Research Article

Science Communication
2018, Vol. 40(6) 749–777

DOI: 10.1177/1075547018808025
journals.sagepub.com/home/scx
SAGE

From White Lab Coats and Crazy Hair to Actual Scientists: Exploring the Impact of Researcher Interaction and Performing Arts on Students' Perceptions and Motivation for Science

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Abstract

We examine the impact of researchers' interaction and drama-based techniques when learning science on students' views of scientists and motivations for studying science. We do so through mixed-methods in five secondary schools in three countries. Students changed their perception of scientists toward a less stereotyped image, particularly where their interaction with researchers was higher. Pupils' interest for scientific careers significantly increased where drama-based techniques were more inserted into the pedagogical approach. Promoting long-term interaction with scientists in school settings combined with embedded drama-based methods

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in science learning/teaching can contribute to reconstructing students' views on who can be engaged in science.

Keywords
art-based methods, public perception of scientists, stereotype, STEM

Introduction

In the era of digital technologies and significant socioecological changes, educating young generations in science, technology, engineering, and mathematics (STEM) to improve their skills and values for lifelong learning, such as reflexivity, collaboration, and communication, has been highlighted as a main concern (Demirel, 2009; European Commission, 2015). Young people's engagement in science through reasoning and critical understanding is expected to positively contribute to building innovative and democratic knowledge-based societies, as argued by the European Union through the Responsible Research and Innovation framework in science education (European Commission, 2015). Furthermore, STEM trainings are expected to provide young people with more opportunities to deal with current and future occupational demands. The last European report on STEM jobs showed that demand from STEM-related professionals increased by 12% from 2000 to 2013 and was expected to grow by 8% until 2015 while all occupations were expected to rise by only 3% (Caprile, Palmén, Sanz, & Dente, 2015). STEM careers' recruitment, however, decreased dramatically in the last decade across Europe, and nowadays, despite the upturn, to increase the number of students—particularly girls—interested in pursuing a scientific career is still a priority at the policy level (Kearney, 2016). In this regard, it has been highlighted that the still prevalent socially perceived incompatibility of female gender roles in science can particularly discourage girls from studying STEM courses (Martinot, Bagès, & Désert, 2012).

Efforts to reverse this trend have often been addressed to produce more attractive curricular methods in science education, with a focus on inquiry-based learning (Kearney, 2016; Kudenko & Gras-Velazquez, 2016). In this sense, previous research has shown that arts-based techniques, and particularly drama, are useful for describing, exploring, or discovering scientific issues within inquiry-based learning projects (Dorion, 2009; Metcalfe, Abbott, Bray, Exley, & Wisnia, 1984). Furthermore, efforts to increase the attractiveness of scientific careers have also been directed toward breaking negative stereotypes around science and scientists. Indeed, an unappealing image of scientists perceived by students can potentially drive them away from considering STEM disciplines as career choices (Boylan, Hill, Wallace, & Wheeler, 1992; Cheryan, Master, & Meltzoff, 2015).

In this study, we examine if and how the establishment of a direct interaction between secondary school students and researchers who are at an early stage of their careers, together with the use of drama-based techniques for science learning, have an impact on students' stereotyped perceptions of scientists as well as on their motivations for studying STEM careers. To do so, we tested different techniques based on performing arts through a series of workshops in different European sociocultural settings. Specifically, we examine (a) whether students initially perceived a stereotyped image of scientists and showed interest in pursuing STEM careers. We then assess (b) whether such an image and motivation changed after participating in the workshops and (c) whether stereotypes were important in terms of scientific career choice, controlling by sex and case study.

Stereotypes and Engagement in Science Through Arts

Previous research shows that scientists are commonly depicted by children and adolescents as middle-aged or elderly males with crazy hair who wear white lab coats and eyeglasses; work in a laboratory; employ scientific tools, formulas, and equipment; and have a "eureka" moment while doing experiments (Chambers, 1983). This stereotyped perception of their look and work has been shared across Western countries for more than 50 years (Mead & Metraux, 1957). Even today, U.S. children draw more male than female scientists, though this trend has diminished in the past decades (Miller, Nolla, Eagly, & Uttal, 2018). Studies also document how children and adolescents perceive scientists' personality, such as the pertinent study of McNarry and O'Farrell (1971) in which high school students attributed unappealing traits to scientists such as being frightening, colorless, and stubborn. Even though stereotypes related to scientists' personality are not always negative, as for instance they are commonly perceived as more self-confident than nonscientists (McCorquodale, 1984), young people typically relate scientists to unattractive personal traits such as being unfriendly, serious, and crazy (Ruiz-Mallén & Escalas, 2012). Media has typically echoed and contributed to the consolidation of these generalizations and an overestimation of the characteristics of scientists' look, personality, and work, by offering to young people a simplified image of this group, making scientists different from ordinary people, including children and adolescents (Tintori, 2017).

Putting students in contact with scientists so that they can get to know the actual person who works in science and not the one represented in fiction has been suggested as a way to break negative stereotypes, particularly among girls (Finson, 2002). This was done, for instance, in a study conducted by Bodzin and Gehringer (2001) with primary school children that brought a female engineer and a male physicist into elementary schools. Each of them introduced themselves as a scientist, conducted a short experiment with the students, prompted questions, and responded to theirs. To assess the impact of this intervention, children were asked to draw a scientist before and after the visit. Overall, results showed a decrease in the number of stereotyped attributes depicted in the posttest, such as lab coats, eyeglasses or goggles, and male characters, suggesting that occasional interactions between actual scientists and children can positively change pupils' perceptions of scientists. This is particularly important for motivating students to learn science, as based on stereotypical activation theory (Wheeler & Petty, 2001) those who do not recognize themselves in the stereotypical image of scientists can potentially show inconsistent behavior in terms of their academic performance in STEM subjects. Moreover, even if students hold a positive image of scientists, it may not be enough to become interested in pursuing STEM careers because their attitudes toward science lessons seem to hold a deeper importance (DeWitt et al., 2013).

In this regard, applying drama-based approaches within science education can be useful to go beyond cognitive learning aspects and also work on the procedural, emotional, and motivational dimensions of learning (European Commission, 2015; Metcalfe et al., 1984; Ødegaard, 2003). For instance, in a study with primary school students in the United Kingdom, McGregor (2014) found how the use of theatrical techniques positively influenced their understanding of science by fostering pupils' creative thinking abilities among other skills. Another research through a multi-case study in U.S. primary schools, in which teachers introduced drama in their science lessons, highlighted that this approach fostered students' dialogic learning through embodied knowledge and the dramatic enactment of scientific concepts and phenomena. Such embodied meaning making was a powerful way to engage pupils with science (Varelas et al., 2010). Furthermore, drama has been applied to relate scientific topics to affective contexts of social, cultural, and intellectual discourse (e.g., playing stories of scientists), and to reflect on the role of science in such societal contexts, producing critical insights of science as a practice and of who does science (Ødegaard, 2003). All in all, the integration of both rational and emotional dimensions within science education using dramatic activities can provide a rich source of individual and collective experimentation and exploration (Baraúna-Teixeira &

Motos-Teruel, 2009), which in turn can affect students' perceptions of scientists and attitudes toward science.

In this study, we merge both approaches by asking what would happen if researchers had more continuous interactions with students through science learning activities that use performing arts: How would that affect both students' stereotyped perceptions of scientists and their motivation for pursuing STEM careers? We hypothesize that students' perceptions and attitudes toward scientific careers can change as a result of both interacting with actual scientists and experimenting science learning more creatively through drama techniques.

Method

Context of the Study

This study was part of the European Commission Horizon 2020 project PERFORM (www.perform-research.eu). From December 2016 to June 2017, our team worked with five public secondary schools in low-to-middle income neighborhoods in Barcelona (Spain), Bristol (the United Kingdom), and Paris (France). In each school, teachers were asked to involve a group of students (referred here as Perform group) in a set of workshops based on inquiry-based learning that used performing arts for pupils' creation and performance of short artistic shows on scientific topics of their interest. Participation was on a voluntary basis and 135 students were involved: 64 in Barcelona, 29 in Bristol, and 46 in Paris (see Table 1).

These workshops were designed and facilitated by two science communicators in each setting, and in Paris two actresses also participated. Science communicators invited the teachers of the involved schools to participate in the workshops, as well as researchers at early stages of their careers (e.g., PhD students and postdocs). Fifteen teachers and 20 researchers (including both females and males at each school) voluntarily participated and helped students include scientific content in their performances through dialogue, reflection, and discussion. While the researchers regularly attended the workshops in Bristol and Barcelona, in Paris fewer researchers participated and were not present in every workshop.

In each school, we also involved in the research another group of pupils in the same school year, but in a different classroom, as a Control group (n = 123). Students in the Control group did not interact with science communicators or participant researchers.

We obtained informed consents from all participants, including parental consents from students.

Table 1. Description of the Participant Schools and Individuals by Case Study.

Study site	Barcelona		Bristol	Paris	
Secondary school	INS Santa Eulàlia	IES Castellbisbal	Fairfield High School	Collège Les Toupets	Collège Marie Curie
Location	Terrassa	Castellbisbal	Bristol	Vauréal	Paris
Number of workshops (number of hours each)	7 (2 hours)	7 (2 hours)	2 (4 hours) + 2 (2 hours)	8 (2 hours)	8 (2 hours)
Perform group (age)	22 girls, 15 boys (15-17 years old)	17 girls, 10 boys (15-17 years old)	14 girls, 15 boys (13-15 years old)	15 girls, 6 boys (14-15 years old)	14 girls, 11 boys (14-15 years old)
Control group (age)	9 girls, 15 boys (14-16 years old)	8 girls, 12 boys (15-17 years old)	8 girls, 12 boys (13-15 years old)	15 girls, 21 boys (14-15 years old)	12 girls, 13 boys (14-15 years old)
Involved teachers	2 females; 2 males	1 female; 1 male	1 female; 1 male	5 females	2 females
Involved early career researchers	2 females; 1 male	2 females; 3 males[a]	7 females; 1 male	1 female; 1 male[b]	2 females

[a]Only participated in the two final workshops. [b]Only participated in the first workshop.

Workshops and Drama-Based Techniques

The project experimented with the three drama-based techniques with which the science communicators involved in each case study had previous experience. Stand-up comedy was used by Big Van Ciencia in Barcelona through developing short monologues in which students spoke directly to an audience and explained scientific contents through storytelling and the use of humor. Science busking was applied by Science Made Simple in Bristol through the production of short performances in a public space in which students explained scientific contents through the use of a practical demo. Improvisational theatre was applied by TRACES in Paris through the production of short science-based theatrical pieces, based on students' previous improvisation exercises. These diverse drama-based techniques were employed because of their potential to approach science in creative, embodied, and active ways, fostering motivational aspects related to the role of science in society (Ødegaard, 2003). Although the artistic techniques differed across case studies and therefore the learning activities also differed accordingly, the workshops were designed by following a common methodological protocol. In doing this, we aimed to develop similar learning outcomes that mainly consisted of improving students' transversal skills (e.g., critical thinking, creativity, among others) and fostering positive perceptions and attitudes toward science and scientists (Heras & Ruiz-Mallén, 2017).

In all cases, students were organized by teachers into groups of three to five and were guided by the science communicators to create and perform their own short scientific monologues, science busks, or theatrical plays about the scientific topics they were interested in. Throughout the sessions, the common methodological protocol established the combination of reflection activities about several science dimensions (i.e., the links between science and societal challenges, the scientific method, critical thinking, and gender and ethics in science) with performance activities adapted to each artistic practice (see Figure 1 for more details about the global description of the workshops). These reflection activities, in which students interacted with the science communicators and the early career researchers involved, were common to the three case studies and were meant to generate critical reflections among students and feed the artistic pieces with scientific content and the resultant discussions. Through these activities, students were invited to (a) select a scientific topic, (b) think about related research questions, (c) look for reliable information to answer them, and (d) reflect on ethical and gender issues related to the selected scientific topics. Performance activities, in turn, included different theatrical and creative exercises to train students' performance skills and to support them in developing and rehearsing their science-based artistic piece.

The workshops, including the last one in which students performed their creations, lasted 12 hours in Bristol, 14 hours in Barcelona, and 16 hours in Paris. These differences were mainly defined by (a) technique requirements in Paris, where the collective format of the performance required an extra rehearsal of the whole group, and (b) time restrictions in Bristol, where the school provided less time for the intervention.

In Barcelona, activities were distributed in six workshops of 2 hours each and a last 2-hour session for rehearsal and performance of the scientific monologues. In each workshop, the first part of the session was devoted to a reflection activity, while in the second part students worked on their scientific monologues, bringing to the creative work the reflections and contents worked during the first part. Students worked at home on the development of their script for the monologue, which they improved and rehearsed with the science communicators and researchers during the last session. The final performance produced in each school was a 30-minute show introduced by a presenter (performed by one or two students) and enacted at the events hall of each school, in front of other students. Each show combined between seven and nine short monologues (2-4 minutes) about a research question on the selected scientific topic each (e.g., nanoscience, lab-on-a-chip, drugs), in

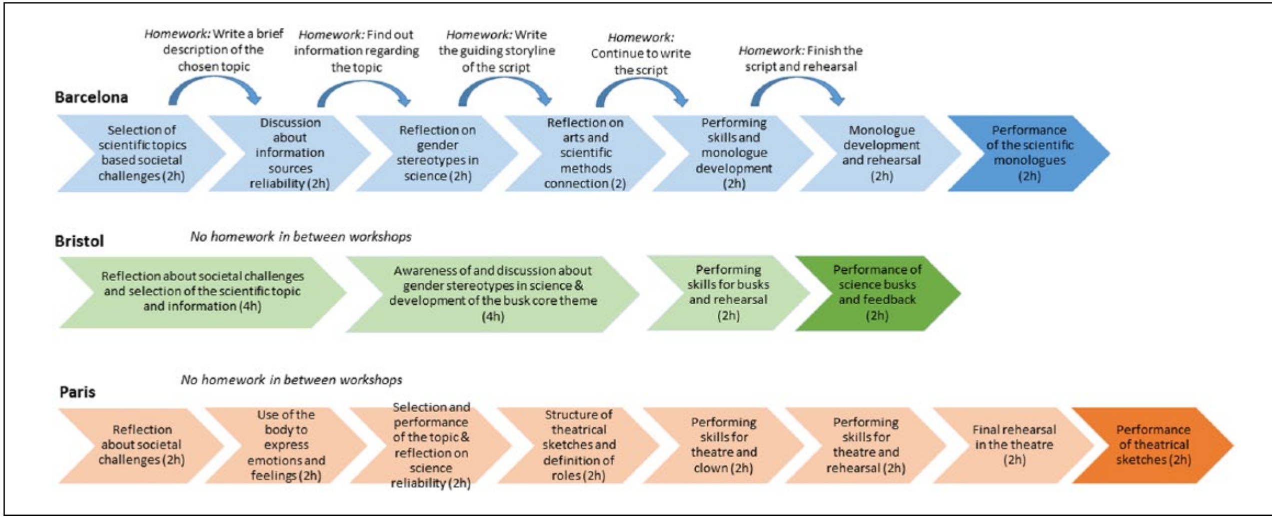

Figure 1. Description of the workshops by case study.

which students mixed stand-up comedy with theatrical dialogues. Two groups chose for their monologue a topic directly related to the work of a participant researcher.

In Bristol, the activities were distributed in two workshops of 4 hours and two workshops of 2 hours. The reflection activities were introduced during the first two sessions, while the last two were devoted to busk creation, rehearsal, and performance. The busk creation included the exploration of different props (e.g., objects) that students could introduce in their performance to represent their scientific contents and related research questions. The final performance produced was composed of seven short busks (2-5 minutes) that were performed simultaneously in the hall of the secondary school at lunch time, capturing the attention of other students and engaging small audiences into short discussions afterwards. Each busk illustrated one scientific concept (e.g., bioengineering, taste, optical illusions, sound) that was directly or indirectly related to the field of research of the participant researchers.

In Paris, the activities were distributed in seven workshops of 2 hours each and a last session of 2 hours for performing the resulting theatrical pieces. Such distribution included three workshops combining the reflection activities with theatrical exercises and four sessions completely devoted to training performing skills and to the creation of the theatrical play and its rehearsal. Indeed, the improvisational theatre approach applied in Paris was more demanding in terms of body presence and choral coordination than the stand-up comedy and science busking, which were more focused on individual verbal and script elements. In this sense, most of the tasks and exercises conducted to produce the theatrical pieces required Parisian students to express their research questions with the body, for example, through mimicry of ideas and emotions. Also, differently to the other case studies, in Paris, the science reflection activities were led by science communicators, while the theatrical activities and creation were led by two actresses. These aspects placed a more salient focus of the pedagogical approach on artistic and aesthetical elements and in the leading role of the actresses (as directors) than in the other case studies. As a result, two 10-minute theatrical pieces were created in each school and performed collectively by each group of students, in front of other students from the school. Two pieces were played at a municipal theatre and the other two at the secondary school events hall. Each theatrical piece was composed of several sketches focused on students' research questions about seven different topics (e.g., optical illusions, effect of drugs, animal conservation, Internet security). Only two topics were directly connected to the research of the involved early career researchers.

Table 2. Number of Students Participating in Data Collection Methods Used in Each Case Study.

Study site	Barcelona		Bristol		Paris		Total	
Group	Perform	Control	Perform	Control	Perform	Control	Perform	Control
Pre-survey	64	42	29	20	46	61	139	123
Post-survey	63	42	22	19	41	49	126	110
Both pre- and post-survey	56	34	19	10	40	43	115	87
Observations	64	—	29	—	46	—	139	—
Focus group	20	—	8	—	19	—	47	—

Data Collection and Analysis

We collected data for this study in each school through pre- and post-surveys with both Perform and Control groups. We also conducted systematic observations during the workshops involving Perform students and a focus group in each school after the workshops also with Perform students (Table 2).

Before the intervention, we conducted a pre-survey with 262 students from both the Perform (n = 139) and Control groups (n = 123): 106 from Barcelona, 49 from Bristol, and 107 from Paris. Afterwards, students were invited to answer a post-survey, but we only received responses from 105 pupils in Barcelona, 41 in Bristol, and 90 in Paris (126 and 110 in Perform and Control groups, respectively). All of them were asked to write down three characteristics that came to their minds when thinking about somebody working in science, as well as to mark with an "x" if they agreed with the following statement: "The idea of studying a scientific career makes me feel motivated."

In order to explore whether Perform students had a stereotyped image of scientists and whether this view changed after the intervention, we analyzed the list of characteristics that students reported in both surveys (n = 115 Perform students). To do so, we followed a similar proceeding as the one used when working with free-listings (Pennec, Wencelius, Garine, Raimond, & Bohbot, 2012). We calculated the total number of items reported by all the students and then analyzed the frequency of occurrence of every item reported. We also categorized the reported items into five categories: (a) Look, related to the appearance of people working in science; (b) Personality, including emotional and cognitive traits of scientists' predicting behavior; (c) Skills, referred to abilities and competences attributed to scientists; (d) Work, including items related to research activities and fields of study, symbols of research, work environment, and challenges; and (e) Training, including attributes related to STEM studies and careers. We created a new variable for the stereotyped image that was coded as 1 if the trait reported was stereotyped and 0 otherwise. Following previous literature on scientists' stereotypes, this variable only included characteristics related to look, personality, and work (Chambers, 1983; McCorquodale, 1984; McNarry & O'Farrell, 1971; Ruiz-Mallén & Escalas, 2012). We then calculated the percentage of students who reported at least one stereotyped trait, by category, and explored whether there were differences according to pupils' sex and case study before and after the intervention by using Fisher's exact tests.

To examine Perform students' motivation toward scientific careers, its relation with the stereotyped image of scientists, and the potential impact of the intervention on it, we only considered those students who provided answers to both questions in the pre- and post-surveys (n = 111 Perform students). We first calculated the percentage of students who acknowledged feeling motivated when thinking about studying STEM careers. We then compared students' answers between the pre- and the post-surveys by case study and sex, separately, and analyzed the differences between the results of both surveys by using Wilcoxon ranking tests. We calculated the variation of students' answers between the pre- and post-surveys and explored whether this variation was significantly different between Perform and Control groups (n = 87 students in Control group) by using Wilcoxon ranking tests. Finally, we ran factorial logistic regressions between students' motivation and the three stereotyped categories (e.g., personality, work, and look) in the Perform group controlling by case study and sex.

Survey data were complemented with qualitative data from observations and focus groups. We conducted systematic observations during the workshops to collect information on the interaction between Perform students and researchers, as well as on the students' overall engagement in the activities. We used an Excel spreadsheet to record observations from each workshop in each school by using three categories: (a) the role of researchers during the activities, (b) students' dialogic interactions with researchers, and (c) students' emotional engagement (Heras & Ruiz-Mallén, 2017). After the workshops, we conducted a focus group in each school with 8 to 10 Perform students who were selected for representativeness of gender and performance groups. Students were asked to share their experiences on (a) the interaction they had with the researchers during the workshops and (b) their views and attitudes toward science in general. We did not ask focus group participants for their particular interest in pursuing a STEM career because we had already done so in the survey and at the individual level. Focus groups were recorded and transcribed.[1]

We analyzed data gathered from both systematic observations and focus groups by using a directed approach to content analysis (Hsieh & Shannon, 2005). Content analysis was chosen among the different analysis traditions as it helped us explore students' answers in detail and identify themes, patterns, and meanings related both to their experience of the workshops and their views of science. The analysis was supported by the software Atlas.ti and guided by three categories: (a) students' perception of and (b) students' interaction with participant researchers, and (c) students' attitudes toward science.

Limitations

Potential limitations of this study mainly relate to the small size of our sample in each case study and the role of potential omitted variables. In this last regard, it is possible that our estimations were biased by individual and contextual factors influencing perceptions and attitudes toward science and scientists from which we did not have information about and consequently we cannot control for, such as students' previous interaction with scientists as well as their family background.

Moreover, we have no precise information about the type and amount of information that students in Perform and Control groups could have exchanged about the workshops, which may have biased some of our results. Also, design factors such as the difference of hours spent with each technique in each case study or the different participation of female and male researchers in each setting, for which we did not control due to the limited size of our sample, might have entailed additional bias.

Our sample included schools that slightly differed from low and middle socioeconomic backgrounds in three different countries, based on different reference standards. Such relativity has not made it possible to control for this variable in our statistical models, so we controlled by case study.

Results

How Did Students Perceive Scientists? Were These Images Stereotyped?

Before the intervention, 132 students out of the 139 surveyed in the Perform group did provide an answer when asked for the three main characteristics they had in mind when thinking of a scientist. From the seven who did not, three were from Paris, two from Barcelona, and two from Bristol.

The richness of perceptions associated with scientists was considerably high since students mentioned a total of 80 characteristics. Overall, the most common and first reported characteristics were *smart* or synonyms like *clever* or *intelligent* (52% of the items mentioned by all students), *lab coat* (17%), and *experimenting* (15%).[2]

Looking at the type of characteristics, the skills associated with scientists' jobs were the most reported: Overall, 60% of students listed at least one characteristic related to skills. Although these were mainly referred to being *smart, hard-worker*, and *persistent*, students also reported a considerable variety of competences such as being *logical, creative, knowledgeable, ingenious, self-critical, efficient, cautious*, and *responsible*, among others.

Items also referred to scientists' personality traits and characteristics of their work, which were reported by about 48% and 36% of respondents, respectively. Students perceived scientists' as *curious* and highly *motivated* people, who were sometimes *interesting* people but sometimes *boring, serious, crazy*, or *nerdy*, which in turn referred to stereotyped traits. Other reported personality traits identified as stereotypes were *inflexible, annoying*, and *introverted*. Nonstereotyped personality traits were also diverse and ranged from *calm* to *open-minded* or *funny*. A stereotyped image was also prevalent when referring to scientists' work, since *experimenting* and *laboratory* were some of the most cited traits in this broad category (15% and 4% of the words mentioned by all students).

Twenty-two percent of the students mentioned at least one trait related to scientists' appearance, which also included stereotypes. These stereotypes were, for instance, *lab coat, eyeglasses/goggles, old, grey hair*, and *man*. In contrast, only 1% of the students identified scientists as ordinary or people close to them (e.g., *normal* and *like my science teacher*). Finally, 3% of respondents mentioned at least one trait related to scientists' training. Pupils perceived scientists as people who have to *study hard*. Interestingly, only one student mentioned the achievement of a *scientific career* to become a scientist.

Overall, 51% of pupils mentioned at least one stereotyped characteristic of scientists. Significant differences existed between case studies ($\chi^2 = 7.66$; $p < .05$ in the Kruskal–Wallis tests), with the most stereotyped image among French pupils (68%) and the least stereotyped among those from Barcelona (45%). No significant differences were found according to gender: A similar percentage of boys (47%) and girls (54%) perceived scientists through the lenses of stereotypes.

How Did This Image Change After the Intervention, If It Did So?

In the post-survey 88 Perform students out of the 126 who answered the survey wrote at least one characteristic of scientists. Fourteen pupils in

Paris, 13 in Barcelona, and 11 in Bristol did not give any answer. Overall, in the three case studies together, students provided a considerable number of characteristics during the post-survey, 63 in total. As in the pre-survey, *smart* was the most frequently reported (Table 3). But differently than in the pre-survey in which the second and third most listed items were the stereotyped traits *lab coat* and *experimenting*, in the post-survey these were replaced by the nonstereotyped attributes *creative* and *persistent*. Although this general pattern was shared in Barcelona and Bristol, in Paris two stereotyped items remained in the post-survey among the three most frequently mentioned: *lab coat* and *goggles*.

Connected with these results, during workshops, we observed differences between case studies in the degree and quality of the interaction between participant researchers and pupils. In Bristol, the high number of researchers involved in the activities (eight) made it possible for each of them to support one group of three to five students. We observed that most of the researchers constantly interacted with the students throughout all the workshops (e.g., asking questions, leading discussions, supplying information and ideas). In general, students perceived researchers' participation as useful, as mentioned by these students in the focus group:

Interviewer: How was the interaction with the researchers?
Girl UK1114: They helped you
Boy UK1123: Yes, for our group it was fine, we kind of . . . it was normal

Similarly, in Barcelona, although the participant researchers in each school had two specific interventions, they adopted an assisting role during the workshops, actively supporting the science communicators in the activities (e.g., providing examples, taking notes, contributing to conversations among students). In turn, students generally paid attention to their interventions and welcomed their comments. They seemed curious and attracted by the figure of the researcher. During one of the focus groups in Barcelona, pupils referred to researchers' enthusiasm and other positive traits related to their personality, skills, work, and training, as shown in the following independent quotes:

> GirlSP2114: Also, they [the researchers] are people that are committed to their job and they like it. They explained to us everything very well and enjoyed it. Yes . . . [they did it] with much emotion

> GirlSP2202: I already knew that if you want to study science you need to put a lot of effort and with them [researchers] we could notice that. They seemed to

Table 3. Percentage of the Most Cited Words Over the Total Listed (>5%) by Case Study, Before and After the Intervention.

Total		Total		Barcelona		Barcelona		Bristol		Bristol		Paris		Paris	
Before	%	After	%	Before	%	After	%	Before	%	After	%	Before	%	After	%
Smart	53	Smart	41	Smart	61	Smart	55	Smart	66	Smart	45	Smart	33	Lab coat[a]	22
Lab coat[a]	17	Creative	16	Curious	20	Creative	17	Lab coat[a]	28	Creative	28	Hard-worker	22	Smart	20
Experimenting[a]	15	Persistent	10	Hard-worker	14	Persistent	14	Logical	14	Persistent	14	Lab tools[a]	22	Goggles[a]	20
Curious	13	Lab coat[a]	10	Experimenting[a]	13	Curious	9	Creative	14	Lab coat[a]	7	Like my teacher	20	Hard worker	11
Hard worker	12	Hard worker	8	Motivated	11	Patient	9	Goggles[a]	14	Serious	7	Teaching	13	Does research	11
Goggles[a]	9	Goggles[a]	8	Persistent	9	Motivated	8	Motivated	11	Chemistry	7	Creative	11	Curious	7

[a]Highlighted stereotyped characteristics.

have struggled a lot but also to enjoy much what they do. I think they have demonstrated us, me, that they are doing what they want, even if it takes them a lot to get there . . .

Very differently, in Paris more than half of the students worked without the help of the researchers in most of the workshops, and students expressed that they wished they had had more interaction with the researchers during the workshops. Only in two groups did the researchers become significantly more involved because students chose topics related to their research. In both schools, we observed few opportunities for direct interaction as the involvement of the two researchers was reduced to two specific interventions (i.e., introduction of their research in the first workshop and co-facilitation of one activity in the third workshop). Researchers' spontaneous participation was low because they adopted a passive role. As one of them informally told us during one of the workshops, researchers felt they lacked the skills for interacting with adolescents in a school context. Parisian students confirmed these observations in the focus groups, as shown in the following quote:

Interviewer: Did the fact of seeing and interacting with researchers change your perception of the scientists?
GirlFR1108: Well, no. In fact we have not seen them that much
BoyFR1105: No, we have not
BoyFR1203: At the beginning they talked, but then they were looking at us
GirlFR1108: And without real contact [it was not possible] to know more about what she was doing, her real job . . .

Despite these observed differences, when looking at the global picture of the characteristics reported by students, we found a statistically significant decrease in the percentage of pupils listing one or more stereotypes across the three case studies (Table 4). Interestingly, such diminution was more significant in the case study with the highest number of participant researchers and interaction, Bristol ($p < .05$), than in Barcelona and Paris ($p < .1$), and Bristolian students particularly reported less stereotypes related to look traits ($p < .05$). We also observed this reduction in the Control group, but to a lesser extent (results not shown).

Following what these surveys showed, qualitative data contributed to explaining this decrease in Perform students' stereotyped view of scientists. Indeed, students participating in one of the focus groups in Barcelona reflected on this change in their perceptions and associated it

Table 4. Percentage of Students Who Reported at least One Stereotyped Characteristic of Scientists and Results of the Fisher Exact Test Between the Pre- and Post-Survey by Case Study.

Type of stereotyped trait	Barcelona (n = 56)		Bristol (n = 19)		Paris (n = 40)	
	Before	After	Before	After	Before	After
Total	44.6%	28.6%*	52.6%	26.3%**	67.5%	45.0%*
Personality	23.2%	23.2%	15.8%	15.8%	15.0%	10.0%
Work	16.1%	5.4%*	10.5%	0.0%	40.0%	12.5%***
Look	10.7%	5.4%	36.8%	10.5%*	32.5%	35.0%

Note. Statistical significance is given by *$p < .1$, **$p < .05$, ***$p < .01$.

with the exaggerated, pre-conceived image of scientists they had before interacting with the researchers during the workshops, which was generally based on the one showed by media. The following piece of discussion reflects this:

> Interviewer: With the workshops and the monologues, did your perception of science change at all?
> GirlSP2122: Yes
> GirlSP2210: Sure
> GirlSP2122: You know, the typical (scientist) that you see in the movies, with the glasses . . .
> BoySP2113: Right, when someone says 'scientist' and you think of a guy that spends 8 days within a lab, white coat and it's really crazy.
> GirlSP2206: I think of Einstein, but he was like that, he wore white coat and glasses.
> GirlSP2122: But actually, they are common people.

Similarly, during the focus group their peers in Paris also identified that the prevailing stereotyped view was mostly due to media, as shown here:

> GirlFR2110: When you mention to me (the word) 'scientist' it directly comes to my mind the picture of an old person with a white coat in a laboratory
> BoyFR2203: Yes, but this comes from comics
> Many of them: Yes, it is clear.

No statistically significant differences were found in the students' stereotyped views between girls and boys.

Table 5. Percentage of Perform Students Answering Positively to the Question "The Idea of Studying a Scientific Career Motivates Me," Before and After the Intervention, by Case Study and Sex.

Perform students	Group (number)	Motivation Before	Motivation After	Wilcoxon ranking test
All	Perform (n = 111)	21.6%	28.8%	1.23
By case study	Barcelona (n = 54)	31.5%	29.6%	−0.208
	Bristol (n = 18)	11.1%	27.8%	1.246
	Paris (n = 39)	12.8%	28.2%	1.67*
By sex	Girls (n = 66)	21.2%	30.3%	1.19
	Boys (n = 45)	22.2%	26.7%	0.488

Note. Statistical significance to Wilcoxon ranking tests between pre- and post-surveys is given by $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$.

Were Students Motivated Toward Scientific Careers and How Did Motivation Change After the Intervention, If It Did So?

Overall, before the workshops students' interest in studying a scientific career was low, as only 22% of Perform students reported that this idea was motivating for them. When comparing responses before and after the intervention, pupils tended to provide more positive answers to this question, thus showing a positive, but not statistically significant, trend in their motivation for pursuing STEM careers (from 22% to 29%). This trend was not observed in the Control group, and we found significant differences between Perform and Control students in this regard ($p < .1$).

Differences between Perform pupils before and after the intervention were only statistically significant for Parisian students, as their motivation for studying a scientific career increased from 13% of pupils in the pre-survey to 28% in the post-survey ($p < .1$; Table 5). Interestingly, Paris was the case study in which we observed students more actively involved in the design of the theatrical pieces through playing and performing while reflecting and reasoning about the selected scientific topics. Such interest and engagement might explain the raise in their motivations, as we discuss later.

In Bristol, although not significantly, motivation toward scientific careers also increased from 11% to 28%. This was the case in which a higher number of researchers interacted with students and this situation may have encouraged them to appreciate the value of studying science. Only two students in the focus group perceived their interaction with researchers as superficial because the researcher of their group could only attend the first workshop and was replaced by another one who was not fluent in English. As this student partly reported in the focus group:

> Girl UK1118: She [the researcher] didn't do anything (. . .) Like after the first session just talking to her, she kind of just like moved away.

In contrast, the percentage of students motivated for scientific careers in Barcelona slightly decreased after the workshops, although not significantly, from 31% to 30%. In the focus group students acknowledged they realized that science was something difficult that required a lot of hard work, as the following quotes show:

> Interviewer: What is your view about science right now?
> GirlSP1102: None
> GirlSP1108: That it's hard, but well . . .
> BoySP1113: Why?
> GirlSP1108: Well, it's not going to be easy, right?
> BoySP1113: But there are two kinds of science, right? There is the one we were taught here. . . . But then, maybe when you go into a lab you don't practice it as we do here, I mean, like a fun thing and so on. When you go into a lab, I think it is more of stressing yourself.
> GirlSP1122: That's obvious, they are not going to be laughing around, you know?
> GirlSP1206: Well, I think everyone can get to learn it, but with effort.

We did not find statistically significant differences in the motivation to pursue STEM careers between girls and boys.

How Did the Perceived Image of Scientists Relate to Such Motivation?

Finally, we ran logistic regressions between Perform students' motivation to pursue a scientific career and their stereotyped image of scientists both before and after the workshops to identify potential relationships linked to our intervention (Table 6). Results showed statistically significant associations between students' motivation and their stereotyped image of scientists' work (p = .02) and look (p = .05) before the workshops, but in opposite directions. While listing stereotyped traits of scientists' work was positively associated with pupils' interest in pursuing a scientific career, perceiving their look as stereotyped was negatively related to their motivation for studying STEM careers. When controlling by case study, we also

Table 6. Logistic Regression Between Perform Students' Motivation for Studying a Scientific Career and Their Stereotyped Image of Scientists, Before and After the Intervention, Controlling by Sex and Case Study.

	Motivation	
Explanatory variables	Before	After
Stereotyped personality	−0.90	−0.87
Stereotyped work	1.22**	−0.84
Stereotyped look	−1.39**	−0.96
Boy	.054	0.05
Barcelona	^	^
Bristol	−0.12	0.11
Paris	−1.15**	0.36

Note. Statistical significance is given by $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$; ^omitted variable because of collinearity.

found that Perform students' motivation in Paris was significantly lower than in Barcelona before the intervention.

In contrast, and interestingly, after their participation in the workshops we did not find these same significant relationships. This implies that, in general, the relationship between students' stereotyped image and their motivation toward scientific careers changed in a meaningful way over the course of the intervention.

Discussion

Quantitative and qualitative analysis exploring associations between the intervention and stereotyped image of scientists and motivation variables reveal three interesting patterns that deserve discussion about related education and communication challenges and their implications for young people's understanding and interest in science.

The Still Prevalent Stereotyped Image of Scientists Among Young People

Before the intervention, in general, both girls and boys depicted a stereotyped image of scientists that was mainly prevalent when referring to their look and work; *lab coat* and *eyeglasses/goggles*, as well as *experimenting* and *laboratory*, were the most cited traits in these categories. They also referred to unappealing traits of scientists' personality like *crazy, boring*, and *nerdy* while only few of them identified scientists as ordinary people. When reflecting about where this image comes from during the focus group, students associated it with the one showed by the media. Indeed, these beliefs about the universal traits and attributes shared by people who work in science have been largely and traditionally reinforced by fictional characters (Long, Boiarsky, & Thayer, 2001). And these findings suggest that the way science is mainly portrayed by the media still contributes to unattractive stereotypes about scientists' work, showing, for instance, that scientists work in isolation and conduct dangerous experiments (Tintori, 2017). In this sense, students mentioned traits related to the narrow view of science shown by the media, such as those situating scientists working in *isolation* or in specific areas mainly related to natural and experimental sciences like *biology* and *chemistry* and requiring *lab tools* or a *microscope*. By focusing on this simplified image of science, the media can be indirectly hiding the wide variety of jobs that can be reached through the study of STEM careers and, therefore, limiting the interest of young people for other scientific careers outside this scope. Such a distant and reduced representation of science by the media that is affecting students' perceptions of scientists might also contribute to explaining why students' motivation for pursuing STEM careers was so low across the three case studies before the intervention. If students view scientists as being far from "normal people," they might see themselves as being far away from "the science world." Besides media, however, there are other factors narrowing the representation of scientists and fostering the salience of stereotypes about them. For instance, in the case of engineers and computer scientists, the way that their own institutions communicate their work and present their working environment (e.g., computer science departments decorated with science fiction books and *Star Trek* posters) is suggested as also strengthening this stereotyped image and particularly discouraging girls from these professions (Cheryan et al., 2015). In this sense, there is a need to continue broadening the representation of the scientific field by the media and academic institutions themselves, beyond scientists' look, to shift the still prevailing stereotyped image among young people. Finding ways to alter these stereotypes so as to increase young peoples' identification with scientists and their interest in science within the school context leads us to our second discussion point.

The Reduction of Stereotypes After Interacting With Researchers

Our findings suggest that bringing researchers to the classroom to support students through an inquiry-based learning process applying artistic methodologies could be associated with a decreased percentage of students who describe scientists with stereotyped traits. This change was particularly significant in the case of Bristol, which might be explained by the positive effect of having the highest number of researchers participating in the workshops and helping students in the creation of their busks with the highest level of interaction. In contrast, in Paris, although stereotypes were also significantly reduced, the percentage of students perceiving a stereotyped image of scientists was still considerably high afterwards (almost 50%). French students held the most stereotyped view of scientists before the intervention, which might explain why it was more difficult to amend it. Also, it was the case study with the lowest number of researchers involved, being only two in each school and one participating only in the first workshop.

Yet this result also reveals that the mere presence of researchers in a school might not be enough to overcome students' simplified beliefs about them. Differences in the level of reduction of stereotyped views among case studies might be also due to the type and quality of dialogic interactions between pupils and researchers during the activities. In Bristol and Barcelona, as well as in a previous study showing the positive impact of occasional researcher interaction with students (Bodzin & Gehringer, 2001), researchers actively interacted with and assisted students, while in Paris researchers adopted a more passive role. Parisian researchers felt they did not have the skills to interact with young people in their classrooms, which might explain their passivity. And this attitude may be perpetuating unappealing stereotypes that imply scientists' with shy and boring personalities and a lack of social skills (Tintori, 2017).

Students' preconceived images are affected not only by both cognitive and perceptive aspects (e.g., accuracy of their images according to previous knowledge and stereotypic vs. reasoned traits), but also by negative and positive attitudes (Scherz & Oren, 2006). In this sense, it is possible that the closer interaction between students and researchers that existed in Bristol, through which they seemed to share knowledge and also interest in the scientific topics of their busks, might have supported more positive images of science and scientists than in the other cases where such interaction was lower.

The Potential of Artistic Approaches and Researchers' Interaction for Realizing Motivations

As shown in our results, students' motivation to pursue a scientific career increased in Bristol and Paris after the interventions but such change was only statistically significant in the French case study. This is a remarkable result as in Paris students had less contact with researchers. However, and interestingly, Paris was the site where more time was devoted to implementing the intervention and to developing the artistic component of students' scientific performance, which might partly explain these results. The way the artistic approach and workshops were run by facilitators (using improvisational theatre to inquire about scientific topics) was a key factor influencing the emphasis of the pedagogical approach on embodiment. Indeed, and in contrast to the other case studies, two actresses guided part of the workshops and supported Parisian pupils in fostering body awareness and presence in stage while helping them understand scientific concepts and ideas. This embodied approach actively engaged students in using the "physical vocabularies" of movement, image, and sound, together with words, as modes of dialogue and communication (Nicholson, 2005). French pupils could thus engage with different expressive languages beyond the verbal by using performing resources and artistic elements to share and express ideas, feelings, and emotions related to each of the different scientific topics presented. This can be conducive to processes of "aesthetic engagement" (Bundy, 2003), in which students' experiences of the artistic form could contribute to the creation of meaning. We venture that the time devoted and the emphasis given to the artistic approach by the science communicators and actresses in the two Parisian schools fostered a different contact of students with science than in the other two cases, mainly due to students' appropriation of their research questions through embodiment. And, in turn, such embodiment might have positively influenced students' motivational aspects related to learning science basically because it fosters an affective dimension through which pupils can connect with and learn about science in a more emotional way. This experience represents a way of processing scientific contents and communicating science that was rare or completely absent in their schooling contexts. Theatrical exercises focused on embodiment that put to test other skills for science learning than those used when learning science through traditional teaching methods (e.g., use of the body vs. writing exercises). These may have enhanced the self-confidence of Parisian students who previously felt less competent in the science classroom and consequently less interested in science. Although students' perceived ability in science is not the focus of this article, this is a variable clearly affected by their stereotyped image of scientists (DeBacker & Nelson, 2000). Such drama techniques have the potential, at their best, to contribute to engaging diverse profiles of students by providing a different contact with science and going beyond stereotypes to open their views on who can do science, which in turn can affect their perceived ability in science (e.g., through motivation or identification).

This said, the lack of further significant changes in students' motivation for studying STEM careers in the other two case studies might suggest limitations related to the time devoted to the intervention and the capacity of the specific pedagogical strategies based on stand-up comedy and science busking to address the emotional dimension of students' motivation when learning science, and to counterbalance other factors affecting this motivation. In Barcelona, in turn, students might have been discouraged from studying scientific careers because they perceived from researchers that these careers and jobs require a lot of effort and perseverance, as shown in the focus groups. Such a difference might also be related to other factors for which we did not control, such as students' age because it may still be early for them to know the career they would like to pursue in the future. This could be specially the case in Bristol, as students were 12 and 13 years old. The different scientific topics selected by students in each case study can also be a key factor in driving interest and, consequently, motivation (Bathgate, Schunn, & Correnti, 2014). As reported in Schreiner and Sjøberg (2004), students prefer to study more contemporary and controversial socioscientific topics than those that are disconnected from their daily lives. It is thus possible that students who worked with scientific topics more connected to their reality enjoyed the intervention more and were more interested in learning than other students, and consequently increased their motivation for studying a scientific career.

Conclusions

In relation to our initial questions, our findings suggest that overall, students initially held a stereotyped image of scientists and showed low motivation for STEM careers across the three case studies. While this image became less stereotyped after interacting with researchers and participating in science education activities based on performing arts, students' low motivation remained in the case of Barcelona while Bristolian and Parisian pupils became more interested in STEM careers, although this change was only significant in Paris. Findings also show that stereotyped images of scientists' work and look were relevant for scientific career choice before the intervention, but such association was not significant afterwards, probably due to a decrease in the stereotyped image perceived by the students. Two important conclusions for addressing stereotypes around science and scientists and fostering interest in scientific careers at schools emerge from these findings.

On the one hand, our study reveals that involving actual researchers in a series of science learning activities using drama-based methods with students at their secondary schools partly reduces the stereotyped thinking that makes them associate scientists with unattractive attributes of their work and look. This is relevant for science education and communication practice because these findings can encourage secondary schools, but also universities and research centers, to seek out suitable strategies for bringing scientists to the classroom beyond sporadic visits and with traditional methods (e.g., giving a talk). By participating in drama-based activities conducted by teachers in tandem with science communicators/artists when teaching and learning science at school, researchers can work with students on scientific topics in a more creative, intimate, and inspiring way. This is important because the way researchers show themselves as individuals and talk about their daily routine in the scientific field could represent a "new" image that pupils can use to replace their existing beliefs and build their interests in science.

On the other hand, our experience suggests that such interaction with scientists at schools and the use of drama-based techniques was not always enough to positively influence students' attitudes toward STEM careers, which probably requires more time and more integration of the artistic dimension within the pedagogical approach. But it also suggests that involving researchers in science learning activities and embedding artistic techniques in a more holistic way than simply employing an artistic approach to communicate scientific content can have the potential to foster students' interest in science and related careers. We thus encourage future research to shed new light on how the interaction between researchers and students at the school context, supported by the use of different performing arts, can pedagogically nurture science teaching and learning to reinforce motivational outcomes in inquiry-based learning as well as bring students closer to the reality of research.

Acknowledgments

We thank the five participant schools and the students, teachers, and researchers involved in this study, as well as the science communicators implementing the workshops: TRACES (France), Big Van Ciencia (Spain), and Science Made Simple (the United Kingdom). We are also thankful to Morgan Jenatton for reviewing the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the European's Union H2020 research and innovation programme under Grant Agreement No. 665826: PERFORM "Participatory Engagement with Scientific and Technological Research through Performance." I. Ruiz-Mallén is also thankful to the Spanish government's Research Agency through a "Ramón y Cajal" research fellowship (RYC-2015-17676).

Notes

1. Further details on qualitative data collection are available from the authors.
2. The complete lists of items are available from the authors.

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