Article

Participation in the Science Fair: A call for data

Priscilla Wehi[1]*, Barbara J. Anderson[1]* and Esther Haines[2]*
[1]Landcare Research Manaaki Whenua, Private Bag 1930, Dunedin 9054
[2]Department of Physics, University of Otago, PO Box 56, Dunedin 9054

There are many reasons to encourage diverse participation in science (Westminster Business School 2014). Importantly, the recruitment and retention of talent for the scientific workforce needs to be socially inclusive to ensure we access the necessary talent. Scientific progress also benefits from the range of perspectives that arise from diverse, heterogeneous teams (Kandola & Fullerton 1998 in Westminster Business School 2014). Science is an increasingly collaborative activity, and current thinking suggests that a diverse workforce enables us to incorporate multiple perspectives to enhance creativity and innovation, while also ensuring that the outcomes of research are relevant and accessible to all groups. In addition, there is an underlying moral and social case for diversity in the scientific workforce (Westminster Business School 2014).

Diversity within the science research community also results in broader benefits for New Zealanders. We all benefit from understanding how to use scientific information. Scientific work underlies many aspects of our lives, from food to medical interventions to environmental and natural hazard decision-making. It is therefore valuable to understand scientific process and to be able to interpret scientific information if we are to fully participate in society politically and economically. For these reasons also, supporting participation in scientific endeavour among a broad range of students is desirable. However, despite the importance of achieving diversity in the scientific workforce and ensuring that all New Zealanders are equipped to use scientific information, there is little monitoring of relevant data about the factors that affect differential participation in science, technology, engineering and mathematics (STEM).

Diversity statistics and interventions often focus on women's participation in science. The representation of women in STEM careers is low, both globally and in New Zealand (Botcherby & Buckner 2012; Bray & Timewell 2011). This is particularly so for senior management and senior academic positions, as well as in specific subjects such as physics, engineering, mathematics and computer science (Botcherby & Buckner 2012; Bray & Timewell 2011). However, there are other diversity indicators that merit attention. Māori are a small minority of scientists in STEM in New Zealand, and increasing their contribution will help achieve the Vision Mātauranga Policy (2015) and realise the potential of Māori knowledge as a source of science and innovation.

Economic inequalities may be important in reducing the pool of available talent entering a science career. Economic inequality is linked to a lack of 'educational investment' by low-income groups in society; that is, the current pattern of rising inequality in New Zealand undermines educational opportunities and hampers skills development for disadvantaged individuals (OECD 2014). In New Zealand, the decile ranking

*Correspondence: wehip@landcareresearch.co.nz, andersonb@landcareresearch.co.nz, esther.haines@otago.ac.nz

Priscilla Wehi is an ecologist, 2014 Rutherford Discovery Fellow and 2014 Otago Science Fair judge. Her three children provide her with plenty of extracurricular activity. She has a particular interest in cricket behaviour, stable isotopes, and how culture and ecology interact.

Barbara J. Anderson studies species responses to environmental change, biotic interactions and conservation prioritisation. She is a 2012 Rutherford Discovery Fellow and 2014 Otago Science Fair judge, and hails from Central Otago. She tweets at @tinkerbel405.

Esther Haines is a physicist, chief judge for the Otago Science Fair, and past national convenor of the Association for Women in the Sciences. She blogs at http://reflectwomenset.blogspot.com/

of schools indicates the overall socioeconomic status of student families. Students from low-decile schools may, therefore, have fewer opportunities to develop skills and succeed educationally compared with students from high-decile schools.

Annual Science Fairs in New Zealand provide an opportunity to foster children's curiosity and enable them to learn from first-hand experience what is involved in doing science. Although working on a science project may inspire a child to undertake a career in science or technology, all children who attempt a science fair project will benefit from learning first-hand about the difficulties and rewards of doing science. However, we do not know whether all children have the same opportunity to participate in this valuable learning experience. What factors encourage participation and what factors act as barriers to participation? In this paper we use data from the 2014 Otago Science Fair to explore diversity in science projects and participation. We considered three questions. First, does participation and achievement in science fairs vary with gender? Because the ethnicity of science fair participants was not recorded, we were unable to look at how participation varied with ethnicity, so our second question had two parts: (a) did participants include Māori cultural dimensions in their projects, and (b) were Māori students proportionately represented in schools with high participation rates in the science fair? Finally, we asked whether participation by students from rural schools differed from participation by students from urban schools. We recognise that the dataset presented here is limited (one region and one year) and is therefore preliminary, so with this in mind we urge other science fair organisers to collect and analyse data on participation and achievement. By doing so, we can gain a national picture of trends in science fair participation, and better understand how diversity in science can be achieved.

We analysed Otago Science Fair data (2014) by compiling information on student gender, student year, school, and project theme from all entries on display. None of the participating students was approached for information relating to this study, and student names were not recorded in our digital database. It was impossible to accurately identify student ethnicity from the science fair entries on display, and in a small number of cases ($n = 12$), student gender was unclear. These were therefore recorded as 'unassigned'. We also sought to identify projects where the students had identified their topic as relevant or important for Māori. To do this, we read each project on display, and scored the project based on whether awareness of either mātauranga Māori or the importance of the topic to Māori communities was evident. Thus, for example, if a student project investigated cockle size and distribution, it was not considered to be linked to Vision Mātauranga goals, but if the same project identified that knowledge of cockle size and distribution was important for cultural harvesting and the provision of traditional foods on the marae, it was scored as linked to Vision Mātauranga.

We next accessed the Ministry of Education website http://www.educationcounts.govt.nz/directories/list-of-nz-schools to add data on 2014 school decile rankings, the total number of students on school rolls, and the numbers of Māori students at each school. Decile rankings of 9 and 10 are indicative of high socioeconomic catchments. Some schools, particularly intermediates, hold school science fairs to select the best school entries; these then go forward to the regional science fair. This selection process potentially creates a source of bias in our analysis of the Otago Science Fair entries. The data compiled here remain useful to identify trends in science fair participation and achievement, but with a caveat: that we recognise the assumption that students who succeed in local school science fairs are representative of all local school students. All figures and statistics were produced in R (version 3.10; R Development Core Team 2014).

Who is entering the Otago Science Fair?

Ninety nine schools in the Otago region have students who are eligible to enter the Otago Science Fair, and 86 of these schools include years 7 and 8 students. Only 29 schools (29/99) include years 9–13 students. In 2014, 265 science fair projects were on display, of which the great majority were undertaken by students at intermediate level (years 7 and 8; Figure 1), and secondary school student participation was low. Participation was approximately equal for male and female students, and award numbers were approximately proportional to male and female student participation ($X^2 = 2.12$, $p = 0.34$; Figure 2).

The percentage of Māori students at participating schools ranged from 5% to 35%, but fewer Māori students attend the high-decile schools that were well represented in the science fair entries (Figure 3). Without ethnicity data on participating students, our interpretation here is necessarily limited. However, there were no projects at the Otago Science Fair, by any student, that identified a Māori cultural dimension relevant to the investigated topic. Few rural students participated in the Otago Science Fair in 2014, and travel time to Dunedin was important (Figure 4). Only one-quarter (25/99) of the eligible schools in the Otago region sent one student participant or more to the 2014 Otago Science Fair, and this subset was heavily biased towards schools in the main urban area, Dunedin.

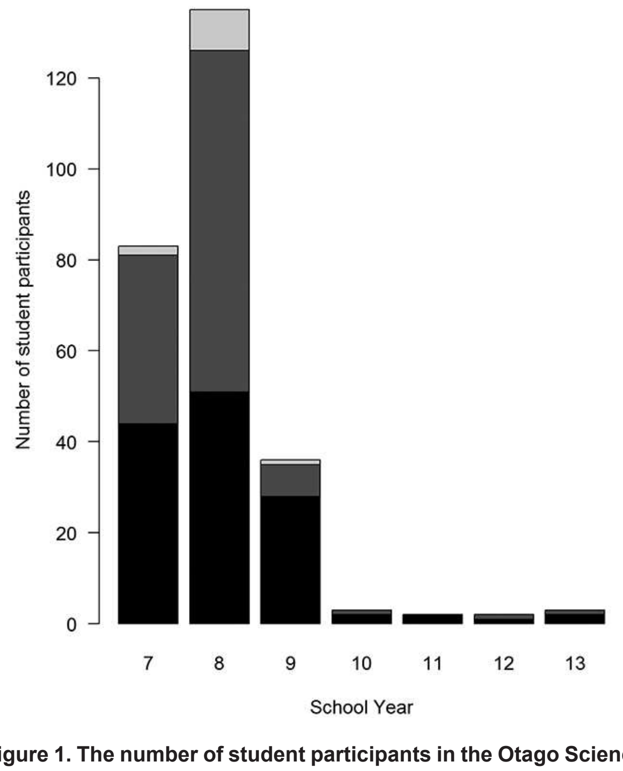

Figure 1. The number of student participants in the Otago Science Fair 2014, sorted by year level and gender. Years 7 and 8 students are 'intermediate' students aged approximately 11–12 years old. Year 13 students are in their final year of school. Dark grey represents males, medium grey represents female students, and light grey represents students of unassigned gender.

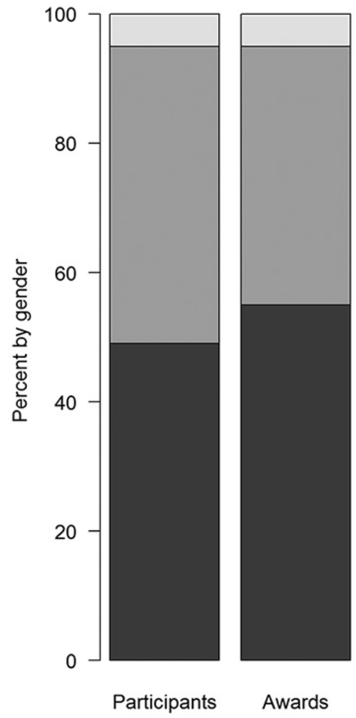

Figure 2. Student participation and awards in the Otago Science Fair 2014 by gender. Note that any one entry is eligible to win multiple awards. Dark grey represents male students, medium grey represents female students, and light grey represents students of unassigned gender.

Finally, we examined which factors might predict whether or not a school participated, using a generalised linear model. We included return travel time (calculated using return travel time to the science fair exhibition hall at Otago Museum, from the AA routefinder); school roll; urban or rural classification; school decile ranking; proportion of students identifying as Māori; and whether the school was a non-integrated state school or not in this model. Schools where students had a short return travel time ($p<0.001$, Figure 4), and larger schools ($p=0.002$, Figure 4), were more likely to have students participate in the science fair, as were higher-decile schools ($p=0.049$). Thus, some 'rural' schools near Dunedin, such as Warrington, had students participate in contrast to distant but 'urban' schools, such as Wakatipu High School, in Queenstown, that did not have any students participate.

Is diversity well represented in the Otago Science Fair entries?

It was heartening to see that participation rates by male and female students in the 2014 Otago Science Fair were similar. Participation in the science fair is compulsory at many intermediate schools, where the majority of entries arise. The data concur with some other studies of equality of gender participation in science in years 9–11 in New Zealand secondary schools (Bray & Timewell 2011); gender bias in science usually arises amongst older students, i.e. beyond year 11 (e.g. Bray & Timewell 2011). Nonetheless, more recent analyses of science achievement in New Zealand schools highlight a recent drop in female student science scores relative to males (Caygill *et al.* 2013), and suggest that monitoring of male and female participation and

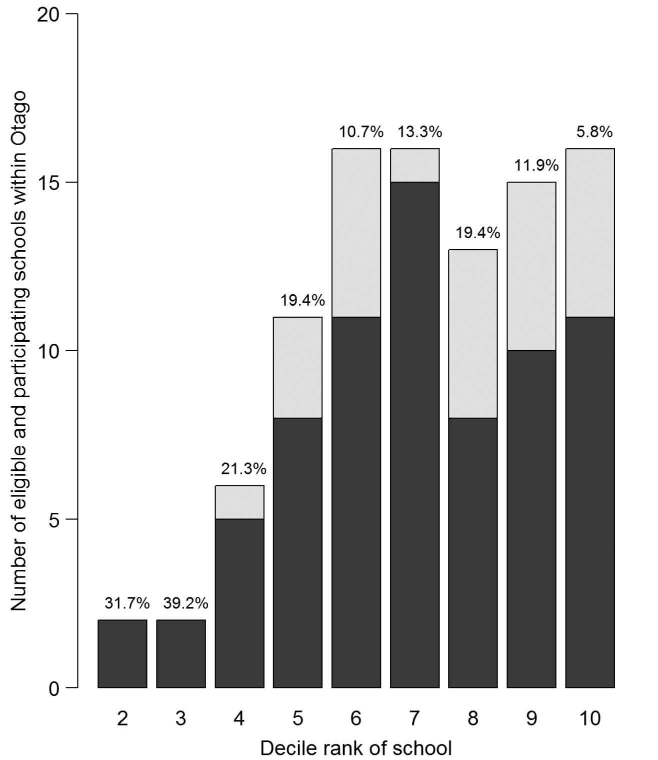

Figure 3. Participation of eligible Otago schools in the Otago Science Fair 2014, sorted by decile ranking. Dark grey shading indicates schools that did not have any students who participated in the 2014 science fair. Light grey indicates schools with one or more students who participated. The median percentage of Māori students for each decile is recorded at the top of each decile column.

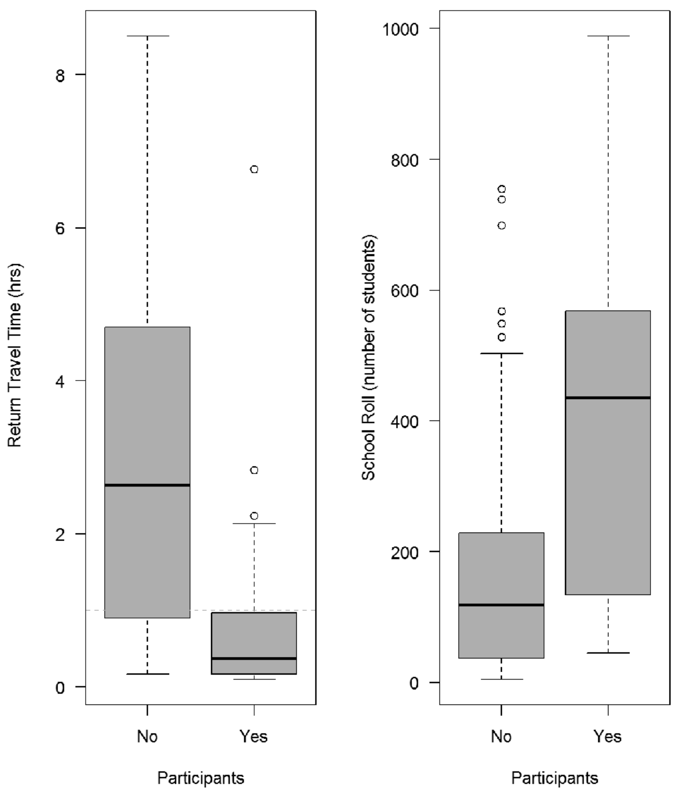

Figure 4. Return travel time and school roll for schools that had no students participating in the Otago Science Fair ($n=74$ schools) and for schools that had at least one student participate ($n=25$ schools). The central line represents the median, edges of the boxes represent the first and third quartiles, and whiskers represent the range, with outliers greater than 1.5 times the inter-quartile range represented by open circles. Note that the most extreme outlier for a participating school on the first panel represents a single student with a return travel time of 4¾ hrs (equivalent to 558 km) whose aunt (BJA) happened to be a judge.

achievement rates in science remains an important activity. The data presented here did not investigate differences in the types of projects investigated by male and female students (i.e. whether they were in the physical, mathematical, technological or biological sciences). We suggest that keeping future records of topics chosen by male and female students, particularly at higher year levels, could prove informative.

The Otago Science Fair entries from 2014 do not provide any supporting evidence of research that connects mātauranga Māori, or the interests of Māori communities to science. Given that the government has signalled a strong interest in connecting science and society (for example, in the National Science Challenges), further encouragement and support in this area could lead to positive outcomes. There are many topics for students to explore that may have special relevance to Māori. As a few examples, students could examine habitat preferences for highly valued plant species; the physics of the dimpled exteriors seen on traditional waka; the technology of hāngi; or understanding the prevalence of genetically inherited disease markers. Incentives for projects that integrate the goals of Vision Mātauranga provide one pathway to increase participation in this type of science. The Manawatū Science Fair offers awards for excellent research projects that support Vision Mātauranga goals, as well as for projects in te reo Māori. These initiatives could be usefully extended to all regions. Monitoring and research that teases out whether socioeconomic factors affect participation and opportunity in science could also be valuable, given that schools with low-decile catchments and a high proportion of Māori students were less likely to participate in the Otago Science Fair. Issues contributing to the lack of science fair projects from distant schools may also be worth examining further. For example, as part of science fair judging, participants are required to discuss their projects in person with judges. In some regions, this might occur early in the week, with the prize-giving occurring a number of days later (for example, during the 2014 Otago Science Fair, judging occurred on a Monday morning, but prize-giving occurred the following Sunday afternoon). It is possible this could act to deter participation by students from distant schools or rural families who have to organise two separate trips to Dunedin to accommodate this timetable. Moreover, despite recent initiatives by the Otago Science Fair committee to encourage high-quality science by providing mentoring for students on science fair projects, inequalities remain for rural students. The mentoring consists of school visits by university students to assist with projects, but again, the distance of many rural schools from Dunedin raises issues of accessibility. Using technology such as Skype could overcome these kinds of issues.

Finally and most importantly, we urge all science fairs to record data on participation and achievement rates for students, so that long-term trends can be assessed through space and time. Using these data, we can better identify diversity issues such as gender, socioeconomic and ethnic biases and work to create both improved scientific understanding among a greater proportion of New Zealanders, and a strong, diverse scientific workforce.

What can we do to encourage diversity in science?

Based on our experience with the Otago Science Fair, we urge:

- First and foremost, better data collection to build a more comprehensive picture of long-term trends. One way to achieve this would be through a national online registration system for student science fair projects. This will allow the tracking of participation and achievement rates by under-represented groups, and compilation of general diversity and other statistics.
- Regional awards for projects that support Māori aspirations, experience and knowledge; and for projects in te reo Māori.
- Consideration of how to support student participation from small, distant and low-decile schools, for example through timetabling, technology, and rural district awards.

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