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11 Science Olympiad students

A case study of aspiration, attitude, and achievement

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Introduction

This chapter describes some of the characteristics of students who come to the Australian Science Olympiad summer camp, their interest in science as presented in the media, and career aspirations. Low interest in school science, falling enrolment in school science courses, and concerns about the future of appropriately educated individuals in science and technology are widely reported, discussed in the media, and the cause of existential angst in the science education community in developed countries (e.g., Maltese & Tai, 2010; Royal Society, 2010; Universities Australia, 2012). This is reflected in governments seeking to “stem the flow from STEM,” setting ambitious targets to increase the numbers and attract high ability students into STEM subjects. Gifted school students considering careers and university entrance are thus faced with a plethora of choices, pressures and their own competing interests. For example, we know that highly gifted students in science also have highly developed interests and achievements outside science (Oliver & Venville, 2011).

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By any measure, Australia is a successful industrialised country, with students who achieve at high levels in international comparisons such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). Recently, the performance of Australian students (and by implication, their teachers) on PISA appears in a different light. A smaller proportion of Australian students now reach the highest levels which has caused a flutter of concern in the corridors of power. This has resulted in focused examination of the provision for identifying gifted and talented students in Australia, with the aim to provide more appropriately for “academically able students” (ACER, 2011, p. ii). This raises questions of what is meant by gifted, how to assess giftedness in students, and finally how best to provide for them. The Australian Council for Educational Research has set out the approaches, assessments, and measures used to identify students. As they are at pains to point out, some of the instruments and frameworks are grounded in evidence or can be quantified (such as reasoning tests, Weschler, or Raven’s progressive matrices), whilst others draw upon more erudite concepts such as Gardner’s multiple intelligences, although without clear or rigorous research-based assessments to measure these, their use in quantifying and identifying giftedness has been somewhat limited.

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The Olympic motto, "*citius, altius, forties*," exhorts participants to excel in sporting endeavours. Inevitably, there are winners and losers in sport. Schooling and education, though, have different purposes compared with sport. However, school systems, sectors, and countries use data to compare and make judgements about student performance, teacher quality, and curriculum design. The Australian Government Department of Education supports the Olympiad programmes through the centrally funded "Mathematics and Science – Increasing Participation" programme, to "raise the engagement, curiosity and participation of school students" in response to concerns about science and mathematics education, university enrolments, the supply of qualified teachers, and the much heralded decline on Australian's attainment (http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/BudgetReview201213/Mathematics). At the national level, there is a commitment to champion the most able school students in science through the Olympiad programme. Long-term government funding for these sorts of programmes appears precarious and mirrored in other places.

The Australian Curriculum (http://www.australiancurriculum.edu.au/) has been recently introduced across Australia. Political tensions surround the implementation of a centrally determined curriculum as the funding and provision for education in Australia have been managed both at federal and a more local level through the state and territory governments. In line with changes to school starting age, the curriculum documents provide teachers, parents, and others with a description of what Australian children "should learn as they progress through school" (http://www.australiancurriculum.edu.au/). These include what many would recognise as the traditional knowledge, understanding, and skills associated with curriculum areas with national standards for student achievement in some, but not yet all, subjects or learning areas. The curriculum up to Year 10 is structured in a way that specifies the eight learning areas with science, mathematics, English, and history in the throes of being implemented in schools across the country. In addition, seven "general capabilities" and three "cross-curriculum priorities" have been explicitly identified throughout each learning area.

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For senior secondary students, curriculum documents in biology, chemistry, earth and environmental science, and physics provide a rationale, course structure content, and standards (see, for example, the physics achievement standard typical for Year 11 students at http://www.australiancurriculum.edu.au/SeniorSecondary/science/physics/AchievementStandards).

Underpinning the Australian curriculum are the guiding principles of equity and excellence to support teachers working with students with language or dialect needs, disabilities or learning needs, or gifted and talented individuals, so all have the opportunity to reach their potential. Therein lies a particular difficulty – how to identify and then provide for gifted students. Here, we do not distinguish between the "gifted" and "talented" as Gagné (1995) might but recognise that the fulfilment of gifts can only be brought about by opportunities to flourish, develop skills, and be successful, and in that respect, the Olympiad programme

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can stake a claim. The spectrum of giftedness means that not all individuals have their learning needs met in mainstream school. They may appear in school to be disinterested in school subjects, rather than engaged, enthused, and challenged. For enthusiastic high school students in science, participating in external competitions and events such as the Mathematics and Science Olympiads, Titration competition, BHP Billiton Awards, and CREST (Creativity in Science and Technology) programmes offers opportunities for curriculum enrichment and individual pursuit of excellence.

The literature suggest that these sorts of specific curricular activities and groupings to accelerate gifted students' learning have been shown to be effective (Duan, Shi, & Zhou, 2010; Hattie, 2009) in the short term. For example, high school students in Beijing grouped and accelerated through a designated gifted education programme "outperform their similarly gifted peers who received [a] normal education" (Duan, Shi, & Zhou, 2010, p. 89), suggesting that optimising the environment would support the cognitive development of gifted students. Joan Freeman's scholarship on gifted children has brought insight, clarity, and analysis in unearthing the "qualia" of giftedness. Do "gifted" children, labelled as such, behave differently from their non-labelled peers? Does a label confer on such individuals expectations and pressures that may overwhelm rather than inspire? Clearly a tension exists – how to support the needs of very able (but young) learners in science without creating the suggestion that "great things are expected" from them. Providing for small numbers of identified gifted students may well be detrimental to them and to others not identified or included in programmes for gifted students. The long-term effects of accelerating children in school may not be entirely positive for these gifted individuals in terms of emotional problems (Freeman, 2006, 2012, 2013). There is thus particular value in offering these students enrichments activities outside the school curriculum.

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The International Science Olympiads

The International Science Olympiads are known as the "Olympic Games" for the brightest and best of the youth from all around the world. Taking place annually, the Olympiads are venues for excelling, competing and reaching out to others. Countries vary in the process employed to select students, and Australia offers all home students the opportunity to be selected for the summer camp. The Olympiads particularly test application, reasoning, and understanding of the body of knowledge, and the Australian Science Olympiad Examination (ASOE) papers reflect these sorts of thinking rather than recalling. Some schools have special provision to prepare identified gifted and talented school students for the national Olympiads, and some universities offer training programmes in preparation. Although there is no evidence that the preparatory courses confer advantage to students when the final team selection takes place, the provision of such programmes enables highly able science students to be extended and provides an

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avenue for teachers to support extension or enrichment. In other countries, students may participate in several rounds of regional or local science competitions, submit portfolios of their practical work or other evidence of the achievements before a final selection to represent their country.

The Australian Science and Mathematics Olympiads are well established, with an administrative base in Canberra, and the teaching taking place at one of the prestigious universities during the summer holidays in January and at Easter. Olympiads are both inspirational and aspirational in serving and meeting the needs of gifted students.

The qualifying examinations to select students for the summer camp are developed with the focus on highly developed reasoning skills set in the context of a particular science subject. Teachers identify the most able students and suggest the ASOE as an exercise in intellectually stretching their students. Past examination papers are available to teachers and students through the Australian Science Innovations website at https://www.asi.edu.au/site/past_exams.php, with the intent to support students' participation and overcome the twin barriers of inequity across the educational sector and access to these sorts of enriching opportunities. From about three thousand students participating in the qualifying round, approximately seventy-five students are selected to attend the training programme at the summer camp, with about twenty-five students in each science discipline in biology, chemistry, and physics.

By any measure, the students attending the summer camp are amongst the top performing in Australia. Alumni, or past students, include prestigious Rhodes scholars, several first authors of publications in highly ranked journals such as *Nature* and *Science*, and recipients of national awards for their contributions to science.

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The teaching staff, many drawn from past Olympiad teams, come from across Australia to teach, support, and accompany the Olympiads students on their journey from selection to the summer camp to the participation at one of the International Science Olympiads. Each year, Australia sends teams of four or five high school students to compete in the International Science Olympiad. Aims of the International Science Olympiads are described as

- "challenge and stimulate these students to expand their talents and to promote their career . . . and to [bring] together young people from over the world in an open, friendly and peaceful mind" (http://www.ibo-info.org)
- "enhance friendly relations among young people from different countries . . . [and] encourage cooperation and international understanding" (http://www.icho.sk/)
- "promote future collaborations and to encourage the formation of friendship in the scientific community" (http://ipho.phy.ntnu.edu.tw/)

Science competitions at this level are rigorous and highly competitive with both theory and practical examinations (up to five and six hours duration, respectively)

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science. Students from Australia have performed well each year bringing back medals to celebrate individual success on the international arena.

Attitudes and aspiration

This section considers responses to questions students were asked at the summer camp about any of their role models, and more specifically about their participation in the science summer camp, their interests in science, and career intentions. We drew on the data collected using questions from the Bennett and Hogarth (2005, 2009) survey of school students in England. Elsewhere we have described the self-reported benefits of being surrounded by "others who had similar goals and values and supported by their peers" (Oliver & Venville, 2011, p. 21). The sample size (n = 69) comprised all science students attending the summer camp in Australia. The age-matched sample group (n = 98) was drawn from schools in England (Bennett & Hogarth, 2009).

Olympiads' role models

Role models are considered to be important for students, not least because they contribute to the development of identity and foster ambition. Unsurprisingly, the "old, dead men" of science feature in the list of inspiring individuals (Galileo, Fermi, Einstein) and Australian scientists:

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> Galileo for publishing his work despite the Church condemning him as a heretic
>
> (Physics)

> Albert Einstein is my role model because of his numerous significant contributions in the fields of Physics and Chemistry
>
> (Chemistry)

> Enrico Fermi is a significant role model to me because of his great contribution to science. I particularly admire his determination and meticulousness in problem solving.
>
> (Physics)

> I admire Fiona Woods for her dedication to improving the quality of life of burns victims; her invention has inspired me to strive for greatness.
>
> (Biology)

> Barry Marshall in his research into the link between Helicobacter pylori and peptic ulcer disease, ingested H. pylori himself and contracted the disease. His dedication to his work and his willingness to go to any length in his research is something I greatly admire.
>
> (Physics)

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However, students also included teachers, and those who come from very different backgrounds but are admired for their qualities:

> My maths teacher because he knows when to joke and when to take things seriously.
>
> (Chemistry)

> Helen Keller persevered to overcome her disabilities and pursued her dream, no matter what anyone said, and succeeded.
>
> (Biology)

> I really admire Carlos Ruiz Zafon for being such a brilliant author and Susan Boyle for showing us how to pursue our dreams no matter what.
>
> (Physics)

> Phillip Hellmuth is an excellent poker player who has succeeded in winning large amounts of money from bad poker players. Also, I admire his genteel table manner.
>
> (Physics)

It looks from this albeit small sample, that students draw from a variety of influences, science achievement, personal worth, and value as models.

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An innate interest in science?

Olympiad students report that they enjoy their science lessons more than an age-matched sample of school students and their teachers help their interest in science (Oliver & Venville, 2011). It is clear that teachers have a role in developing and sustaining interest and enthusiasm in science students, even when the constraints of the curriculum do not meet the learning needs of the most able:

> I'm chronically bored at school.
>
> (Physics)

This sort of comment highlights yet another tension in schools for teachers: how to support very able science students alongside mainstream students and maintain an inclusive classroom. The Olympiad summer camp, with the opportunity to delve very deeply and intensely into one subject area, seems to be one possible way at offering gifted students a way of learning in a new way alongside other very able and interested students. Nearly twice as many Olympiad students (60 percent) compared with an age-matched control group agreed with the statement "My current science teacher makes me interested in science," and this finding was particularly strong for the biology (70 percent) and physics (64 percent) students. When asked to agree with statements about why their science teacher supported their own interests, teacher enthusiasm was the highest ranked response by 50 percent.

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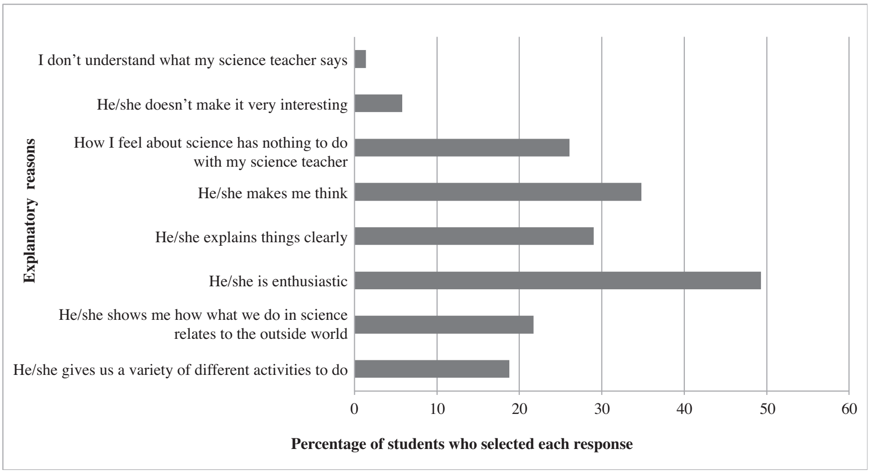

Figure 11.1 Second level responses to the statement, *My current science teachers makes me interested in science.*

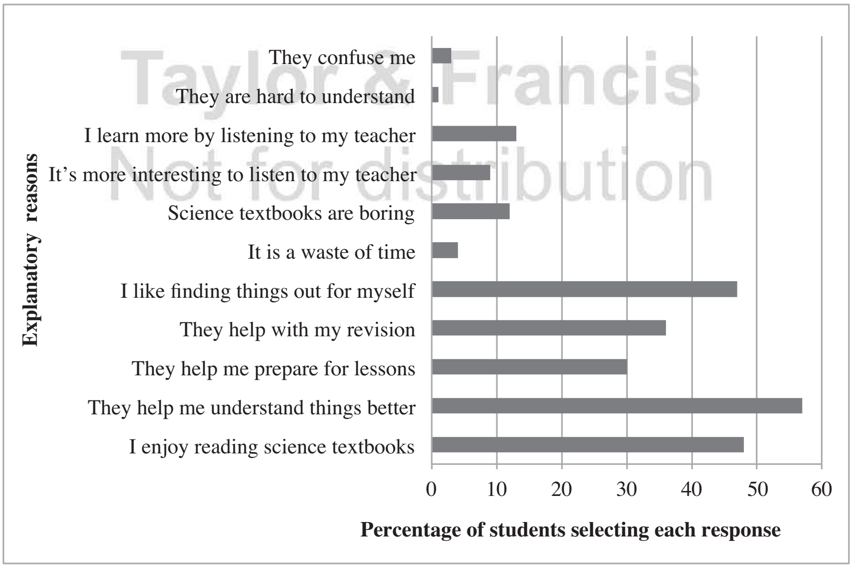

Figure 11.2 Second level responses to the statement, *I enjoy reading science textbooks.*

That individual teachers are identified as role models reflects the efforts that teachers make to stimulate, challenge, and support those gifted students. The low numbers of responses to other exploratory reasons suggest that the science lessons and the teaching are not as well aligned to these learners' needs as teachers might anticipate. In this respect, a "what works well" or "best evidence" briefing could be helpful.

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Apart from the science lessons themselves, the school science curriculum is supported by learning, outside the classroom, practical activities and textbooks. Compared with their peers, 71 percent of Olympiad students enjoy reading their science textbooks compared with 25 percent (Oliver & Venville, 2011). One might speculate about this, but it would appear that these students derive satisfaction from finding things out for themselves, for personal enjoyment and most importantly for helping them gain deeper understanding. These responses suggest a deep affective commitment to learning about science.

For example, one student wrote,

> I like reading from textbooks and analysing it comfortably myself.
>
> (Chemistry)

Despite students reporting high levels of enjoyment of reading their textbooks, there was generally low agreement to the explanatory reasons. There may be an opportunity here for resources that can stimulate, extend, and enrich students' experiences of school science.

Olympiad students' aspirations

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This section describes both the students' immediate aspirations having been invited to participate in the summer camp, and their long-term plans, if any, for careers whether in science or not. The summer camp is an intense experience not just for the long hours engaged in science each day but the range of activities that lie outside the scope of a normal school day. (See http://www.youtube.com/watch?v=tgpTqAb9bJU.) Students' comments reflected appreciation of the opportunity to be offered a place at the Olympiad summer camp and the intellectual challenges that would bring:

> Looking forward to meeting new peoples and learning at a vastly accelerated pace
>
> (Biology)

> I am looking forward to . . . the rare opportunity. It is quite a unique experience to be amongst the smartest in the country but I would really like to be able to learn more about Physics and extend my knowledge
>
> (Physics)

> I think I'll enjoy the fast paced learning, and the opportunity to think beyond the square.
>
> (Physics)

The two-week immersion experience of lectures, tutorials, and university laboratory experiences is worthwhile in its own right but also serves the utilitarian purpose of selecting students for the national team. Necessarily, then, students

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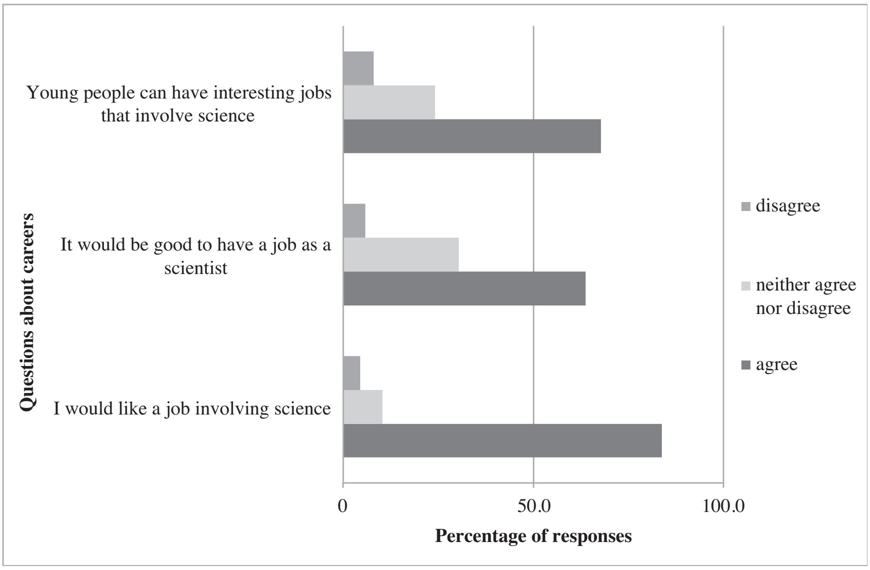

Figure 11.3 Olympiads' career aspirations

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are in a competitive yet supportive environment. Elsewhere, other enrichment programmes offer opportunities for high achieving and enthusiastic science students to explore in depth topics in science, often in collaboration with laboratory scientists.

When asked about their career intentions, we were mindful of one of the stated purposes of the Science Olympiads, in promoting science as a career to students. Perhaps unsurprisingly, many of the Science Olympiad students have a positive attitude toward science as a career.

When asked about their future can career prospects, some were still undecided, although more than 80 percent expressed a desire to have a career using science. Unlike a group of aged-matched peers, more than 60 percent thought that young people were able to have interesting jobs in science were positive about working as a scientist (Bennett & Hogarth, 2005, 2009). There were a number of comments from students who felt that participation in the Olympiad had resulted in them rethinking their career options, confirming that they wanted to become a scientist or research scientist, or simply resulted in them reimagining themselves as being capable at science.

Conclusion and further thoughts

It is difficult to tease out the differential impact on students' achievement, attitudes, and aspirations: teachers, parents and families, specific role models, and the

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school environments amongst other factors. What is evident about these students is their commitment to learning and enjoying science. The picture presented in this chapter is a "snapshot" of students along a trajectory in pursuit of science. It would be interesting, therefore, to revisit these students some years hence and ask them further about the impact of their experience with the Olympiad programme.

The case for enrichment rests on meeting the needs of gifted students. Students reported that experiencing a gifted enrichment program provided them with "more interesting activities and elicited better study skills . . . a better work ethic" (Hertzog, 2003). In this sense, the "hothousing" atmosphere of the Australian Olympiad summer camp certainly meets that description. Moreover, the benefits of these sorts of programmes may be cumulative, so subsequent experience of another enrichment programme reinforces the positive experience.

'Enjoyment" and "interest" both load onto the "engagement" variable in the PISA analyses across countries. What is unusual about this group of high achieving students is that high levels of "engagement" and "achievement" are both evident, and the students see themselves as "science-types." It would be interesting to see if this pattern is replicated across other countries and, if so, to learn what can be done to support gifted science learners.

Reference

Australian Council for Educational Research. (2011, May). *Issues in assessment for the identification of academically able students.* Camberwell, Victoria, Australia.

The Australian Curriculum. (2014, June). Retrieved 30 November 2016, from http://www.australiancurriculum.edu.au/

Australian Science Olympiads. (2014, June). Retrieved 30 November 2016, from https://www.asi.edu.au/site/programs_aso.php

Bennett, J., & Hogarth, S. (2005). *'Would* YOU *want to talk to a scientist at a party?': Students' attitudes to school science and science.* Department of Educational Studies Research Paper Series No. 8. York: The University of York.

Bennett, J., & Hogarth, S. (2009). Would you want to talk to a scientist at a party? High school students' attitudes to school science and to science. *International Journal of Science Education*, *31*(14), 1975–1998.

BHP Billiton Science and Engineering Awards. (2014, June). Retrieved 30 November 2016, from http://www.scienceawards.org.au/default.asp

CREST Award. (2014, June). Retrieved 30 November 2016, from http://www.csiro.au/crest

Duan, X., Shi, J., & Zhou, D. (2010). Developmental changes in processing speed: Influence of accelerated education for gifted children. *Gifted Child Quarterly*, *54*(2), 85–91.

Freeman, J. (2006). Giftedness in the long term. *Journal for the Education of the Gifted*, *29*, 384–403.

Freeman, J. (2012). A quality of giftedness. *Gifted and Talented International*, *27*(2), 13–71.

Freeman, J. (2013). The long-term effects of families and educational provision on gifted children. *Educational and Child Psychology*, *30*(2), 7–17.

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Gagné, F. (1995). From giftedness to talent: A developmental model and its impact on the language of the field. *Roeper Review*, *18*(2), 103–111.
Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses related to achievement*. London: Routledge.
Hertzog, N. B. (2003). Impact of gifted programs from the students' perspectives. *Gifted Child Quarterly*, *47*(2), 131–143.
Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the Fridge: Sources of early interest in science. *International Journal of Science Education*, *32*(5), 669–685.
Oliver, M., & Venville, G. (2011). An exploratory case study of Olympiad students' attitudes toward and passion for science. *International Journal of Science Education*, *33*(16), 2295–2322.
The Royal Society. (2010). *Science and mathematics education, 5–14*. London: The Royal Society.
Universities Australia. (2012). *STEM and non-STEM first year students*. Canberra: Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education.

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