). Concerning the specialized research field, our results show a high awareness towards STEM disciplines; a predominance of chemistry among the science disciplines; and an increase of biomedicine compared to studies conducted before the COVID-19 pandemic (Christidou et al., 2012; Martins et al., 2021). The former increase seems to reflect the context of the pandemic experienced during the DAST application. As expected, students incorporated references to health situations related to COVID-19. Notably, research fields related to the human and social sciences were absent and the environmental sciences had a residual appearance. This asymmetrical presence of scientific fields corroborates the suggestion made by Leavy and Hourigan (2021) regarding the “importance to maintain a balanced and more expansive view of the work of scientists” (p.417).

Regarding the scientist’s activity in the drawings, the results also denote the influence of the pandemic context.

Like in the study conducted by Quílez-Cervero et al. (2021) and Leavy and Hourigan (2021), students' descriptions incorporated references to activities like searching/discovering a vaccine against COVID-19. Although this context seems to have contributed to expanding the notion of a scientist's work, students' knowledge of scientific practices seems to be limited. Indeed, in-depth descriptions of the scientist's activity were the exception. Moreover, some descriptions seem to portray the activities conducted in the classroom, but not in the science community.

Is there any relationship between the presence of stereotyped images about scientists and the gender of students?

Results indicate differences according to the gender of the students. In general terms, drawings made by male students presented more alternative stereotyped indicators (male, old scientist, crazy hair and mythical stereotypes) than those made by girls. This trend was also evident in a study carried out in the Portuguese context (Martins et al., 2021), as well as in other countries (Chionas & Emvalotis 2021; Emvalotis & Koutsianou, 2018). In contrast to earlier findings (Christidou et al., 2012), however, there were no differences between boys and girls regarding the environment where the scientist is working (indoor/outdoor).

These trends may result from the influence of different agents of socialization. Besides parents' and peers' influence, mass media also has an important role in shaping students' views of science (Tintori, 2017). Moreover, several international studies have shown that students' conceptions are influenced by films, series, books, and magazines where a stereotypical image of scientists is conveyed and reinforced (Buldu, 2006; Steinke et al., 2007). However, the student's exposure to these different agents of socialization is not the same between gender, which can explain why boys have more stereotyped views of scientists than girls. Therefore, we suggest future research to understand how students' images are shaped, which sources of information are more relevant and contribute to more informed views among girls.

Is there any relationship between the presence of stereotyped images about scientists and grade level?

There were also differences among student grade levels. As in other investigations (Bozzato et al., 2021; Chambers, 1983), an association was detected between the grade level and the appearance of stereotypes in the drawings. However, the association depended on the type of indicators: first, the number of standard stereotyped indicators increased as students advanced grade level; second, students in the fifth grade tended to represent fewer alternative indicators and greater diversity of research fields and scientific activities.

The reduced number of stereotypical images of scientists among students in grades 1 and 2 may be due to the specific characteristics of the Portuguese educational curricula. In the first cycle, science is taught in Environmental Studies, which includes contents from the History of Portugal, Physical and Human Geography, and different fields within the Natural Sciences (biology, physics, mineralogy, astronomy). In addition to the minimum hours of the Environmental Studies subject, only 3 hours per week, evidence indicates that teachers in the first years of schooling pay little attention to science compared to other subjects. This is especially relevant in the first two grades, where the main concern of many teachers is to focus on helping students develop their knowledge of reading, writing and math. So, although the Environmental Studies subject starts in grade 1, it is reasonable to think that only in grade 3 or 4 do students begin to confront representations of science more frequently. Moreover, introducing a Natural Sciences subject in the fifth grade promotes, or at least does not dilute, stereotypes already created about the image of scientists, such as wearing lab coats and eyeglasses and being surrounded by symbols of knowledge and relevant captions. However, the greater exposure to scientific activities within the scope of the Natural Sciences discipline, as well as the greater maturity of the students, contributes to reducing alternative images and broadening the STEM disciplines portrayed, as well as the type of scientific activities.

Conclusion

The present study sought to investigate Portuguese primary school students' images of scientists and their work. Portuguese students participating in this study tended to report the same stereotyped image of scientists described in other countries. Moreover, students' knowledge seems to be limited to a few fields of specialization and to be influenced by the pandemic context experienced during the DAST application. The results also showed differences according to the student's gender and grade level that may result, among other factors, from the influence of the atypical organization of the Portuguese education system in the first years of schooling. These findings suggest that teachers should promote a more realistic and humanized view of the scientist and scientific activity. Considering the evidence that many teachers share the same stereotype as children (Milford & Tippett, 2013; Moseley et al., 2003; Valente et al., 2018), one of the great challenges is to improve initial and continuous training of teachers. This training should not only demystify possible stereotypes the (future) teachers themselves might have, but also raise awareness of the importance of working with students on both science content and the nature of scientific activity.

Teacher training should also increase the confidence and autonomy of these professionals to plan and implement strategies that promote more informed views of the scientific enterprise among elementary students. Among the various possible strategies, we highlight the importance of promoting discussions about science and scientists, as well as the establishment of partnerships between schools and scientific institutions/ scientists. The establishment of interactions between scientists and students must, naturally, seek to challenge the most stereotyped elements of the scientist's image. For example, it will be important to establish contact with researchers who develop part of their work in the field, thus seeking to portray a more diversified image of the activities and environments of scientific work. This study also suggests the relevance of further studies, namely with a larger sample and one that is representative of the entire Portuguese territory. Furthermore, future research could analyze, in more detail, other factors that may affect the images that students have of scientists or the impact that interactions between scientists and students might have on their images of scientists.

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