Journal of Science Teacher Education

ISSN: 1046-560X (Print) 1573-1847 (Online) Journal homepage: https://www.tandfonline.com/loi/uste20

Fijian Pre-Service Teachers' Ideas about Science and Scientists

Runaaz Ali Sharma & Eileen Honan

To cite this article: Runaaz Ali Sharma & Eileen Honan (2020): Fijian Pre-Service Teachers' Ideas about Science and Scientists, Journal of Science Teacher Education, DOI: 10.1080/1046560X.2019.1706904

To link to this article: https://doi.org/10.1080/1046560X.2019.1706904

Published online: 06 Jan 2020.

JOURNAL OF SCIENCE TEACHER EDUCATION
https://doi.org/10.1080/1046560X.2019.1706904

Routledge
Taylor & Francis Group

Check for updates

Fijian Pre-Service Teachers' Ideas about Science and Scientists

Runaaz Ali Sharma and Eileen Honan

College of Humanities and Education, Fiji National University, Suva, Fiji

ABSTRACT
This paper reports findings from a small study with Fijian pre-service teachers about their perceptions of science and scientists. No known study of this nature has been conducted in Fiji nor in other Pacific Island Countries. The study drew on previous studies using Draw-A-Scientist Test as well as critiques of the instrument using qualitative methods associated with critical literacy approach to understand the relationship between Fiji school science curriculum and pre-service teachers' knowledge of science and scientists. 88 pre-service teachers participated in this study. Data collection included participants' drawings and written descriptions of scientists, notes taken during group discussions about their knowledge of science and scientific activities, and transcripts of interviews with some of the participants. While the findings resonate with similar studies conducted elsewhere, they have particular significance in a Pacific context where countries are attempting rapid technological transformations.

KEYWORDS
Nature of science; scientist; draw-a-scientist test; Fiji; pre-service teachers

Introduction and background

Like many other countries in the Global South, Fiji is grappling with issues associated with climate change, post-industrial capitalism, and the geopolitical upheavals of the 21st Century. The Fijian economy is rapidly changing from one characterized by aid dependency, agriculture, and subsistence lifestyles to one that is technologically rich, with a focus on improving trade imbalances. The International Council of Associations for Science Education (ICASE) has argued that "improving teaching and learning in STEM education has become an economic factor in developing countries, emerging economies, and in long established economies such as Europe and the United States" (Kennedy & Odell, 2014, p. 248).

School science globally is seen as the foreground for the development of a robust understanding of the Nature of Science (NOS). This understanding would enable school leavers to look at:

> socio-scientific issues and evaluating what is fruitful, plausible and meaningful in the 'scientific' arguments presented—able to use scientific knowledge to make informed personal and societal decisions. Students would leave with an awareness of the role and status of scientific knowledge, an appreciation of its history and development, an understanding of the process of scientific inquiry and the awareness that the people who engage in science are part of that society and influenced by it. (Science Learning Hub- Pokapū Akoranga Pūtaiao, 2011)

CONTACT Runaaz Ali Sharma runaaz.ali@fnu.ac.fj College of Humanities and Education, Fiji National University, Suva, Fiji

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/uste.

Having a population that is able to make these informed decisions is critical to small island states such as Fiji, where a focus on sustainability in an environment affected by climate change realities is critical (Crossley & Sprague, 2014).

There are many variations of how one views and defines NOS. What is common to all of these is that scientific knowledge involves imagination and creativity because it is a human endeavor. Scientific knowledge is subjective, tentative and involves the use of a variety of methods. Additionally, scientific knowledge is developed through a social process and therefore is not a product of solitary work (N. G. Lederman, Antink, & Bartos, 2014).

N. G. Lederman et al. (2014) and Tala and Vesterinen (2015) point out that a good understanding of NOS and scientific inquiry reflect the qualities of scientific literate citizens. In particular, descriptions of science and scientists could be a window through which perceptions about NOS could be assessed. According to Clough and Olson (2008, p. 143), NOS includes issues such as "what science is, how it works, the epistemological and ontological foundations of science, how scientists function as a social group and how society influences and reacts to scientific endeavors". The conceptions of science, scientists, scientific activity and NOS, are interrelated (Christidou, 2011).

In this paper, science refers to a subject of lifelong utility for all citizens. Science is "the process by which we increase and refine the understanding of ourselves and universe through continuous observation, experimentation, applications and verification." (Tomar & Achary, 2016, p. 1). It is a cumulative body of knowledge and systemized learning of and about the natural phenomenon and "a catalyst for social change and economic growth, and saving countless lives" (Ramirez & Cayón-Peña, 2017, p. 114). Hence, science is both a body of knowledge and a process of acquiring it (Tomar & Achary, 2016, p. 1).

The term scientists in this study, therefore, refer to people who do science, the people who are involved in the acquiring process. Scientists employ a variety of methods to make descriptions, explanations and predictions about elements of the phenomenon of nature that result in the formation of concepts and theories that can be challenged and modified in light of new evidence (N. G. Lederman et al., 2014; Tomar & Achary, 2016). Essentially, the divide of science into natural and human sciences is based on the differing processes employed by scientists. For instance, those scientists who study 'hard science' see science as something done in the laboratory, involving measurements and controlled repeatable experiments (Ramirez & Cayón-Peña, 2017). Studies suggest that an over-emphasis in education on hard sciences contribute to confirming stereotypes of scientists as working in areas such as chemistry, physics and molecular biology (Ramirez & Cayón-Peña, 2017).

In this context, it is in everyone's interest that pre-service teachers develop a robust understanding of science (Gogolin & Krüger, 2017). We argue that how pre-service teachers view science and scientists is a window to capturing their understanding of the NOS. Unraveling pre-conceptions about science, its nature, its usefulness, and its applicability will help us understand the type of science education pre-service teachers have received in their schooling. In turn, their understanding of NOS will have an impact on their future students, as they impart this understanding in their future classrooms. Knowledge of NOS is important for teachers because it reflects their attitudes toward science and their understanding about science and scientists (Reinisch, Krell, Hergert, Gogolin, & Krüger, 2017), which according to Christidou (2011), Jain, Lim, and Abdullah (2013), and McCarthy (2015) directly influences their students' views.

The relationship between perceptions of science and scientists is a well-documented area of research in science education (Mansour, 2015). There are arguments (Clough & Olson, 2008) that knowing what a scientist does can contribute to the knowledge of NOS. Numerous studies have been conducted with pre-service teachers about their conceptions of scientists including those by Milford and Tippett (2013), Mansour (2015) and Subramaniam, Esprívalo Harrell, and Wojnowski (2013).

However, no known study of this nature has been conducted in Fiji nor in other Pacific Island Countries. There is increasing attention being paid to the need for research in the Pacific (Fa'avae, 2018) that takes a critical view of education processes, policies, and approaches used in this region, but adopted from other countries. This paper responds to this call through using tools, methods, and ideas drawn from critical policy studies (Fairclough, 2013) and from critical literacy approaches to multimodal texts (O'Halloran, Tan, & Marissa, 2017; Van Leeuwen, 2015) to examine Fijian pre-service teachers' perceptions of science and scientists.

The findings of this study contribute to an understanding of the relationship between Fiji school science curriculum, pre-service teachers' knowledge of NOS, and the preparation of teachers who can develop this knowledge in their students.

Pre-service teachers' knowledge of NOS is affected by the science education that they have experienced in their schooling. Like many other countries in the Pacific and elsewhere, Fiji's history of science education began during the colonial years.

School science education in Fiji

Science education in Fiji began in the 1960s in secondary schools and was mainly imported from Britain and New Zealand. Science education in primary schools in Fiji formally began in the 1970s. The Pacific Regional movement in the 1970s and 1980s adopted a global approach to science education namely "science for all" which had two parallel goals—to prepare students for a scientific career and secondly to make scientific and technological knowledge accessible to all citizens for their everyday interaction (Muralidhar, 1997). There have been several curriculum development initiatives in the region since then. The National Curriculum Framework (NCF) is a recent curriculum reform in Fiji covering all years of school education (Ministry of Education, 2013). The NCF adopts a constructivist view of science education with a focus on process rather than content. It envisions that, through the study of science, students would be:

> empowered to make effective use of all five senses through self-discovery to collect information and investigate problems in a scientific manner. Children and students use the scientific research and investigation process to help them to question, understand, appreciate and respond to changes and interactions as they develop physically, spiritually, mentally and socially. As part of this process, they develop an understanding that all living things are interdependent, and they will appreciate that they are part of the living and non-living systems. (Ministry of Education, 2015, p. 44)

Reading the NCF through the lens of "critical policy studies" (Fairclough, 2013), it could be argued that the purpose of science education stated in the NCF is generalist and nonspecific, so it could be the description of science education from any curriculum written in the last 20 years across English speaking countries. Although there is mention of the appreciation of "the traditional use of science in their cultures" (Ministry of

Education, 2013, p. 44), there is little else to distinguish the Science curriculum as a distinctly Fijian curriculum.

The National Curriculum Framework also does not focus on the development of an understanding of the NOS. Perhaps the curriculum document assumes that, in learning science through a process approach, an appreciation of the NOS will be developed in learners. Abd-El-Khalick (2012) argues for an explicit reflective approach to the NOS studies which moves attention away from such implicit approaches of doing science to learn the NOS.

Moreover, the representations of scientists in the curriculum are minimal. Scientists are represented in the form of examples associated with the theories and laws associated with the concepts in the secondary school curriculum; for instance, mentioning of Isaac Newton while explaining the concept of gravity. On the other hand, in the primary school science curriculum textbooks, there is a section at the end of each topic where pictures of careers related to the topic are shown such as "botanists studying plants" (Ministry of Education, 2017, p. 17) or "a lab technician" studying about materials and matter (Ministry of Education, 2015, p. 79). However, the career of a "scientist" (Ministry of Education, 2015, p. 79) is described separately, giving the mistaken impression that botanists and lab technicians are not scientists. As well, these images are mostly of white men, giving another mistaken impression, that Fijians or women cannot have careers in science-related occupations.

To enter primary teacher education programs in Fiji, students only have to complete Year 10 (10th grade) science from their secondary schooling. Therefore most of the pre-service teachers knowledge about science and scientists are drawn from these primary school textbooks and some parts of the secondary school curriculum. Secondary schooling spans from Years 9–13 where, Basic science is compulsory for all the students upto year 10 (lower secondary) . From year 11(upper secondary), science (biology, chemistry and physics) is an optional subject not pursued by most pre-service primary school teachers.

In the next section, a brief description of the science education courses at the Fiji National University (FNU) is provided. Students enrolled in these courses participated in the research reported in this paper.

The nature of science in FNU pre-service teacher education

There are two compulsory science education courses in the first two years and an optional science education course in the final year of the three years Bachelor of Education Primary program at FNU. In both compulsory courses, students learn about NOS, as well as develop their scientific literacy. In both these courses, students also learn about the content and disciplinary knowledge as well as pedagogical strategies while the concepts of NOS and of scientific literacy are embedded across all topics. There is little local traditional and cultural knowledge in the pre-service science education curriculum; indeed, most of the reading materials for the courses are Australian or from the USA.

Given the relative lack of information about the NOS in the school science curriculum and the students' general lack of science education beyond Year 10, we wanted to collect information about their existing understanding prior to engaging with course content. Also, we were interested to see if pre-service teachers had any knowledge of local scientists and science as it is practised in Fiji. The following research questions guided the study:

(1) What are the perceptions of science and scientists held by pre-service teachers at the beginning of their programs?
(2) Do pre-service primary teachers demonstrate any knowledge of local science and scientists?

The methods used to answer these questions are described in greater detail below but focused on the use of three data collection tools. The first was the use of drawn images of scientists, which has long been considered as a successful way to examine perceptions of scientists (Christidou, 2011). Notes recording a whole class brainstorming session that preceded the completion of these drawings were consulted as well as semi-structured interviews conducted with some participants after the drawing sessions had been completed. An explanation for the use of the drawing method known as DAST (Draw a Scientist Test) follows.

Examining pre-service teachers' perceptions of science and scientists through drawings

DAST has a long history in research for eliciting students' and teachers' perceptions of scientists. Chambers (1983) is the original developer of the DAST. The effectiveness of the DAST has been demonstrated through numerous studies which have shown consistency in results over years of implementation. One aspect of these results particularly relevant in the current context of this study is the general stereotypical images of scientists as male and white. In critical literacy terms, these images are not neutral or transparent, but provide representations of societal and personal attitudes and beliefs (Janks, 2019).

For example, Rubin, Bar, and Cohen (2003), in their study of Israeli pre-service teachers' descriptions of scientists, and Finson (2010), in his examination of cultural differences in DAST, found that the perceptions of scientists were common across different countries and reflected western ideas about what a scientist was. Other examples of studies of the perception of scientists include Finson, Beaver, and Crammond (1995), Meyer, Guenther, and Joubert (2019), Thomas and Hairston (2003), and Türkmen (2015). These studies show a common set of stereotypical images cutting across gender, race, and culture. Scientists are dominantly and stereotypically perceived as elderly or middle-aged male, in a white coat and glasses who work in a laboratory. Other studies (Milford & Tippett, 2013; Thomas, Pedersen, & Finson, 2001) compared pre-service teachers and school students' drawings and found they held similar views.

Despite widespread use and acceptance of DAST, methodological aspects of the tool have been questioned by some researchers (Kearney, Pederson, & Finson, 2009; Reinisch et al., 2017). Reinisch et al.'s criticism that 'design of these assessments provokes prevailing stigmatisations and prejudices about scientists' (2017, p. 1957) is especially pertinent to the current study. Researchers like Rennie and Jarvis (1995) thought that the use of only drawings was problematic, as drawing without words represented an abstract idea posing difficulties in comprehending.

In response to these criticisms, several studies have adapted and revised the DAST to include sentences or annotation of drawings to improve interpretation (Türkmen, 2008, 2015). As well, Fung (2002) postulated that while the DAST was a simple and feasible method, it should consider interviews with the subjects for a deeper understanding of participants' constructs of a scientist.

Also, the type of prompt given for students to draw the scientist was questioned by Symington and Spurling (1990) who argued that when students were asked to draw a scientist, the students' drawings represented what they perceived to be the public stereotype of a scientist instead of their own perception of a scientist. Symington and Spurling (1990) revised DAST and named this version Draw-a-Scientist- Test revised prompt (DAST-R). They added "Do a drawing which tells what you know about scientists and their work" section. After testing the DAST-R, they compared students' drawings, given both sets of prompts. They found enough differences to support their revision of the DAST prompt.

These arguments were considered when developing the methodological approach used in this study, which is described in the next section.

Methodology

The purpose of this study was to develop an understanding of pre-service teachers' conceptions of the NOS through their images and explanations of science and scientists. The methodology used drew on previous studies using DAST as well as critiques of the instrument discussed in the previous section.

Participants and context

The participants in this study were 88 pre-service teachers (25 male and 63 female) aged between 19 to 22 years enrolled in their first science education course in the Bachelor of Education (Primary) Program at the FNU. As explained earlier, to enter a pre-service teaching degree in Fiji, a student only has to have completed Year 10 Basic Science. In this study, students were asked if they had completed Year 10 or Year 13 science and if they had completed Year 13, which science subjects were studied. In Year 10 in Fiji, only Basic Science is offered. Of the 88 students who participated in this study, 47 had completed Year 10, 31 had completed Year 13, and 10 did not respond to this question.

Data collection

Data were collected during the first class in the first of the two science education courses. The pre-conceptions of pre-service teachers about science and scientists was considered an important first step to begin their science education journey. The processes used were adopted after examining the critiques of previous uses of DAST discussed in the earlier section of this paper.

Two lecturers worked with the participants on the processes described below:

(1) Brainstorm: pre-service teachers took part in oral class discussion in groups about their definition and descriptions of science and scientific activities. Observational written notes were taken of group discussions and presentations.
(2) Imagine with prompts: Next, the pre-service teachers worked individually. They were prompted to close their eyes and imagine a scientist at work. They were asked to focus closely on the image that they were visualizing by thinking about their responses to the following questions:

- What is your scientist doing in your imagination?;
- Where is your scientist working?;
- How old is your scientist?;
- What is the scientists' ethnicity?;
- Is the scientist a male or a female?; and
- How does the scientist look?

After 2 minutes, they were asked to open their eyes.

(3) Drawing and describing the scientist: The pre-service teachers were asked to draw the scientist of their imagination on paper, keeping in mind all the prompts that were given. They were also asked to describe their drawing in a paragraph below their drawings. Additionally, the pre-service teachers were asked to name three male and female local or international scientists they knew about.

(4) Interviews: 30 of the participants were interviewed. Initial attempts at categorizing of the images revealed some responses that required further clarification and explanation. It was these students who were asked to do follow up interviews. The interviews lasted for no more than 20 minutes, and there were no set questions. Rather, the students' drawings were shared with them, and they were asked to elaborate and explain some of the features they had used.

Specifically, the differences between the methods employed in this study and those who used the original DAST and the DAST-R are: the brainstorming activity about science and scientific activities; imagining a scientist with prompts before actually drawing the scientist; the written descriptions of the drawings; naming some male and female scientists participants knew about; and the follow-up interview with selected participants.

Data analysis

The first step in data analysis was to summarize participants' conceptions of science and scientific activities from the observational notes taken during group/class discussions/presentation.

The second step was to collate the drawings collected and begin to categorize them using the "Draw a Scientist Test–Checklist" (DAST-C) (Finson et al., 1995; Narayan, Park, & Peker, 2007).This checklist provides a set of features to be identified in each drawing, categorized under sub-headings (Personal Characteristics; Symbols of Research; Symbols of knowledge; Signs of technology; Work environment; Gender; Racial ethnicity group and Overall appearance of the scientists).

This process allowed the identification of drawings that were unclear, or that could not be readily categorized. Those students who had completed these drawings were asked to participate in the follow-up interview (described above).

The DAST-C scoring was completed through viewing the drawings as well as making use of the written descriptions and the extra information provided in the interviews. The scoring was undertaken by two researchers independently first, then compared to give an inter-rater reliability of 92% which was considered an acceptable reliability measure. This scoring provided an overview of the results of the exercise.

The third step in the analysis involved applying techniques drawn from critical theories including critical literacy to the data. First, we wanted to move beyond the superficial accounts of stereotypical images and examine how these Fijian pre-service teachers associated science and scientists with their daily lives and their own communities. Our understanding of critical literacy approaches (Janks, 2010, 2019) that examine the underpinning ideologies represented in images and texts provided a particular reading of the category used in DAST-C named as 'overall appearance of the scientists'. These categories of 'eccentric, sinister, neutral, and positive' appear to suggest generally negative and stereotypical associations with scientists (e.g. the mad scientist). So the third stage of analysis began with removing that category from the results represented in Table A1.

We then moved to undertaking critical readings of the drawings collected. As Janks (2019, p. 563) explains:

> Reading critically is about understanding the ways in which a text is positioned and is working to position us, the readers. This understanding is necessary to enable us to answer critical questions about power and exclusion.

This form of textual analysis can be applied to all kinds of texts, including images, photographs, drawings, and other texts that use multiple modes to create meaning (Van Leeuwen, 2015). The third stage of our analysis critically interrogated the drawings, the descriptions of the drawings, and the responses during the participant interviews and brainstorming session to provide us with an understanding of the depiction of scientists and science and relate these to the science education offered to these students in their schooling.

This moves beyond the argument that realistic images of science and scientists are more important than positive or negative views in the development of scientific literacy (Cakmakci et al., 2011). It could be argued that if Fijian students or pre-service teachers do not identify Fijians as scientists in these kinds of drawing activities, then it is unlikely that they could imagine Fijians as scientists in their daily lives.

In the following sections, we describe the findings of the analyses. The results are a product of examining the analysis using the DAST-C scoring (as presented in Table 1), as well as applying a critical reading of the data. The data represented here is categorized as (I) Interview, (W) Written description, (D) Drawing, or (N) Notes taken during the brainstorming session.

Findings

Science and scientific activities

Science, according to the participants, was described in myriads of ways. The most popular definitions of science are relating science to the study of nature, living and non-living things, plants and animals, the environment and the ecosystem. Other descriptions of science included statements like; "science is an eye-opener for this world" because of its various methods of solving problems; it is about the study of "time and space and about where we originated"; "proving laws and theories" and "inventing new technologies"(N).

Moreover, the description of scientific activities told a story of its own. Experimentation in laboratories was the key scientific activity listed by all. Experimentations were described as mixing chemicals or conducting tests on animals 'like "toads" or "dissecting toads". The other scientific activity was exploration. Exploration included the use of five senses or making observations of plants and animals and planets. The third scientific activity discussed by a few participants was measuring, but it was related to procedures followed in an experiment such as filling chemicals in beakers. Other scientific activities discussed by participants reflected their experiences of learning science such as writing bulky notes, learning theories, drawing and cramming definitions (N).

Stereotypical images of the scientist

In the DAST-C rubric, the scores for each of the categories were converted into percentages (refer to Table 1). The physical appearance of the scientists in the drawings included wearing of lab coats (79%), and eyeglasses (51%), having unkempt hair (46%), or to a lesser extent facial hair (26%), and having pens and pencils in pockets (2%).

The most common symbols of research drawn by participants included test-tubes (54%), flasks (57%), Bunsen burners/candles (36%) especially in association with chemistry and laboratories, followed to a lesser extent by experimental animals (9%), microscopes and stethoscopes (3%). Books (12%), filing cabinets (22%) and formulas, note pads, question marks, certificates (5%) represented the symbols of knowledge. Additionally, signs of technology evident in the drawing included solutions in glassware (61%), machines such as computers, voltmeters, (6%) and other symbols of technology such as solar panels and circuits (4%).

89% of the scientists drawn were shown working indoors in a laboratory. 84% were male scientists, 44% were depicted as older scientists (over 50 years of age) and 92% of the drawings were of white scientists (Drawing 1 represents the overall depiction of scientists as white males wearing protective clothes confined in a laboratory).

Science and scientific activities in the Fijian context

The examination of the data using a critical lens resulted in the creation of the second set of categories that focused on the type of scientific activities undertaken, rather than just describing the location. Here we considered the relationship between the drawings and the particular contextual circumstances of undertaking this type of research in Fiji. We considered if the activities represented in the drawings would be familiar to Fijian school students only through their text books. We considered if women were represented in these activities, and whether the activities seemed to be undertaken by Fijians.

These categories are outlined in Table A2, along with the number of drawings represented in each category, and the level of school science education achieved by the pre-service teachers who completed these drawings.

Scientist as chemists

The greatest number of responses (44) represented science as operating within a laboratory, and in all of these cases, the scientists were engaged in some form of chemistry. This reflects the student responses in the brainstorming session when they were asked to describe scientific activities. Most responded with "experimenting in laboratory" or "measuring chemicals" (N).

32 used the words "experiment" or "experimenting" in their descriptions of what the scientist is doing (W). Many of these (22) have a naïve view of science experimentation

portraying anything being done in a laboratory as an experiment, such as measuring chemicals in a cylinder; evaporating water; or testing acidity, or dissection of toads (W, I) (see for example Drawing 1)

However, 10 responses seem to indicate some understanding of experimentation. They describe elements of fair testing and the effects that one variable has on another. For example, the density of saltwater compared to freshwater, changing quantities of chemicals to see the changes in the reactions, and different electrochemical cells that will light an electric bulb (W) (see for example Drawing 1 & 2).

Those 12 responses that did not include the words experiment or experimentation generally focused on mixing chemicals (D, W). Common activities done in chemistry lessons were drawn and described including, mixing chemicals, observing chemical reactions, and titration (see for example Drawing 3).

The drawings in this collection were significant also because of the addition of safety features such as goggles and other protective clothing (D). These images also had quite accurate depictions of test tubes and beakers and flasks and other items described by one respondent as “scientific tools”(I). These students also seemed to have quite accurate knowledge of the “scientific diagram” that is a feature of both primary and secondary science classrooms, with labels and arrows and equations neatly added (see for example Drawing 1).

Only 3/44 of drawings in this category were of women.

Real and authentic activities

16 of the responses were categorized as providing some form of authentic or realistic view of science and scientists. The scientists represented are part of the community, whether it is a woman working for the department of agriculture or someone testing solar panels, or an archeologist studying fossils.There are marine activities undertaken as well as an understanding that medical doctors are also scientists (see for example Drawing 4).

Additionally, scientists in this collection also express emotions while following the processes of doing science. So we have someone who ‘looks sad and tired because he has not slept a few nights’ and another who is trialing alternative solutions “because his previous solution has not turned out to be positive”(see for example Drawing 2).

Moreover, images portray work being done, with practical activities being undertaken and many of them are done outside of the traditional laboratory setting (see for example Drawing 5). The issues and settings focused on are contemporary including someone updating his data on a computer, and another has the “skills and knowledge” in “manufacturing vehicles”(W, I). This collection also has a greater proportion of females represented than the other drawings (6/15).

Interestingly 11 of the responses in this category were from students who had only completed Year 10 science. It could be inferred here that understanding the practical implementation of science and the way in which scientific endeavor operates within their communities has come from their own personal experiences rather than the curriculum. And it could be that this practical understanding is subsumed by a theoretical view of science that is taught in the Year 13 subjects. Previous studies using DAST have indicated that the more science studied at school, the more entrenched the stereotypical images of scientists become (Milford & Tippett, 2013; Subramaniam et al., 2013; Türkmen, 2015).

Dissecting toads activity

In the brainstorming session, students defined science as “a study of nature and the environment”, and “a study of living and non-living things in the environment”. The drawings in this group (7) reflect this understanding of science through the representation of a familiar school science activity, that of dissecting a toad. In most countries of the Global North this activity is now banned in schools for various reasons including animal cruelty and safety issues related to students using sharp tools. However, in Fiji it is still part of the curriculum, featuring in both Year 8 and Year 10 Basic Science curriculum. This may be why 6 of the drawings were done by students with a year 10 science background, with one student not stating the level of secondary science background.

The impact of the live dissection of a toad is almost visceral. In one image the scientist is not even present, the toad spread across the table, with the heart the only colored part and the words “the student notices that it still alive by looking at the heartbeat”(W)(see for example drawing 6).

This emotional reaction is countered however, by the argument that students are developing the scientific skills of dissection. As well, the language used to describe the scientist, and the act of dissection is specific and exact. Words such as sharp blade; internal organs; dissection (W) are all part of the scientific lexicon, and therefore could be evidence of some knowledge of the NOS.

As some have argued, school science activities are not only far removed from the activities and practices of science and scientists, but also sometimes provide false or misleading assumptions about the nature of science (J. S. Lederman et al., 2014; Muspratt & Freebody, 2013). However, in this case there seems to be some understanding of the purpose of the activity and its relationship to “real” science. For example, one interviewee explained, “the scientist in the drawing is dissecting a toad in order to study about human organs” (I). While two interviewees explained that the purpose was “to see the internal organs of the frog” (I).

General

There are 22 drawings that could be described loosely as general depictions of scientists that do not fit with the other unique categories. Here are scientists outside of the laboratory, not doing chemistry experiments, but also not engaging in the authentic experiences described earlier. The focus is on clothing, the scientists depicted are all male, and in some cases, the scientist is not drawn at all.

One group of drawings (4) in this collection depict scientists engaged in various investigations. So the focus moves away from the laboratory to the actual implementation of the scientific activity such as creating a volcano using vinegar and baking powder or traveling in space to do experiments on gravity (see for example Drawing 7)

Overall in all of the drawings, the physical appearance of scientist included wearing lab coats, eyeglasses, having an unkempt appearance, and to a lesser extent having facial hair. In this category, 6 of the drawings focus on the clothing that the scientists wear rather than on what they do. Indeed some do not mention what the scientists are doing at all except for vague descriptions such as “doing his experiment” (W) but provide details such as “blue shirt, blue dress, white coat, specs, hand gloves, goggles and boots”(W).

There are two drawings that depict science teachers and one that depicts a student as a scientist doing experiments in a school laboratory. On the one hand, these images contribute to the message that scientists are not superior to everyone else, that scientists can be part of the community, and that even science teachers are scientists (see for example Drawing 8). On the other hand, it could be argued that these students' understanding of the difference between doing science and teaching about science is limited.

In this group there are 2 scientists using magnifying glasses and three using microscopes (D,W) possibly providing evidence that these students have seen these instruments in operation.

All of the drawings in this category are of male scientists if they include a person at all.

Fijian scientists

In countries like Fiji that are grappling with issues related to developing a 21st Century economy, it is important that primary school teachers develop the idea in their students that anyone can be a scientist, that anyone who wants to find answers to their questions are scientists. To do this, teachers need to help students understand the nature of science through authentic scientific activities carried out in classrooms rather than learning only content from textbooks. Students will, therefore, learn the processes of doing science as well as learning the content.

The pre-service teachers who participated in this study will become these primary school teachers. Their ability to undertake these teaching activities will depend on their own understanding of the NOS, as well as their understanding of the role of science in Fijian societies.

Unfortunately, critical readings of the drawings in this collection indicate that there was no evidence that pre-service teachers could see Fijians as scientists. Overall the depictions were of white men and the descriptions included sometimes their country of origin (this man is from England) (I), and there were 6 students who drew famous male scientists such as Newton or Einstein (see for example Drawing 9). There were no depictions of persons of color, and the closest to a Fijian national was the occasional representation of black curly hair (see for example Drawing 1&2). Implicit in these drawings is an understanding that science is undertaken by white men, and that Fijians are excluded from operating within this discipline (Janks, 2019).

As well, when asked to write the names of scientists (W) in the DAST responses the most common response (57) was to name famous scientists including Einstein, Newton, Darwin, Edison etc. Conversely, no female scientist was named. There was no local scientist apart from two who named a secondary school biology teacher and a student as a scientist (W, I).

Discussion

In many classrooms, science is seen, quite correctly, as an empirical activity. But in too many classrooms, that is all it is; that all one has to do to do science and to be a scientist is to "look" at the natural world. Science has become solely an experiential endeavor (Muspratt & Freebody, 2013). There is too little understanding of the close connection between experimental science and theoretical science, how one plays off the other, and that they are inextricably entangled. As one student expressed, “Science is not always about intelligence. But science means creating new things whereby all people can create new things. Every individual can be a scientist themselves” (I)

On a positive note, some of the images of scientists in this study provide examples of the concrete rather than the abstract, where there are real people doing real science, and often in Fijian contexts. Unfortunately however there seems to be little recognition that Fijians themselves can be scientists, with the stereotypical views reported in other research studies replicated here (Meyer et al., 2019; Türkmen, 2015).

Common across all categories is the misunderstanding that all scientific activities are experiments. Observing, making models, testing and trialing, dissecting, and exploring are all science processes that are drawn in the pictures but are described as experiments. Ramirez and Cayón-Peña (2017) have argued that this emphasis on “hard sciences” narrows perceptions of the role of science and scientists in contemporary contexts. Given that in Fiji, it is more likely to find scientists undertaking environmental studies than doing physics in a laboratory, this is an important misunderstanding of the work that scientists do.

The connection between the content of science textbooks used in primary and secondary schools in Fiji and this misunderstanding could be further explored through an analysis of the terminology used. Given research studies that have reported on scientific errors in school science textbooks (see for example King, 2010), thorough scrutiny of the texts used in Fijian schools is important.

The location (laboratories) and descriptions (white, male) of many of the scientists represented in the drawings reflects findings from other studies using the DAST tools. Indeed, the overall stereotypicality of the drawings and descriptions echoes the findings of other studies around the world (Thomas & Hairston, 2003; Türkmen, 2015). But the significance of this finding for a country like Fiji is important to note. Critical literacy approaches to analyzing images and text uncover the ideologies underpinning these representations (O’Halloran et al., 2017). From this perspective, it could be argued that positive perceptions of one’s own identity is interwoven with the identity of others that surround you (DeWitt & Archer, 2015). It could also be argued that one does not dream of being a scientist, unless one sees scientists who look like you. It could be argued that the colonial history of Fiji is more ahistorical (Sharma, Coombs, Chandra, & Sagaitu, 2015), and that the education system continues to promulgate a view of knowledge as Western, and that the powerful holders of that knowledge (in this case scientists) can only ever be white, and male, and removed from the reality of Fijian life.

Concluding thoughts

In some ways, this small study of one group of Fijian pre-service teachers’ perceptions of science and scientists provides only a minimal contribution to the large body of work that has employed similar methodologies and described similar findings. However, in the Pacific context, this study is important for a number of reasons. First, generally, research that focuses on Fijian schooling is rare, and unfortunately most commonly found in unpublished dissertations undertaken by Fijians studying in other countries (Rinehart, 2018).

Secondly, there is an unquestioned usage of textbooks in Fiji, textbooks that have been adapted to be used here, but are generally modifications of textbooks used in the Global North. This study is a small beginning in a more critical view of the knowledge contained in these texts. Making use of critical literacy approaches and critical policy studies to examine the power relations and ideologies represented in these texts could lead to a reviewing of the scientific knowledge presented to Fijian students.

Thirdly, the study shows the pervasive nature of the stereotypical images of science and scientists reported widely including the overwhelming representation of men as scientists. The literature reviewed for this study covered the use of DAST in countries as diverse as Israel, Turkey, Egypt, Republic of China, South Africa and the United States of America. The recent social media campaigns about women in STEM could be having an impact on these stereotypes but it appears there is still a long way to go.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Fiji National University-College of Humanities and Education Research Committee [ACT325].

References

Abd-El-Khalick, F. (2012). Examining the sources for our understandings about science: Enduring conflations and critical issues in research on nature of science in science education. *International Journal of Science Education*, *34*(3), 353–374. doi:10.1080/09500693.2011.629013

Cakmakci, G., Tosun, O., Turgut, S., Orenler, S., Sengul, K., & Top, G. (2011). Promoting an inclusive image of scientists among students: Towards research evidence-based practice. *International Journal of Science and Mathematics Education*, *9*(3), 627–655. doi:10.1007/s10763-010-9217-4

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw- a-scientist test. *Science Education*, *67*(2), 255–265. doi:10.1002/sce.3730670213

Christidou, V. (2011). Interest, attitudes and images related to science: Combining students' voices with the voices of school science, teachers, and popular science. *International Journal of Environmental and Science Education*, *6*(2), 141–159.

Clough, M. P., & Olson, J. K. (2008). Teaching and assessing the nature of science: An introduction. *Science & Education*, *17*(2–3), 143–145. doi:10.1007/s11191-007-9083-9

Crossley, M., & Sprague, T. (2014). Education for sustainable development: Implications for Small Island Developing States (SIDS). *International Journal of Educational Development*, *35*, 86–95. doi:10.1016/j.ijedudev.2013.03.002

DeWitt, J., & Archer, L. (2015). Who aspires to a science career? A comparison of survey responses from primary and secondary school students. *International Journal of Science Education*, *37*(13), 2170–2192. doi:10.1080/09500693.2015.1071899

Fa'avae, D. T. M. (2018). Complex times and needs for locals: Strengthening (local) education systems through education research and development in Oceania. *International Education Journal: Comparative Perspectives*, *17*(3), 80–92.

Fairclough, N. (2013). Critical discourse analysis and critical policy studies. *Critical Policy Studies*, *7*(2), 177–197. doi:10.1080/19460171.2013.798239

Finson, K. D. (2010). Drawing a scientist: What we do and do not know after fifty years of drawings. *School Science and Mathematics*, *102*(7), 335–345. doi:10.1111/j.1949-8594.2002.tb18217.x

Finson, K. D., Beaver, J. B., & Crammond, B. L. (1995). Development and field test of a checklist for the draw-a- scientist test. *Proquest Education Journals*, *95*(4), 195–205. doi:10.1111/j.1949-8594.1995.tb15762.x
Fung, Y. H. (2002). A comparative study of primary and secondary school students' images of scientists. *Research in Science & Technological Education*, *20*(2), 119–213. doi:10.1080/0263514022000030453
Gogolin, S., & Krüger, D. (2017). Diagnosing students' understanding of the nature of models. *Research in Science Education*, *47*(5), 1127–1149. doi:10.1007/s11165-016-9551-9
Jain, J., Lim, B. K., & Abdullah, N. (2013). Pre-service teachers' conceptions of the nature of science. *Procedia-Social and Behavioral Sciences*, *90*, 203–210. doi:10.1016/j.sbspro.2013.07.083
Janks, H. (2010). *Literacy and power*. New York, NY: Routledge.
Janks, H. (2019). Critical literacy and the importance of reading with and against a text. *Journal of Adolescent & Adult Literacy*, *62*(5), 561–564. doi:10.1002/jaal.941
Kearney, K., Pederson, J., & Finson, K. (Eds.). (2009). *Visual data: Understanding and applying visual data to research in education*. Charlotte, NC: Information Age Publishing.
Kennedy, T., & Odell, M. (2014). Engaging students in STEM education. *Science Education International*, *25*(3), 246–258.
King, C. J. H. (2010). An analysis of misconceptions in science textbooks: Earth science in England and Wales. *International Journal of Science Education*, *32*(5), 565–601. doi:10.1080/09500690902721681
Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A., & Schwartz, R. S. (2014). Meaningful assessment of learners' understandings about scientific inquiry-The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching*, *51*(1), 65–83. doi:10.1002/tea.21125
Lederman, N. G., Antink, A., & Bartos, S. (2014). Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: A pathway to developing a scientifically literate citizenry. *Science & Education*, *23*(2), 285–302. doi:10.1007/s11191-012-9503-3
Mansour, N. (2015). Science teachers' views and stereotypes of religion scientists and scientific research: A call for scientist–Science teacher partnerships to promote inquiry based learning. *International Journal of Science Education*, *37*(11), 1767–1794. doi:10.1080/09500693.2015.1049575
McCarthy, D. (2015). Teacher candidates' perceptions of scientists: Images and attributes. *Educational Review*, *67*(4), 389–413. doi:10.1080/00131911.2014.974510
Meyer, C., Guenther, L., & Joubert, M. (2019). The draw-a-scientist test in an African context: Comparing students' (stereotypical) images of scientists across university faculties. *Research in Science & Technological Education*, *37*(1), 1–14. doi:10.1080/02635143.2018.1447455
Milford, T. M., & Tippett, C. D. (2013). Pre-service teachers' images of scientists: Do prior science experiences make a difference? *Journal of Science Teacher Education*, *24*(4), 745–762. doi:10.1007/s10972-012-9304-1
Ministry of Education. (2013). *The Fiji Islands national curriculum framework: Education for a better future* (2nd ed.). Suva, Fiji: Government Printers.
Ministry of Education. (2015). *Year 8 basic science* (pp. 79). Suva, Fiji: Government Printers.
Ministry of Education. (2017). *Elementary science: Year 5* (pp. 17). Suva, Fiji: Government Printers.
Muralidhar, S. (1997). Human resource development and science education in the Pacific: Where are we heading? *Directions: Journal of Educational Studies*, *19*(2), 45–59.
Muspratt, S., & Freebody, P. (2013). Understanding the disciplines of science: Analysing the language of science textbooks. In M. Khine (Ed.), *Critical analysis of science textbooks* (pp. 33–59). Dordrecht, The Netherlands: Springer.
Narayan, R., Park, S., & Peker, D. (2007). Sculpted by culture: Students' embodied images of scientists. *Proceedings of EpiS-TEME*, *3*, 45–51.
O'Halloran, K. L., Tan, S., & Marissa, K. L. E. (2017). Multimodal analysis for critical thinking. *Learning, Media and Technology*, *42*(2), 147–170. doi:10.1080/17439884.2016.1101003
Ramirez, J. M., & Cayón-Peña, J. (2017). The role of scientists in a human- centered society. *Cadmus*, *3*(2), 113.
Reinisch, B., Krell, M., Hergert, S., Gogolin, S., & Krüger, D. (2017). Methodical challenges concerning the draw-a-scientist test: A critical view about the assessment and evaluation of

learners' conceptions of scientists. *International Journal of Science Education*, *39*(14), 1952–1975. doi:10.1080/09500693.2017.1362712
Rennie, L. J., & Jarvis, T. (1995). Three approaches to measuring children's perceptions about technology. *International Journal of Science Education*, *17*(6), 755–774. doi:10.1080/0950069950170607
Rinehart, R. E. (2018). New critical pan-pacific qualitative inquiry: Reciprocal respect in Aotearoan and Pacifica research methodologies. *International Review of Qualitative Research*, *11*(1), 28–38. doi:10.1525/irqr.2018.11.1.28
Rubin, E., Bar, V., & Cohen, A. (2003). The images of scientists and science among Hebrew and Arabic-speaking pre-service teachers in Israel. *International Journal of Science Education*, *25*(7), 821–846. doi:10.1080/09500690305028
Science Learning Hub- Pokapū Akoranga Pūtaiao. (2011). *The nature of science in the curriculum*. Retrieved from https://www.sciencelearn.org.nz/resources/416-the-nature-of-science-in-the-curriculum
Sharma, A., Coombs, S., Chandra, S., & Sagaitu, M. (2015). Fiji: Evolution of education from colonial to modern times. *Education in Australia, New Zealand and the Pacific*, *15*, 243.
Subramaniam, K., Esprívalo Harrell, P., & Wojnowski, D. (2013). Analyzing prospective teachers' images of scientists using positive, negative and stereotypical images of scientists. *Research in Science & Technological Education*, *31*(1), 66–89. doi:10.1080/02635143.2012.742883
Symington, D., & Spurling, H. (1990). The draw-a-scientist test: Interpreting the data. *Research in Science and Technological Education*, *8*(1), 75–77. doi:10.1080/0263514900080107
Tala, S., & Vesterinen, V. M. (2015). Nature of science contextualized: Studying nature of science with scientists. *Science & Education*, *24*(4), 435–457. doi:10.1007/s11191-014-9738-2
Thomas, J., & Hairston, R. A. (2003). Adolescent students' images of an environmental scientist: An opportunity for constructivist teaching. *Electronic Journal of Science Education*, *7*(4), 1–15.
Thomas, J. A., Pedersen, J. E., & Finson, K. (2001). Validating the draw-a-science-teacher-test checklist (DASTT-C): Exploring mental models and teacher beliefs. *Journal of Science Teacher Education*, *12*(4), 295–310. Retrieved from https://www.tandfonline.com/action/showCitFormats?doi=10.1023/A:1014216328867
Tomar, A., & Achary, R. (2016). Science, science education and cognitive psychology. *Research Journal of Educational Sciences*, *4*(4), 1–10. Retrieved from http://www.isca.me/
Türkmen, H. (2008). Turkish primary students' perceptions about scientist and what factors affecting the image of the scientists. *Eurasia Journal of Mathematics, Science & Technology Education*, *4*(1), 55–61. doi:10.12973/ejmste/75306
Türkmen, H. (2015). Still persistent global problem of scientists' image. *Asia-Pacific Forum on Science Learning and Teaching*, *16*(1), 1–21.
Van Leeuwen, T. (2015). Multimodality. In D. Tannen, H. E. Hamilton, & D. Schiffrin (Eds.), *The handbook of discourse analysis* (Vol. 1, pp. 447–466). New York, NY: Wiley Blackwell.

Appendix

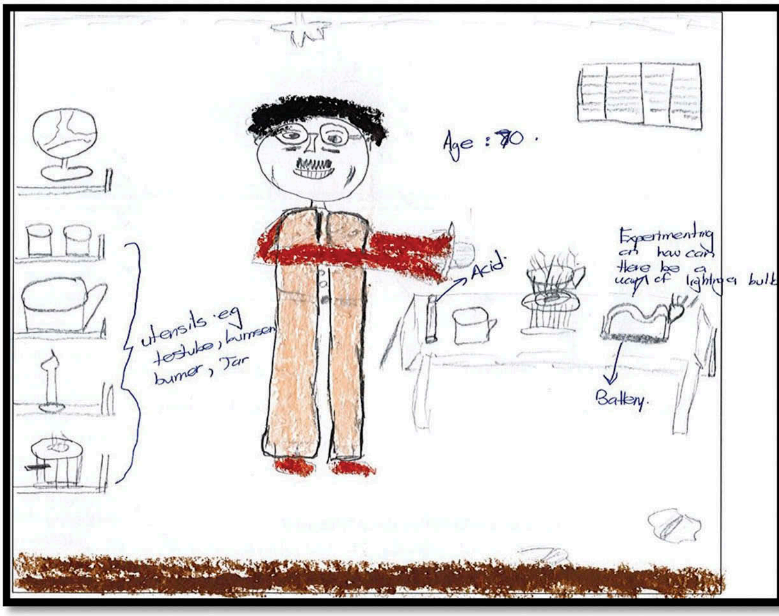
Table A1. Features of scientist drawing (DAST-C) adapted from Finson et al. (1995).

	Total (N = 88)	% drawings
Physical appearance		
Lab coat	70	79
Eye glass	45	51
Facial hair	23	26
Pencils/pens in pocket	2	2
Unkempt appearance	40	46
Symbols of research		
Test tubes	48	54
Flasks	50	57
Microscope	3	3
Bunsen burner	32	36
Experimental animals	8	9
Symbols of knowledge		
Books	11	12
Filing cabinet	19	22
Other symbols of knowledge (formula, note pad, certificate displayed on wall, question mark)	4	5
Signs of Technology		
Solutions in glassware	54	61
Machines	5	6
Other symbols of technology; solar panels, wires	4	4
Work Environment		
Working Indoor	78	89
Working Outdoor	10	11
How many drawings depicted woman and men?		
Drawing of men	74	84
Drawings of women	10	12
Sex not obvious	4	4
Age of Scientist		
35 years or less	13	15
36–50 years	36	41
Older than 51 years	39	44
Ethnicity/Race		
Drawings of scientists who appear to be White	81	92
Drawing of scientists who appear to be local or of color	2	2
Drawing from which ethnicity cannot be judged	5	6

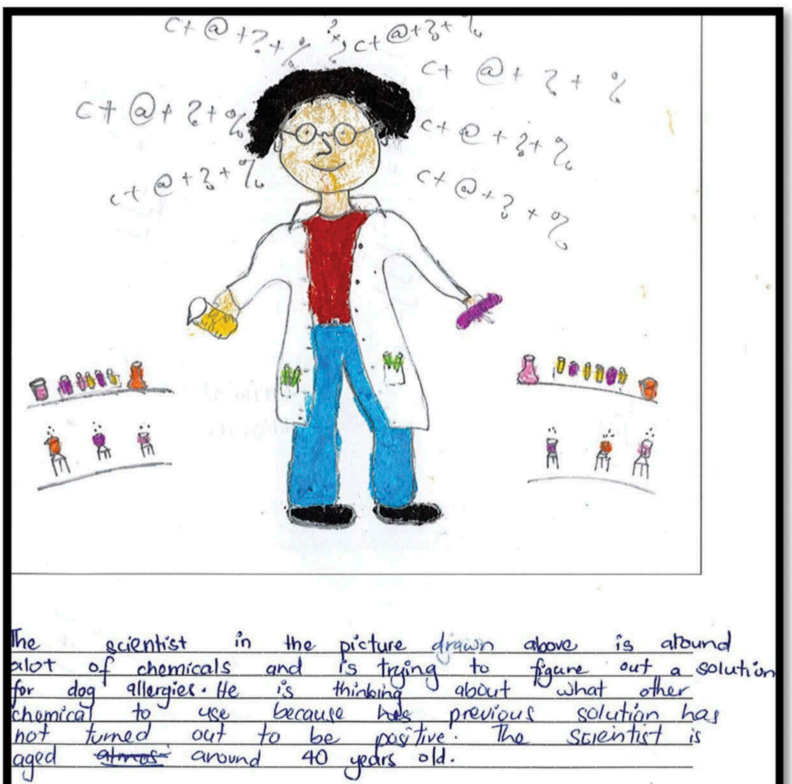
Table A2. Thematic classification of scientist drawing.

	Number of Students		
	Level of school science		
Themes	Year 10/Form 4	Year 13/Form7	Not stated
Scientist as Chemists	21	19	4
Real and authentic activities	10	3	2
Dissecting toads activities	6	0	1
General	11	9	2

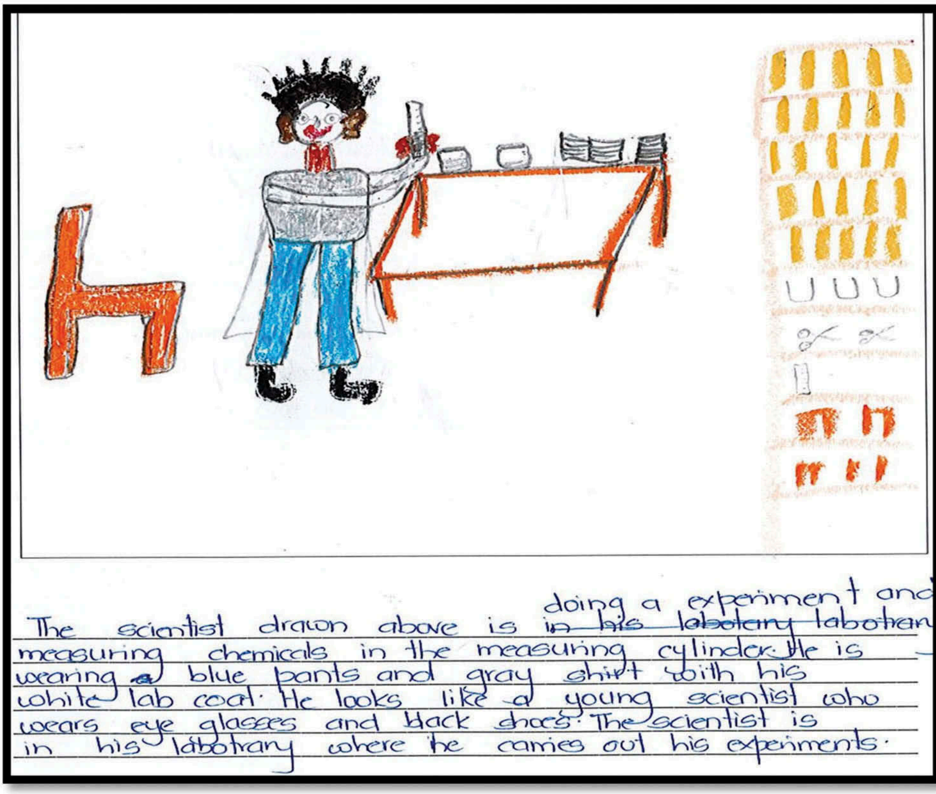
Drawing 1. Repesenting the overall depiction of scientists as white males wearing protective clothes confined in a laboratory.



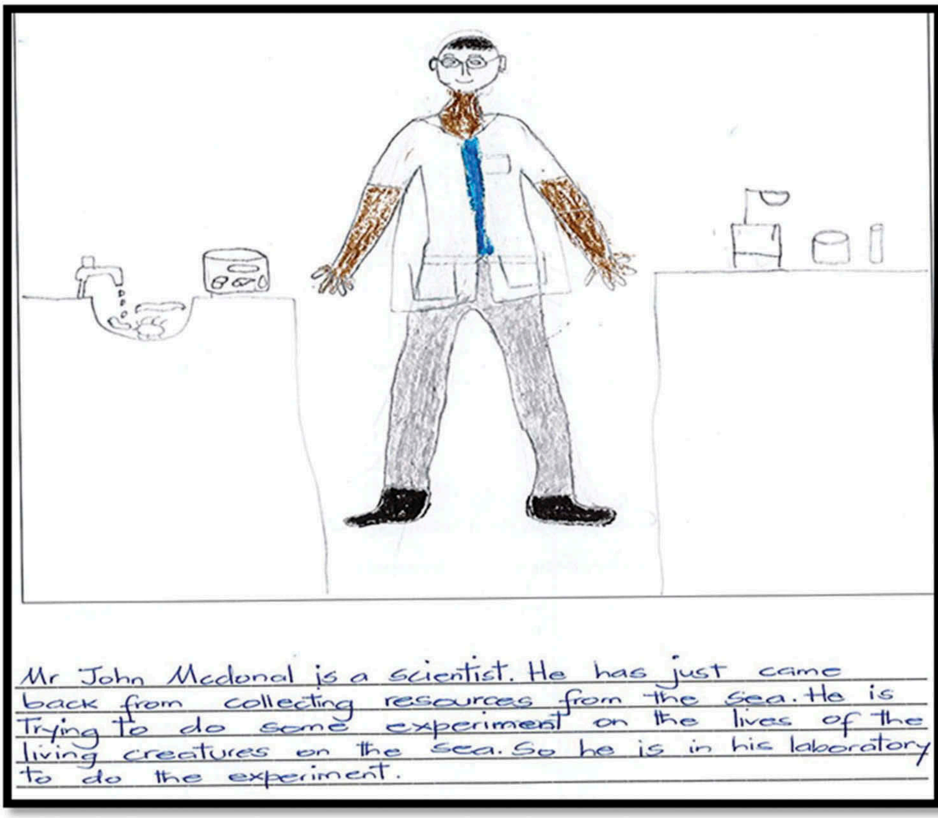
Drawing 2. Representing scientist who is trialling alternative solutions while following the processes of doing science.



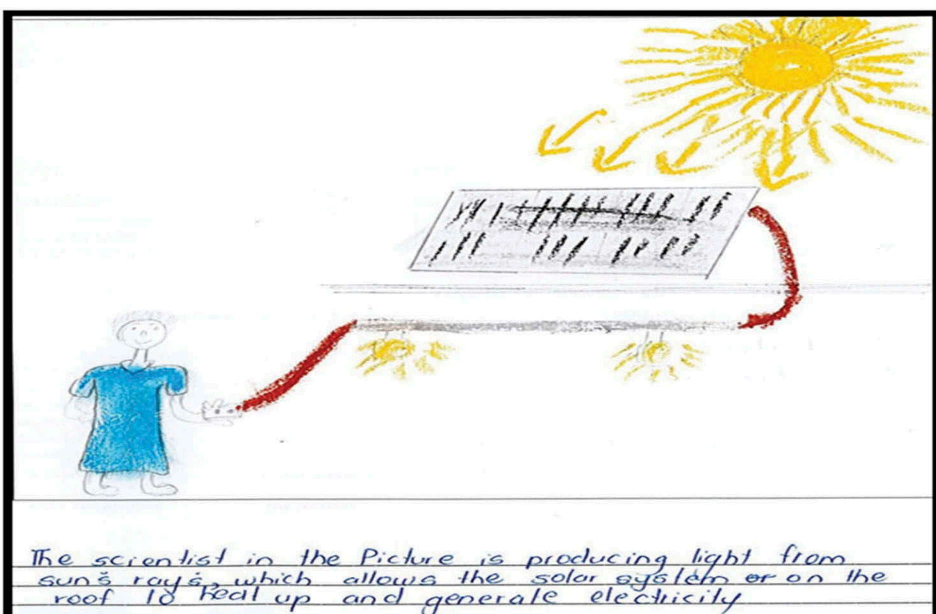
Drawing 3. Representing scientist doing chemistry-based experiments in the laboratory.



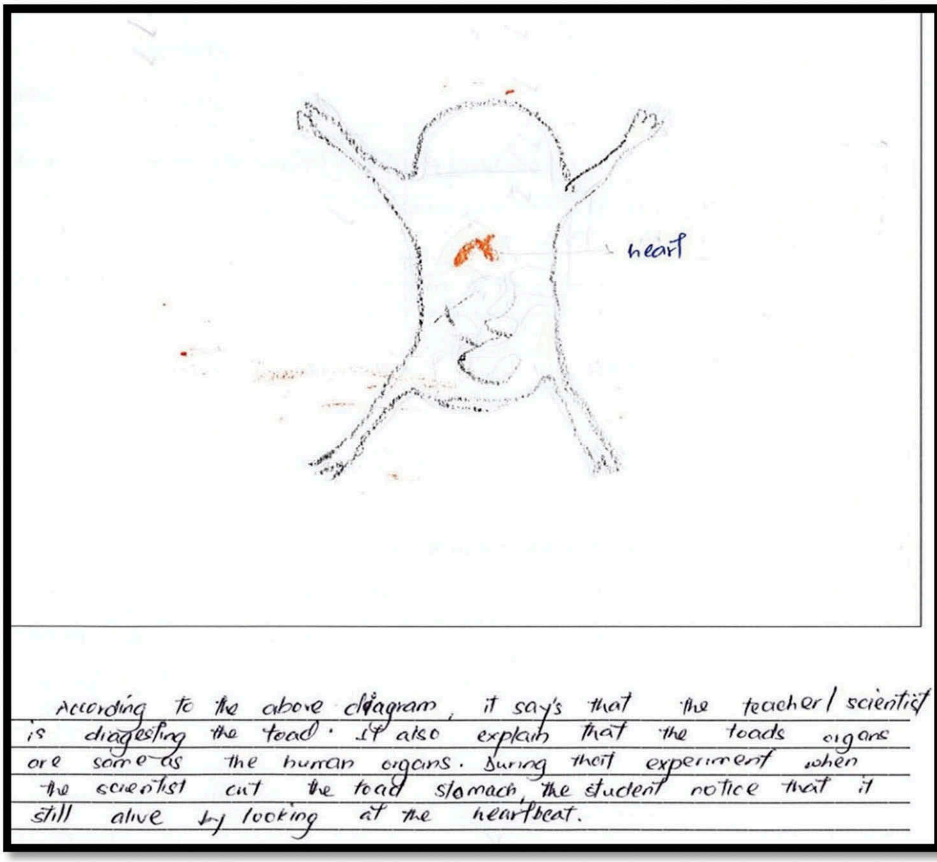
Drawing 4. Represents scientist undertaking marine studies.



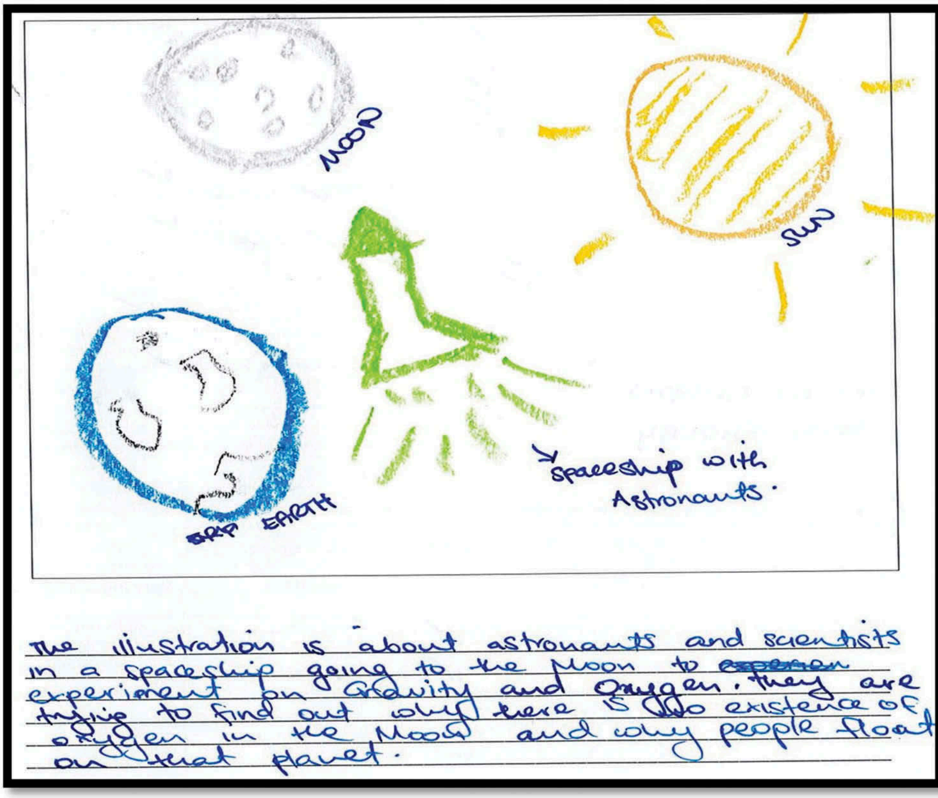
Drawing 5. Representing scientist working outside of the traditional laboratory setting.



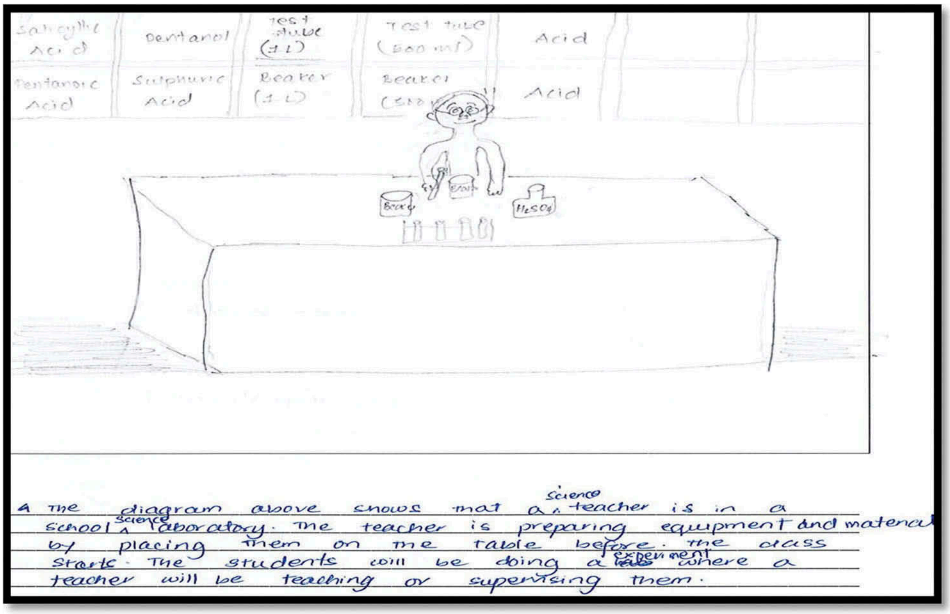
Drawing 6. Representing toad dissection as a scientific activity.



Drawing 7. Representing scientists engaged in investigations that moves focus away from the laboratory to the actual implementation of scientific activity.



Drawing 8. Representing a science teacher as scientist.



Drawing 9. Representing famous male scientists such as Newton.