

RESEARCH ARTICLE

“To see ourselves as others see us”*: Post-primary school students’ drawings of scientists before and after participation in a career orientation programme

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The stereotypical image of a scientist has negative consequences in terms of promoting a perception of scientists and relevant careers that is both positive and realistic. This study employs a modified Draw a Scientist Test (DAST) to investigate the perceptions held by post-primary school students in Ireland about scientists and their work. Participants completed the DAST before and after partaking in a Career Orientation Programme that aimed to promote careers in science and portray scientists and their working life realistically. After completing the programme, participants’ drawings were less stereotypical, with fewer images of male scientist working alone. Drawings also reflected activities the participants did throughout the programme, suggesting that first-hand experience can broaden perceptions of scientific careers.

Keywords: Draw-a-Scientist-Test; Transition Year; Science Camp; Perceptions of Scientists; Career-Orientation

♦Received 31 July 2018 ♦Revised 27 September 2018 ♦Accepted 29 September 2018

Introduction

As in many countries, Ireland has a shortage of graduates with the appropriate skills in science, technology, engineering and maths (STEM) disciplines to meet the demand of the labour market (Walsh & Loxley, 2015). Intertwined with this issue is the low uptake of physical science subjects at school and consequently at third level which is affected by how people perceive science and scientists (Cakmakci et al., 2011). Unfortunately, the prevailing conception of a scientist is inaccurate and unrealistic. The predominant image is that of an elderly male scientist, with crazy hair, wearing a lab coat and glasses, working alone on some secret invention (Reinisch et al., 2017). This image negatively influences students’ subject choice, third-level course preferences and ultimately their career path (Lee, 1998).

Challenging the stereotypical image of a scientist among post-primary school students, and in particular girls, is important as they face decisions about subject choice and career pathways (Farenga & Joyce, 1999). The stereotypical conception of a scientist exists also among some pre-service and in-service teachers (Finson et al., 1995). It may be difficult for some teachers and schools to provide a realistic image of a scientist and associated careers, when they themselves may have limited access or experience interacting with scientists in the workplace (Perry & Ball, 1998).

In combatting such trends, informal science education offers an alternative vehicle to broaden and improve the accuracy of students’ perceptions of scientists. The authors are science public engagement professionals with experience in science, teaching, and both formal and informal science education; in addition, they work in a university setting with access to scientists working in academia and industry. Thus, the authors created an opportunity for post-primary school students (aged 15-16 years) in the Transition Year (TY), to experience the working life of scientists in Ireland.

The TY represents a unique feature of the Irish post-primary educational system, in which students can choose to take a curriculum-free year after completing the first three years of post-primary (Junior Cycle) and before commencing the final two years of post-primary education (Senior Cycle). The Department of Education provides a broad set of guidelines to direct the TY. These guidelines promote “*Education through experience of adult and working life as a basis for personal development and maturity*” (Department of Education and Science, p.4, 1993). As such, an important element of the TY is work experience. Through participation in work experience, students may revise their original perception of a particular career path or reconsider a path previously dismissed as unattractive (Clerkin, 2012). Identifying and securing appropriate science work placements for students in the TY can be challenging. The issue of insufficient numbers of students pursuing science at third level to meet the STEM sectors employment needs runs parallel to this. Thus, the authors aimed to address both concerns simultaneously by creating a bespoke programme for students in the TY seeking authentic work experience in science. This paper

* “To see ourselves as others see us” – a quote from Robert Burns’ poem ‘To a Louse’

investigates if the TY students' perception of scientists becomes more aligned with reality after participating in a work experience programme.

Theoretical Framework

Our perception of scientists starts in early childhood, with children of primary school age envisaging a scientist in a stereotypical way (Fung, 2002). A person's experience of their science teacher at school (Türkmen, 2008), along with the manner in which scientists are portrayed in books (McAdam, 1990), movies (Barnett et al., 2006), on the internet (Schummer & Spector, 2007) and in the general media (Tan et al., 2017; McCarthy, 2015) all influence our perception of scientists. For many people, their own sense of self may contrast strongly with their perceived image of scientists. Thus, the stereotypical image of a scientist may be discouraging. If people cannot relate any aspect of their sense of self with their perception of a scientist, their likelihood of pursuing science is severely diminished (Bennett & Hogarth, 2009).

To investigate people's perception of scientists, Chambers (1983) developed the DAST. The test itself is uncomplicated and in its most basic form prompts the participant to draw a scientist. Recent DAST studies show that typical stereotypes of scientists still prevail (Reinisch et al., 2017). The DAST instrument has its limitations and criticisms. The biggest concern with the DAST is whether it actual reports the participants' conception of a scientist, or merely a common representation of a scientist. Some studies conclude that drawings alone are insufficient (Ehrlén, 2009). To overcome this limitation, more recent versions of the DAST prompt the participant to explain their drawing (Reinisch et al., 2017).

Interventions to improve the accuracy of the public's perception of scientists are desirable. Informal science education is an effective mechanism of improving the competence, knowledge, skills and attitudes of people towards science (Kim & Dopico, 2016). Participation in a dedicated science camp has the potential to refine and reshape participants' perceptions of scientists more positively and broadly (Farland-Smith, 2009). Research shows that students who participate in a weeklong science-focused camp are more likely to pursue STEM careers than their peers who do not (Kong et al., 2014).

In this Action Research (AR) project, we investigate the following research question: *How does the career orientation programme (COP) influence TY students' perceptions of scientists?*

Methods

Programme Overview

The weeklong COP has an overarching goal to increase students' positive attitudes towards science and give them a realistic experience of the working life of a scientist. An overview of the structure and content of the COP in both AR cycles is presented in Table 1. The programme combines traditional laboratory sessions in physics, biology and chemistry with workshops that focus on communication, innovation and team-working skills, highlighting the breath of skills required in scientific professions.

Table 1. Overview of the structure and content of the Career Orientation Programme for both cycles of the study. Changes to the content of the programme in cycle 2 made after evaluation of cycle 1 are highlighted in blue

COP Schedule: Action Research Cycle 1					
	Monday	Tuesday	Wednesday	Thursday	Friday
Morning	Registration & Pre-DAST	Biology Lab Session (Exploring bacteria and making hand-sanitizer gel)	Visit to Industry Site (Contact lens manufacturing)	Physics Lab session (Light: reflection and refraction)	Poster session Special break (ice-cream prepared with liquid nitrogen)
Mid-morning	Team working workshop (build a tower from newspapers challenge)	Chemistry Lab Session (Anodising Aluminium)	Career talks & Course Information session	Chemistry Lab session (using spectroscopy to solve a murder mystery)	Feedback session & Post-DAST
Afternoon	Science Debate on the topic of raw materials	Biology Lab session (Water health analysis)	Biology Lab session (PCR Gels and Microbiology plates)	Communication workshop (using improvisation techniques)	
Late-afternoon	Physics Lab session (Build your own generator)			Preparation time for poster session	
COP Schedule: Action Research Cycle 2					
	Monday	Tuesday	Wednesday	Thursday	Friday
Morning	Registration & Pre-DAST	Interview skills workshop	Chemistry Career Talk	Physics Lab session (The physics of sound)	Poster session
Mid-morning	Team working workshop (build a tower from newspapers challenge)	Biology Career Talk	Visit to Industry Site (pharmaceutical manufacturer)	Chemistry Lab session (using spectroscopy to solve a murder mystery)	Special break (ice-cream prepared with liquid nitrogen)
Afternoon	Science Debate on the topic of raw materials Physics Career Talks	Chemistry Lab Session (Anodising Aluminium)		Engineering-Design workshop (Crystal Drop Challenge)	Feedback session & Post-DAST
Late-afternoon	Physics Lab session (Build your own generator)	Biology Lab session (Water health analysis)	Biology Lab session (PCR Gels and Microbiology plates)	Preparation time for poster session	

In addition, there are dedicated career orientation workshops in which students learn from scientists (postdoctoral researchers, teaching faculty and graduate students) about third level courses and careers options. Although the COP is hosted in a university setting, we aim to expose participants to the broad range of career options available to those pursuing science, and not to limit the focus to scientific careers in academia alone. As such, the programme embeds links to industry where possible, most explicitly in the form of a site-tour of a local scientific industry. All aspects of the programme are designed to engage the students, challenge their existing perception of science and broaden their first-hand experience of science.

The Education and Public Engagement (EPE) team that lead the programme, treat it as an evidence-based innovation that can be enhanced through AR, whereby the EPE team act as the AR practitioners. After each cycle, the EPE team reflect on the feedback from the students and volunteer scientists (researchers, teaching faculty and graduate students) to identify areas for improvement in the next cycle. In this particular study, the EPE team sought to understand the participant's perception of scientists before and after participating in the programme. The EPE team hypothesised that although the participants had a positive disposition towards science, having applied to participate in the COP, their perception of scientists may be limited and stereotypical. The EPE team hypothesise that exposure to real scientists and scientific work experiences throughout the COP, would promote a more realistic perception of scientists among the participants.

Selection of participants

The programme is open to all students in the TY nationwide. To recruit participants for the programme, the COP was advertised on the university website and through the national science teaching professional association. Those interested were requested to submit an application form. A panel (consisting of the EPE team, the chief-technical officers of each of the science departments and the manager of the Faculty of Science and Engineering) then selected students for the programme based on merit. That is, the panel select those students who have a genuine interest and aptitude towards science. In cycle 1 of the AR study, 31 students participated in the programme (12 Female; 19 Male). In cycle 2, the number of students was reduced to 14 (7 Female; 7 Male). The majority of applicants had little or no experience of science beyond what they experience in school. Therefore, there is an opportunity to investigate their perception of scientists and to improve the accuracy of this perception through the COP.

The Draw a Scientist Test (DAST)

We used a modified DAST test as used by Reinisch et al. (2017) to reveal student's perception of scientists before and after taking part in the COP. This version of the DAST, requests participants to:

"Imagine that tomorrow you are going on a trip (anywhere) to visit a scientist in a place where the scientist is working right now. Draw the scientist busy with the work this scientist does. Add a speech bubble, which tells what this scientist might be saying to you about the work you are watching the scientist do. Label the drawing."

Furthermore, the DAST prompts the participant to explain their drawing:
"What is the scientist in your drawing doing?"

This version of the DAST has several advantages. In the case of unclear drawings, the researcher does not rely solely on the participants' drawing skills but can use the written text to lessen the ambiguity. Additionally, compared to the original DAST (Chambers, 1983), this modified DAST prompts the participant to give more detail and thus allows the participant opportunity to give a more comprehensive account of their perception of a scientist.

Participants completed the pre-DAST on the first morning of the programme, prior to commencing any workshop sessions and completed the post-DAST on the final day of the programme after all workshop sessions were complete. In the first cycle, participants had 15 minutes to complete the DAST and an unlimited amount of time to complete the post-DAST. This apparent discrepancy in drawing time occurred only for practical reasons; to adhere to the timetable it was necessary to impose a restriction for the pre-DAST but not so for the post-DAST test. However, during the second research cycle, participants were given approximately 25 minutes to complete both the pre- and post-DASTs to remove this discrepancy. Participants were provided only with a pen/pencil to complete the DAST; no colouring pencils or other materials were provided.

The DAST was analysed in accordance with the framework outlined by Reinisch et al. (2017) under three categories – *appearance*, *location* and *activity*. The 'appearance' category refers to the physical appearance of the scientist drawn in the DAST and was examined under ten sub-headings: Sex, Number of scientists, Clothes, Protective clothing, Glasses, Headgear, Beard, Bald or half-bald, Crazy hair and Fictive.

The 'location' category refers to the location of the scientist as drawn in the DAST. The sub-headings in the location category were: Surroundings (Inside/Outside/Both), Technology (e.g. computers), Knowledge (e.g. books, formulas), Research instruments (e.g. pipettes) and Danger (e.g. smoke).

The 'activity' category refers to the type of work the scientist is doing in the DAST. The sub-headings in activity category were:

- Inquiry: Depiction of scientist doing manual, analytical or task-orientated activities such as using a microscope
- Artistic-Engineering: Depiction of a scientist doing creative activities such as inventing a new instrument
- Social-teaching: Depiction of a scientist involved with knowledge transfer such as teaching or supervising students
- Conventional: Depiction of a scientist doing administrative tasks such as accounting
- Social-Scientific exchange: Depiction of a scientist involved in networking activities such as attending a conference
- Unrealistic: Depiction of a scientist doing fictive activities such as creating a secret substance

These categories and sub-headings are the same as those outlined by Reinisch et al. (2017) with the following exceptions. The sub-category 'crazy hair' was included to reflect the fact that many of the DASTs depicted persons with wild or crazy hair in line with the common stereotype of a scientist. Also, we did not attempt to make any interpretation of the age of the scientist drawn in the DASTs. The presence or absence of a sub-category feature within a drawing was recorded as 1 or 0, respectively and the totals (absolute frequency) calculated. We also calculated the percentage frequency of each relative to the sample size.

Results

AR Cycle 1

Analysis of the DASTs in AR cycle 1 revealed that participants' conceptions of scientists verged on the stereotypical. As exemplified by Figure 1(a), the typical image of a male scientist, wearing glasses and a lab coat, pursuing solitary work with aspects of danger prevailed. However, the extent to which the participants' images were stereotypical varied, with some examples of less stereotypical images (Figure 1(b-d)). In some instances, the gender and clothing of the scientist was not deemed important as in Figure 1(b). In other cases, the scientist was not working in a typical laboratory setting (Figure 1(c)) or was working with another scientist (Figure 1(d)).

The results of the pre- and post-DASTs are detailed in Tables 2-4. Table 2 shows the frequencies for the depiction of each of the sub-categories of 'Appearance' in the pre-DASTs. While the majority of scientists depicted in the pre-DAST did not distinguish between male and female (Neutral 51.6%), more male scientists (41.9%) were drawn compared to female scientists (6.5%). However, the number of female scientist depicted increased slightly (16.75%) in the post-DAST. Another common feature that emerged was the depiction of a scientist working alone (pre-DAST 96.8%; post-DAST 96.7%). Interestingly, in the majority of images clothing was not seen as important (pre-DAST 54.8%; post-DAST 40%). However, when clothing was given importance, almost a third of participants in the pre-DAST and half of the participants in the post-DAST drew a scientist wearing a lab coat. While one participant drew a distinctively fictive scientist in the pre-DAST, there were no examples of fictive scientists in the post-DAST. Many other participants drew scientists that were either bald or half-bald (pre-DAST 16.1%; post-DAST 20%) or having crazy hair (pre-DAST 16.1%; post-DAST 16.6%). Other stereotypical projections such as having a beard, wearing protective clothing or wearing headgear were present but not prevalent.

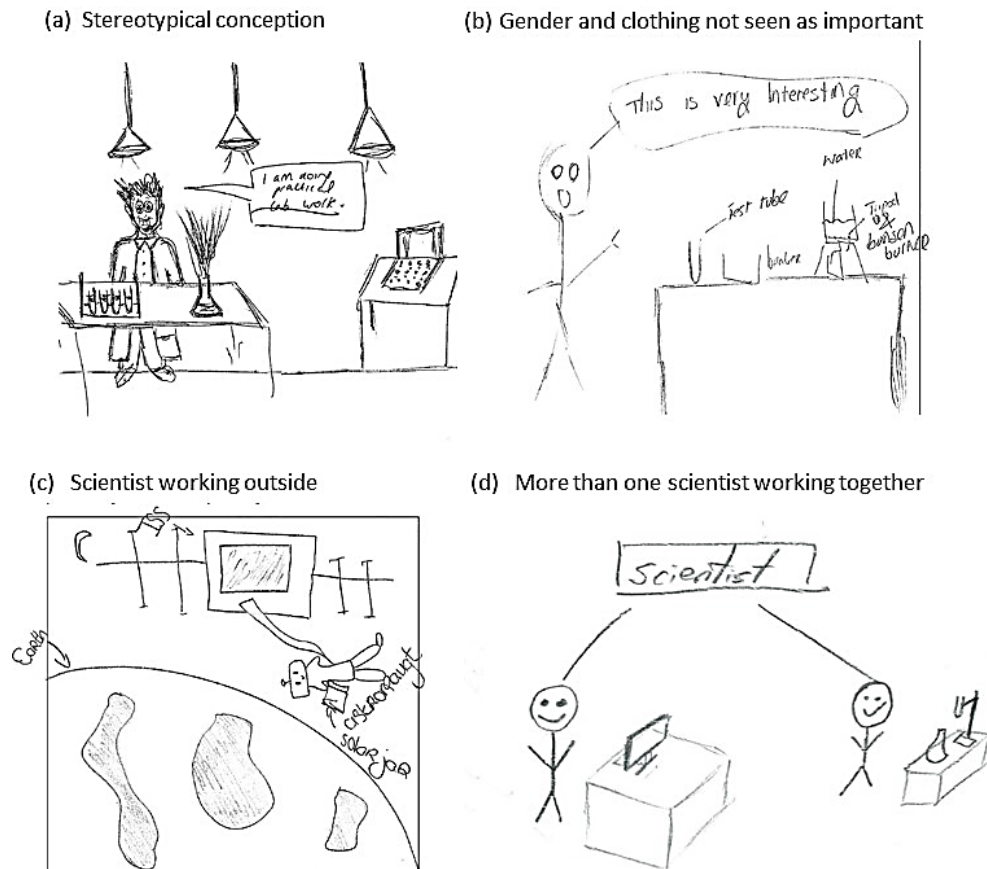


Figure 1. Pre-DAST examples of (a) stereotypical conception of scientists - male, wearing a lab coat, glasses/goggles, using scientific equipment and demonstrating danger [smoke]. Pre-DAST examples of less stereotypical conceptions of scientists where (b) the gender and clothing of the scientist is not seen as important, (c) the scientist is working outdoors (at the international space station) and (d) two scientist are working together

Table 2. Absolute and percentage frequencies of the pre-DAST and post-DAST responses during Cycle 1 for the category 'Appearance'

Category	Cycle 1: Pre-DAST (N=31)			Cycle 1: Post-DAST (N=30)		
	Absolute frequency			Absolute frequency		
	(Percentage frequency)			(Percentage frequency)		
Gender	<u>Male</u>	<u>Female</u>	<u>Neutral</u>	<u>Male</u>	<u>Female</u>	<u>Neutral</u>
	13 (41.9%)	2 (6.5%)	16 (51.6%)	10 (33.3%)	5 (16.7%)	15 (50%)
Number of scientists	<u>One</u>	<u>More than one</u>		<u>One</u>	<u>More than one</u>	
	30 (96.8%)	1 (3.2%)		29 (96.7%)	1 (3.3%)	
Clothing						
- Wearing a lab coat		10 (32.3%)			15 (50%)	
- Wearing everyday clothes		3 (9.7%)			3 (10%)	
- Clothing not seen as important		17 (54.8%)			12 (40%)	
Protective clothing		1 (3.2%)			4 (13.3%)	
Glasses		8 (25.8%)			6 (20%)	
Headgear		1 (3.2%)			0 (0%)	
Beard		1 (3.2%)			0 (0%)	
Bald or half-bald		5 (16.1%)			6 (20%)	
Crazy hair		5 (16.1%)			5 (16.6%)	
Fictive		1 (3.2%)			0 (0%)	

Table 3 shows the frequencies for the depiction of each of the sub-categories of 'Location' in the pre-DASTs. The perception of a scientist working indoors (pre-DAST 90.3%) was much more prevalent than that of a scientist working outdoors (pre-DAST 9.7%), a feature that persisted in the post-DAST. Slightly less than a third of participants drew items such as a computer to depict technology in the pre-DAST (29.0%) which decreased slightly in the post-DAST (13.3%). Fewer participants drew books, formulas or scientific terms that depicted 'knowledge' (pre-DAST 6.5%; post-DAST 13.3%). In contrast, the majority of participants drew research instruments (pre-DAST 80.6%; post-DAST 90%) with conical flasks and Bunsen burners featuring most often. Three participants in the pre-DAST (9.7%) and four in the post-DAST (13.3%) incorporated some element of danger in their image in the form of smoke or explosions, consistent with the stereotypical perception of scientists at work.

Table 3. Absolute and percentage frequencies of the pre-DAST and post-DAST responses during Cycle 1 for the category 'Location'

Category	Cycle 1: Pre-DAST (N=31)			Cycle 1: Post-DAST (N=30)		
	Absolute frequency			Absolute frequency		
	(Percentage frequency)			(Percentage frequency)		
Surroundings	<u>Inside</u>	<u>Outside</u>	<u>Both</u>	<u>Inside</u>	<u>Outside</u>	<u>Both</u>
	28 (90.3%)	3 (9.7%)	0 (0%)	30 (100%)	0 (0%)	0 (0%)
Technology		9 (29.0%)			4 (13.3%)	
Knowledge		2 (6.5%)			4 (13.3%)	
Research instruments		25 (80.6%)			27 (90%)	
Danger		3 (9.7%)			4 (13.3%)	

The pre- and post-DASTs of cycle 1 featured scientists involved in predominantly enquiry-based activities (pre-DAST 93.5%; post-DAST 83.3%). No participant depicted a scientist involved in enterprising, conventional tasks such as administration, or social-scientific exchange such as attending a conference.

Table 4. Absolute and percentage frequencies of the pre-DAST and post-DAST responses during Cycle 1 for the category "Activity"

Category	Cycle 1: Pre-DAST (N=31)	Cycle 1: Post-DAST (N=30)
	Absolute frequency	Absolute frequency
Enquiry	29 (93.5%)	25 (83.3%)
Artistic-engineering	5 (16.1%)	0 (0%)
Social-teaching	1 (3.2%)	2 (6.7%)
Enterprising	0 (0%)	0 (0%)
Conventional	0 (0%)	0 (0%)
Social-scientific exchange	0 (0%)	0 (0%)
Unrealistic	0 (0%)	1 (3.3%)

Across both pre- and post-DASTs, only three participants in total depicted a scientist involved in teaching. In the post-DAST data, there was one example of a scientist portrayed to be involved in an activity characterised as 'unrealistic'. The participant described the scientists to be:

"working in his secret science submarine, studying potions and creepy animals with his pet goofer" – Post-DAST Cycle 1

Some participants drew images of scientists engaged in more creative or engineering-based activities (pre-DAST 16.1%) such as designing a new rocket or developing new medicines to cure cancer. For example, one participant wrote about the scientists in his/her drawing saying that:

"One of them is working on a computer coming up with new ideas to push technology forward, new designs to help make machines more efficient. The other is working in a lab coming up with new medicines."–Pre-DAST Cycle1

Taken together, the DAST results of cycle 1 reported in Tables 2-4, portray a generally stereotypical perception of scientists in terms of their physical appearance, work location and activities while at work. It is interesting that even despite the fact that the participants have a genuine interest in science, their perception of a scientists is limited.

Images of school-related activities in pre-DASTs

A trend that emerged from the pre-DASTs was that participants frequently drew scientists involved in activities that they themselves would have experienced during the Junior Cycle science programme at school. Table 5 lists examples of such activities, the frequency of which these types of activities appeared in the pre-DASTs as well as the corresponding topic in the Junior Cycle science curriculum.

Table 5. The frequency of pre-DAST depicting a scientist involved in an activity that the participants are likely to have completed themselves at school as part of their science curriculum

Example of activity depicted in pre-DAST	Absolute frequency (% frequency) (N=31)	School science curriculum activity
"...separating a solute from a solvent by getting the solute by itself".	2 (6.5%)	Chemistry: Separating mixtures
"I'm measuring the acidity of chemicals".	4 (13.9)	Chemistry: Classification of substances
"I'm doing the experiment to prepare CO ₂ ".	1 (3.2%)	Chemistry: Preparation and properties of carbon dioxide
"The scientist is dissecting a sheep's heart".	1 (3.2%)	Biology: The circulatory system
"teaching everyone about the optic nerve".	1 (3.2%)	Biology: Human biology – the eye
"The scientist in this drawing is finding the conditions necessary for the germination of seeds -> water, oxygen and warmth."	1 (3.2%)	Biology: Reproduction and germination in plants

Images of scientists separating solutions (6.5%) and measuring the acidity of chemicals (13.9%) were most common. Overall, 32.3% of participants drew a scientist involved in a task that would be familiar to the drawer from their experience of school science. While ones perceptions of scientists derive from a range of places, this illustrates that students' experience of science at school is one factor that strongly influences their perceptions of scientists.

Images of COP activities in post-DASTs

While it is disappointing that a broader range of activities was not reflected in participants' post-DASTs, another trend did emerge. The post-DAST data frequently depicted scientists performing similar activities to that which the participants had done themselves throughout the COP. Activities such making contact lenses, testing horse DNA, and building electrical circuits

were illustrated in the post-DASTs and not in the pre-DASTs. These are activities that the participants had the opportunity to do themselves throughout the programme. Table 6 reports the frequency of these COP activities appearing in the post-DAST responses during cycle 1.

Table 6. The frequency of post-DAST depicting a scientist involved in an activity that the participants completed themselves during the COP and the corresponding COP workshop

Description of activity	Frequency (N= 31) (% Frequency)	Corresponding workshop in COP
Scientist making a generator or electrical circuit	2 (6.5%)	Physics laboratory workshop: Creating your own electrical generator
Scientist making contact lenses	1 (3.2%)	Industry site tour to contact lenses manufacturer
Scientist studying Staphylococcus aureus, horse diseases DNA	8 (25.8%)	Biology laboratory workshop: Investigating the prevalence of a viral disease of horses and testing for <i>Staphylococcus aureus</i>
Scientist studying bacteria, making hand sanitizer	3 (9.7%)	Gross Germs workshop: Learn about bacteria and antibiotics and make own hand-sanitizer
Scientist investigating patient overdose	2 (6.5%)	Spectroscopy in a Suitcase workshop: Solve murder mystery by measuring the concentration of aspirin in blood

One could argue that the participants drew these types of activities simply because it was at the forefront of their mind having completed the tasks recently. While this may be the case, it is noteworthy that some participants drew images of activities they did on the first day of the programme, while others drew activities they did on the last day. It is clear that taking part in the COP made an impression the participants. What is less clear is how long that impression will last. However, one participant drew an image of a scientist in a hospital reflecting her experience of visiting a hospital department earlier in the year, suggesting that these type of experiences may have a longer-term impact on participants. Notably, when participants drew activities they had done throughout the programme in their post-DASTs, the activities mainly belonged to either biology or chemistry with far fewer depicting activities related to physics.

Evaluation and Revision after AR Cycle 1

After evaluating the pre- and post-DASTs of cycle 1, the following aspects were identified for improvement. Firstly, the authors wished to broaden participants' perceptions of the activities of scientists particularly in the 'artistic-engineering' domain. To make participants more aware of the creative, artistic and engineering aspects of science professions, a workshop called 'The Crystal Drop' was included in the programme for cycle 2. This workshop asks participants to design,

built and test a device to protect a sugar crystal when being dropped from a height. Secondly, to improve participants' awareness of the importance of 'knowledge exchange' among scientists, a workshop on communication and interview skills was included in the programme. Thirdly, the authors wished to promote physics in particular, as in cycle 1 it was less popular than biology and chemistry. In cycle 1, the physics workshops involved experiments that students were likely to have complete previously in school, which proved disengaging. To engage students with physics more effectively, new workshops were developed around the concept of sound, of which participants would have had no prior experience. Changes to the content of the COP are highlighted in blue in Table 1. Finally, to increase the overall quality of experience for participants and to ease the process of facilitating the COP, the number of participants was decreased to 14 (7 Female; 7 Male).

AR Cycle 2

As in cycle 1, the pre-DAST for cycle 2 depicted many stereotypical images of scientists (Figure 2(a)), as well as unrealistic images of scientists (e.g. working with potions, Figure 2(b)) or images of scientists featuring aspects of danger (Figure 2(c)).

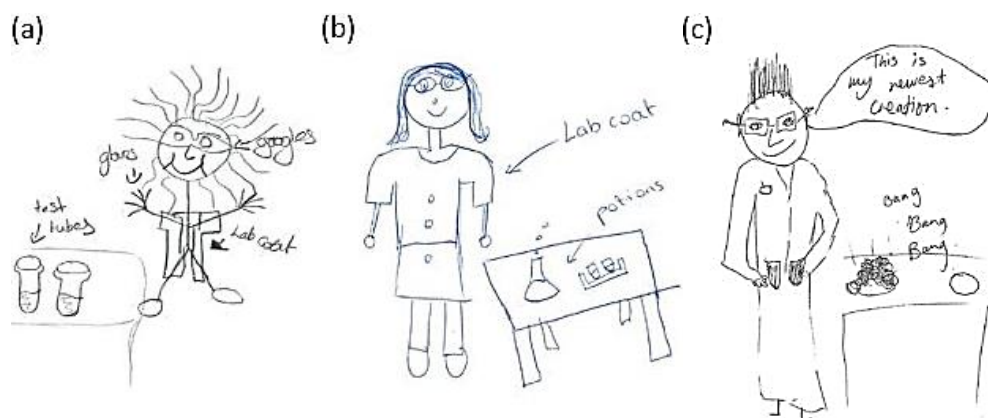


Figure 2. Examples of pre-DASTs in cycle 2 showing (a) a stereotypical conceptions of scientists, (b) an unrealistic conception of a scientific activity [using potions], and (c) an indication of danger/explosives

Table 7 shows the frequencies for the depiction of each of the sub-categories of 'Appearance' in the pre- and post-DASTs in cycle 2. In the pre-DAST, participants drew more male scientists than female scientists (64.3% versus 21.4%). While the number of female scientists drawn in the post-DAST remained approximately the same, the frequency of scientists being drawn as male decreased from to 35.7%. Correspondingly, the number of images in which gender was not important increased. In the pre-DASTs of cycle 2, scientists were depicted to work alone

exclusively (100%), while in the post-DASTs three participants depicted more than one scientist working together (21.4%). While these changes are promising, other stereotypical aspects prevailed such as wearing a lab coat (57.1%) and glasses (42.9%).

Table 7. Absolute frequencies of the pre-DAST and post-DAST responses during Cycle 2 for the category 'Appearance'

Category	Cycle 2: Pre-DAST (N=14)			Cycle 2: Post-DAST (N=14)		
	Absolute frequency (Percentage frequency)			Absolute frequency (Percentage frequency)		
Gender	Male	Female	Neutral	Male	Female	Neutral
	9 (64.3%)	3 (21.4%)	2 (14.3%)	5 (35.7)	4 (28.6%)	5 (35.7%)
Number of scientists	One		More than one	One		More than one
	14 (100%)		0 (0%)	11 (78.6%)		3 (21.4%)
Clothing						
	Wearing a lab coat			8 (57.1%)		
	Wearing everyday clothes			2 (14.3%)		
	Clothing not seen as important			4 (28.6%)		
Protective clothing	2 (14.3%)			1 (7.1%)		
Glasses	6 (42.9%)			6 (42.9%)		
Headgear	0 (0%)			1 (7.1%)		
Beard	0 (0%)			2 (14.3%)		
Bald or half-bald	1 (7.1%)			3 (21.4%)		
Crazy hair	3 (21.4%)			0 (0%)		
Fictive	0 (0%)			0 (0%)		

Table 8 shows the frequencies for the depiction of each of the sub-categories of 'Location' in the images drawn of scientists in the pre- and post-DAST in cycle 2. The perception of a scientist working indoors dominated in both tests, with no examples of scientists working outdoors. Similar to the outcome of cycle 1, participants drew a few examples of technology and knowledge and drew several examples of research instruments in both the pre- and post-DASTs in cycle 2.

Table 8. Absolute frequencies of the pre-DAST and post-DAST responses during Cycle 2 for the category 'Location'

Category	Cycle 2: Pre-DAST (N= 14)			Cycle 2: Post-DAST (N= 14)		
	Absolute frequency (Percentage frequency)			Absolute frequency (Percentage frequency)		
Surroundings	Inside	Outside	Both	Inside	Outside	Both
	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)
Technology	2 (14.3%)			2 (14.3%)		
Knowledge	3 (21.4%)			2 (14.3%)		
Research instruments	9 (64.3%)			12(85.7%)		
Danger	1 (7.1%)			0 (0%)		

Table 9 shows the frequencies for the depiction of each of the sub-categories of 'Activity' in the images drawn of scientists in the pre- and post-DAST in cycle 2. There was a notable increase in the number of images depicting scientists involved in enquiry-based activities (64.3% in pre-DAST, 92.9% in post-DAST).

Table 9. Absolute frequencies of the pre-DAST and post-DAST responses during Cycle 2 for the category 'Activity'

Category	Cycle 2: Pre-DAST (N= 14)		Cycle 2: Post-DAST (N= 14)	
	Absolute frequency (Percentage frequency)		Absolute frequency (Percentage frequency)	
Enquiry	9 (64.3%)		13 (92.9%)	
Artistic-engineering	4 (28.6%)		4 (28.6%)	
Social-teaching	2 (14.3%)		1 (7.1%)	
Enterprising	0 (0%)		0 (0%)	
Conventional	1 (7.1%)		0 (0%)	
Social-scientific exchange	0 (0%)		0 (0%)	
Unrealistic	1 (7.1%)		0 (0%)	

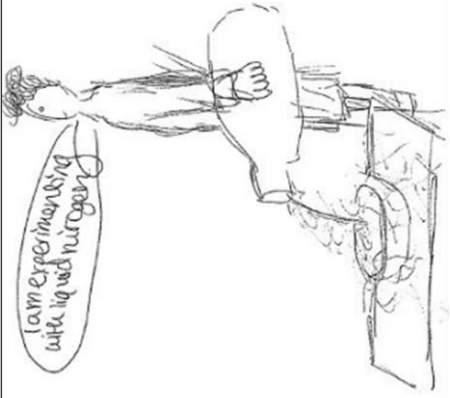
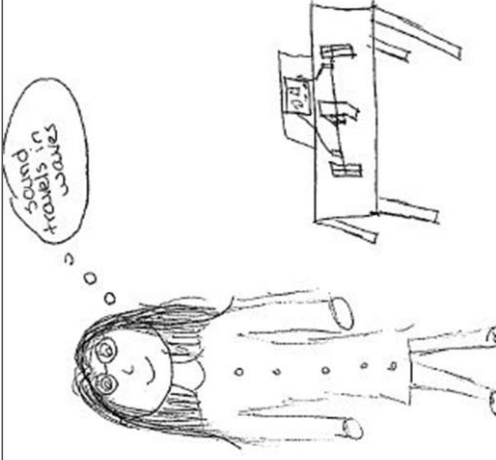

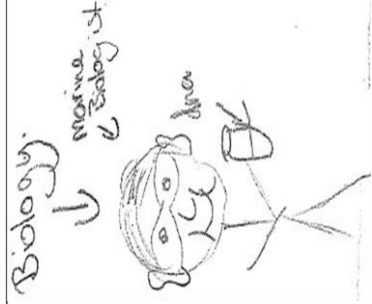

In the pre-DAST of cycle 2, many of the participants' statements about the activity the scientist in their drawing was doing were vague with no obvious links to their school science curriculum. For example, "*She is doing chemistry experiments*" and "*He is looking at some machine to see the results of his experiment*". However, there were also examples in the pre-DASTs where participants described their scientist as doing an activity that that could be categorised as "Artistic-engineering", such as

"The scientist is creating compounds and mixtures to test as alternatives to other medicines. The scientist is thinking about the applications of his developments to improve the efficiency and improve the world."

As in the post-DASTs of cycle 1, the analysis of cycle 2 showed many images of scientists involved in COP activities as shown in Table 10.

In terms of influencing the participants' perception of the work activities of scientists, there was no example of 'scientific exchange' in the pre- or post-DASTs despite the addition of a workshop based around communication skills. Although the number of images depicting 'artistic-engineering' activities stayed the same, the number is noteworthy with more than one-quarter of participants depicting such activity (28.6% in both pre- and post-DASTs).

Table 10. The frequency of post-DAST depicting a scientist involved in an activity that the participants completed themselves during the COP during the second cycle and the corresponding COP workshop

Example of drawing		Frequency (N = 14)	Corresponding workshop in COP
(a)		6	Making ice-cream with liquid nitrogen
(b)		3	Physics laboratory session: The properties of sound
(c)		2	Chemistry laboratory workshop: Anodising aluminium
(d)		2	Biology laboratory workshop
(e)		1	Spectroscopy in a Suitcase workshop: Solve murder mystery

Discussion

Previous studies have shown that science camps similar to the COP presented here are successful, at least to an extent, in impacting the long-term career goals (Bischoff *et al.*, 2008) and scientific literacy (Foster & Shiel-Rolle, 2011) of participants. The objective of this study was to investigate if the COP influenced TY students' perceptions of scientists. The authors are aware that perceptions are notoriously resistant to change (Finson *et al.*, 2006) and that this intervention is only a week in duration. Despite these limitations, after two cycles of AR the data suggests that the programme does broaden certain aspects of the participants' perceptions of scientists. In both cycles of the AR, the number of images depicting male scientists was less in the post-DAST than in the pre-DAST test. Correspondingly, the number of images depicting either female scientists or images in which the gender of the scientist was unimportant increased. In this regard, it appears that the participants' changed their perception of the gender of a scientist slightly after the COP. In future AR cycles, the EPE team will record the ratio of male to female scientists (postdoctoral researchers, teaching faculty, graduate students) involved in the COP and analyse the DASTs in light of this.

While the perception of a scientist working alone persisted after the COP in cycle 1, there were more examples of scientists working together after the COP in cycle 2. The COPs in both AR cycles had a distinct focus on team working. The COP in cycle 2 included an additional activity involving teamwork (The Crystal Drop workshop) which proved particularly engaging. Perhaps, this additional workshop reinforced a new perception of scientists, one in which collaboration and teamwork are integral to the activities of scientists.

The COP did not alter participants' perception that scientists work solely indoors. On reflection, this resistance to change may not be surprising. While, the COP included access to scientists working in industry and academia, both groups work in laboratory or manufacturing environments, perpetuating the stereotype. Future AR cycles may address this by including an element of science fieldwork. Similarly, the post-DAST did not report any marked increase in participants' awareness that scientists are active in activities involving enterprise or scientific exchange. On the final day of the COP, participants presented posters on a given topic and became active in scientific exchange themselves. However, we may not have expressed explicitly enough that 'real scientists' disseminate their research at conferences in a similar way. Also, the EPE team noted that the COP might be reinforcing some stereotypes unintentionally. The perception of a scientist wearing a lab coat and glasses persisted in the post-DASTs of the AR cycles. The COP places a large emphasis on safety, a message echoed strongly on the site tours to industry. Therefore, in some cases such as this COP, trying to alter the stereotypical perception of a scientist wearing a lab coat and glasses is not appropriate.

The main success of the COP was that the participants' perception of the tasks that scientists do expanded after the programme. Before partaking in the COP, participants' pre-DASTs depicted

images of scientists doing vague tasks (AR Cycle 2) or tasks they themselves had done previously in school (AR Cycle 1). After the COP, participants had collected a breath of new science experiences and reflected these in their post-DASTs. This result is encouraging, as it highlights the power of practical and hands-on activities in altering participants' perceptions.

Conclusions

This study showed that post-primary students' in the TY have a stereotypical perception of scientists and their work. This stereotype exists even amongst a group who were positively disposed towards science, having elected to take part in a science COP voluntarily. The intervention was a weeklong programme that aimed to challenge participants' existing perception of science and broaden their first-hand experience of science. While the programme was not successful in changing participants' perceptions across all criteria, certain aspects of their perception did become more accurate after partaking in the programme. Participants were less likely to draw images of scientists in which the scientist was male and working alone after taking part in the programme. Furthermore, participants' drawings after the programme reflected a broader set of scientific tasks which they themselves gained first-hand experience of throughout the programme.

Acknowledgments

This publication has received support through the Synthesis and Solid State Pharmaceutical Centre, which is funded by Science Foundation Ireland (SFI) and co-funded under the European Regional Development Fund under Grant 12/RC/2275

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