ATSE

# WONDER OF SCIENCE


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# Executive Summary

In Term 3, 2012, students from Year 6 to Year 9 from 15 schools across North, Far North and North West Queensland participated in the Australian Academy of Technological Sciences and Engineering (ATSE) Wonder of Science Challenge. This program aimed to enthuse students about science-based careers, and linked teachers and students with Young Science Ambassadors from universities and industry (ATSE, Queensland Division, 2012a). Student representatives from each class presented findings from a research project to an audience comprised of their peers and scientists at a culminating student challenge day.

To evaluate the 2012 Wonder of Science Challenge, a research team from the School of Education at James Cook University was commissioned to report on the program's progress towards meeting its primary objective. This evaluation, presented here, will provide feedback to key stakeholders (i.e. ATSE, Queensland Division; industry and university sponsors; and participating schools) and inform the program's future development.

This report presents an independent evaluation of the four ATSE Wonder of Science Challenge priorities, which are to:

- Inspire and develop the love of science in young people;
- Demonstrate industry engagement in communities through support of education and development of opportunities for young people;
- Develop and deliver activities that fit within the national science curriculum for students in the middle phase of learning from Years 6 to 9; and
- Prioritise activities in rural, remote and Indigenous communities with the support of university and industry ambassadors. (ATSE, Queensland Division, 2012a, p. 2)

Data were collected from the three categories of Wonder of Science Challenge participants: students, teachers and Young Science Ambassadors. Data collection instruments included surveys, student focus-group interviews, teacher interviews and student work samples. The instruments were designed to gather information to answer five research questions (RQs):

RQ1. How workable, effective and sustainable are the student research project model and supporting curriculum resources?

RQ2. What impact has the program had on participating students, teachers and Young Science Ambassadors?

RQ3. How can the teacher professional development be refined and improved before its next implementation?

RQ4. How can the school program be refined and improved before its next implementation?

RQ5. How can the student challenge day be refined and improved before its next implementation?

## Key Findings of the Evaluation of the ATSE Wonder of Science Challenge

The evaluation of the Wonder of Science Challenge identified 11 key findings.

**Key finding 1**
The Wonder of Science Challenge did not substantially engage with the challenge of working in rural, remote and Indigenous communities.

The majority of schools involved in the 2012 program were situated in metropolitan locations. Little evidence was available to the evaluation team reporting on how the program's organisers have engaged significantly with the challenge of meeting this aspirational priority.

**Key finding 2**
The majority of teachers had limited access to resources (i.e. classroom assistance, science resources or additional funding) to assist in the teaching of science and identified the need for further support in this area.

It is important that organisers are aware of the limitations imposed on a majority of teachers and plan a program that allows for those limitations. In the case of the Wonder of Science Challenge, the necessity for specialised science equipment was a significant impediment to more widespread adoption of the program, particularly by Year 7 classes.

**Key finding 3**
Teachers' evaluations of their self-efficacy in teaching science indicate that their confidence in their science teaching ability could be enhanced through the provision of targeted professional development.

Teachers reported confidence in teaching science, but a majority recognised the importance of further professional development.

**Key finding 4**
Teachers found the student research project model to be workable and effective but were concerned about the long-term sustainability of the Challenge due to limited student participation and class time.

**Key finding 5**
The Year 7 challenge topic, 'Design a solar powered vehicle to complete a revolution of a circle in 10 seconds', did not align well with the Year 7 Science Understanding content descriptors belonging to the Earth & Space Sciences sub-strand of *The Australian Curriculum: Science*.

**Key finding 6**
The quality and provision of supporting curriculum resources need to be improved to better support implementation of the student research projects. This includes providing complete unit outlines that align with *The Australian Curriculum: Science* and are teacher-friendly, providing assessment criteria for the student presentations and timely and adequate provision of specialist science equipment for particular research projects (e.g. class sets of solar car kits).

**Key finding 7**
The Wonder of Science Challenge positively influenced students' engagement, interest, enjoyment, motivation, attitudes towards science-related careers and science learning. These outcomes arose from students' positive experiences of all aspects of the Wonder of Science Challenge, including the student research projects, Young Science Ambassadors and the student challenge day.

**Key finding 8**
The Wonder of Science Challenge had a variable impact on participating teachers. While some teachers' attitudes towards and self-efficacy in teaching science remained unchanged, one teacher articulated proposed transformations to his classroom pedagogy and assessment strategies arising from his experience.

**Key finding 9**
Teachers generally reported an overall positive experience of the Wonder of Science Challenge. They perceived the student research project and the student challenge day the most valuable aspects of the Challenge. Teachers concerns arising from their participation chiefly related to inequitable access to supporting resources provided by the program; namely, professional development, curriculum resources and Young Science Ambassadors.

**Key finding 10**
The allocation of Young Science Ambassadors to schools and the Ambassadors' subsequent workload as part of the Wonder of Science Challenge were not equitable.

**Key finding 11**
Young Science Ambassadors reported an overall positive experience of the Wonder of Science Challenge. They perceived the Challenge to be of most value to students and to themselves. While they strongly agreed that the Challenge was an excellent opportunity for industry to engage with schools, feedback suggests that the full potential of this opportunity was not realised, as they perceived their involvement in the Challenge to be only somewhat valuable to industry.

**Key finding 12**
Teachers' feedback on the adequacy of the professional development day in preparing them to implement the Wonder of Science Challenge was mixed, as they had a number of unanswered questions and concerns about the student research projects and the student challenge day. Teachers appreciated hearing from and connecting with other teachers and experts and developed a better understanding of effective group work and how to implement open-ended student-led investigations.

## Conclusion

The 2012 Wonder of Science Challenge was partially successful in its initial year of operation. The program achieved some success in one of the four ATSE priorities—to '[i]nspire and develop the love of science in young people' (ATSE, Queensland Division, 2012a, p. 2)—as student participants reported positive experiences and outlooks as a result of the program.

Two other ATSE priorities were achieved to some extent. Students and teachers engaged with activities related to the Foundation to Year 10 *Australian Curriculum: Science* (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2012c) but gave variable evaluations of the unit's resources. Industry engaged in some communities through the classroom presence of Young Science Ambassadors, presentations by established scientists and the provision of resources; however, this engagement was not clearly evident to teachers.

Little progress was achieved for one ATSE priority. In 2012, the Wonder of Science Challenge did not '[p]rioritise activities in rural, remote and Indigenous communities'

(ATSE, Queensland Division, 2012a, p. 2). Little evidence was available to suggest that the planned student research projects were suitable for adoption by schools in these communities.

## Recommendations

This section summarises the 13 recommendations identified by the Wonder of Science Challenge evaluation in response to the five RQs.

### *RQ1. How workable, effective and sustainable are the student research project model and supporting curriculum resources?*

**Recommendation 1**
The Wonder of Science Challenge organisers should advertise the program and make information and resources available at the beginning of the school year.

Student participation in the Wonder of Science Challenge could be enhanced if schools are aware of the program early in the school year. This approach would provide sufficient planning time and better support schools to engage multiple classes in the student research projects.

**Recommendation 2**
The Year 7 challenge topic (i.e. 'Design a solar powered vehicle to complete a revolution of a circle in 10 seconds') should be re-evaluated and redesigned to better align with the Year 7 science curriculum.

An inquiry-based challenge would better suit the intent of the Earth and Space Sciences content descriptor that focuses on renewable and non-renewable energy. A designed-based challenge aligns better with the intent of the Physical Sciences sub-strand.

**Recommendation 3**
The Wonder of Science Challenge organisers should monitor equipment requirements of future programs to ensure appropriate equipment is available to all participants.

To support the participation of diverse schools in the Wonder of Science Challenge, schools must have adequate access to science resources. If student research projects require specialist science equipment (e.g. solar car kits for the Year 7 challenge), the ATSE should consider making such equipment available to schools—particularly primary schools and schools that are under-resourced. Alternatively, the research projects could be designed such that specialist equipment is not required.

**Recommendation 4**
The ATSE should make every effort to revise the format and substance of the 2012 school curriculum resources. Specifically, the Wonder of Science Challenge organisers should ensure that the 2013 unit plans are accessible, detailed and user-friendly for teachers and align with *The Australian Curriculum: Science*. The organisers should also provide schools with detailed assessment criteria for the student presentations at the commencement of the Challenge.

## *RQ2. What impact has the program had on participating students, teachers and Young Science Ambassadors?*

### Impact on students

**Recommendation 5**
The key aspects of the Wonder of Science Challenge that engaged students—namely, the student research projects, Young Science Ambassadors, and student challenge day—should continue to be included in future versions of the program.

These key aspects of the program positively influenced students' engagement, interest, enjoyment, motivation and attitudes towards science-related careers and science learning.

### Impact on teachers

**Recommendation 6**
The ATSE should make every effort to ensure equitable school access to supporting resources—that is, professional development, curriculum resources and Young Science Ambassadors.

To assist all schools to engage with the Wonder of Science Challenge, it is important that the organisers provide equal assistance to all schools; for example, by:

- providing alternative resources for teachers who cannot attend the professional development day, such as a teacher's pack that includes essential information for implementing the Wonder of Science Challenge and pre-empts common questions and concerns
- providing all schools with a full complement of necessary curriculum resources (including unit plans, assessment criteria and, as appropriate, specialist equipment) early in the school year, to ensure that they are well informed about the Challenge and are ready to implement it in Term 3 (as per Recommendation 3)
- implementing a structured approach to assigning Young Science Ambassadors to schools to ensure all schools have equitable access to an Ambassador.

### Impact on Young Science Ambassadors

**Recommendation 7**
In 2013, the Wonder of Science organisers should make changes to the Young Science Ambassador program, as suggested in Recommendation 6. Specifically, the organisers should adopt a more structured approach to assigning Young Science Ambassadors to schools.

It is important to the long-term sustainability of the program that all schools have equitable access to a Young Science Ambassador, and that Ambassadors have equitable workloads with respect to the number of schools to which they are assigned.

**Recommendation 8**

The Wonder of Science organisers should provide Young Science Ambassadors with school engagement guidelines and adopt an improved communication strategy to provide ongoing support for Ambassadors.

**Recommendation 9**

The ATSE should explore ways of enhancing industry engagement with the Wonder of Science Challenge with a view to benefiting both schools and industry. Such measures are likely to support more sustainable connections with industry in schools and make supporting the Wonder of Science Challenge more attractive to industry.

## Engaging with rural, remote and Indigenous communities

**Recommendation 10**

The Wonder of Science Challenge organisers should reconsider recruitment strategies and purposefully target schools in rural, remote and Indigenous communities. The organisers should seriously consider the choice of research project topic, use of technology and modifications to the student presentation format.

To meet the ATSE's objective of prioritising activities in diverse communities, the 2012 approach will need to be modified to offer alternative information and opportunities to schools. To this end, the organisers should:

- encourage Indigenous community participation through research topics that provide opportunity to value Indigenous knowledge and perspectives, as well as ensure all schools have access to appropriate information to enable both Indigenous and non-Indigenous students to engage with Indigenous knowledge and perspectives
- explore technology solutions to widen student participation in rural, remote and Indigenous communities; for example, video linking technology such as Skype or opportunities for student presentation videos to be hosted on YouTube could allow students to present research findings directly from their community
- consider the establishment of region-specific events as preliminary rounds of the student challenge day. Winning teams could represent their region in a student challenge finals day. This could encourage rural and remote schools' participation (and enhance participation, more broadly), as it negates the need for excessive travel. This model would reduce the ATSE's ongoing program costs. Other educational programs have already adopted a similar model (for example, Opti-MINDS [http://www.opti-minds.com], which implements regional and state finals).

## *RQ3. How can the teacher professional development be refined and improved before its next implementation?*

**Recommendation 11**

The Wonder of Science organisers should refocus the teacher professional development day to prioritise teachers' self-efficacy in student research project implementation.

Such a modified program would include workshops to engage teachers actively in strategies to develop students' science inquiry skills in the areas of questioning and predicting; planning and conducting investigations; processing and analysing data and information; evaluating; and communicating.

**Recommendation 12**
The teacher professional development day should clearly outline all aspects of the Wonder of Science Challenge so that teachers are confident about implementing the Challenge at their schools. As indicated by teacher feedback, this should include information about obtaining resources and materials for the student investigations, time guidelines for completing the student research projects, the running of the student challenge day and the expectations and criteria for student presentations.

### *RQ4. How can the school program be refined and improved before its next implementation?*

Recommendations 1–4, already presented, consider improvements necessary to the school-based component of the Wonder of Science Challenge—the student research projects.

### *RQ5. How can the student challenge day be refined and improved before its next implementation?*

**Recommendation 13**
The Wonder of Science Challenge organisers should consider changes to the student challenge day format to enhance students' engagement in this experience. These changes could include modifications to the presentation schedule, opportunities for student networking, presentations by a wider range of science professions and opportunities for students to complete additional science activities.

This might involve:

- changes to the schedule of student presentations to allow students to watch presentations by teams in different year levels
- the inclusion of a challenge day activity to provide students with the opportunity to meet and network with students from other schools
- presenting to students a broader view of the role of science in society by inviting guest speakers who use science in various professional vocations (e.g. doctors, engineers, pharmacists and physiotherapists). Guest speaker presentations could be supported by relevant industry site visits or excursions to enhance students' learning
- offering students the opportunity to participate in additional science activities on the student challenge day—for example, demonstrations and hands-on activities and experiments.

(*See also* the modification of the student challenge day format suggested in Recommendation 10.)

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# 1 Background and Purpose

## 1.1 Introduction

A recent report entitled *Health of Australian Science* notes the broad trend of lower participation rates in secondary and tertiary Science, Technology, Engineering and Mathematics (STEM) subjects to be a key vulnerability of the Australian science system (Office of Chief Scientist, 2012). The ATSE also has concerns that the supply of professionals with science, technology and engineering qualifications is insufficient to meet the current and future needs of Australia's growing industries (ATSE, Queensland Division, 2012a). These concerns are not new—several reports highlight the shortage of science-, technology- and engineering-qualified people (e.g. European Commission High Level Group report, 2004; Kelly, Butz, Carroll & Adamson, 2004; Victorian Parliament Education and Training Committee, 2006).

The trend of lower student participation in school science subjects has contributed to the enrolment situation in most tertiary STEM courses (Office of Chief Scientist, 2012). In Australia, participation in sciences at senior secondary school has declined over the 30-year period from 1976 to 2007 (Ainley, Kos & Nicholas, 2008). A 2010 study of Australian students highlighted the decline in the proportion of students choosing to study Physics, Chemistry and Biology in senior secondary school (Lyons & Quinn, 2010). In 2006, only 20 per cent of 15-year-old students in Australia planned to pursue a career in engineering or health sciences (Organisation for Economic Cooperation and Development [OECD], 2012).

Many students express disappointment in their secondary science experience (Hackling, Goodrum & Rennie, 2001; Tytler, 2007). They perceive school science to be neither relevant nor engaging, and lacking connection to their prior experiences and interests. Students are largely positive about science in primary school, but their enthusiasm wanes as they progress to secondary school (e.g. Breakwell & Beardsell, 1992; Osborne, Simon & Collins, 2003). Osborne, Driver and Simon (1998) found that students' positive attitudes towards school science appeared to peak at or before the age of 11 and significantly declined thereafter, particularly among girls. Similarly, the *Students' Positive Affect Towards Science* (PATS) index, created for the Trends in International Mathematics and Science Study (TIMMS) showed that 78 per cent of Year 4 students in Australia had high PATS scores (corresponding to a more positive affect) compared with less than half (47 per cent) of students in Year 8 (Martin, Mullis & Foy, 2008).

Studies into the decline in student interest in science have identified three key factors: the nature of the science curriculum, a shortage of teachers with science qualifications, and teachers' poor self-efficacy in teaching Science. A number of studies have identified problems with the nature of the traditional science curriculum, suggesting that it is not meaningful or interesting to school students (Aikenhead, 2005; Fensham, 2006; Lyons, 2006). Other research has suggested that the lack of suitably qualified teachers is a major issue for school science delivery, resulting in the allocation of science classes to non-science trained teachers (Harris & Farrell, 2007; Tytler, 2007). While it has been suggested that students' interest in science can be enhanced by adopting inquiry-based approaches that 'link with their lives and interests and broader aspirations' (Tytler, Osborne, Williamson, Tytler & Cripps, 2008, p. viii; *see also* Aikenhead, 2005; Goodrum & Rennie, 2007), non-science trained teachers often demonstrate a lack of confidence in teaching science, particularly science inquiry. Teachers who lack confidence to teach science inquiry are more likely to use teacher-centred modes of instruction (Osborne et al., 2003).

Teachers' self-efficacy in science inquiry can be improved through targeted professional development (Lokan, Hollingsworth & Hackling, 2006). In 2007, only one-third of Year 4 teachers and half of Year 8 science teachers reported participating in professional development activities concerned with improving students' critical thinking or problem-solving skills (Martin et al., 2008). It is important that teachers are supported throughout their career, from their initial teacher education on, with opportunities for continual science professional development (Barufaldi & Reinhartz 2001; Murphy, Neil & Beggs, 2007).

Master's (2009) review proposes strategies such as access to good quality pre-service and in-service teacher education programs and ongoing expert advice and support, in addition to clear expectations and measures of learning to improve levels of science achievement. Lokan et al. (2006) also outline 'an ideal blueprint for effective science teaching in Australia', wherein 'classroom science is linked to the broader community … students are actively engaged with inquiry, ideas and evidence … [and] challenged to develop and extend meaningful conceptual understandings' (p. xxi). However, Tytler (2007) argues that factors such as a rigid curriculum, the need for professional development for teachers who are less confident, and the conservative attitudes of many parents, teachers and university academics might mitigate the delivery of more contextual learning experiences. He also suggests that the delivery of authentic inquiry-based science lessons may prove challenging for teachers, as it requires 'a new set of teaching and learning skills that give more agency to students, and open up the possibility of new knowledge being produced, rather than simply rehearsals of well-known knowledge elements' (Tytler, 2007, p. 60).

In summary, evidence from both national and international studies highlights the need to address the issue of declining student participation in STEM. Many commentators see direct links between the decline in science enrolments and inadequacies of school science—predominantly a failure to engage students in science. The problem of diminishing numbers in science is occurring against a backdrop of concern that post-industrial societies may not have the capability to support future technology and science-based innovation strategies. Positive early engagement with science is viewed as an important approach to ease the decline in STEM participation. Several authors advocate an inquiry-based approach to engage students in science learning, while teachers require ongoing professional learning to develop the pedagogical skills and confidence to be able integrate authentic inquiry strategies effectively in schools.

## 1.2 The ATSE Wonder of Science Challenge

The Wonder of Science Challenge was proposed by the ATSE as one way of addressing concerns around students' attitudes towards science and the decline in STEM participation. This initiative aims to '[foster] excellence in technological sciences and engineering to enhance Australia's competitiveness, economic and social wellbeing and environmental sustainability' (ATSE, Queensland Division, 2012a, p. 3). The objective of the Wonder of Science Challenge is to 'increase enthusiasm for science- and engineering-based careers through an enhanced science and technology experience for Queensland school students' (ATSE, Queensland Division, 2012a p. 2).

The priorities of the Wonder of Science Challenge, articulated by the ATSE, are to:

- Inspire and develop the love of science in young people;
- Demonstrate industry engagement in communities through support of education and development of opportunities for young people;

- Develop and deliver activities that fit within the national science curriculum for students in the middle phase of learning from Years 6 to 9; and
- Prioritise activities in rural, remote and Indigenous communities with the support of university and industry ambassadors. (ATSE, Queensland Division, 2012a, p. 2)

In 2012, the Wonder of Science Challenge coincided with the introduction of *The Australian Curriculum: Science* for Foundation to Year 10 in Queensland schools. The new curriculum 'provides opportunities for students to develop an understanding of important science concepts and processes, the practices used to develop scientific knowledge, of science's contribution to our culture and society, and its applications in our lives' (ACARA, 2012a, paragraph 2). The curriculum is organised around three interrelated strands that focus on the development of science understanding, knowledge and skills:

> ***Science Understanding:*** Comprises key science knowledge to be developed from the *Biological sciences*, *Chemical Sciences*, *Earth & Space Sciences*, and *Physical Sciences* sub-strands.
>
> ***Science as a Human Endeavour:*** Highlights the role and nature of science in contemporary decision-making and problem-solving, and as a unique way of knowing and doing. It also acknowledges ethical and social implications associated with the decision-making process in scientific contexts. The strand gives recognition to the contributions of many different people from different cultures in scientific advances, and that there are extensive, rewarding science-based career paths.
>
> ***Science Inquiry Skills:*** Focuses on the development of science investigative skills such as identifying and posing questions; planning, conducting and reflecting on investigations; processing, analysing and interpreting the evidence; and using appropriate methods to communicate findings. It is also concerned with the application of skills such as evaluating claims, investigating ideas, solving problems, drawing valid conclusions and developing evidence-based arguments. (ACARA, 2012b)

The ATSE has positioned the Wonder of Science Challenge as an annual competition for students in Years 6 to 9. In 2012, schools were supplied with an inquiry problem (linked to *The Australian Curriculum: Science*) to be theoretically and experimentally researched to arrive at a 'solution'. The ATSE provided four inquiry problems—one for each participating year level. At the conclusion of their research, participating schools selected a team comprising a maximum of four students to represent them at the culminating student challenge day. At this competition, each team presented and defended the validity of their findings against those of a team from another school. Judges with expertise in science rated the teams' reports and the discussion that those reports generated. The problems could be presented in whatever format the students believed would best display the results of their investigation or design; for example, Microsoft PowerPoint slideshows, models, posters, video or any combination of these.

In 2012, the following problems were available to student participants:

Year 6: Earthquakes may or may not produce a Tsunami: Investigate.

Year 7: Design a solar powered vehicle to complete a revolution of a circle in 10 seconds.

Year 8: Design a Rube Goldberg machine to pop a balloon.

Year 9: Investigate whether changing salt levels have an impact on an eco-system. (ATSE, Queensland Division, 2012b, p. 6)

The Wonder of Science Challenge was implemented in three stages:

Stage 1: a professional development and briefing day for teachers from participating schools

Stage 2: the development of student research projects in schools, mentored and supported by ATSE Young Science Ambassadors

Stage 3: a competitive, culminating student challenge day on which students gather to present their research projects.

The professional development day involved teachers attending a one-day workshop in July 2012 to meet with the Wonder of Science Challenge organisers, learn about the Challenge and connect with Young Science Ambassadors (*see* Appendix 1 for the teacher professional development day program). Participants were briefed on the Challenge, learnt about school-based research projects and introduced to other ATSE school initiatives. The day concluded with a dinner attended by the ATSE president-elect. It was anticipated that, at the conclusion of the day, teachers would have a clear understanding of their roles and responsibilities in the Challenge and have had an opportunity to network with teachers from other schools and Young Science Ambassadors.

Students in each participating school undertook the student research projects over a 5–6-week period during August–September 2012. Schools were responsible for making pedagogical decisions about the implementation of the research projects and who would participate (e.g. a whole year level, particular classes or groups of students within a class). Young Science Ambassadors were allocated to each school to mentor students and teachers in their project work. Support was facilitated through face-to-face visits and email communications.

The final culminating activity brought all participants (students, teachers and Ambassadors) together for a one-day student challenge. Students presented their research projects in competitive rounds with the assistance of visual aids (e.g. PowerPoint slideshows). The competition required pairs of teams to critique one another's work and defend their own methodologies and findings. Teachers and students also participated in science activities throughout the day. These included industry site visits that afforded students the opportunity to observe practical applications of science and engineering and explore science-related careers. The day concluded with a dinner for all participants addressed by an inspirational speaker—a marine biologist from James Cook University (JCU), Townsville, Queensland.

An outline of the Wonder of Science Challenge, produced by program organisers in May 2012 (*see* Appendix 2), specified that the program would be funded by the ATSE for three years. After this period, it is envisaged that the program would 'develop a level of self sufficiency and sustainability [so that] regions would have the capacity to develop the program on their own' (p. 2). In considering the long-term sustainability of the program, it was also intended that 'the focus on linking schools and industry over a three-year initial partnership could provide the basis for an ongoing productive conversation between a school and its partner industry' (p. 2).

# 2 The Evaluation Model

## 2.1 Introduction

As previously articulated, the objective of the Wonder of Science Challenge is to 'increase enthusiasm for science and engineering based careers through an enhanced science and technology experience for Queensland school students' (ATSE, Queensland Division, 2011, p. 2). The Challenge comprises an innovative professional learning program supported with curriculum resources and Young Science Ambassador mentors and is designed to allow students and teachers to develop student-led research projects based on *The Australian curriculum: Science*. Completed student research projects were then presented in a culminating competition at a student challenge day.

The intention of the evaluation of the Wonder of Science Challenge was to report on the program's progress in 2012 towards meeting its purpose and priorities (outlined in Section 1.2).

In addressing the priorities identified by the ATSE, the evaluation of the Wonder of Science Challenge was framed around the following RQs:

RQ1. How workable, effective and sustainable are the student research project model and supporting curriculum resources?

RQ2. What impact has the program had on participating students, teachers and Young Science Ambassadors?

RQ3. How can the teacher professional development be refined and improved before its next implementation?

RQ4. How can the school program be refined and improved before its next implementation?

RQ5. How can the student challenge day be refined and improved before its next implementation?

## 2.2 Methods

The evaluation used a mixed-methods approach to data collection across the three key stages of the Wonder of Science Challenge (outlined in Section 1.2). Quantitative and qualitative approaches were used to gather data from participants in the Challenge. Triangulation of data and perspectives increased the credibility and trustworthiness of findings. Data were gathered from participant teachers using a series of three surveys. Participating students and Young Science Ambassadors completed end-of-project surveys. All surveys were comprised of a variety of question and response formats including dichotomous questions, multiple-choice questions, Likert-style rating scales and open-ended questions allowing for free response. Teacher interviews and student focus groups were conducted in two schools and samples of student work and other relevant artefacts were collected. Table 1 summarises the data collection methods adopted in the evaluation study and their corresponding RQs.

**Table 1. Instruments used for data collection and their alignment with the RQs**

| Data collection instrument | RQs | | | | |
|---|---|---|---|---|---|
| | RQ1 | RQ2 | RQ3 | RQ4 | RQ5 |
| Initial teacher survey | | | ✓ | ✓ | |
| Teacher professional development day survey | ✓ | ✓ | ✓ | | |
| End-of-project teacher survey | ✓ | ✓ | ✓ | ✓ | ✓ |
| End-of-project student survey | | ✓ | | ✓ | ✓ |
| Young Science Ambassador survey | | ✓ | | ✓ | |
| Teacher interviews | ✓ | ✓ | ✓ | ✓ | ✓ |
| Student focus-group interviews | ✓ | ✓ | | ✓ | ✓ |
| Analyses of student work | | ✓ | | ✓ | ✓ |

The evaluation process occurred towards the end of the Wonder of Science Challenge. A limitation of the evaluation process was the short lead-time between notification of participating schools and the start of the Challenge. The delays in finalising schools and the evaluation study limited the time available to recruit and follow participants. A period of eight weeks was required to meet systemic requirements and attain human ethics approval from JCU; the Department of Education, Training and Employment; the Townsville Catholic Education Office; and the Cairns Catholic Education Office before researchers could contact school participants. Table 2 presents a timeline of the evaluation process.

**Table 2: Evaluation timeline**

| Timeline | Research stage | Key research activity/activities | Key output/s |
|---|---|---|---|
| August 2012 | Preparatory stage | **Human ethics clearance from:**<br>JCU<br>Department of Education, Training and Employment<br>Townsville Catholic Education Office<br>Cairns Catholic Education Office<br><br>Preparation of data collection instruments | Statements of ethics approval<br><br>Data collection instruments |
| **August–September (5–6-week period) 2012** | **Implementation of the ATSE Wonder of Science Challenge in participating schools** | | |
| September 2012 | Data collection | **Data collection from all participant teachers:**<br><br>Initial teacher survey<br><br>Professional development day evaluation | **Key data**<br><br>Teacher survey data |
| **21 September** | **Wonder of Science student challenge day** | | |
| September–October 2012 | Data collection | **Data collection from two case study classes:**<br><br>Teacher interviews<br><br>Student focus-group interviews<br><br>Collection of student work and assessment arising from the Wonder of Science Challenge | **Key data**<br><br>Student work<br><br>Interview data from case study teachers and students |
| October 2012 | Data collection | **Data collection from all participants:**<br><br>End-of-project teacher survey<br><br>End-of-project student survey<br><br>Young Science Ambassador survey | **Key data**<br><br>Survey data:<br>• teachers<br>• students<br>• Young Science Ambassadors |
| October–November 2012 | Data analysis | **Analysis of:**<br><br>Teacher, student and ATSE Young Science Ambassador survey data<br><br>Teacher and student interview data<br><br>Student work arising from the project | Final collation of data for reporting |
| November–December 2012 | Reporting | Finalisation of evaluation report | Final evaluation report |

### 2.2.1 Survey instruments

This section outlines the development of five survey instruments used in the evaluation study:

- initial teacher survey (*see* Appendix 3)

- teacher professional development day survey (*see* Appendix 4)
- end-of-project teacher survey (*see* Appendix 5)
- end-of-project student survey (*see* Appendix 6)
- Young Science Ambassador survey (*see* Appendix 7).

Table 3 summarises survey returns as a percentage of the 15 schools that participated in the Wonder of Science Challenge in 2012.

**Table 3: Survey returns from the 15 schools in the evaluation study**

| Survey instrument | Returns, n | Return rate |
|---|---|---|
| Initial teacher survey | 8 | 53% |
| Teacher professional development day survey | 5 | 33% |
| End-of-project teacher survey | 4 | 27% |
| End-of-project student survey | 27 | 47%* |
| Young Science Ambassador survey | 4 | 44% |

*Note:* *From seven schools.

### *2.2.1.1 Initial teacher survey*

All consenting teachers who participated in the Challenge completed initial teacher surveys. The surveys were distributed via email and post (with a postage-paid return envelope). The purpose of the initial survey was to examine teachers' views about science teaching. The survey was divided into five sections:

- 'Information about you' (i.e. background, teaching experience and science qualifications)
- 'Teaching science at your school'
- 'Teaching across the curriculum'
- 'Different approaches to science teaching'
- 'Your attitudes to science teaching'.

The survey was based on the evaluation RQs, specifically those RQs that focused on refinements and improvements of the teacher professional development and school program for the next implementation. Items from the survey were drawn from a number of published surveys examining teacher attitudes to science and science teaching. Items examining teachers' confidence in teaching science and other curriculum subjects were adapted from instruments developed by Murphy and Beggs (2005) and the OECD (2006). Survey items related to self-efficacy in science teaching were adapted from the *Science Teaching Efficacy Belief Instrument—Preservice* developed by Enochs and Riggs (1990).

### *2.2.1.2 Teacher professional development day survey*

All consenting teachers who attended the professional development and program briefing were asked to complete an evaluation of the day. The survey asked teachers to share their views on the quality and purpose of the professional development and on their satisfaction with the day. Participant teachers also completed a free-response section to provide further information about knowledge gained, emerging concerns they had about the Challenge and how they planned to implement the Challenge in their school. The survey comprised the following sections:

- 'Quality of the professional development'
- 'Nature of desired professional development'
- 'Satisfaction with the Wonder of Science Professional Development Day'
- 'Preparedness to enact the Wonder of Science Challenge'
- free-response questions.

The aim of the teacher professional development survey was to inform RQs concerning the workability, effectiveness and sustainability of the student research project model and supporting curriculum resources; the impact of the program on participants; and refinements and improvements of the teacher professional development for the next implementation. Question 1 (quality of the professional development) included a series of statements that asked teachers to respond using Likert-style rating scales. The statements were guided by standards for professional learning published by Queensland Department of Education, Training and Employment (2012). Question 2 (nature of desired professional development) incorporated a series of statements (similar in layout to Question 1) that were drawn from the United States (US) *National science education standards* (National Committee on Science Education Standards and Assessment, National Research Council, 1996). The research team devised the open-ended questions specifically for the evaluation study.

### *2.2.1.3 End-of-project teacher survey*

Participant teachers completed a final survey after the culminating student activity. The purpose of the end-of-project survey was to obtain teachers' feedback on their overall experience of the Challenge. The survey asked teachers to provide feedback on the student research projects and curriculum resources, improvements required prior to further implementation, compatibility with the curriculum framework, the extent to which the project engaged students and the learning that occurred.

The survey was divided into three sections:

- 'Your experience of the Wonder of Science Challenge'
- 'Preparedness to enact the Wonder of Science Challenge'
- 'Your views about teaching science following the Wonder of Science Challenge'.

The end-of-project survey was devised to inform all of the evaluation RQs. The first two sections included a combination of statements requiring response on a Likert-style rating scale and free-response questions. Items were designed by the research team specifically for the evaluation study. Survey items belonging to the section 'Your views about teaching science following the Wonder of Science Challenge' were modified from the initial teacher survey.

#### *2.2.1.4 End-of-project student survey*

Students who participated in the Challenge were asked to complete the end-of-project survey after the final culminating activity. The survey aimed to explore students' experiences of the Wonder of Science Challenge and their views about science in general. The student survey comprised six sections:

- 'All about you'
- 'Your experience of the Wonder of Science Challenge'
- 'Your views on science'
- 'Your views on careers and science'
- 'Your views on learning science'
- 'Your experience of science in school'.

The survey was based on the evaluation RQs, specifically those concerned with the impact of the program on participants and refinements and improvements of the school program and student challenge for the next implementation. Items from the survey were drawn from a number of attitudinal surveys devised for students. The *Student questionnaire for PISA 2006* (OECD, 2005) informed the development of items belonging to the sections 'All about you', 'Your views on science', 'Your views on careers and science' and 'Your views on learning science'. Survey items belonging to the section 'Your experience of science in school' were adapted from Barmby, Kind and Jones' (2008) attitudes towards science measures. Survey items that explored students' experiences of the Wonder of Science Challenge were designed specifically for the evaluation.

#### *2.2.1.5 Young Science Ambassador survey*

A survey prepared for the ATSE Young Science Ambassadors was completed after the culminating activity. Participants were sent the end-of-project survey via email to complete and return online. The survey, which was designed specifically for the evaluation study, explored the Ambassadors' views on the effectiveness of the program, how they enacted the partnership with schools and the value of industry engagement in the project. The survey was divided into three sections:

- 'Information about you'
- 'Your experiences of the ATSE Young Science Ambassador Program'
- 'Satisfaction with the ATSE Young Science Ambassador Program'.

### 2.2.2 Teacher interviews and student focus groups

Two participant schools were identified and consented to participate in the case study element of the evaluation—a primary school and a secondary school. For the purpose of this evaluation report, these schools will be referred to by pseudonyms—as Wattle Tree State School and Melaleuca State High School, respectively. They were identified based on survey responses and selected to represent the geographic spread of the participant schools (i.e. the Cairns and Townsville regions).

Individual semi-structured interviews were conducted with the class teachers—Mr Matthews (a Year 7 teacher at Wattle Tree State School) and Ms Ellis (a Year 9 teacher at Melaleuca State High School). The interviews explored their experience of all phases of the Wonder of Science Challenge. Interview questions were framed around the following themes:

- the teacher professional development day
- implementing the Wonder of Science Challenge
- student engagement and learning arising from the student research projects
- working with Young Science Ambassadors
- the Wonder of Science student challenge day
- reflection on the experience.

A focus-group interview was also conducted with students from each school: Mark, Jane, John and Rebecca (pseudonyms), Year 7 students at Wattle Tree State School, and Samantha, Kylie and Trent (pseudonyms), Year 9 students at Melaleuca State High School. These students represented their classes at the student challenge day. The purpose of the focus groups was to provide a deeper insight into how the Wonder of Science Challenge was experienced by the students as well as their attitudes towards science, learning and achievement. The student focus groups explored the following key themes:

- student research projects
- Young Science Ambassadors
- the Wonder of Science student challenge day
- interest, enjoyment and learning.

### 2.2.3 Collection of student work

The research team collected student work samples from Wattle Tree State School and Melaleuca State High School to provide examples of students' achievements arising from the Challenge. Student work included copies of their culminating event presentation, accompanying notes, research carried out by the students and preparatory work conducted in class as part of the student research projects.

## 2.3 Data analysis

The surveys comprised dichotomous questions, multiple-choice response items, Likert-scale items and free-response questions. For the multiple-choice response and Likert-scale items, a coding framework was developed to guide the coding of participants' responses. Codes were analysed manually for descriptive statistics such as frequencies and percentages. Responses to open-ended questions were first read to identify the range of responses before being aggregated into broader themes.

All interview and focus-group recordings were fully transcribed and processed with NVivo version 10 (QSR International, 2012) software to identify emerging themes related to participants' experience of the Wonder of Science Challenge.

# 3 Demographic Information

To evaluate the effectiveness of the ATSE Wonder of Science Challenge, it was important to gain an understanding of all participants: schools, teachers, students and Young Science Ambassadors. The context was an important consideration for data interpretation.

## 3.1 School participation in the Wonder of Science Challenge

A summary of the 15 schools that participated in the Challenge in 2012—eight primary schools and seven secondary schools—is presented in Table 4. These schools represented both the government and non-government sectors and were drawn from Cairns, Townsville, Mount Isa and surrounding districts. Most of the participating schools are located in metropolitan areas; two schools are remote and one is provincial. The schools varied in size from 20 student enrolments to over 2,000, and the proportion of Indigenous students enrolled ranged from zero to 35 per cent. Nine of the 15 schools also have Index of Community Socio-Economic Advantage values lower than 1000, indicating that the students in those schools have some level of educational disadvantage. Of the 15 schools listed in Table 4, nine schools—five primary and four secondary—consented to participating in the evaluation study.

An important objective for the ATSE in the first implementation of the Wonder of Science Challenge was to '[*p*]*rioritise activities in rural, remote and Indigenous communities* [emphasis added] with the support of university and industry ambassadors' (ATSE, Queensland Division, 2012a, p. 2). However, most schools that participated in the first year of the trial are located in metropolitan areas and the Indigenous student population of five schools (i.e. 33 per cent of participating schools) was greater than 25 per cent of the student population (*see* Table 4). It is not possible to identify the proportion of students who participated in the Challenge who identified as Indigenous.

**Key finding 1: In 2012, the Wonder of Science Challenge did not substantially engage with the challenge of working in rural, remote and Indigenous communities.**

## 3.2 Teacher participation in the Wonder of Science Challenge evaluation

The eight teachers who participated in the initial teacher survey ranged from early career teachers to those who had taught for more than 20 years (*see* Table 5). Six teachers held a bachelor of education qualification, while two had completed a graduate diploma of education following a bachelor of science. With the exception of these two teachers, no other formal qualifications in science were held. In the past 18 months, five (63 per cent) had participated in some form of science professional development.

**Table 4: Schools that participated in the ATSE Wonder of Science Challenge in 2012**

| School | Sector | Approximate enrolments | Location | Indigenous students | School ICSEA value* |
|---|---|---|---|---|---|
| **Primary schools** | | | | | |
| 1 | Government | 30 | Remote | 0% | 1027 |
| 2 | Government | 400 | Provincial | 19% | 904 |
| 3 | Government | 600 | Metropolitan | 33% | 862 |
| 4 | Government | 600 | Metropolitan | 31% | 892 |
| 5 | Government | 700 | Metropolitan | 6% | 1054 |
| 6 | Government | 900 | Metropolitan | 35% | 844 |
| 7 | Government | 600 | Metropolitan | 9% | 1027 |
| 8 | Non-government | 900 | Metropolitan | 4% | 1060 |
| **Secondary schools** | | | | | |
| 9 | Government | 1400 | Metropolitan | 11% | 1003 |
| 10 | Government | 600 | Metropolitan | 26% | 885 |
| 11 | Government | 1400 | Metropolitan | 29% | 914 |
| 12 | Government | 600 | Metropolitan | 22% | 880 |
| 13 | Government | 900 | Metropolitan | 7% | 967 |
| 14 | Government | 2200 | Metropolitan | 19% | 917 |
| 15 | Non-government | 400 | Remote | 14% | 1007 |

*Data source: My School*™ website (ACARA, n.d.). 2011 data.

*Notes:* Schools that participated in the evaluation study are shaded. *ICSEA = Index of Community Socio-Economic Advantage, a measure of the average level of educational advantage of schools' student populations. Median ICSEA value for Australian schools = 1000.

**Table 5: Teaching experience of surveyed teachers (N = 8)**

| Years of teaching experience | Teachers, n (%) |
|---|---|
| <5 | 1 (12) |
| 5–10 | 5 (63) |
| 11-19 | 0 |
| >20 | 2 (25) |

## 3.3 Student participation in the Wonder of Science Challenge evaluation

Evaluation data were collected from 27 consenting students who participated in the Wonder of Science Challenge. All of these students represented their schools at the student challenge day. As shown in Table 6, 23 (85 per cent) of the respondents were female and the students ranged in age from 11 to 15 years old: four students were in Year 6, 16 were in Year 7 and seven students were in Year 9. Year 8 was not represented in the sample. Four Year 9 students and four Year 7 students participated in focus-group interviews; all these students submitted survey data and attended the student challenge day.

Twenty-five of the students were born in Australia. One of the students was born in Japan and one in Papua New Guinea, and moved to Australia when they were very young. All the students indicated that they mainly speak English at home.

Sixty per cent of the students identified Science as their favourite school subject. Seven students cited Mathematics, while one to two students identified Health and Physical Education, English, Dance, Drama, Art and Music.

The students were also asked whether their parents/guardians encouraged them to do well in Science at school and whether their parents/guardians used science in their work. In response to the first question, 100 per cent of students responded 'yes', while 60 per cent responded 'yes' to the latter.

**Table 6: Gender, ages and year levels of the students surveyed (N = 27)**

<table>
<tr><th rowspan="2">Gender</th><th colspan="10">Female</th><th colspan="10">Male</th></tr>
<tr><td colspan="10">23</td><td colspan="10">4</td></tr>
<tr><th rowspan="2">Year of birth</th><th colspan="4">1997</th><th colspan="4">1998</th><th colspan="4">1999</th><th colspan="4">2000</th><th colspan="4">2001</th></tr>
<tr><td colspan="4">1</td><td colspan="4">6</td><td colspan="4">3</td><td colspan="4">13</td><td colspan="4">4</td></tr>
<tr><th rowspan="2">Year level</th><th colspan="5">Year 6</th><th colspan="5">Year 7</th><th colspan="5">Year 8</th><th colspan="5">Year 9</th></tr>
<tr><td colspan="5">4</td><td colspan="5">16</td><td colspan="5">0</td><td colspan="5">7</td></tr>
</table>

## 3.4 Young Science Ambassador participation in the Wonder of Science Challenge evaluation

Four Young Science Ambassadors consented to participate in the evaluation: two males and two females (Suzie, Michelle, Tom and Mike [pseudonyms]), aged from 22 to 28 years old. As required by the Young Science Ambassador program, all were undertaking postgraduate research studies (i.e. a master's degree or doctorate). The fields of expertise of the Young Science Ambassadors were geography, biomedical science, physics and marine science.

Suzie and Michelle learnt about the Young Science Ambassador program through their individual institutions (via a faculty newsletter and an email distributed to postgraduate students, respectively). Tom was encouraged to participate in the program by a colleague who had worked as an Ambassador previously. Mike had participated in the program in 2011.

All of the participants were motivated to apply for the program, as they were passionate about science and about engaging students with science in fun and interesting ways, as illustrated by the following comments:

> Suzie: I am passionate about science communication.
>
> Michelle: I enjoy interacting with young students. I believe programs like [the] ATSE [Young Science Ambassador program] are essential for keeping students interested in, and passionate about, science.
>
> Tom: I applied because I am always interested in science outreach. I personally get a great kick out of showing kids science and showing them the practical/fun aspects of it.
>
> Mike: A great opportunity to do something fun and good for the kids.

# 4 Science at the Challenge Schools

## 4.1 Science teaching

A minority of teachers (33 per cent) reported that their schools possessed excellent science teaching resources, while 50 per cent of teachers did not have an assistant to aid in science preparation and/or teaching (*see* Table 7). This will have implications for the success of Wonder of Science Challenge science activities in future. There is a significant risk that schools will not have access to adequate specialised science equipment and that teachers will not to have support to prepare science activities. This will influence teacher and school decisions about Wonder of Science Challenge involvement and how many classes may be involved at each school. At Wattle Tree State School, the opportunity to participate in the Wonder of Science Challenge passed from teacher to teacher until one teacher accepted, as Mr Mathews explained:

> I think [the Wonder of Science Challenge] was offered to [the teacher] next door … and [the teacher] felt like she had enough on her plate and it sort of got passed on to me and I happily accepted it. I think the reason why it got passed around until it got to me was teachers were just unwilling to look at something that's not [clearly organised], [it should be such that] you open up your unit and follow this link and this is step-by-step, it's all laid out in front of you.

**Table 7: Teachers' classroom support for teaching science, and their rating of their schools' resources for teaching science (n = 6*)**

| Item | Responses, n | | |
|---|---|---|---|
| Do you have a classroom assistant to help with science preparation and/or teaching? | **Never** | **Sometimes** | **Most of the time** |
| | 3 | 2 | 1 |
| How would you rate your school's resources for teaching science? | **Poor** | **Satisfactory** | **Excellent** |
| | 3 | 1 | 2 |

*Note:* *Two teachers did not answer these questions.

The teachers were asked whether they were aware of any additional funding that their schools had obtained for science; six of the eight teachers who responded to this question did not know of any additional funding. The teachers were also asked which subject areas they felt their schools rated as being more important than science, if any. All of the participants identified one or more of the following subjects: English, Mathematics, Health and Physical Education, and the performing arts.

The Wonder of Science Challenge employed an oral presentation assessment mode. It was found that in their own teaching practice, all teacher respondents employed five assessment strategies: formative feedback given on students' work in progress, assessment of visual representations (e.g. drawings, graphs) that show students' understanding or reasoning, notebooking (assessment of students' science notebooks), assessment of experimental science reports and tests or examinations. Eighty-three per cent also assessed student oral presentations (*see* Table 8) and at least one teacher, Mr Mathews, used the student challenge day format for his Term 3 assessment:

[The Young Science Ambassadors] came back when the pairs were ready to do their presentations. They acted as the judges and conferred with me as to what score we were going to give the pairs. So the pairs were the presenters, the class was the knowledgeable experts and the Young Science Ambassadors were the judges.

**Table 8: Assessment strategies employed in science by the surveyed teachers (n = 6*)**

| Assessment strategy | Teachers who employed this strategy, n (%) |
|---|---|
| Formative feedback on students' work in progress | 6 (100) |
| Checklists of student observations | 4 (67) |
| Visual representations (e.g., drawings, graphs) that show students' understanding or reasoning | 6 (100) |
| Oral presentations | 5 (83) |
| Interviews | 2 (33) |
| Concept maps | 3 (50) |
| Notebooking (science notebooks) | 6 (100) |
| Peer review | 3 (50) |
| Self assessment | 4 (67) |
| Portfolios | 3 (50) |
| Experimental science reports | 6 (100) |
| Tests or examinations | 6 (100) |

*Notes:* Shaded strategies were used by all surveyed teachers. *Two teachers did not answer these questions.

Most teachers wished to participate in opportunities to improve their science pedagogy and resources. Seven teachers (88 per cent) indicated that they agreed or strongly agreed with the statement 'I am continually finding better ways to teach Science'. Given the teachers' desire for continual improvement, they also identified a number of areas in which they would benefit from additional support: science resources, classroom assistance/teacher aide time, professional development, networking opportunities with other science teachers and planning and preparation time.

**Key finding 2: The majority of teachers had limited access to resources (i.e. classroom assistance, science resources or additional funding) to assist in the teaching of science and identified the need for further support in these areas.**

## 4.2 Teachers' self-efficacy

Seven teachers rated their confidence in teaching science as 'high', while one rated their confidence as 'medium'; none of the teachers identified a low level of confidence in teaching science. The other key learning areas in which teachers felt highly confident were English (n = 4), Mathematics (n = 6) and Studies of Society and the Environment (n = 5). A medium level of confidence was indicated most frequently in teaching English (n = 4), Technology (n = 4) and Health and Physical Education (n = 4). Languages (n = 8) and the performing arts (n = 5) were most frequently cited as key learning areas in which teachers had the least confidence.

The majority (≥75 per cent) indicated a high level of confidence in developing the identified science inquiry skills, while all the teachers felt highly confident in developing questioning and predicting skills (*see* Table 9). None of the teachers reported a low level of confidence in developing any of the science inquiry skills, which was not surprising given the teachers' high level of confidence overall in teaching science, as reported earlier. These skills are identified in the Science Inquiry Skills strand in *The Australian Curriculum: Science* for Foundation to Year 10 (ACARA, 2012c).

**Table 9: Teachers' ratings of their confidence in developing students' science inquiry skills (N = 8)**

| Science inquiry skills | Responses, n | | |
|---|---|---|---|
| | High | Medium | Low |
| Questioning and predicting | 8 | 0 | 0 |
| Planning and conducting investigations | 6 | 2 | 0 |
| Processing and analysing data and information | 7 | 1 | 0 |
| Evaluating | 6 | 2 | 0 |
| Communicating | 7 | 1 | 0 |

Table 10 presents teachers' agreement with a number of statements related to their self-efficacy in teaching Science. The first two items are worded positively, while the next three items are worded negatively. Again, the teachers' relatively high levels of self-efficacy are reflected in their agreement with the first two statements (e.g. 'I know the steps necessary to teach science concepts effectively') and their general disagreement with the others (e.g. 'Even when I try hard, I don't teach science as well as I would like'). However, two teachers did not disagree with one or more of the negative items.

Collectively, these data indicate that the majority of the teachers surveyed were confident in their science teaching ability. However, it is important to recognise that, while most teachers reported they felt confident to teach science and science inquiry skills, at least one teacher identified a lack of confidence in the areas of science concepts and science investigations. At the same time, the majority of teachers did not strongly agree (or strongly disagree, for negatively worded items) with any of the items in Table 10.

**Table 10: Teachers' self-efficacy in teaching Science (N = 8)**

| Items | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| I know the steps necessary to teach science concepts effectively | 3 (38) | 5 (63) | 0 | 0 | 0 |
| I am typically able to answer students' science questions | 3 (37) | 5 (63) | 0 | 0 | 0 |
| Even when I try hard, I don't teach science as well as I would like | 0 | 1 (13) | 0 | 6 (75) | 1 (13) |
| When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better | 0 | 1 (13) | 1 (13%) | 3 (38) | 3 (38) |
| I find it difficult to explain to students why science experiments do or do not work | 2 (25) | 0 | 0 | 6 (75) | 0 |

*Notes:* The mode for each item is shaded. SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree.

**Key finding 3: Teachers' evaluations of their self-efficacy in teaching science indicate that their confidence in their science teaching ability could be enhanced through the provision of targeted professional development.**

## 4.3 Teachers' attitudes towards teaching science

The evaluation investigated two aspects of teachers' attitudes towards teaching science: their rating of different science approaches and their view of the impact of teachers on student performance.

All teachers rated student investigations as a highly important approach in teaching science, but the rating of student ownership of experimental procedures was contradictory. The teachers rated social interactions, making connections to the real world and linking conclusions to data as very important approaches. Some teachers placed less importance about where science experiments should take place.

Teachers thought that it was important for students to identify investigable questions, design their own experiments and test their ideas experimentally but were less supportive of the idea that students should choose their own investigations (*see* Table 11). Teachers provided variable responses to the items about student choice of experiment and following teacher instructions. It may be that teachers viewed the experimental approaches, whether student- or teacher-directed, as being equally important, thus did not favour one approach over the other. Teachers' responses to items on their attitude to the impact of teachers on student learning may be summarised into two distinct findings: (1) the teachers believed that they make a positive difference for their students and (2) students can underachieve despite the best efforts of the teacher. The teachers were also asked to indicate the extent to which they agreed with a number of statements (*see* Table 12), the first three of which are worded positively, while the next two are worded negatively.

The teachers believed that they are a positive influence on their students' science achievement. This was not surprising, given that they were confident in their science teaching ability (*see* Section 4.2). The majority of respondents (88 per cent) agreed that when the attainment of students improves in Science, it is most often because the teacher has implemented a more effective teaching approach. Similarly, 88 per cent of teachers either disagreed or strongly disagreed that increased effort in science teaching produces little change in some students' science achievement and 63 per cent believed that good teachers could overcome the inadequacy of a student's science background.

In contrast with the idea that teachers are a positive influence on student achievement, some teachers had mixed attitudes to who was responsible for student achievement. There was no consensus in response to the statement that students' underachievement is most likely due to ineffective science teaching. Similarly, teachers were mixed in their response to the notion that students' achievement in science is directly related to the effectiveness of their teachers' practice. While it may be expected that teachers would generally agree with the idea that effective teaching is an important determinant of students' achievement in Science, these variable results probably reflect the diverse and challenging school contexts in which the teachers work.

**Table 11: Teachers' ratings of the importance of a range of approaches to teaching Science (N = 8)**

| Approach to teaching Science | Responses, n (%) | | |
|---|---|---|---|
| | Of high importance | Of some importance | Of little or no importance |
| Students are given opportunities to explain their ideas | 7 (88) | 1 (13) | 0 |
| Students identify science questions that could be investigated | 7 (88) | 1 (13) | 0 |
| Students design their own experiments | 7 (88) | 1 (13) | 0 |
| Students have discussions about the science topics | 8 (100) | 0 | 0 |
| Students do investigations to test their own ideas | 7 (88) | 1 (13) | 0 |
| Students spend time in a laboratory during science experiments | 5 (63) | 2 (25) | 1 (13) |
| Students spend time in outdoor learning spaces during science experiments | 5 (63) | 3 (38) | 0 |
| Students draw conclusions from a science experiment they conducted | 8 (100) | 0 | 0 |
| Students choose their own investigations | 3 (38) | 5 (63) | 0 |
| Students do experiments by following the instructions of the teacher | 3 (38) | 5 (63) | 0 |
| The teacher uses real examples of science and technology to show how school science is relevant to society | 7 (88) | 1 (13) | 0 |

*Note:* The mode for each item is shaded.

Table 12: Teachers' attitudes towards effective Science teaching (N = 8)

| Items | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| Students' achievement in science is directly related to their teacher's effectiveness in science teaching | 2 (25) | 0 | 4 (50) | 2 (25) | 0 |
| When the science grades of students improve, it is most often because the teacher found a more effective teaching approach | 1 (13) | 6 (75) | 1 (13) | 0 | 0 |
| The inadequacy of a student's science background can be overcome by good teaching | 3 (38) | 2 (25) | 3 (38) | 0 | 0 |
| Increased effort in science teaching produces little change in some students' science achievement | 0 | 0 | 1 (13) | 4 (50) | 3 (38) |
| If students are underachieving in science, it is most likely due to ineffective science teaching | 1 (13) | 2 (25) | 2 (25) | 1 (13) | 2 (25) |

*Notes:* The mode for each item is shaded. SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree.

## 4.4 Students' attitudes towards science

Most students' attitudes towards and views about science were very positive; they viewed science as an important subject that was relevant their future. While the ATSE priority to '[i]nspire and develop the love of science in young people' (ATSE, Queensland Division, 2012a, p. 2) may be said to have been realised in these students, a limitation of this finding is that only students who attended the Wonder of Science Challenge student day completed the student survey, thus this finding may not represent the attitudes of the broader student community. These students attended the student challenge day to present the findings of their investigations. Given the competitive nature of the Challenge and the limited number of student places (i.e. four students per school), it is likely that the student representatives who attended were the high achievers in Science from each class, therefore more likely to have positive attitudes towards science in the first place. As few students indicated that they do not enjoy Science or see its worth, it is thus difficult to evaluate whether the Wonder of Science Challenge inspired students who did not have an existing love of science.

As shown in Table 13, the majority of students (≥89 per cent) indicated that they enjoyed science lessons and solving problems and that Science was one of their best subjects. Similarly, 86 per cent of students disagreed with the statement 'I find science difficult'. More than 70 per cent agreed that they learn science better through practical work.

Students' views about science were also very positive, with the majority (≥77 per cent) agreeing with the statements shown in Table 14. Moreover, the students perceived science to be very relevant to them and society.

The majority of students surveyed (85–93 per cent) indicated that they study science because it is useful to them, is a prerequisite for further studies and will improve their career prospects (*see* Table 15). Similarly, all students indicated that it was either important or very important to do well in the school subject of Science (*see* Table 16).

**Table 13: Students' attitudes towards the school subject of Science (N = 27)**

| Items | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| Science lessons are fun | 17 (63) | 7 (26) | 2 (7) | 1 (4) | 0 |
| I look forward to my science lessons | 13 (48) | 11 (41) | 2 (7) | 1 (4) | 0 |
| Solving science problems is enjoyable | 12 (44) | 12 (44) | 2 (7) | 1 (4) | 0 |
| We learn interesting things in science lessons | 17 (63) | 8 (30) | 1 (4) | 1 (4) | 0 |
| I get good marks in science | 15 (56) | 11 (41) | 1 (4) | 0 | 0 |
| Science is one of my best subjects | 14 (52) | 11 (41) | 0 | 2 (7) | 0 |
| In science, I can talk to other students about the work we are doing more than in other subjects | 10 | 9 (33) | 3 (11) | 5 (19) | 0 |
| I only like science when I am doing practical work | 3 (11) | 4 (15) | 12 (44) | 6 (22) | 2 (7) |
| We learn science better when we do practical work* | 5 (19) | 14 (54) | 7 (27) | 0 | 0 |
| We do too much practical work in science | 2 (7) | 4 (15) | 7 (26) | 6 (22) | 8 (30) |
| We do too much written work in science | 4 (15) | 3 (11) | 8 (30) | 8 (30) | 4 (15) |
| I find it difficult to understand the results of science experiments | 0 | 3 (11) | 5 (19) | 11 | 8 (30) |
| I find science difficult | 1 (4) | 2 (7) | 2 (7) | 12 (44) | 10 (37) |

*Note:* The mode for each item is shaded. *n = 26.

**Table 14: Students' views about science (N = 27)**

| Items | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| I generally have fun when I am learning science topics | 14 (52) | 11 (41) | 2 (7) | 0 | 0 |
| I like reading about science | 9 (33) | 12 (44) | 6 (22) | 0 | 0 |
| I am happy doing science problems | 14 (52) | 10 (37) | 3 (11) | 0 | 0 |
| I enjoy acquiring new knowledge in science | 23 (85) | 3 (11) | 1 (4) | 0 | 0 |
| I am interested in learning about science* | 19 (73) | 6 (23) | 1 (4) | 0 | 0 |
| Advances in science and technology usually improve people's living conditions | 16 (59) | 7 (26) | 3 (11) | 1 (4) | 0 |
| Science is very relevant to me | 12 (44) | 11 (41) | 3 (11) | 1 (4) | 0 |
| I find that science helps me to understand the things around me | 19 (70) | 8 (30) | 0 | 0 | 0 |
| Advances in science and technology usually bring social benefits | 14 (52) | 8 (30) | 5 (19) | 0 | 0 |
| When I leave school there will be many opportunities for me to use science | 19 (70) | 5 (19) | 3 (11) | 0 | 0 |

*Notes:* The mode for each item is shaded. SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree. *n = 26.

**Table 15: Students' views about learning science (N = 27)**

| Items | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| Making an effort in school science is worth it because this will help me in the work I want to do later | 18 (67) | 7 (26) | 1 (4) | 1 (4) | 0 |
| What I learn in school science is important for me because I need this for what I want to study later on | 14 (52) | 9 (33) | 2 (7) | 2 (7) | 0 |
| I study science because I know it is useful for me | 15 (56) | 10 (37) | 1 (4) | 1 (4) | 0 |
| Studying school science is worthwhile for me because what I learn will improve my career prospects | 14 (52) | 10 (37) | 2 (7) | 1 (4) | 0 |

*Notes:* The mode for each item is shaded. SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree.

**Table 16: Students' ratings of the importance of doing well in the school subject of Science (N = 27)**

| | Very important | Important | Of little importance | Not important at all |
|---|---|---|---|---|
| **Responses, n (%)** | 18 (67) | 9 (33) | 0 | 0 |

# 5 Evaluation Findings and Discussion

## 5.1 Evaluation of student research project model

Teachers perceived the student research project model workable and effective; however, the sustainability of the project was questioned. The relevance of the student project topics and the ability for more than one class to engage in the projects were seen as important issues for the long-term sustainability of the Challenge. The Wonder of Science Challenge model had a generally positive impact on the students and Young Science Ambassadors surveyed (*see* Sections 6.2.1 and 6.2.3, respectively) but teachers had mixed views (*see* Section 6.2.2). Given the critical importance of teachers to the long-term success and sustainability of the Challenge, efforts are required to address teacher concerns.

Five teachers participated in the teacher professional development day survey. In four schools (i.e. two secondary schools and two primary schools, including Wattle Tree State School), a single class implemented the Challenge. At the secondary schools (including Melaleuca State High School), a single extension science class was selected by the Science head of department to participate in the Challenge.

At three of these schools, the whole class was involved in the research projects, though teachers organised different student groupings to engage in the investigations. In Year 9, students were placed in groups of three or four, while students worked in pairs in one Year 7 class. At Wattle Tree State School, only selected students in a Year 7 class were nominated to participate in the Wonder of Science Challenge. Mr Matthews commented that he intended that the Challenge would be undertaken by a whole class in the following year, and a whole year group the year after that, if well organised.

At Melaleuca State High School, the Year 9 students in Ms Ellis' class were organised into groups of four, with each group assigned a different ecosystem to research. The groups presented to the class in the week before the Wonder of Science Challenge. Ms Ellis commented that if time had permitted, she would have required that the students critique one another's work, as was done in the final presentations. Four students were then chosen from different groups to participate in the student challenge day. Melaleuca State High School's Science head of department made these decisions in consultation with Ms Ellis. Similarly, at one of the primary schools, all students in a selected Year 6 class researched and presented their science investigations prior to the student challenge day. Then, the 'best students (those displaying knowledge, initiative and perseverance) were selected to present as a team' (classroom teacher).

Two teachers commented on important enabling factors that supported the implementation of the Wonder of Science Challenge in their schools. For Ms Ellis, having a motivated class was important: 'I had a class of students who were enthusiastic about the task and who were prepared to devote their lunch times for it'. For another, having a supportive principal and head of department was a key factor, as they provided extra resources, as required. This teacher also recognised the importance of having an extension science class, which offered her the opportunity to adopt to Wonder of Science Challenge at short notice, and funding provided by the ATSE to cover most costs. Mr Matthews thought the use of a scientific inquiry approach to teaching science was very beneficial:

> I was really surprised by how good it was to have an open-ended scientific investigation where the students really took it on board to develop their own scientific knowledge … the students really developed their own depth of knowledge, their own

scientific language that I felt every student achieved to their highest potential. There was a lot of higher-order thinking going on by the time they got to the class presentations. I can definitely see Term 1, Term 2 and Term 3 next year adapting these scientific investigations. I like that idea a lot.

Three teachers identified time as a challenge to the implementation of the Wonder of Science Challenge in their schools. For three teachers, lack of time was the most significant constraint. Ms Ellis identified lack of preparation time as challenging, particularly in the context of her other professional responsibilities: 'Time was limited. It came to a point in the term that I was extremely busy preparing my Year 12 verification submission for the district panel'. She also explained that, while the time allocated to the project by her school (i.e. five 65-minute lessons) was 'adequate', it was difficult for the students to excel at the task:

> I devoted the whole—it would have been three or four weeks—to only that task. But we only have two lessons a week [for Science], so we have 130 minutes a week. To me, that wasn't a lot of time for them to do it in the best capacity that they could have done it. I think that they needed more time to do it, but at the end of the day—I think the task said five lessons. To be honest, I probably allowed them a bit more than five lessons. But I thought the time was adequate, yeah.

Mr Matthews was concerned that the solar car construction needed to occur before the students could start on the science investigation:

> The other concern I had was how to fit it in. We might have had a 10-week timeframe and I was conscious that for the investigation to occur the way I wanted it to, we'd have to have the solar cars produced by three weeks into the investigation. So how to get the equipment quickly and get the investigation to the stage where we could have the vehicles operating to test the variables that we wanted to test [was a concern].

**Key finding 4: Teachers found the student research project model to be workable and effective but were concerned about the long-term sustainability of the Challenge due to limited student participation and class time.**

Teachers also expressed concerns about how well the student research projects aligned with *The Australian Curriculum: Science*. For example, Mr Matthews commented on the differences between the curriculum focus of his class and the other three Year 7 classes at Wattle Tree State School:

> I would have loved this solar challenge to be taken up by the four Year 7 classes because it was a bone of contention amongst the four classes that there are three classes who were doing planets—solar systems, I think—and one class doing solar-powered vehicles with the opportunity to go down to Townsville. So that created some angst for us in that there was one class receiving special treatment, I suppose. So at times that was a bit awkward and it [the Wonder of Science Challenge] didn't really relate to what they [the other classes] were doing.

This comment suggests a misalignment of the Year 7 challenge topic with the Year 7 science curriculum. Note that in Term 3, when the Wonder of Science Challenge was implemented, schools were studying units based on the Earth & Space Sciences sub-strand of *The Australian Curriculum: Science*. As shown in Appendix 8, the Year 7 topic was loosely aligned to the following content descriptor, due to its focus on a solar-powered vehicle: 'Some of Earth's resources are renewable, but other are non-renewable' (ACSSU116; ACARA, 2012c). However, given that the Year 7 topic was a design challenge, it aligns better with the Physical Sciences sub-strand of the science curriculum, as this sub-strand 'is concerned with understanding the nature of forces and motion … and energy' (ACARA, 2012b, paragraph 8).

**Key finding 5: The Year 7 challenge topic, 'Design a solar powered vehicle to complete a revolution of a circle in 10 seconds', did not align well with the Year 7 Science Understanding content descriptors belonging to the Earth & Space Sciences sub-strand of *The Australian Curriculum: Science*.**

Interestingly, the Science head of department at Melaleuca State High School also commented on the nature of the Year 8 challenge, 'Design a Rube Goldberg machine to pop a balloon'. He decided that his school would participate in the Year 9 investigation instead, as he valued an inquiry- rather than design-based challenge:

> [The Year 8 challenge] was a learning experience, not a traditional scientific investigation where students can easily change variables and collect and analyse data on the effects of this. It did not allow students to become the scientists, which was the purpose of [the Wonder of Science Challenge].

## 5.2 Evaluation of supporting curriculum resources

The quality of the supporting curriculum resource documentation, the alignment of this documentation with the school curriculum and the availability of necessary science equipment received the most criticism from teachers who participated in the Wonder of Science Challenge evaluation.

The ATSE provided teachers with guides to assess the student research projects in classes (*see* Appendix 9); however, several teachers commented on the lack of assessment criteria for the final student presentations. They felt that the lack of criteria made it difficult to explain to students on what they were being judged. For example, a primary teacher commented, 'I felt confused at some points regarding criteria and skills students needed'. Teachers were provided with a Challenge booklet that included a scoring guide for the final presentations (*see* Appendix 10); however, this booklet, distributed via email, was intended to assist with 'final preparations for the challenge' (D. Sutton, personal communication, 24 August 2012).

Two other secondary teachers were dissatisfied with the supporting curriculum resources provided. Their comments relate specifically to the Year 9 investigation, 'Changing salt levels can have an impact on ecosystems. Investigate this phenomenon'. According to Ms Ellis, the curriculum resource materials:

> were almost identical to C2C [Curriculum into the Classroom]* resources that were readily available to state school teachers but were missing some linked resources …

---

*C2C units of work were developed by the Department of Education, Training and Employment to guide the implementation of *The Australian Curriculum* for Foundation to Year 10 in English, Mathematics and Science.

> [they] were the main basis of work in class but were not provided in full and could have been added to in order to be more useful.

Another teacher stated that the resources were 'provided too late' and 'not aligned well' with the curriculum and the 'organisation was poor and thus support could not be utilised'. For this teacher, the 'non-alignment with [the] Year 9 curriculum' was a significant constraint.

Mr Matthews did not feel supported by the format and language used in the supporting curriculum resources:

> [In the future,] I would hope and think that they would have more of a framework for teachers, more of a unit—there was a unit plan … but it wasn't something that I found user-friendly as a classroom teacher. It was too wordy and too technical, really, to be relevant to what I needed. I really liked the C2C units and I find those easy to follow, but the ATSE unit plan was … not something that I could use.

This view is reflected in teachers' mixed responses to the curriculum resources provided at the teacher professional development day (*see* Table 17). None of the teachers rated the curriculum resources as more than satisfactory.

**Table 17: Teachers' ratings of curriculum resources provided at the teacher professional development day (n = 4)**

| Aspect of the teacher professional development day | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | Excellent 5 | 4 | Satisfactory 3 | 2 | Poor 1 |
| Curriculum resources provided | 0 | 0 | 3 (75) | 1 (25) | 0 |

While teachers were dissatisfied with the supporting curriculum resources, their evaluation of them differed on alignment with the curriculum (particularly among the Year 9 teachers who were surveyed). It might be the case that while the resources were developed to align with C2C units, these units may have been taken up or adapted differentially in particular schools; thus, schools would be placed differently when implementing the Wonder of Science Challenge.

Teachers presented different experiences when asked about the availability of science resources to complete the Challenge. Ms Ellis was able to access the resources she required, while Mr Matthews was very concerned about resources until the ATSE Science and Technology Education Leveraging Relevance (STELR) Project provided assistance:

> I didn't have the materials that I thought I needed. I didn't have the solar panels or the gearbox, the motors. I wanted to do it as a whole class so I wanted the class to produce 12 solar vehicles, working in pairs, but I didn't know where I could get the equipment required to produce these 12 solar cars. So that was my main concern. The other very fortunate thing that happened was I came into contact with Rod Dunstan from STELR in Melbourne, which is the educational arm of ATSE. He was having a discussion with me about solar car kits and I was thinking about purchasing a couple but somewhere along that conversation he ended up sending me the parts I needed to make 12 or 13 solar vehicles in my room. So that was fantastic.

**Key finding 6: The quality and provision of curriculum resources need to be improved to better support implementation of the student research projects in schools. This includes providing complete unit outlines that align with *The Australian Curriculum: Science* and are user-friendly for teachers, providing assessment criteria for the student presentations and timely and adequate provision of specialist science equipment for particular research projects (e.g. class sets of solar car kits).**

## 5.3 Impact on participating students

The Wonder of Science Challenge had a positive impact on the participating students' perception of science. Students consistently reported a high level of engagement, enjoyment and motivation to complete the science activities. Students particularly enjoyed both the culminating presentations and the dinner guest speaker.

All students surveyed agreed that the Wonder of Science Challenge was fun, while the majority indicated that they: had learnt a significant amount of science (96 per cent), were more interested in science as a result of participating in the Challenge (88 per cent) and would like to participate in another Wonder of Science Challenge (89 per cent) (*see* Table 18). Ninety-six per cent of students disagreed that they had not learnt anything new from the Challenge. These findings suggest that the ATSE priority to '[i]nspire and develop the love of science in young people' (ATSE, Queensland Division, 2012a, p. 2) was achieved.

Mr Matthews thought that a major motivating factor for students was the challenge aspect of the project. The Year 7 investigation started with the construction of a working solar car model, but students then needed to ensure that it could fulfil the brief criterion of completing a full revolution of a circle in 10 seconds. When asked if this end goal was motivating, he responded:

> Oh yeah. They could have built a solar-powered vehicle and just presented on that and it wouldn't have been anywhere near the depth of knowledge or the higher level of thinking that the extra part of the challenge of producing a vehicle that did a 10-second revolution really took them to. They took it on board. Their first part was to get it to go in a revolution first off, then to time that revolution and what could they do, usually, to speed it up.

In addition to the interest, enjoyment and fun offered by the Wonder of Science Challenge, 55 per cent indicated that the Challenge had made them think about a career in science, although 37 per cent remained undecided (*see* Table 18). More broadly, students' views on the school subject of Science also varied. While 96 per cent of respondents agreed that studying science at school would provide them with the basic skills and knowledge for a science-related career, up to a third indicated that they were unsure whether they wanted to study science after secondary school or pursue science-related careers (*see* Table 19).

**Table 18: Students' views on the Wonder of Science Challenge (N = 27)**

| Item | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| The Wonder of Science Challenge was fun | 22 (81) | 5 (19) | 0 | 0 | 0 |
| I learnt a lot about science from the Wonder of Science Challenge | 12 (44) | 14 (52) | 1 (4) | 0 | 0 |
| The Wonder of Science Challenge has made me think about a career in science and engineering | 9 (33) | 6 (22) | 10 (37) | 1 (4) | 1 (4) |
| I did not learn anything new from the Wonder of Science Challenge | 0 | 0 | 1 (4) | 4 (15) | 22 (81) |
| I am more interested in science because of the Wonder of Science Challenge* | 5 (29) | 10 (59) | 1 (6) | 0 | 1 (6) |
| I would like to participate in another Wonder of Science Challenge* | 11 (65) | 4 (24) | 1 (6) | 1 (6) | 0 |

*Notes:* The mode for each item is shaded. SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree. *n = 17.

The Year 7 and Year 9 students interviewed in the focus groups were clear that they were definitely thinking about science-related careers and that major influences were the dinner guest speaker and industry site visits. In the Year 9 focus group, all four students reported that they were now more open to and interested in a career in science, nominating specifically the occupations of orthodontist, surgeon and marine biologist. At least one student was influenced directly by a scientist's presentation:

> The guy that came at dinner time was a marine biologist and it made me want to be a marine biologist. Because he talked about all the different animals he studied in his job. How much fun he had and all the people he could work with. (Samantha, Year 9 student)

Similarly, when the Year 7 students from Wattle Tree State School were asked if they found the information about science careers interesting, they reported that the dinner guest speaker focused them on a future career in science:

> Jane: Yeah, it actually really persuaded me to become a marine biologist.
>
> Mark: Yeah, it was important that they showed us that it isn't just all about working out math and how particles meet and all that; it's also about finding out stuff that is dangerous, and getting yourself involved and ready, and out of your comfort zone. Yeah, medicine, chemists and like that has high science in that because you can mix something up. Then also building, like building a house. You've got to know the science behind how it stays up, how its gravity is pushed in and all that, how much it weighs, and how much you can—what's the density and all that.
>
> Jane: Yeah. When I heard [the JCU scientist] talking about being one, it persuaded me then. I also have a friend that has a dad that gets to do what he loves and gets paid for it. Other than that, I might like to do medicine as well because it has a bit of science in it. It really persuaded

me to be a marine biologist; working with film directors, and going and working with actors, and just going out and having fun when you're doing your actual job and getting paid for it.

John: A lot of jobs have science in it, like forensic scientists and builders, doctors, yeah.

**Table 19: Students' views on studying science and science-related careers (N = 27)**

| Item | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| Studying science at school provides me with the basic skills and knowledge for a science related career | 19 (70) | 7 (26) | 1 (4) | 0 | 0 |
| I will learn many things in school science that will help me get a job | 9 (33) | 15 (56) | 3 (11) | 0 | 0 |
| I would like to work in a career involving science | 12 (44) | 7 (26) | 7 (26) | 1 (4) | 0 |
| I would like to study science after secondary school | 10 (37) | 10 (37) | 5 (19) | 2 (7) | 0 |
| I would like to spend my life doing advanced science | 8 (30) | 6 (22) | 10 (37) | 3 (11) | 0 |
| I would like to work on science projects as an adult | 8 (30) | 9 (33) | 8 (30) | 2 (7) | 0 |

*Notes:* The mode for each item is shaded. SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree.

Seventy-eight per cent of students indicated they felt a high degree of interest during the Wonder of Science Challenge (*see* Table 20), while 70 per cent reported a high level of enjoyment during the science classes and while working with the Young Science Ambassadors (*see* Table 21).

**Table 20: Students' ratings of their level of interesting during the Wonder of Science Challenge (N = 27)**

| | High | Medium | Low | None | Undecided |
|---|---|---|---|---|---|
| **Responses, n (%)** | 21 (78) | 6 (22) | 0 | 0 | 0 |

The students were also asked to identify specific aspects of the Wonder of Science Challenge that they found most enjoyable. They cited the social benefits of participating in the Challenge—that is, meeting people and making new friends—most frequently. They also enjoyed the presentation component of the student challenge day; in particular, delivering their presentations and the competitive format of the presentations, in which they had the opportunity to defend their work and critique the work of others. For example, a Year 6 student explained, 'The … competition [was] interesting and made me think strongly about the subject. The competition was very friendly and teachers and judges told their point of view … a lot of them helped a lot in the contest'. Similarly, a Year 7 student commented, 'I loved the experience and how I had fun and enjoyed presenting and being an informed colleague. I also gained new friends'. However, for one Year 7 student, this aspect of the

Challenge—'Having to judge the other schools and tell them the negatives of their designs'—was not an enjoyable experience.

**Table 21: Students' ratings of their enjoyment of particular aspects of the Wonder of Science Challenge (N = 27)**

| Aspect of the Wonder of Science Challenge | Responses, n (%) | | | | |
|---|---|---|---|---|---|
| | High | Medium | Low | Undecided | Did not do this |
| Working on the Wonder of Science Challenge in science classes* | 16 (70) | 7 (30) | 0 | 0 | 0 |
| Working with a Young Science Ambassador | 19 (70) | 7 (26) | 1 (4) | 0 | 0 |

*Note:* *n = 23; four primary students did not respond to this item, as they did not work on the Challenge in their regular Science classes.

Students also enjoyed learning about science and being challenged. For example, a group of Year 7 students from a single team cited different reasons for why they enjoyed learning about science the most:

> I enjoyed learning about the other types of vehicles and how solar power works.
>
> I enjoyed the fact that it wasn't easy and it was actually hard.
>
> I enjoyed learning about science and considered it as a career choice.

Students in both focus groups enjoyed the group work aspect of the Wonder of Science Challenge and saw parallels between their work on the Challenge and the role of scientists. Samantha (Year 9 student) commented on the division of labour for the Challenge:

> We … gave each other roles to help out and so over the weekend we do—one of us would do … some of the typing and add different things in and then the other one would organise a PowerPoint and everything and then when we came for class next week, we'd all put it together and see our progress.

Three of the Year 7 students, Jane, Mark and John, commented on the benefits of teamwork and the amount of work completed outside class time:

> John: Well, when we first got this task, I thought it was going to be impossible to make this car but Mark said, "it's going to be easy". I'm just thinking, I don't think so. Then he just came up with the motor and all that stuff, and then I found out that it was easy to make it, yeah.
>
> Mark: Yeah, we did a fair bit outside the classroom. We Skyped each other at home deciding what parts we had to each other; what we had, what we could use and then talking about us doing the project at home and going to each other's houses.
>
> Jane: Well, we probably did more at home than at school because at home, we had the time to find more information and work on our car. At school, we couldn't really work on our car because we didn't really have the

right bits, what we had at home, so we just worked on our presentation in class.

The students were asked whether they thought scientists worked in groups or alone:

John: They work in groups. Yeah, you need help from others and ideas from others so you get more precise.

Mark: I learned that it requires a fair bit of teamwork. You've got to all put in 100 per cent, otherwise you don't get 100 per cent, and there's lots more to do in just science; there's science in everything. Everything's part of science.

The students also enjoyed their interactions with the Young Science Ambassadors. While the Year 9 students talked about how their Ambassador assisted their science understanding, the Year 7 students also talked about the ways in which their Ambassador helped them with their final presentation and accompanying PowerPoint slideshow (*see* Appendix 11):

John: Well, one of the Science Ambassadors told us about solar panels and how they're made. Yeah, me and Mark thought [of] making this solar panel that makes electricity and then transforms it – yeah, and then making a light globe to turn on and off, so they taught us a lot, yeah.

Mark: Well, we saw how they developed their PowerPoints and how we could adapt ours to look more like theirs. They explained everything in simple terms and then went a bit more scientific later on.

Researcher: You thought that was a good approach?

Mark: Yeah, to work your way up to it. They really helped us a lot with our presentation; the way to set it out and helped us with the knowledge that we need to know to get us to the level that we need to be for research and stuff.

In comparing the science they did in Term 3 (i.e. the term in which the student research projects were completed) with the science they did in Term 2, the majority of students reported that they completed more experiments, had more ownership of the inquiry process, used their own explanations and conclusions more often, were involved in more in-class science discussions and noted more teacher use of real examples of science and technology (*see* Table 22). The student response to the statement about time in a science laboratory was mixed. Students were interested and enjoyed science during the term, and a major reason for their interest and enjoyment is likely to be linked to the scientific approach adopted by teachers during the Wonder of Science Challenge.

Mr Matthews further described the depth of science learning that this approach facilitated:

> [W]e had people with meters out recording the voltage that the sun's rays would produce. Could they produce that with torchlights or electric lamps? There was science wrapped up in the investigation that I had never even considered and because the class got to listen to everybody's presentation and discuss the presentations, there was a lot more science covered through the investigations and

critiquing the presentations than I could possibly have taught as a teacher-directed unit.

When teachers were asked to compare the Wonder of Science Challenge in Term 3 with Science lessons in earlier terms, Ms Ellis noted that her Year 9 class was an extension science class and that she did not notice any difference in the students' achievement:*

> To be honest, most of the class is getting As and Bs, but that's because it's already a targeted group, so it's hard to say. The other thing is, actually, I only took the class on last term anyway because a lady had left on maternity leave. They were very focused and motivated and did a lot of it at home and all that sort of stuff. So I can't compare how they were in class from the previous two terms but in terms of results, they did very well. They had been doing well all year and they do well in regular science. So they are very high-achieving students anyway.

**Table 22: Students' views on how often they experienced different learning activities in Science in Term 3 compared with Term 2 (N = 27)**

| Item | Students, n (%) | | | | |
|---|---|---|---|---|---|
| | A lot more this term | A little more this term | The same as Term 2 | A little less this term | A lot less this term |
| Students were given opportunities to explain their ideas in their own words | 14 (52) | 6 (22) | 7 (26) | 0 | 0 |
| Students spent time in a laboratory doing practical experiments | 7 (27) | 5 (19) | 11 (42) | 0 | 3 (12) |
| Students wrote conclusions based experiments they conducted | 14 (52) | 3 (11) | 9 (33) | 0 | 1 (4) |
| Students designed their own experiments | 12 (44) | 5 (19) | 6 (22) | 4 (15) | 0 |
| Students chose their own investigations* | 10 (38) | 6 (23) | 6 (23) | 2 (8) | 2 (8) |
| Students had in-class discussions about science topics | 12 (44) | 9 (33) | 6 (22) | 0 | 0 |
| Students did experiments by following the instructions of the teacher | 11 (41) | 2 (7) | 11 (41) | 3 (11) | 0 |
| Students did an investigation to test out their own ideas or questions | 12 (44) | 6 (22) | 8 (30) | 0 | 1 (4) |
| The teacher used real examples of science and technology to show how school science is relevant to society | 11 (41) | 9 (33) | 6 (22) | 1 (4) | 0 |

*Notes:* The mode for each item is shaded. *n = 26.

**See* Appendix 12 for samples of work drawn from a Year 9 student's science notebook from Melaleuca State High School. The sample illustrates the aim, hypothesis, experimental procedure, dependent variables, raw data tables and diagrams of one student's investigation.

However, Mr Matthews noted a significant difference, particularly the students' depth of science knowledge, between the Wonder of Science Challenge and previous terms. The Year 7 students from that class, Mark, Jane and Rebecca, agreed with this assessment:

> Mark: It's probably the funnest thing I've done. It gives you a bit more to think to. When you overcome that, it's really fun. I enjoyed how I learnt more; more than what I usually did before we did this task.
>
> Researcher: Do you think you learnt more in science in that term compared to the term before?
>
> Jane: Yes, definitely.
>
> Rebecca: Yeah, I think it was probably the best task I've ever done this year with science as we got to meet different people from different schools and see how they did it with their PowerPoint and, yeah, it was just fun, really fun.

Most students reported a high level of enjoyment for all aspects of the Wonder of Science Challenge student day dinner and presentations (*see* Table 23).

**Table 23: Students' ratings of their enjoyment of different aspects of the Wonder of Science Challenge (N = 27)**

| Aspect of the Wonder of Science Challenge | Students, n (%) | | | | |
|---|---|---|---|---|---|
| | High | Medium | Low | Undecided | Did not do this |
| Attending the Wonder of Science dinner | 24 (89) | 3 (11) | 0 | 0 | 0 |
| Presenting and defending my team's findings at the student challenge day | 21 (78) | 6 (22) | 0 | 0 | 0 |
| Challenging the findings of teams from other schools | 17 (63) | 9 (33) | 1 (4) | 0 | 0 |
| Learning about other teams' solutions to the challenge | 21 (79) | 5 (19) | 1 (4) | 0 | 0 |

*Note:* The mode for each item is shaded.

When students (N = 27) were asked to expand on what they enjoyed most about the Wonder of Science Challenge, most nominated the student presentations (10 students) or meeting new people (eight students). Other themes mentioned included the dinner guest speaker (four students), learning science (four students), the industry site visits (three students) and the food (one student). The students who were interviewed enjoyed the opportunity to listen to other students and respond to the different experimental approaches:

> Samantha (Year 9): I really liked responding to others, because we haven't done that before. It was a new experience.
>
> Kylie (Year 9): Yeah, it was a good experience to do that. I would like to know more about how other people did their experiments and stuff, because we only saw two groups, how they did theirs. But learning how all the other groups did their experiments would have been interesting.

Mark (Year 7): It felt new and fresh; being somewhere else than just doing it in the classroom, and presenting it to people that you didn't know. As well, it felt better than in the classroom because you didn't have to be very loud to talk because they're only five metres away, and you didn't have to have palm cards because the computer was right in front of you.

John (Year 7): It was great seeing all the other teams put effort into their work like how we were.

Mr Matthews, Ms Ellis and an organiser commented on the benefits of the student presentations. Both teachers highlighted benefits for their students beyond the Wonder of Science Challenge:

Ms Ellis: I loved those rounds. You come in, present and you have a debate or have a discussion about it. I thought it was brilliant.

Mr Matthews: You know, 12-year-old kids who are having an opportunity to take a project they've worked on in school down to Townsville to present at a resort to other students they don't know in an atmosphere that was very impressive for them, mingle with some older kids and younger kids. Confidence-wise … one of the [team] in particular was a very nervous presenter, at the start of the year we did our captain's speeches. The Science Challenge and practising [their] presenting skills [had a strong positive effect on] the way [they] spoke, the clarity of [their] voice, pace, diction, [their] self-confidence just went through the roof. So that was great. ... During Term 3, [they have] just really lifted to another level and his results are showing that. So [the student's parents] were very impressed with [the student] and the Challenge has been good.

Student answers (n = 21) to the question on their most important achievement during the Wonder of Science Challenge could be grouped into four main themes: the student challenge day presentation, learning science, socialising with other students and succeeding in solving the experimental challenge. For example, 'Creating the [solar-powered] vehicle and testing and making it work' was a significant theme that emerged from the 16 surveys completed by Year 7 students from four different schools (*see* Figure 1). This achievement would have been particularly gratifying, given that the challenge 'wasn't easy'. A majority of students nominated an aspect of the Challenge day presentations, whether that was participating (seven students) or winning (four students). Four students suggested their most important achievement was learning about science, while four students nominated the moment their experiment 'worked'. Three students nominated meeting new people or making friends.

Presenting at the student challenge day was also cited as an important accomplishment (e.g. 'My most important achievement in the Wonder of Science Challenge was having the opportunity to present my speech to other schools and receive positive feedback', Year 9 student), while other students were proud to have been part of the experience (e.g. 'Learning something new, meeting new people, getting the chance to be a part of something big … being able to experience it all was amazing', Year 6 student).

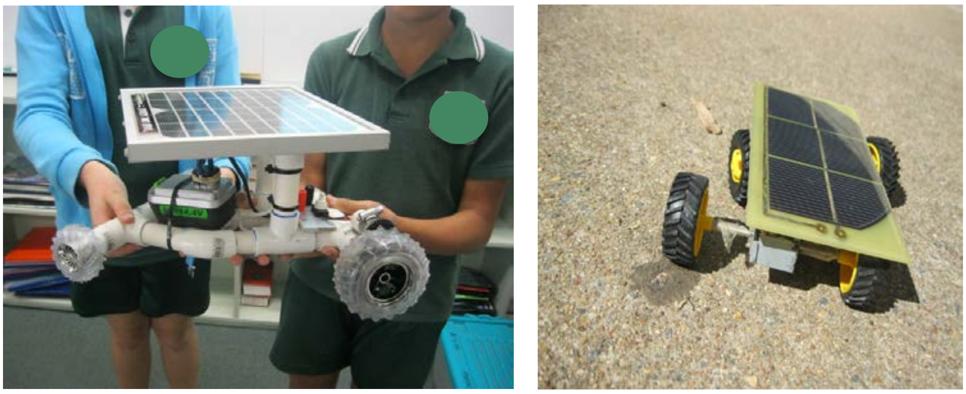

**Figure 1: Two solar vehicles produced by Year 7 students**

Students' responses (n = 17) to the question about whether anything else could have been included in the Wonder of Science Challenge could be grouped into three themes: nothing else required, an extension of the student challenge day and an increased number of events on offer. A majority of students thought that no change was required to the format of the presentation day (eight students), while four thought the student challenge day was too short. Four students indicated that an increased number of events would improve the challenge day: more experiments, more scientist presentations or additional site visits.

Similarly, students' responses (n = 19) to the question asking them to identify which aspects they enjoyed least about the Wonder of Science Challenge all related to their experience of the student challenge day. These included being required to stand in the sun for extended periods at certain industry site visits (a health and safety concern; four students), a change in the scheduling of industry site visits that meant some students did not get the opportunity to visit JCU (two students), inadequate morning/afternoon tea provided for students who were late returning from the industry site visits (two students) and travelling long distances to attend the student challenge day from outside of Townsville (one student).

A Year 6 student did not enjoy preparing for her team's presentation as it was 'confusing and hard'. It is to be noted that this student's teacher also commented, 'I felt confused at some points regarding criteria and skills students needed' (*see* Section 5.2). It is likely that the lack of clarity that this teacher experienced around knowing what she needed to do to prepare her students adequately for the challenge day led some students to feel confused.

Two students in the Year 7 competition were also concerned about inconsistencies in the scheduling of presentations that meant that some teams presented more times than others over the course of the day. Notwithstanding these concerns, the majority of students had an overall positive experience of the Wonder of Science Challenge.

**Key finding 7: The Wonder of Science Challenge positively influenced students' engagement, interest, enjoyment, motivation, attitudes towards science-related careers and science learning. These outcomes arose from students' positive experiences of all aspects of the Wonder of Science Challenge, including the student research projects, Young Science Ambassadors and the student challenge day.**

## 5.4 Impact on participating teachers

The Wonder of Science Challenge had a variable impact on the participating teachers. While some teachers' attitudes and self-efficacy were unchanged by the Challenge, another teacher (Mr Matthews) plans to transform his teaching approach using the Challenge model of student inquiry.

Four teachers consented to completing the end-of-project teacher survey: one primary teacher and three secondary teachers (including Mr Matthews and Ms Ellis). The purpose of the survey was to find out about their experience of the Wonder of Science Challenge and the impact of this experience on their views about science teaching and their teaching practice.

The initial teacher survey asked participants a number of questions related to their confidence in developing their students' science inquiry skills and their views about the importance of different approaches in teaching science (*see* Table 9 and Table 11, respectively). In the end-of-project teacher survey, the teachers were asked to respond to these questions again.

Mr Matthews indicated that his confidence in developing all of the science inquiry skills surveyed (i.e. those included in *The Australian Curriculum: Science*) improved after his participation in the Wonder of Science Challenge (*see* Table 24). A secondary teacher's confidence in developing students' skills in planning and conducting science investigations also improved. With the exception of these cases, the teachers' confidence did not change following their participation in the Wonder of Science Challenge (note that more than 75 per cent of teachers who completed the initial teacher survey reported a high level of confidence in developing science inquiry skills to begin with; *see* Table 9).

As well as indicating any changes in their perceived self-efficacy, the teachers were also asked to rate their level of confidence in developing students' science inquiry skills on a scale of one to 10, where one corresponds to having no confidence in developing a particular skill and 10 corresponds to having a very high level of confidence. Two secondary teachers responded to this aspect of the question; however, their confidence was unchanged by their participation in the Wonder of Science Challenge. As shown by the scores in the far-right column in Table 24, this indicates that they felt quite confident in developing science inquiry skills when they undertook the project.

The teachers were also asked to indicate whether their views on the importance of different approaches to teaching science changed following their participation in the Wonder of Science Challenge (*see* Table 25). Mr Matthews reported that he came to view each of the approaches listed in Table 25 as being more important than he did before, following his first-hand experience of the benefits that came from adopting a science inquiry approach:

> I was really surprised by how good it was to have an *open-ended scientific investigation* where the students really took it on board to *develop their own scientific knowledge*. Different terms—variables, independent variables, friction, diameter of circles—we did some work as a class about that, explaining what was needed, explaining the timeline, that was a fair bit of teacher-directed, whole-class learning. But from that point on, the *students really developed their own depth of knowledge*, their *own scientific language* that I felt *every student achieved to their highest potential*. There was a lot of *higher-order thinking* going on by the time they got to the class presentations. You need more of an awareness that you can get carried away with that teacher-centred learning where you're the expert at the front

of the room and you're sitting in the chairs and this is what we're learning today—than the correct activities that engage pairs or small groups where they can *take ownership of their learning* … when you're presenting, you're catering for the levels in the room and a depth of knowledge tends to be middle-of-the-road. So the lower ones aren't left far behind and it's still challenging enough for your top kids. But if you've got the student-centred investigation, *they can take it as far as they want* and it never ceases to amaze me how far kids will take these ideas. As I said at the start, when I was apprehensive about it—oh, I hope I can get something I can take back to Townsville—well by the time we were ready to have the pairs present, they had just *amazed me with what they were able to produce* [emphases added].

**Table 24: Teachers' ratings of their confidence in developing science inquiry skills after their participation in the Wonder of Science Challenge (N = 4)**

| Science inquiry skills | Responses, n | | | Score* |
|---|---|---|---|---|
| | I feel more confident than I did before | I feel less confident than I did before | My confidence has not changed | My level of confidence (n = 2) |
| Questioning and predicting | 1 | 0 | 3 | 8 |
| Planning and conducting investigations | 2 | 0 | 2 | 8.5 |
| Processing and analysing data and information | 1 | 0 | 3 | 6.5 |
| Evaluating | 1 | 0 | 3 | 7 |
| Communicating | 1 | 0 | 3 | 8.5 |

*Note:* *Teachers' average rating of their level of confidence in developing students' science inquiry skills on a scale of one to 10 (1 = no confidence in developing a particular skill; 10 = extremely confident).

A secondary teacher also indicated that she perceived having students identify science questions that could be investigated, design their own experiments, conduct investigations to test their own ideas and draw conclusions from a science experiment they conducted to be more important after completing the Wonder of Science Challenge. Regardless of whether their views changed over the course of the project, the teachers rated these approaches as being very important in the teaching of science (note that the majority of teachers who completed the initial teacher survey already felt that the identified approaches were of high importance; *see* Table 11).

**Key finding 8: The Wonder of Science Challenge had a variable impact on participating teachers. While some teachers' attitudes towards and self remained unchanged, one teacher articulated proposed transformations to his classroom pedagogy and assessment strategies arising from his experience.**

**Table 25: Teachers' views of the importance of different approaches to teaching science (N = 4)**

| Item | Responses, n | | | Score* |
|---|---|---|---|---|
| | I feel that this approach is more important than I did before | I feel that this approach is less important than I did before | My views about this approach have not changed | Importance of this approach (n = 3) |
| Students are given opportunities to explain their ideas | 1 | 0 | 3 | 9.3 |
| Students identify science questions that could be investigated | 2 | 0 | 2 | 9.3 |
| Students design their own experiments | 2 | 0 | 2 | 8.0 |
| Students have discussions about the science topics | 1 | 0 | 3 | 9.3 |
| Students do investigations to test their own ideas | 2 | 0 | 2 | 9.3 |
| Students spend time in a laboratory during science experiments | 1 | 0 | 3 | 7.7 |
| Students spend time in outdoor learning spaces during science experiments | 1 | 0 | 3 | 9.3 |
| Students draw conclusions from a science experiment they conducted | 2 | 0 | 2 | 9.0 |
| Students choose their own investigations | 1 | 0 | 3 | 8.0 |
| Students do experiments by following the instructions of the teacher | 1 | 0 | 3 | 7.0 |
| The teacher uses real examples of science and technology to show how school science is relevant to society | 1 | 0 | 4 | 8.3 |

*Note:* *Teachers' average rating of the importance of each approach on a scale of one to 10 (1 = not important to successful science teaching; 10 = extremely important).

The four teachers who completed the end-of-project survey indicated that their overall experience of the Wonder of Science Challenge was generally positive. These teachers commented that the Wonder of Science Challenge was 'overall, a great initiative' and 'a very worthwhile project'. One secondary teacher found the experience of the Wonder of Science Challenge negative.

Table 26 presents a summary of teachers' experience and perceptions of the Wonder of Science Challenge (note that one item is worded negatively: 'I did not learn anything new from the Wonder of Science Challenge'). Three out of four teachers responded positively to the first seven items. One teacher's responses to these items were negative.

Concerning whether the Challenge made them think about developing more opportunities to engage with industry in their own science teaching practice, the teachers' experiences were more variable. Only one respondent agreed that this was the case; two disagreed and one was undecided. This is significant given that one of the priorities of the Wonder of Science

Challenge is to '[d]emonstrate industry engagement in communities through support of education and development of opportunities for young people' (ATSE, Queensland Division, 2012a, p. 2). Based on these responses, it is not likely that the industry engagement would be sustained in schools after the Wonder of Science Challenge.

**Table 26: Summary of teachers' experience and perceptions of the Wonder of Science Challenge (N = 4)**

| Item | Responses, n | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| The Wonder of Science Challenge was worth doing | 3 | 0 | 0 | 1 | 0 |
| Overall, the Wonder of Science Challenge aligned with the Australian Science Curriculum | 3 | 0 | 0 | 0 | 1 |
| I learned a lot about teaching science through the Wonder of Science Challenge | 1 | 2 | 0 | 1 | 0 |
| I did not learn anything new from the Wonder of Science Challenge | 0 | 1 | 0 | 1 | 2 |
| I will use ideas that I learned from the Wonder of Science Challenge again in my future teaching practice | 2 | 1 | 0 | 0 | 1 |
| The Wonder of Science Challenge engaged my students | 2 | 1 | 0 | 1 | 0 |
| My students learned a lot about science from the Wonder of Science Challenge | 2 | 1 | 0 | 1 | 0 |
| The Wonder of Science Challenge has made me think about developing more opportunities to engage with industry in the areas of science and engineering in my own teaching practice | 1 | 0 | 1 | 2 | 0 |

*Notes:* The mode for each item is shaded. SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree.

The teachers were asked how much interest they felt while they were involved in the Wonder of Science Challenge. As shown in Table 27, three participants (75 per cent) indicated that they were highly interested, while one teacher felt low interest.

**Table 27: Teachers' ratings of their interest during the Wonder of Science Challenge (N = 4)**

| | High interest | Medium interest | Low interest | No interest | Undecided |
|---|---|---|---|---|---|
| **Responses, n** | 3 | 0 | 1 | 0 | 0 |

The teachers were asked to rate the value of the following aspects of the Wonder of Science Challenge:

- attending the teacher professional development day
- the Wonder of Science supporting curriculum resources
- working on the Wonder of Science Challenge in Science classes
- working with a Young Science Ambassador
- attending the student challenge day
- attending the student challenge day dinner.

Further, the teachers were asked to consider the value of these aspects to them, personally, or to their students. They were also given the option to indicate if they did not have the opportunity to engage with any of these activities.

As shown in Table 27, the teachers' experience of the Wonder of Science Challenge was variable, both in terms of the aspects of the project that they engaged with and their ratings of the value of those aspects in which they did participate. Two teachers did not attend the professional development day, while one did not access the supporting curriculum resources, work with a Young Science Ambassador or attend the student challenge day and dinner. Although the sample size was small, this finding suggests that some schools did not have equitable access to the resources provided by the ATSE to support the implementation of the Challenge, including curriculum resources and a Young Science Ambassador. It also indicates that not all participating teachers were able to attend the professional development day. Collectively, these findings will have important implications for teachers' preparedness and capacity to enact future Wonder of Science Challenges successfully in schools (*see* Section 6).

Of the teachers who were in a position to rate the different aspects of the Wonder of Science Challenge, they generally perceived them to be of medium to high value (*see* Table 28). Working on the Challenge in Science classes, and attending the student challenge day and dinner were of most value to the teachers. Working with a Young Science Ambassador elicited the most variable responses. This aspect was of medium and high value to two teachers and of no value to another. The teacher who indicated that this aspect of the project was highly valuable commented, 'the use of the Ph.D. students was excellent'.

At interview, Ms Ellis and Mr Matthews explained their respective experiences of working with Young Science Ambassadors. While Mr Matthews had a 'fantastic' experience, Ms Ellis' 'didn't really know how to utilise' her Young Science Ambassador:

> Ms Ellis: She [the Young Science Ambassador] came to us on the day that we set up the experiment. I think it was the last week of school. We had [class] on Monday and Tuesday and the Challenge was on the Wednesday. So because we had almost finished—the students were presenting their findings during class time when she was ready to come back—she didn't actually come back a second time. In saying that, I think her non-involvement was almost—I didn't really know how to utilise her skills, I think. I didn't really know how best for her to come—she couldn't come in every lesson, that wasn't feasible for her. But I didn't know when to bring her in. I guess I didn't really ask for her

to come in and then when she was happy to come back at the end, we had finished. So we didn't really get to use her skills as much as I think we could have. Like I said, she came in on the day that they were doing the experiment. It would have probably been better if she'd even come in the day before, when they were preparing.

Mr Matthews: I really thought my Science Ambassadors were fantastic. They turned up when they said they'd turn up and they weren't any problem at all. They were more than willing to stay as long as need be and be as autonomous with the class or work with pairs. Whatever I wanted to do, I didn't have any issues. I found I really got lucky with—well they probably were all like that, but of the people who I had, they were great.

Tom [Young Science Ambassador] came in and he turned up on the day when we got the parts. He spent the day discussing design aspects and really working individually with pairs to help them with their construction ideas, so he was excellent. We had another guy whose background was marine biology. He came along with another Science Ambassador who was studying houseboats in Thailand. So they did a presentation on what they were doing for their master's research and what science meant to them. So the kids found that very interesting.

They came back when the pairs were ready to do their presentations. They acted as the judges and conferred with me as to what score we were going to give the pairs. So the pairs were the presenters, the class was the knowledgeable experts and the Young Science Ambassadors were the judges.

**Table 28: Teachers' ratings of the value of specific aspects of the Wonder of Science Challenge (N = 4)**

| Aspect of the Wonder of Science Challenge | Responses, n | | | | | |
|---|---|---|---|---|---|---|
| | High value | Medium value | Low value | Of no value | Undecided | Did not do this |
| Attending the Wonder of Science Professional Development Day | 2 | 0 | 0 | 0 | 0 | 2 |
| Wonder of Science curriculum resources* | 0 | 1 | 1 | 0 | 0 | 1 |
| Working on the Wonder of Science Challenge in science classes | 3 | 0 | 1 | 0 | 0 | 0 |
| Working with a Young Science Ambassador | 1 | 1 | 0 | 1 | 0 | 1 |
| Attending the student challenge day | 3 | 1 | 0 | 0 | 0 | 0 |
| Attending the Wonder of Science dinner | 3 | 0 | 0 | 0 | 0 | 1 |

*Notes:* The mode for each item is shaded. *n = 3 for this item.

When asked what they enjoyed most about the Wonder of Science Challenge, the teachers each cited different aspects: networking opportunities for students and teachers, the student challenge presentations, the dinner guest speaker, the fact that their students enjoyed the experience and engaging a whole class in a sustained investigation that elicited higher-order thinking from all students.

According to the teachers, the most effective aspect of the Wonder of Science Challenge was the structure of the program; namely, that the science investigations were followed by student presentations. One teacher noted that this format ‘encouraged rich investigative learning amongst students’ and ‘challenged their thinking’. Similarly, for another teacher, the most valuable aspect was the student engagement and higher-order thinking arising from the investigations and presentations.

Regarding aspects that they least enjoyed, the defence force site visit (or ‘recruitment drive’, as one respondent described it) was viewed less favourably by the teachers. One explained, ‘I did not feel that promoting a career in the armed forces was appropriate for children in Years 6–9’. Other aspects that the teachers did not enjoy included the ‘amount of time required for logistics’ (i.e. travelling to and from Townsville for the student challenge day) and a lack of resources to support the Year 7 solar-powered vehicle challenge.

**Key finding 9: Teachers generally reported an overall positive experience of the Wonder of Science Challenge. They perceived the student research projects and the student challenge day the most valuable aspects of the Challenge. Teachers concerns arising from their participation chiefly related to inequitable access to supporting resources provided by the program; namely, professional development, curriculum resources and Young Science Ambassadors.**

## 5.5 Impact on participating Young Science Ambassadors

### 5.5.1 The work of the Young Science Ambassadors as part of the Wonder of Science Challenge

The Young Science Ambassadors were asked to outline their involvement in the Young Science Ambassador program. As part of the program (and Wonder of Science Challenge), Michelle and Mike each worked with one class of students at a single school, while Suzie and Tom worked across three different schools. Suzie supported two student groups (i.e. eight students) in two classes, and the entire class of students in another.

For all of the Young Science Ambassadors, their work entailed travelling to participating schools to work with teachers and students directly. Suzie travelled to her school twice over the course of the Wonder of Science Challenge. On the first trip, the school asked her to speak to 10 classes in Years 5 to 12 about her research and work as a young scientist. She noted that this was not related to her work with the Wonder of Science classes; rather, it was ‘teachers taking advantage of me being there’. At this time, she also began working with students from three classes on the Wonder of Science Challenge and ‘helped the students design their approach to the tasks’. During her second visit to the schools, she assisted the students in refining the end product of their investigations and challenge presentations and ‘worked through any bugs they might have had during the process’.

The school that Michelle worked with also made the most of its access to a young scientist. She was also asked to speak to a number of difference classes (in addition to her Wonder of Science class) about her work and what scientists do. During the course of the Challenge itself, Michelle remained in touch with the class teacher about the progress of her students and offered her expertise whenever required.

Tom worked with two schools on the Year 7 solar car investigation (which included Mr Matthew's students) and one school on the Year 9 ecosystem investigation. Like his colleagues, Tom spoke to students about science and scientists in real life before helping students commence work on their investigations. He emphasised the importance of maintaining detailed notes as their work progressed, including information about their variables and any changes they made and why: 'This is all part of the scientific mindset, and I think that most of the students picked this up'. On a return visit, Tom continued to work with the students on their investigations and reviewed their draft presentations. 'For added fun', he also taught them about diffraction and polarisation using optics kits 'as a rewarding diversion'.

Mike visited with the students at his school approximately five times over the course of the Wonder of Science Challenge to help them design and carry out their investigations and construct their presentations.

The Young Science Ambassadors' feedback about the work that they undertook as part of the Wonder of Science Challenge indicates that the workload among individual Ambassadors was not equitable—some were required to work across multiple schools and classes, while others worked with a single class of students within one school. This finding is also significant in light of teachers' mixed feedback regarding the value of working with Young Science Ambassadors (*see* Section 6.2.2). While, as already noted, Mr Matthews was very positive about his experience, one teacher who was surveyed indicated that they did not work with an Ambassador as part of the Challenge and Ms Ellis expressed concerns about her Ambassador's late involvement in her students' research projects. Collectively, this feedback indicates that the Young Science Ambassador program was not equitable for either the schools or the Ambassadors themselves: schools had variable access to Ambassadors, ranging from no access to good access, while the number of schools and classes that Young Science Ambassadors worked with also varied.

**Key finding 10: The allocation of Young Science Ambassadors to schools and the Ambassadors' subsequent workload as part of the Wonder of Science Challenge, were not equitable.**

### 5.5.2 Participants' satisfaction with their experience as a Young Science Ambassador and the Wonder of Science Challenge

All the Young Science Ambassadors surveyed indicated that their participation in the program met their initial expectations, particularly concerning working with students, as exemplified by the following comments:

Suzie: It was fantastic! Helped me remain engaged in my own research topic, as the students were so enthusiastic about it and reminded me of how awesome young students are.

Michelle: Yes, I enjoyed all of my interactions with the teachers, students and other Young Ambassadors. I was very impressed with the final products of all of the students.

Tom: I think the program was run successfully this year, especially considering that it was the inaugural challenge.

Participants found working with interested students who engaged enthusiastically with the Wonder of Science Challenge the most positive and rewarding aspect of their roles as a Young Science Ambassadors; for example, Tom commented that:

> [g]etting to see kids enthusiastic about the work that they have done and what they have achieved is very rewarding. Seeing how they responded to questioning by their peers at the presentations was also nice, since they seemed to be able to justify their work and their methods.

The Young Science Ambassadors did not report any negative experiences in their roles.

Following expressing their positive experiences of the Young Science Ambassador program and of the Wonder of Science Challenge, Suzie, Michelle, Tom and Mike indicated that if they knew someone who was thinking about applying for the program, they would unreservedly recommend that they do so (e.g. 'it is an amazing experience, and they should do it!' [Michelle]). Tom also indicated that he would encourage colleagues who may not have heard about the program to apply.

### 5.5.3 Young Science Ambassadors' perceptions of the value of their participation in the Wonder of Science Challenge

The Young Science Ambassadors were asked to reflect on how valuable they thought their participation in the Wonder of Science Challenge was for themselves, for teachers, for students and for their industry. As shown in Table 29, they perceived their involvement to be of most value to themselves and to students and to teachers and industry to a lesser extent.

**Table 29: Young Science Ambassadors' perceptions of the value of the Wonder of Science Challenge for key stakeholders (N = 4)**

| Item | Responses, n | | | |
|---|---|---|---|---|
| | Very valuable | Somewhat valuable | Not valuable at all | Undecided |
| For you, personally | 4 | 0 | 0 | 0 |
| For teachers | 1 | 3 | 0 | 0 |
| For students | 4 | 0 | 0 | 0 |
| For your industry* | 1 | 2 | 0 | 0 |

*Notes:* The mode for each item is shaded. *One respondent indicated 'Not Applicable' for this item.

The Ambassadors also offered a number of reasons for their perception that their involvement was valuable:

#### 5.5.3.1 Personal value

The Young Science Ambassadors cited a number of intrinsic rewards for their participation in the Challenge (particularly, their positive experiences of engaging with students) as well as the development of public speaking skills and a greater understanding of the schooling context. For Suzie, in particular (an international student), she 'learnt a lot about FNQ [Far North Queensland]'.

Michelle explained that, for her, 'it's nice to get out of the lab and speak to students. I am always impressed by their insight into my work, and into what being a scientist means'. Tom (an Ambassador from the University of Queensland) valued the opportunity to travel to other regions outside the South East and his extended engagement with students over the course of the Challenge:

> It was very useful to me to have the extended time with classes to see them work through a project and see how their enthusiasm holds up over a long project. Again, the longer personal involvement with a class means that you have time to give more of an impression, and hopefully I left a very positive one for science and scientists.

#### 5.5.3.2 Value for teachers

The Young Science Ambassadors perceived that their engagement with schools was most valuable for teachers as their support and assistance with the student investigations was appreciated. The sharing of expertise was also important: 'It helped to reinforce some small areas that they may have been neglecting regarding the scientific process' (Tom). Suzie also explained, 'I think it helped reinvigorate some teachers … they enjoyed chatting to us'. Interestingly, Tom noted that, while the Ambassadors were a valuable resource for teachers, 'the teachers that I have the privilege working with were all exceptional in their own right, and I have no doubt that they could have run this program on their own'.

#### 5.5.3.3 Value for students

The Young Science Ambassadors were unanimous in their view that the Wonder of Science Challenge engaged students positively with science, and they were interested in and enthusiastic about their investigations: 'They were so enthusiastic about the projects and I hope are feeling more positive about science. At least one teacher now has her students asking to have extra Science classes, which is very exciting to hear' (Suzie).

Tom also felt that working with a Young Science Ambassador was valuable in helping students to develop an appreciation of the work of scientists and an interest in science-related careers:

> I think that seeing someone who is actually involved in science is very important for the students. Particularly, they can get to know you over the course of the project and it helps to show that scientists are real people and that you can have a career in science.

The format of the Wonder of Science Challenge also enabled more personal and sustained engagement with students, Tom felt, compared with, in his experience, other 'science outreach' programs:

> It is also a change of format to the demonstrations/workshops that are run in other outreach programs, and this format is far more personal and involved in the students' actual work—it gives you time to get to know them and for them to know you.

While the Young Science Ambassadors' comments referred primarily to students' interest and engagement, rather than learning, Tom acknowledged that 'from a knowledge perspective, most of the students showed a great enthusiasm with showing off their work and asking questions about science, and I think this is valuable'.

### *5.5.3.4 Value for industry*

The Ambassadors' perceptions of the value of their involvement in the Wonder of Science Challenge for industry varied among the participants. According to Suzie, the Challenge provided an opportunity to develop communication skills suitable for different audiences, which is important for enhancing industry's community engagement.

Michelle perceived that the Challenge 'can only have positive benefits among students considering a career in science', particularly through enhanced opportunities for students in rural and remote communities. In turn, this could benefit industry by encouraging students from these communities to study science at university:

> If we can get people from areas of Queensland and the country to enrol, we are better utilising our skills base, instead of writing off a region who may have promising minds, but no avenues for furthering their interest in science.

For Tom, the wider benefits of a program like the Wonder of Science Challenge 'in a world that is increasingly reliant on science and technology are obvious'. Tom also explained that 'instilling an appreciation for science' in students would help to 'solidify the place of science in the community'.

Given the Ambassadors' views on why their engagement with the Wonder of Science Challenge was valuable, all four participants strongly agreed that, overall, the Challenge was an excellent opportunity for industry to engage with schools (*see* Table 30).

**Table 30: Young Ambassadors' rating of the value of the Wonder of Science Challenge as an opportunity for industry to engage with schools (N = 4)**

| Item | Responses, n | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| Overall, the Wonder of Science Challenge was an excellent opportunity for industry to engage with schools | 4 | 0 | 0 | 0 | 0 |

*Note:* SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree.

**Key finding 11: Young Science Ambassadors reported an overall positive experience of the Wonder of Science Challenge. They perceived the Challenge to be of most value to students and to themselves. While they strongly agreed that the Challenge was an excellent opportunity for industry to engage with schools, feedback suggests that the full potential of this opportunity was not realised, as they perceived their involvement in the Challenge to be only somewhat valuable to industry.**

## 5.6 Evaluation of the teacher professional development day

Twenty-one school staff members attended the teacher professional development day, including classroom teachers and Science heads of department (12 from primary schools and nine from secondary schools). Five participants consented to the evaluation survey and one (Mr Matthews) was interviewed. Teachers' perceptions of the role of the teacher professional development day were mixed. While they appreciated the networking opportunities that the day afforded and learnt about effective group work and science inquiry, they had a number of unanswered questions and concerns related to the student research projects and student challenge day.

Table 31 presents teachers' views about the extent to which the teacher professional development achieved a number of professional learning objectives, drawn from the US *National science education standards* (National Committee on Science Education Standards and Assessment, National Research Council, 1996). In the context of a small sample size, the teachers' views about the professional development were mixed. The items for which the majority of teachers (more than 60 per cent) responded positively are highlighted in green. According to these respondents, the teacher professional development day articulated a clear vision of the intended purpose and nature of the professional learning; addressed issues or topics significant in science and of interest to teachers; introduced them to scientific resources that expanded their science knowledge; built on their current science understanding, abilities and attitudes; and encouraged and supported teachers to network and collaborate with other professionals. At the same time, at least one (and up to all) of the teachers either disagreed with or were undecided about whether the professional development met each of the objectives listed (e.g. the development of teachers' science content knowledge, an understanding of how students learn in Science and the provision of learning content aimed at improving Science outcomes for all students).

The teachers were also asked to rank the importance of each of the professional learning objectives on a scale of one to four, where one corresponds to 'Most important' and four corresponds to 'Least important'. Given that the aim of the teacher professional development day was to inform teachers about the Wonder of Science Challenge and prepare them to enact the Challenge in their schools, five of the items that related to this aim scored an average of less than two. These were that the teacher professional development day: 'Communicated a clear vision of the intended purpose and nature of the professional learning' (score: 1.0), 'Encouraged and supported teachers to network and collaborate with other professionals or people in industry' (score: 1.3), 'Addressed teachers' needs as learners' (score: 1.8), 'Developed teachers' understanding of how students learn science' (score:1.8) and 'Provided learning content aimed at improving science outcomes for *all* students' (score:1.8). Interestingly, while teachers indicated that the latter two items were important, 40 per cent of respondents disagreed that the professional development day met these objectives.

**Table 31: Teachers' views about the extent to which the teacher professional development day achieved a number of professional learning objectives (N = 5)**

| The teacher professional development day: | Responses, n | | | | | Importance* (n = 4) |
|---|---|---|---|---|---|---|
| | SA | A | NA | D | SD | |
| Communicated a clear vision of the intended purpose and nature of the professional learning | 1 | 2 | 1 | 1 | 0 | 1.0 |
| Involved teachers actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings | 0 | 2 | 2 | 1 | 0 | 2.3 |
| Addressed issues or topics significant in science and of interest to teachers | 1 | 3 | 1 | 0 | 0 | 2.3 |
| Introduced you to scientific resources that expanded your science knowledge and your ability to access further knowledge | 2 | 2 | 1 | 0 | 0 | 2.3 |
| Built on your current science understanding, abilities and attitudes | 0 | 3 | 2 | 0 | 0 | 2.8 |
| Incorporated ongoing reflection on the process and outcomes of understanding science through inquiry | 2 | 1 | 1 | 1 | 0 | 2.8 |
| Encouraged and supported teachers to network and collaborate with other professionals or people in industry | 3 | 1 | 1 | 0 | 0 | 1.3 |
| Addressed teachers' needs as learners | 1 | 2 | 2 | 0 | 0 | 1.8 |
| Developed your science content knowledge | 0 | 0 | 3 | 2 | 0 | 3.3 |
| Developed your science pedagogical content knowledge | 1 | 3 | 1 | 0 | 0 | 2.5 |
| Developed your understanding of science inquiry processes | 0 | 4 | 0 | 1 | 0 | 2.8 |
| Provided learning that could be easily transferred into your classroom practice | 2 | 1 | 1 | 1 | 0 | 2.8 |
| Developed teachers' understanding of how students learn science | 0 | 2 | 1 | 2 | 0 | 1.8 |
| Provided tools to assess students' understanding of scientific concepts and processes | 1 | 1 | 2 | 1 | 0 | 2.5 |
| Provided learning content aimed at improving science outcomes for *all* students | 1 | 1 | 1 | 2 | 0 | 1.8 |

*Notes:* SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree. The items for which the majority of teachers responded positively are highlighted in green. The mode for each item is shaded. *An average of teachers' ratings of the importance of each item on a scale of one to four (1 = most important; 4 = least important).

The teachers were asked to rate specific aspects of the teacher professional development day on a scale of one to five, where one corresponds to 'Poor', while five corresponds to 'Excellent'. These aspects were:

- organisation of the day
- overall science content covered
- information about the Wonder of Science Challenge
- information about how to enact the Wonder of Science Challenge in schools
- curriculum resources provided.

As shown in Table 32, 50–75 per cent of the teachers indicated that these aspects were dealt with in a satisfactory manner, while one respondent felt that all of the aspects were less than satisfactory.

The teachers were asked to identify the most useful aspects of the teacher professional development day. All five respondents indicated that the opportunity to connect with and hear from other teachers and 'experts' (e.g. industry representatives, Young Science Ambassadors and academics) was the most valuable aspect of the day. For one teacher, the professional development day highlighted the 'magnitude of the Challenge' and motivated him to 'start straight away'.

**Table 32: Teachers' ratings of different aspects of the teacher professional development day (N = 4)**

| Aspects of the teacher professional development day | Responses, n | | | | |
|---|---|---|---|---|---|
| | Excellent 5 | 4 | Satisfactory 3 | 2 | Poor 1 |
| Organisation of the day | 0 | 1 | 2 | 1 | 0 |
| Overall science content covered | 0 | 1 | 2 | 1 | 0 |
| Information about the Wonder of Science Challenge | 0 | 1 | 2 | 1 | 0 |
| Information about how to enact the Wonder of Science Challenge in your school | 0 | 1 | 2 | 1 | 0 |

*Note:* The mode for each item is shaded.

Five themes emerged from the teachers' responses concerning what ideas or knowledge they gained from the professional development day: a deeper understanding of group work dynamics and strategies to use the in the classroom (arising from a session focused on team work, led by JCU academics), ideas about how to implement open-ended student-led science investigations that promote higher-order thinking, knowledge and input from Young Science Ambassadors, ideas about working in Indigenous communities and specific details about the Wonder of Science Challenge itself.

While one of the teachers surveyed indicated that the professional development day did not influence her classroom practice, each of the four other respondents identified different ways in which their professional learning translated into their practice: through partnerships forged with other schools and industry, increased learning outcomes in science arising from student engagement in investigations and group work strategies learnt on the day. As one teacher commented, 'I used some of the group work strategies and knowledge in a number of classes and have (re)considered these issues from a new perspective, encouraging me to look further into group work teaching pedagogies'.

The teachers were asked whether they shared the knowledge that they gained from the professional development day with their school colleagues and, if so, to provide an example. All the teachers indicated that they had shared what they had learnt in different ways, ranging from simple information sharing to sharing science-teaching practices. One of the participants, the Head of Science at Melaleuca State High School, attended on behalf of Ms Ellis, so he shared what he learnt with his colleague. Another teacher shared information about the Wonder of Science Challenge at a school staff meeting, while one indicated that all staff supported the student challenge team. One teacher responded with 'end of investigation presentations', but it is unclear to whom these presentations were made (e.g. to other science classes or teachers). Another shared ideas about the student-led investigation, the student challenge format and networking contacts with teaching colleagues.

The teachers were asked whether, overall, the teacher professional development day adequately prepared them to implement the Wonder of Science Challenge at their school. In the context of a small sample size, responses to this question were mixed: three respondents either agreed or strongly agreed that the professional development met this aim, while two teachers either disagreed or remained undecided (*see* Table 33). One teacher commented: 'By the time the PD [professional development] day was held, it was clear that much of the organising should already have been done in the school and classroom'. This comment captures teachers' general concerns that more time was required to plan for and enact the Wonder of Science Challenge in their schools. Similarly, when asked to identify any aspects of the professional development day that required further refinement or modification before future implementation, the teachers called for the provision of more information about the Wonder of Science Challenge prior to the professional development day and for more clarity around the details of the Challenge itself. Another teacher commented, 'the PD needs to be focused. It seemed to be a mix of different topics without a clear focus'.

**Table 33: Teachers' rating of the adequacy of the teacher professional development day in preparing them to enact the Wonder of Science Challenge at their schools (N = 5)**

| Item | Responses, n | | | | |
|---|---|---|---|---|---|
| | SA | A | NA | D | SD |
| Overall, the teacher professional development day adequately prepared me to implement the Wonder of Science challenge at my school | 1 | 2 | 1 | 1 | 0 |

*Note:* SA = strongly agree; A = agree; NA = neither agree nor disagree; D = disagree; SD = strongly disagree.

All the teachers indicated that they had unanswered questions or concerns about the Wonder of Science Challenge at the end of the professional development day. These all related either to implementing the student investigations in classes or to the student challenge day. Specifically, these questions concerned:

- how to obtain resources and materials for the student investigations
- how much time was required to complete the student investigations in classes
- how the student challenge day would be conducted
- how the student presentations should be structured

- how the student presentations would be judged/what the criteria were.

For one teacher, her unanswered questions and concerns led her to withdraw from the Wonder of Science Challenge after the professional development day:

> I had many concerns regarding the program. Firstly, there just seemed too many factors that could not be defined at the time of the PD regarding specifically the aims of the assessment, involvement of science mentors [Young Science Ambassadors] and [the student challenge day] presentation … I think the overall expectations of the whole thing could have been more clearly defined along with the involvement of mentor scientists. If the process and the PD was better organised and defined … I would possibly reconsider our involvement [next year]. The concept is great.

This teacher's decision to withdraw was also influenced by concerns that the format and length of the student presentations were 'too demanding'. While the findings of this evaluation study indicate that the presentations were deemed a success for students and teachers alike, this teacher may not have been adequately informed about the student challenge day following the professional development day.

Mr Matthews also explained that he was unclear and apprehensive about the student research projects after the professional development day:

> When I'd finished my initial PD down in Townsville, I felt pretty daunted and overwhelmed by what we had to do. I was confident the class would produce something that I could take back to Townsville, but I had no idea of the success that was going to come. At the start, I was feeling fairly apprehensive and fairly overwhelmed by the task.

In response to their unanswered questions and concerns (particularly those pertaining to the student challenge day), a 'Program update' was distributed to teachers via email. This update included 'Teacher information material' (*see* Appendix 13) and a Challenge booklet (*see* Appendix 10). Although these materials sought to respond to teachers' questions regarding the Wonder of Science Challenge, they were provided towards the end of the development of the student research projects in schools, and were intended to assist teachers with their with '*final preparations* [emphasis added] for the challenge' (D. Sutton, email communication). Thus, it seems that information was not disseminated in a timely manner and would have served teachers better if provided at the professional development day.

Teachers indicated that they would have liked it if schools and teachers had been provided with more details about the Wonder of Science Challenge prior to the professional development day, so that attendees would have been more informed and could have contributed to discussions and decision-making more effectively on the day. As Mr Matthews explained:

> I had very little information about it other than it was to do with building a solar car with your class. I just knew there was some PD down in Townsville coming up and you were going to do an investigation with your class, basically. When I got down to Townsville, it was really the first time I had any information as to what was happening.

**Key finding 12: Teachers' feedback on the adequacy of the professional development day in preparing them to implement the Wonder of Science Challenge was mixed, as they had a number of unanswered questions and concerns about the student research projects and the student challenge day. Teachers appreciated hearing from and connecting with other teachers and experts and developed a better understanding of effective group work and how to implement open-ended student-led investigations.**

## 5.7 Participants' suggestions to improve the Wonder of Science Challenge

While a number of recommendations were developed in response to the key findings arising from this evaluation study (*see* Section 6), the participants in this study—teachers, students and Young Science Ambassadors—also offered a number of suggestions to refine or enhance the Wonder of Science Challenge based on their experience of the program. These suggestions refer to the student challenge day and to the Young Science Ambassador program.

### 5.7.1 Participants' suggestions to enhance the student challenge day

**Reconsider the industry site visits**
Teachers were concerned about the appropriateness of some visits (namely, the defence force site visit) and the implications for student wellbeing (i.e. spending extended periods standing in the sun then requiring students to present and participate in a program that extended into the evening). One teacher also indicated that she was 'a little disappointed at the off-campus activities'.

**Widen student participation in the student challenge day**
The teachers called for 'opportunities for more students to be involved'. At the same time, they were cognisant of the financial cost of involving more students. It was suggested that one way to enable more students to be participate in the student challenge days (and at less cost) would be to hold regional challenge days in Cairns and Townsville then allow 'finals' for the top-achieving teams to be held in one location.

In considering challenge topics for 2013, the Science head of department at Melaleuca State High School also suggested that the Wonder of Science Challenge include an explicit focus on inquiry topics that are pertinent to North Queensland, such as ocean acidification. Enhancing the relevance of the topics to the regions prioritised by the program could also encourage more schools to participate.

**Enhance students' experience of the student challenge day**
Students' experience of the culminating challenge day could be enhanced by scheduling the presentations such that: students have opportunities to watch other teams present, opportunities or activities are scheduled for students to meet and network with students from other schools and a broader view of the role of science in society is provided by inviting guest speakers who use science in professional vocations (e.g. doctors, engineers, pharmacists and physiotherapists). One teacher suggested that opportunities to connect

with other students could also have been provided while the student investigations were being undertaken, so that they could communicate about their projects.

Ms Ellis also suggested increasing the number of rounds of student presentations. At the same time, she raised some concerns about the fairness of the judging:

> I would have liked to have seen more rounds, I think. I know that's hard when you only have five schools but I think had they presented more times and critiqued more schools, I thought that would have been really good.
>
> The other thing that I wasn't sure about was the continuity between the judges … I thought one of the group of judges was really, really harsh to the students to the point where the kids were looking at their teacher for support and almost for acknowledgement of what they actually did. It's almost like the judges really questioned their topic and questioned their relevance to the task and that was really clear that they did that. I don't know if that was really fair because I really felt for the kids … One of the questions they asked caused one of the other judges to say to them, 'Oh look, they're not chemists, why are you pushing this question? They're in Grade 9'. I saw a third judge who wasn't actually judging that particular group come in, sit down and start asking the students questions and they weren't the judge … I thought that was really tough when the experience I had had the round before wasn't like that at all. It was much more positive and lovely and supportive … the criteria seemed to be interpreted very differently.

Similarly, students' suggestions to improve the Wonder of Science Challenge relate chiefly to ways in which their experience of the challenge day could be enhanced:

- Offer additional science activities on the day (e.g. demonstrations and hands-on activities and experiments).
- Include additional guest speakers in the program to provide 'more inspirational speeches from scientists' (Year 6 student). A student also suggested linking a site visit to the guest speaker's field of expertise: 'The dinner night presentation was based on marine biology so I thought a trip to Reef HQ would have expanded our knowledge of the marine biology presentation at the dinner night' (Year 6 student).
- Ensure that students have the opportunity to attend all of the industry site visits on offer to avoid disappointment. Students also wanted to learn more about JCU's science and engineering facilities.
- Provide students with opportunities to watch other presentations (note that this feedback was also offered by a participating teacher).
- In the interest of fairness, ensure that students have equitable opportunities to present during the day (i.e. they should present an equal number of times).

### 5.7.2 Participants' suggestions to enhance the Young Science Ambassador program

Suzie, Michelle and Tom offered a number of suggestions to enhance the Young Science Ambassador program and/or the Wonder of Science Challenge.

**Support Young Science Ambassadors with adequate assistance and guidance to support their engagement with schools and during the student challenge day**

It is not surprising that, given this was the inaugural year of the Wonder of Science Challenge, there were some concerns about the adequacy and timeliness of information provided to the Young Science Ambassadors from Challenge organisers (e.g. ‘Because this was the first year, some of the guidance provided to the Ambassadors and teachers was a bit vague. I expect that will improve for next year anyway, when the program is run again’ [Suzie]).

Michelle also suggested that the role of the Young Science Ambassadors during the student presentations be clarified (e.g. in terms of the best way to facilitate questions and discussion) to assist in the smooth facilitation of sessions.

**Provide Young Science Ambassadors with opportunities to connect with one another**
The Ambassadors felt that networking with each other would be helpful professionally and to support one another during the Challenge itself.

**Share human resources more effectively among schools by compiling a register of Young Science Ambassador activities**
Tom was concerned that schools may not have had equitable access to a Young Science Ambassador (a concern that was also shared by teachers). As he explained:

> I would also suggest setting up a central register of who is visiting what schools on what days, sort of like a group calendar … This could help coordinate trips and show Ambassadors which schools have fewer visits, and coordinate visits with other Ambassadors. It could also be used for schools to show when they [the Young Science Ambassadors] are available for visits.

A central register like this could be published on the new Wonder of Science website for easy access by schools and Young Science Ambassadors.

# 6 Conclusions and Recommendations

The purpose of the Wonder of Science Challenge is to ‘increase enthusiasm for science and engineering based careers through an enhanced science and technology experience for Queensland school students’ (ATSE, Queensland Division, 2012a, p. 2). In its first implementation in 2012, the Challenge comprised a teacher professional development day, the development of student-led research projects in schools supported by curriculum resources and mentored by Young Science Ambassadors, and a culminating student challenge day during which students presented and defended their findings during competitive rounds.

The intent of the evaluation study of the Wonder of Science Challenge was to report on the program’s progress in meeting its purpose and priorities, which are to:

- Inspire and develop the love of science in young people
- Demonstrate industry engagement in communities through support of education and development of opportunities for young people
- Develop and deliver activities that fit within the national science curriculum for students in the middle phase of learning from Years 6 to 9
- Prioritise activities in rural, remote and Indigenous communities with the support of university and industry ambassadors. (ATSE, Queensland Division, 2012a, p. 2)

The evaluation of the program was framed around the following RQs:

RQ1. How workable, effective and sustainable are the student research project model and supporting curriculum resources?

RQ2. What impact has the program had on participating students, teachers and Young Science Ambassadors?

RQ3. How can the teacher professional development be refined and improved before its next implementation?

RQ4. How can the school program be refined and improved before its next implementation?

RQ5. How can the student challenge day be refined and improved before its next implementation?

Data were generated through a series of surveys for teachers, students and Young Science Ambassadors; teacher interviews; and student focus-group interviews. Samples of student work and other classroom artefacts arising from the Challenge were also collected. These data provided detailed feedback from participants about their experiences of the Wonder of Science Challenge and provided a rich picture of the impact of the Challenge on teachers, students and Young Science Ambassadors and insights into the extent to which the program is workable, effective and sustainable. Insights have also been gained into how the effectiveness of the Wonder of Science Challenge can be enhanced in its next implementation in 2013.

The research conducted as part of the evaluation of the ATSE Wonder of Science Challenge indicates that the program has been generally successful in terms of its impact on participating teachers, students and Young Science Ambassadors. A number of key findings arose from the analysis of the data presented in Section 3 (‘Demographic Information’), Section 4 ('Science at the Challenge Schools') and Section 5 ('Evaluation Findings and Discussion'). Following, these key findings are restated and briefly discussed in the context of the RQs. Additionally, a number of recommendations are presented to guide planning for future developments of the program, with a view to enhance subsequent implementation, its impact and sustainability. Recommendations to inform future evaluations of the Wonder of Science Challenge are also provided.

## 6.1 How workable, effective and sustainable are the student research project model and supporting curriculum resources?

Teachers reported that the student research projects were effective as they 'encouraged rich investigative learning amongst students', 'challenged their thinking', and stimulated higher-order thinking. Mr Matthews also noted a significant difference in his students' depth of science knowledge compared to previous terms in science.

Overall, while teachers found the student research project model workable and effective, they were concerned about the long-term sustainability of the Challenge due to limited student participation and class time (**Key finding 4**).

According to the schools who participated in the evaluation study, the Wonder of Science Challenge was generally implemented in single classes at each school and, at one school, only a small group of students participated outside of their regular Science lessons. Implementation was also challenged by the limited time available to develop the research projects in schools. For example, Ms Ellis reported that the time allocated to the program made it difficult for the students to excel at the task.

**Recommendation 1:** Student participation in the Wonder of Science Challenge could be enhanced by informing schools of the program at the beginning of the school year to enable sufficient time to incorporate the Challenge into their work programs, and to plan accordingly. This would provide sufficient planning time and better support schools to engage multiple classes in the student research projects.

Mr Matthews' experience of having other Year 7 classes at Wattle Tree State School undertake a unit on the solar system while his class designed a solar-powered vehicle led the research team to look more closely at the Year 7 Science Understanding content descriptors. It found that the topic aligned loosely with a descriptor belonging to the Earth and Space Sciences sub-strand that concerned renewable and non-renewable energy; however, a design-based challenge such as this aligns better with the Physical Sciences sub-strand (**Key finding 5**).

**Recommendation 2:** The Year 7 challenge topic (i.e. 'Design a solar powered vehicle to complete a revolution of a circle in 10 seconds') should be re-evaluated and redesigned to better align with the Year 7 science curriculum. An inquiry-based challenge would better suit the intent of the Earth and Space Sciences content descriptor that focuses on renewable and non-renewable energy. A designed-based challenge aligns better with the intent of the Physical Sciences sub-strand.

It is also interesting to note that the designed-based nature of the Year 8 challenge (i.e. 'Design a Rube Goldberg machine to pop a balloon') motivated one Science head of department to preferentially implement the Year 9 challenge at his school (i.e. 'Investigate whether changing salt levels have an impact on an eco-system'), as it is better suited a scientific inquiry approach. The current offering of design- and inquiry-based challenges offers both primary and secondary schools some flexibility in the types of challenges in which they wish to engage their students.

An analysis of schools' demographic data and of the science at participating schools (*see* Sections 3 and 4, respectively), found that the majority of teachers had limited access to resources (i.e. classroom assistance, science resources or additional funding) to assist in the teaching of science and identified the need for further support in these areas (**Key finding 2**). It is likely that many schools do not have access to adequate specialised science equipment, and that teachers do not have support to prepare science activities, which will influence teacher and school decisions about their involvement in the Challenge and how many classes can participate at each school. Resourcing for science is a particularly important issue for schools that are under-resourced, and for primary schools that do not have access to specialist science equipment. For example, Mr Matthews was concerned about whether his class would have been able to construct solar cars for the Year 7 challenge, until a class set of equipment was provided by STELR.

**Recommendation 3:** The Wonder of Science Challenge organisers should monitor equipment requirements of future programs to ensure appropriate equipment is available to all participants. If student research projects require specialist science equipment (e.g. solar car kits for the Year 7 challenge), the ATSE should consider making such equipment available to schools—particularly primary schools and schools that are under-resourced. Alternatively, the research projects could be designed such that specialist equipment is not required.

Overall, teachers' ratings of the curriculum resources provided by the ATSE to support the implementation of the student research projects were satisfactory; however, it was noted that the unit plans were not complete (i.e. missing key resources) and, for at least one secondary school, did not align well with the Year 9 curriculum. Mr Matthews also commented that the Year 7 unit plan was 'too technical'. All teachers called for the provision of criteria for the culminating student presentations—particularly for the critical evaluation component of the presentations (wherein students critique the work of others).

The evaluation found that the quality and provision of supporting curriculum resources needs to be improved to better support implementation of the student research projects in schools. This includes providing complete unit outlines that align with the Science curriculum and are user-friendly for teachers, providing assessment criteria for the student presentations and, as already noted, timely and adequate provision of specialist science equipment for particular research projects (**Key finding 6**).

**Recommendation 4:** The ATSE should make every effort to revise the format and substance of the 2012 school curriculum resources. Specifically, the Wonder of Science Challenge organisers should ensure that the 2013 unit plans are accessible, detailed and user-friendly for teachers and align with *The Australian Curriculum: Science*. The organisers should also provide schools with detailed assessment criteria for the student presentations at the commencement of the Challenge.

## 6.2 What impact has the program had on participating students, teachers and Young Science Ambassadors?

### 6.2.1 Impact on students

The Wonder of Science Challenge positively influenced participating students' engagement, interest, enjoyment, motivation, attitudes towards science-related careers and science learning. These outcomes arose from students' positive experiences of all aspects of the Wonder of Science Challenge, including the student research projects, Young Science Ambassadors and the student challenge day (**Key finding 7**). They also support the ATSE's priority to '[i]nspire and develop the love of science in young people' (ATSE, Queensland Division, 2012a, p. 2).

The Challenge had a positive impact on the participating students' perceptions of science. Students consistently reported high levels of engagement, enjoyment and motivation to complete the science activities. Students particularly enjoyed both the culminating presentations and the dinner guest speaker. In addition to the interest, enjoyment and fun offered by the Wonder of Science Challenge, 55 per cent of surveyed students indicated that the Challenge had made them think about a career in science; however, 37 per cent remained undecided (*see* Table 18). The Year 7 and Year 9 students who were interviewed were clear that they were definitely thinking about science-related careers following their participation in the Challenge and that major influences were the dinner guest speaker and industry site visits.

The specific aspects of the Wonder of Science Challenge that students found most enjoyable were meeting people and making new friends. They also enjoyed the presentation component of the student challenge day; in particular, delivering their presentations and the competitive format of the presentations, in which they had the opportunity to defend their work and critique the work of others. Students also enjoyed learning about science and being challenged.

When comparing the science they did during the Wonder of Science Challenge to that in Term 2, the majority of students reported that they completed more experiments, had more ownership of the inquiry process, used their own explanations and conclusions more often, were involved in more in-class science discussions and noted more teacher use of real examples of science and technology (*see* Table 22). Students were interested and enjoyed Science during the term, which is likely to be linked to the scientific approach adopted by teachers during the Wonder of Science Challenge.

At interview, Ms Ellis could not identify a significant difference in the achievement of her students as part of the Challenge, compared with other units in Science, as the Year 9 science extension class in which the project was implemented was already a high-achieving class. However, Mr Matthews noted a significant difference, particularly the students' depth of science knowledge between the Wonder of Science Challenge and previous terms. He attributed this to the inquiry approach that he adopted and the culminating student presentations: 'there was a lot more science covered through the investigations and critiquing the presentations than I could possibly have taught as a teacher-directed unit'.

**Recommendation 5:** The key aspects of the Wonder of Science Challenge that engaged students—namely, the student research projects, Young Science Ambassadors, and student challenge day—should continue to be included in future versions of the program.

### 6.2.2 Impact on teachers

The Wonder of Science Challenge had a variable impact on the participating teachers (**Key finding 7**). While most teachers' confidence in developing students' science inquiry skills remained unchanged, one secondary teacher's confidence in developing students' skills in planning and conducting science investigations improved, while Mr Matthews indicated that that his confidence in developing all of the science inquiry skills surveyed improved after his participation in the Wonder of Science Challenge (*see* Table 24). More than 75 per cent of teachers who completed the initial teacher survey reported a high level of confidence in developing science inquiry skills to begin with (*see* Table 9).

For Mr Matthews, his experience of the Wonder of Science Challenge was transformative. He viewed different approaches to teaching science (*see* Table 26) as more important following his first-hand experience of a science inquiry approach. Particularly valuable for him was implementing an open-ended scientific investigation in which students developed their own knowledge and understanding of scientific language. As a result, Mr Matthews articulated proposed transformations to his classroom pedagogy and assessment strategies arising from his experience (**Key finding 8**); specifically, he plans to transform his science teaching practice using the Challenge model of student inquiry and adopt the format of the student challenge day oral presentations as an assessment strategy. Mr Matthews' experience suggests that these approaches, as they are used in the Wonder of Science Challenge, have the potential to transform teachers' pedagogical and assessment practices in science, if they are properly supported to implement the program.

Teachers generally reported having an overall positive experience of the Wonder of Science Challenge. They perceived the student research projects and the student challenge day to be the most valuable aspects of the Challenge. Teachers concerns arising from their participation relate chiefly to inequitable access to supporting resources provided by the program; namely, professional development, curriculum resources and Young Science Ambassadors (**Key finding 9**). This finding has important implications for teachers' preparedness and capacity to enact the Wonder of Science Challenge successfully in schools.

**Recommendation 6:** The ATSE should make every effort to ensure equitable school access to supporting resources—that is, professional development, curriculum resources and Young Science Ambassadors.

- In cases where teachers cannot attend the professional development day, alternative resources should be provided (e.g. a teacher's pack that includes essential information for implementing the Wonder of Science Challenge and pre-empts common questions and concerns).
- All schools should be provided with a full complement of necessary curriculum resources (including unit plans, assessment criteria and, as appropriate, specialist equipment) early in the school year, to ensure that they are well informed about the Challenge and ready to implement it in Term 3 (as per Recommendation 3).
- A structured approach to assigning Young Science Ambassadors to schools should be implemented to ensure that all schools have equitable access to an Ambassador.

Given teachers' mixed responses to the question of whether the Challenge made them think about developing more opportunities to engage with industry in their own science teaching practice, ensuring that teachers have a positive experience of the Young Science

Ambassador program is particularly important. This is particularly so given that one of the priorities of the Wonder of Science Challenge is to '[d]emonstrate industry engagement in communities through support of education and development of opportunities for young people' (ATSE, Queensland Division, 2012a, p. 2). The Young Science Ambassador program represents a critical component of the ATSE's industry engagement strategy. If teachers do not have a positive experience of the Young Science Ambassador program (which is likely if they do not have equitable access to the expertise of an Ambassador in schools), it is probable that industry engagement will not be sustained in schools after the Wonder of Science Challenge.

The surveyed teachers also felt that it was important to recognise and acknowledge the critical role that they played in the successful implementation of the Wonder of Science Challenge. The time-consuming nature of the project coupled with only intrinsic rewards for teachers raised questions about the long-term sustainability of the Challenge (i.e. some schools may not elect to participate again).

### 6.2.3 Impact on Young Science Ambassadors

The Young Science Ambassador program is a key component of the ATSE's industry engagement strategy as part of the Wonder of Science Challenge and supports its priority to '[d]emonstrate industry engagement in communities through support of education and development of opportunities for young people' (ATSE, Queensland Division, 2012a, p. 2). Two key findings arose from the evaluation of the Young Science Ambassador program. These findings related to the workload of participating Young Science Ambassadors and their overall experience of the Wonder of Science Challenge.

In relation to the first of these findings, the allocation of Young Science Ambassadors to schools and the Ambassadors' subsequent workload as part of the Wonder of Science Challenge were not equitable (**Key finding 10**). It was found that some schools had limited or no access to a Young Science Ambassador during the implementation of the student research projects, while other schools (e.g. Wattle Tree State School) reported a highly positive experience of the program. At the same time, some Young Science Ambassadors were linked to a single class at one school, while others worked across multiple classes at a number of schools. This unequal sharing of the expertise of the Young Science Ambassadors meant that some schools gained little or no benefit from the program, while the Ambassadors themselves had highly variable workloads across schools.

As outlined in Section 5.5.2, one of the Ambassadors, Tom, suggested that human resources could be shared more effectively among schools by establishing a central register that included information about which schools particular Ambassadors were assigned to and their specific activities, to coordinate the distribution of Ambassadors across schools more effectively.

**Recommendation 7:** In 2013, the Wonder of Science organisers should make changes to the Young Science Ambassador program, as suggested in Recommendation 6. Specifically, the organisers should adopt a more structured approach to the assigning of Young Science Ambassadors to schools. It is important to the long-term sustainability of the program that all schools have equitable access to a Young Science Ambassador and that Ambassadors have equitable workloads with respect to the number of schools to which they are assigned.

Ms Ellis' concerns about her Young Science Ambassador's limited engagement with her class were also reflected in Suzie, Michelle and Tom's suggestion that Young Science

Ambassadors require adequate assistance and guidance from the ATSE to support their engagement with schools.

**Recommendation 8:** The Wonder of Science organisers should provide Young Science Ambassadors with school engagement guidelines and adopt an improved communication strategy to provide ongoing support for Young Science Ambassadors.

In relation to Recommendations 7 and 8, the establishment of a Wonder of Science website (as suggested by the ATSE) would assist in facilitating a central register of Young Science Ambassadors and activities. It could provide a medium through which the ATSE could communicate regularly with Ambassadors and that Ambassadors could use to network and communicate with one another. Similarly, it could also allow students from different schools to communicate with each other about their research projects as they are being developed.

The Young Science Ambassadors reported an overall positive experience with the Wonder of Science Challenge. They perceived the Challenge to be of most value to students (because they engaged positively with science and developed an appreciation of science-related careers and the work of scientists) and to themselves, personally (through the development of communication skills and the intrinsic rewards arising from working with students). While they strongly agreed that the Challenge was an excellent opportunity for industry to engage with schools, feedback suggests that the full potential of this opportunity was not realised, as they perceived their involvement in the Challenge to be only somewhat valuable to industry (**Key finding 11**).

At interview, the Young Science Ambassadors could not articulate any benefits of their involvement to industry, other than the broader benefits of the Wonder of Science Challenge itself (i.e. that the Challenge could benefit industry by encouraging students from rural and remote communities to study science at university and enhance students' appreciation for science). As outlined in Section 6.2.2, teachers expressed varying views about whether the Challenge made them think about developing more opportunities to engage with industry in their own science teaching practice.

**Recommendation 9:** The ATSE should explore ways of enhancing industry engagement with the Wonder of Science Challenge with a view to benefiting both schools and industry. Such measures are likely to support more sustainable connections with industry in schools and make supporting the Wonder of Science Challenge more attractive to industry.

### 6.2.4 Engaging with rural, remote and Indigenous communities

While the Wonder of Science Challenge had an overall positive impact on participating teachers, students and Young Science Ambassadors, the Challenge sought to '[*p*]*rioritise activities in rural, remote and Indigenous communities* [emphasis added] with the support of university and industry ambassadors' (ATSE, Queensland Division, 2012a, p. 2). In 2012, 15 schools participated in the Wonder of Science Challenge. These schools were drawn from Cairns, Townsville, Mount Isa and surrounding districts. The analysis of school demographic data found that the Wonder of Science Challenge did not substantially engage with the challenge of working in rural, remote and Indigenous communities (**Key finding 1**). Twelve of the schools that participated in the first year of the program are located in metropolitan areas, two are remote and one is provincial. While it is not possible to identify the proportion of Indigenous students who participated in the Challenge, the Indigenous student population of five schools (i.e. 33 per cent of participating schools) was greater than 25 per cent of the student population (*see* Table 4).

**Recommendation 10:** The Wonder of Science Challenge organisers should reconsider recruitment strategies and purposefully target schools in rural, remote and Indigenous communities. The organisers should give serious consideration to the choice of research project topics, use of technology and modifications to the student presentation format.

To meet the ATSE's objective of prioritising activities in diverse communities, it will be necessary to modify the 2012 approach and offer alternative information and opportunities to schools. To this end, the organisers should:

- encourage Indigenous community participation through research topics that provide opportunity to value Indigenous knowledge and perspectives, as well as ensure all schools have access to appropriate information to enable both Indigenous and non-Indigenous students to engage with Indigenous knowledge and perspectives
- explore technology solutions to widen student participation in rural, remote and Indigenous communities; for example, video linking technology such as Skype or opportunities for student presentation videos to be hosted on YouTube could allow students to present research findings directly from their community
- consider the establishment of region-specific events as preliminary rounds of the student challenge day. Winning teams could represent their region in a student challenge finals day. This could encourage rural and remote schools' participation (and enhance participation, more broadly), as it negates the need for excessive travel. This model would reduce the ATSE's ongoing program costs. Other educational programs have already adopted a similar model (for example, Opti-MINDS [http://www.opti-minds.com], which implements regional and state finals.

## 6.3 How can the teacher professional development be refined and improved before its next implementation?

The teacher professional development day in July 2012 briefed participating teachers about the Wonder of Science Challenge, introduced them to the Young Science Ambassadors, engaged them in a workshop about school-based research projects and familiarised them with other ATSE school initiatives (*see* Appendix 1). While the professional development day intended to prepare participating teachers to implement the Wonder of Science Challenge with their classes, an analysis of science teaching at the participants' schools (*see* Sections 4.1, 4.2 and 4.3) provided valuable contextual information regarding teachers' readiness to implement the Wonder of Science Challenge.

Analysis of the initial teacher survey data found that teachers' evaluations of their self-efficacy in teaching science indicate that their confidence in their science teaching ability could be enhanced through the provision of targeted professional development (**Key finding 3**). While a majority of the teachers who participated in the teacher surveys reported they felt confident to teach science and science inquiry skills, at least one teacher identified a lack of confidence in the areas of science concepts and science investigations. At the same time, a majority of teachers did not strongly agree with any of the self-efficacy items (or strongly disagree, for negatively worded items) in Table 10. Similarly, professional development was identified as an area in which teachers felt they would benefit from additional support (*see* Section 4.1).

It is also important to acknowledge that the teachers generally rated their confidence for teaching science as being high to begin with (*see* Section 4.2). This is not surprising, given that particular classes were specifically chosen by their schools to participate in the Wonder of Science Challenge—in primary schools, this is presumably because they have an interest in teaching science and, in secondary schools, they taught high-achieving science students (e.g. science extension classes). At the same time, primary teachers are less likely to be confident teachers of science than secondary teachers (Osborne et al., 2003; Tytler, 2007). The provision of high-quality professional development that enhances teachers' preparedness to implement the Wonder of Science Challenge—particularly their self-efficacy in implementing the student research projects—should encourage more teachers to participate in the Challenge, thus broaden student involvement.

**Recommendation 11:** The Wonder of Science organisers should refocus the teacher professional development day to prioritise teachers' self-efficacy in student research project implementation. This could entail targeted workshops that focus on how to develop students' science inquiry skills—questioning and predicting; planning and conducting investigations; processing and analysing data and information; evaluating; and communicating.

Teachers' views about the extent to which the teacher professional development achieved a number of professional learning objectives varied (*see* Table 31). At least one (and up to all) of the teachers either disagreed with or was undecided about whether the professional development met each of the objectives listed (e.g. the development of teachers' science content knowledge, an understanding of how students learn in science and the provision of learning content aimed at improving science outcomes for all students). Similarly, teachers' feedback about whether the professional development day adequately prepared them to implement the Wonder of Science Challenge was mixed, as they had a number of unanswered questions and concerns about the student research projects and the student challenge day (**Key finding 12**). These questions concerned:

- how to obtain resources and materials for the student investigations
- how much time was required to complete the student investigations in classes
- how the student challenge day would be conducted
- how to structure the student presentations
- how the student presentations would be judged/what the criteria were.

As outlined in Section 5.5, teachers were provided with materials that sought to respond to some of these questions (particularly those regarding the student challenge day) (*see* Appendices 10 and 13); however, they were distributed with the intention of assisting teachers with their final preparations for the Challenge. The timely provision of key information is essential in supporting teachers' preparedness to enact the Wonder of Science Challenge in their schools.

**Recommendation 12:** The teacher professional development day should clearly outline all aspects of the Wonder of Science Challenge and provide timely information so that teachers are confident about implementing the Challenge in their schools. As indicated by teacher feedback, this should include information about obtaining resources and materials for the student investigations, time guidelines for completing the student research projects. the running of the student challenge day and the expectations and criteria for student presentations.

The aspects of the professional development day that teachers perceived most valuable were hearing from and connecting with other teachers and experts, developing a better understanding of effective group work and learning how to implement open-ended student-led investigations (**Key finding 12**). This finding supports the recommendation to focus on developing teachers' understanding of science inquiry (**Recommendation 11**), and highlights the importance of the teacher professional development day as an opportunity to network with teachers and other professionals—a particularly valuable opportunity for teachers from rural and remote communities.

## 6.4 How can the school program be refined and improved before its next implementation?

Section 6.1 outlined four recommendations to improve the school-based component of the Wonder of Science Challenge—the student research projects. These recommendations support the ATSE's priority to '[d]evelop and deliver activities that fit within the national science curriculum for students in the middle phase of learning from Years 6 to 9' (ATSE, Queensland Division, 2012a, p. 2).

First, the teachers who participated in the evaluation study generally found the student research project model to be workable and effective. However, it was noted that schools required sufficient notification of the Wonder of Science Challenge in order to incorporate the Challenge into their work programs and adequate time following the teacher professional development day to develop the student research projects in classes (**Recommendation 1**).

Second, a review of the Year 7 challenge topic found it should be re-evaluated and redesigned so that it better aligns with the Year 7 science curriculum, depending on the Science Understanding content descriptors and consideration should be given to whether it should be an inquiry- or design-based challenge (**Recommendation 2**).

Third, the importance of adequate access to science resources to support the school's participation in the Wonder of Science Challenge, particularly for student research projects that require specialist science equipment (such as the Year 7 solar car challenge) was emphasised. Alternatively, the research projects could be designed such that specialist equipment is not required (**Recommendation 3**).

Finally, while teachers' ratings of the curriculum resources that were provided by the ATSE to support the implementation of the student research projects were satisfactory, they expressed concerns regarding the quality of the curriculum resources and the alignment of the topics to *The Australian Curriculum: Science*. It was recommended that the ATSE revise the student research projects and supporting curriculum resources to ensure: the topics adequately align with *The Australian Curriculum: Science*; the unit plans are accessible and user-friendly for teachers and sufficiently detailed for schools to adopt and work from; and assessment criteria for the student presentations be provided at the commencement of the Challenge (**Recommendation 4**).

## 6.5 How can the student challenge day be refined and improved before its next implementation?

Overall, students, teachers and Young Science Ambassadors received the student challenge day very positively. The competitive format of the student challenge presentations and the inspirational dinner guest speaker were particularly valued by participants. The recommendations presented herein are provided simply to refine or enhance aspects of the student challenge day, as participant feedback indicates that the key components of the day were successful.

The teachers who participated in the evaluation study called for 'opportunities for more students to be involved' in the student challenge day; however, they were cognisant of the financial cost of having more students participate, particularly if they were from schools outside of Townsville. As outlined in **Recommendation 10**, the establishment of regional finals could provide an opportunity for more students to participate in the challenge day and negate the need for large numbers of students to travel to a single culminating event. An analysis of the data generated by the end-of-project teacher survey also found that the time and logistical requirements of travelling to Townsville to attend the student challenge day were cumbersome for out-of-town schools. The implementation of regional rounds would also alleviate this concern.

Refining the program and offering additional activities could further enhance students' experience of the student challenge day, as outlined in **Recommendation 13**.

**Recommendation 13:** The Wonder of Science Challenge organisers should consider changes to the student challenge day format to enhance students' engagement in this experience. These changes could include modifications to the presentation schedule, opportunities for student networking, presentations by a wider range of science professions and opportunities for students to complete additional science activities. This might involve:

- changes to the schedule of presentations to allow students to watch presentations by teams in different year levels
- the inclusion of a challenge day activity to provide students with the opportunity to meet and network with students from other schools. This would be particularly valuable if students had communicated with other schools via the proposed Wonder of Science Challenge website about their research projects (*see* Section 6.2.3)
- presenting to students a broader view of the role of science in society by inviting guest speakers who use science in professional vocations (e.g. doctors, engineers, pharmacists and physiotherapists). Guest speaker presentations could be supported by relevant industry site visits or excursions to enhance students' learning
- offering students the opportunity to participate in additional science activities on the day—for example, demonstrations and hands-on activities and experiments.

(*See also* Section 5.5.2 for additional suggestions made by participants to enhance the student challenge day.)

## 6.6 Recommendations for further evaluation studies

Recommendations arising from the research team's experience of the evaluation process could be considered by the ATSE if it wishes to commission evaluations of future Wonder of Science Challenges.

As noted in Section 2.2, a limitation of the current evaluation was the short lead-time between notification of participating schools and the start of the Challenge. The delays in finalising schools and the evaluation study limited the time available to recruit and follow participants. As was the case for this study, eight weeks is generally required to obtain human ethics approval from universities; the Department of Education, Training and Employment; the Townsville Catholic Education Office; and the Cairns Catholic Education Office before researchers can contact potential participants and collect data. Therefore, it is recommended that future evaluation studies be commissioned such that adequate time is provided to gain human ethics approval for the study. This would allow sufficient time to invite schools to participate in the evaluation well in advance of the Challenge commencing.

Another limitation of this evaluation study was the small number of participants who consented to complete some of the survey instruments. Timely human ethics approval would minimise this issue by enabling researchers to collect survey data from participants during the teacher professional development day and the student challenge day, after which time it can be difficult to encourage schools to participate in the evaluation.

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# Appendices

## Appendix 1: The teacher professional development day program

ATSE

Queensland Division

# WONDER OF SCIENCE

| | | |
|---|---|---|
| 0900-0920 | Changes caused by energy | Prof. Jeff Loughran, Pro Vice Chancellor, Faculty of Science & Engineering, JCU |
| 0920 – 0940 | A Rube Goldberg sort of explanation | David Sutton |
| 0940-1010 | Science in a box | Peter Pentland |
| 1010-1030 | The impact of a YSA on an ecosystem | Young Science Ambassadors |
| 1030-1050 | The changing coastline of industry | Industry ambassadors |
| **1050-1120** | **COFFEE** | |
| 1120-1220 | The anthromorphologicality of teams | Dr Victoria Kuttainen, Jennifer Burnett, JCU |
| 1220-1230 | YSA shuffle | Speed dating with YSAs |
| 1230-1330 | How not to go round in circles when doing an extended investigation | Jane Backhaus RegionalOrg Manager (Science), Metropolitan Region, DETE |
| **1330-1415** | **FOOD** | |
| 1415-1425 | The use of industry in finding solutions | Industry Ambassadors |
| 1425-1625 | The journey or the destination: “The challenge” | Students from Brisbane Girls Grammar School |
| 1630-1700 | Networking and evaluation | |

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## Appendix 2: An outline of the Wonder of Science Challenge

**Wonder of Science outline**

The Wonder of Science is a program whose aim is to enthuse young people about the study of science. This year it focuses on Years 6-9 in schools in north Queensland, with a particular focus on schools in rural, remote and indigenous communities.
The program has the support of the respective Regional Executive Directors.
The Wonder of Science challenge involves students undertaking a research project that forms part of their study of science for Term 3. They work up their research project over a period of 7 weeks and then attend a student conference where they present their findings through a competition. The students also respond to questions about the findings. Prizes are awarded to the winning team from each year level

The program works like this:

- Schools are invited to nominate a class that will use this program as part of its study of science for Term3.
- Successful nominated classes will be invited by the President of the sponsoring body (ATSE) to participate in the Wonder of Science challenge.
- The students in the class will form into teams and develop a research project over the 7 week period of the program using a given topic based on the curriculum. This is not n enrichment activity, but the study of science for that year level for that part of the Term.
- The topics are drawn from the QSA curriculum and are:
    - Year 6 Earthquakes may or may not produce a tsunami. Investigate
    - Year 7 Design a solar vehicle to complete one revolution in 10 seconds.
    - Year 8 Design a Rube Goldberg machine to pop a balloon.
    - Year 9 Changing salt levels can have an impact on eco systems. Investigate this phenomenon.
- While students will work in teams, they will write up their findings in individual reports. Teachers will be provided with an assessment matrix to assist in this part of the Term's assessment.
- Towards the end of the7 week period, the teacher and class will choose a team of four students to represent them at the student conference in Townsville. The conference is being hosted by James Cook University and will be held there.
- Students will present their findings at the conference by means of a competition involving the same year level from other schools.
- The challenge involves a school team presenting the findings its their research. This is followed by a team from another school responding to and challenging these findings. The reporting team then has an opportunity to reply to the challenge. The judge, or juror, also has an opportunity to ask clarifying questions. A scoring matrix will be supplied before the competition.
- There will be two rounds, in a round robin format, followed by finals between the highest scoring two teams in each year level. Prizes will be awarded to the winning team from each year level.
- We are investigating ways of streaming the challenge back to the team's schools so their classmates can be involved.
- Student team members and their teachers will have their accommodation and transport costs provided to enable them to attend the student conference.

- A faculty member from JCU with specific research interests in science education and the middle phase of learning will undertake an evaluation of the program. This is essential if we are to build on this program to improve the next round.
- As the Principal is the Accountable Officer, all communication from ATSE will be through the Principal. Similarly, ATSE will not accept any duty of care obligations. These remain the school's responsibility.

Teacher support:

- A teacher development day will be held at JCU on Saturday 21 July.
- There will be professional development in undertaking an investigation, team building, as well as a mock run-through of the challenge format itself.
- The briefing day will be supported by the Regional science coordinators for both EQ and the Catholic Education systems. Staff of JCU will be involved as well.
- To recognise teachers' work and celebrate this opportunity to work together, a dinner will be held for those attending teachers on the evening of 21 July.
- ATSE is also selecting Young Student Ambassadors to provide face to face support to schools and an ongoing support via email, Skype etc. These ambassadors are PhD students who have submitted applications to be a part of this program and support schools.
- Sponsoring organisations have also been invited to nominate an Industry Ambassador whose role is similar to the Young Student Ambassadors.
- It is envisaged that these ambassadors will be present at the teacher briefing day
- ATSE is approaching Fellows of the Academy with interest or expertise in the relevant areas of inquiry to be resources and corresponding members for schools and students.
- During the 7 week period ongoing support will be available to individual schools based on their needs.
- Teachers (teacher briefing day) and student and teachers (student conference) will have airfares, accommodation and TRS reimbursement available. Regional Science coordinators will advise the level of support to be provided to each school. Reimbursement will reflect individual schools' geographic and transport challenges. Costs will be covered for one team of four students, one teacher to accompany the students, and one teacher to attend the teacher briefing day.

Forward planning:

- The ultimate aim of the program is to develop a level of self sufficiency and sustainability that regions to establish and develop their own similar program.
- Support will be provided for a period of three years, after which time it is envisaged that regions would have the capacity to develop the program on their own.
- The program is in its first year, but the focus on linking schools and industry over a three year initial partnership could provide the basis for an ongoing productive conversation between a school and its partner industry.
- This program front-ends well on to both STELR and QMEA initiatives (both these can be googled)

# Appendix 3: Initial teacher survey

**ATSE Wonder of Science Challenge**
**Teacher Survey**

The purpose of this survey is to find out your experiences and views about science teaching. Please answer as honestly as possible.

**Your help in completing this survey is very much appreciated!**

**Section 1. Information about you**

1. Please indicate your gender: □ male □ female
2. Please indicate your age: □ 20s □ 30s □ 40s □ 50s □ 60s
3. About how many years have you been teaching?

   □ <5 □ 5-10 □ 10-15 □ 15-20 □ 20+
4. Which grade do you mostly teach (please refer to your Wonder of Science students)?

   □ Year 6 □ Year 7 □ Year 8 □ Year 9
5. What professional qualifications do you have? Tick all that apply.

   □ TAFE Certificate □ Diploma □ Bachelor degree □ Masters □ Ph.D.
6. Do any of your qualifications include science qualifications?

   □ No □ Yes – please specify: ……………………..
7. Please indicate your position with the school (tick as many that apply).

   □ Primary teacher □ Secondary science teacher □ Head of Science

   □ Other leadership position – please specify: ……………………………………..
8. As a teacher, have you participated in any science professional development in the last 18 months? □ No □ Yes. If yes, please provide details:

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Section 2. Teaching science at your school**

1. Do you have a classroom assistant to help with science preparation and/or teaching?

   □ Never □ Sometimes □ Most of the time
2. How would you rate your school's resources for teaching science?

   □ Excellent □ Satisfactory □ Poor
3. How much time do you have for teaching science per week?

   □ 30 minutes □ 1 hour □ 1-2 hours □ More than 2 hours
4. Which subject(s), if any, do you feel your school rate as being more important than science?

______________________________________________

______________________________________________

______________________________________________

5. Do you employ the following of assessment strategies when teaching science?

| | **Yes** | **No** |
|---|---|---|
| Checklists of student observations | | |
| Visual representations (e.g., drawings, graphs) that show students' understanding or reasoning | | |
| Formative feedback on students' work in progress | | |
| Oral presentations | | |
| Interviews | | |
| Concept maps | | |
| Notebooking (science notebooks) | | |
| Peer review | | |
| Self assessment | | |
| Portfolios | | |
| Experimental science reports | | |
| Tests or examinations | | |

Please specify any other forms of assessment that you use in science:

______________________________________________________________________

______________________________________________________________________

9. Do you know of any extra funding which your school has obtained for science? □ No □ Yes. If yes, please provide details:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**Section 3. Teaching across the curriculum**

1. Please rate your confidence in teaching each of the following key learning areas. Please write N/A next to any subjects that you do not teach.

| **Key Learning Area** | **High** | **Medium** | **Low** |
|---|---|---|---|
| Science | | | |
| English | | | |
| Mathematics | | | |
| The Arts | | | |
| Technology | | | |
| Health and Physical Education | | | |
| Languages | | | |
| Studies of Society and the Environment | | | |
| History | | | |

2. Please rate your confidence in developing the following science inquiry skills in your students.

| | High | Medium | Low |
|---|---|---|---|
| Questioning and predicting | | | |
| Planning and conducting investigations | | | |
| Processing and analysing data and information | | | |
| Evaluating | | | |
| Communicating | | | |

**Section 4. Different approaches to science teaching**

1. How important do you perceive the following approaches when teaching science?

| | High importance | Some importance | Little or no importance |
|---|---|---|---|
| Students are given opportunities to explain their ideas | | | |
| Students identify science questions that could be investigated | | | |
| Students design their own experiments | | | |
| Students have discussions about the science topics | | | |
| Students do investigations to test their own ideas | | | |
| Students spend time in a laboratory during science experiments | | | |
| Students spend time in outdoor learning spaces during science experiments | | | |
| Students draw conclusions from a science experiment they conducted | | | |
| Students choose their own investigations | | | |
| Students do experiments by following the instructions of the teacher | | | |
| The teacher uses real examples of science and technology to show how school science is relevant to society | | | |

**Section 5. Your attitudes to science teaching**

1. Please indicate the extent to which you agree with the following statements.

| | Strongly agree | Agree | Neither agree or disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| When the science grades of students improve, it is most often because the teacher found a more effective teaching approach | | | | | |
| Even when I try hard, I don't teach science as well as I would like | | | | | |
| I know the steps necessary to teach science concepts effectively | | | | | |
| Increased effort in science teaching produces little change in some students' science achievement | | | | | |
| When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better | | | | | |
| I am typically able to answer students' science questions | | | | | |
| I am continually finding better ways to teach science | | | | | |
| If students are underachieving in science, it is most likely due to ineffective science teaching | | | | | |
| The inadequacy of a student's science background can be overcome by good teaching | | | | | |
| Students' achievement in science is directly related to their teacher's effectiveness in science teaching | | | | | |
| I find it difficult to explain to students why science experiments do or do not work | | | | | |

2. Please indicate what areas in science, if any, you would benefit from additional support (e.g., assistance in the classroom, teacher aide time, science resources, professional development).

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## Appendix 4: Teacher professional development day survey

**ASTE Wonder of Science Challenge**
**Evaluation of Teacher Professional Development Day**

Please respond to the following statements in relation to the Wonder of Science Professional Development day.

**Question 1. Quality of the professional development.**

Please indicate the extent to which the professional development achieved the following. Please tick only one box in each row; do not tick in between boxes.

| **The professional development day:** | **Strongly agree** | **Agree** | **Neither agree or disagree** | **Disagree** | **Strongly disagree** |
|---|---|---|---|---|---|
| Communicated a clear vision of the intended purpose and nature of the professional learning. | | | | | |
| Involved teachers actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings. | | | | | |
| Addressed issues or topics significant in science and of interest to teachers. | | | | | |
| Introduced you to scientific resources that expanded your science knowledge and your ability to access further knowledge. | | | | | |
| Built on your current science understanding, abilities and attitudes. | | | | | |
| Incorporated ongoing reflection on the process and outcomes of understanding science through inquiry. | | | | | |
| Encouraged and supported teachers to network and collaborate with other professionals or people in industry. | | | | | |
| Addressed teachers' needs as learners. | | | | | |
| Developed your science content knowledge. | | | | | |
| Developed your science pedagogical content knowledge. | | | | | |
| Developed your understanding of science inquiry processes . | | | | | |
| Provided learning that could be easily transferred into your classroom practice. | | | | | |
| Developed teachers' understanding of how students learn science. | | | | | |
| Provided tools to assess students' understanding of scientific concepts and processes. | | | | | |
| Provided learning content aimed at improving science outcomes for *all* students. | | | | | |

**Question 2. Nature of desire professional development**

Thinking more broadly about the purpose of the Wonder of Science Professional Development day, from your perspective, please rank the importance of each of the items in Question 1 on a scale of 1 to 4 (1 = most important, 4 = least important).

| **The professional development day should have:** | **Rank** |
|---|---|
| Communicated a clear vision of the intended purpose and nature of the professional learning. | |
| Involved teachers actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings. | |
| Addressed issues or topics significant in science and of interest to teachers. | |
| Introduced you to scientific resources that expanded your science knowledge and your ability to access further knowledge. | |
| Built on your current science understanding, abilities and attitudes. | |
| Incorporated ongoing reflection on the process and outcomes of understanding science through inquiry. | |
| Encouraged and supported teachers to network and collaborate with other professionals or people in industry. | |
| Addressed teachers' needs as learners. | |
| Developed your science content knowledge. | |
| Developed your science pedagogical content knowledge. | |
| Developed your understanding of science inquiry processes. | |
| Provided learning that could be easily transferred into your classroom practice. | |
| Developed teachers' understanding of how students learn science. | |
| Provided tools to assess students' understanding of scientific concepts and processes. | |
| Provided learning content aimed at improving science outcomes for *all* students. | |

**Question 3. Satisfaction with the Wonder of Science Professional Development day**

How would you rate the following aspects of the Wonder of Science Professional Development day?

| | **Excellent 5** | **4** | **Satisfactory 3** | **2** | **Poor 1** |
|---|---|---|---|---|---|
| Organisation of the day | | | | | |
| Overall science content covered | | | | | |
| Information about the Wonder of Science Challenge | | | | | |
| Information about how to enact the Wonder of Science Challenge in your school | | | | | |
| Curriculum resources provided | | | | | |

**Question 4. Preparedness to enact the Wonder of Science Challenge**

Please respond to the following question:

| | Strongly agree | Agree | Neither agree or disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| Overall, the Wonder of Science Professional Development day adequately prepared me to implement the Wonder of Science challenge at my school. | | | | | |

**Question 5.** What ideas/knowledge did you gain from the professional development day?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Question 6.** Please identify any aspects that you would have liked to have been covered in more detail.

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Question 7.** Briefly summarise how your school will enact the Wonder of Science Challenge and how this was decided; e.g., the entire year level is participating; only selected class/es are participating; only selected students in a class are participating.

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Question 8.** In what ways, if any, did the professional development day impact on your classroom practice?

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**Question 9.** Did you share the knowledge that you gained from the professional development day with your school colleagues? If so, please provide an example.

______________________________________________

______________________________________________

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______________________________________________

**Question 10.** Did you have any unanswered questions or concerns about the Wonder of Science Challenge at the end of the professional development day? If so, what were they?

______________________________________________________________________________

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**Question 11.** Please identify the most useful aspects of the Professional Development day.

______________________________________________________________________________

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______________________________________________________________________________

**Question 12.** Please identify aspects of the professional development, if any, that require further refinement or modification before future implementation.

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______________________________________________________________________________

**Any other comments?**

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

## Appendix 5: End-of-project teacher survey

**ATSE Wonder of Science Challenge**
**End of project teacher survey**

The purpose of this survey is to find out about your experience of the Wonder of Science Challenge, and the impact of this experience on your views about science teaching and your teaching practice.

**Your help in completing this survey is very much appreciated!**

**Section 1.Your experience of the Wonder of Science Challenge**

1. Please indicate how much you agree with the following statements.

| | Strongly agree | Agree | Neither agree or disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| The Wonder of Science Challenge was worth doing | | | | | |
| I learned a lot about teaching science through the Wonder of Science Challenge | | | | | |
| The Wonder of Science Challenge has made me think about developing more opportunities to engage with industry in the areas of science and engineering in my own teaching practice | | | | | |
| I did not learn anything new from the Wonder of Science Challenge | | | | | |

2. How much interest did you feel were you while you were involved in the Wonder of Science Challenge?

| High interest | Medium interest | Low interest | No interest | Undecided |
|---|---|---|---|---|
| | | | | |

3. Please **rate the value** of the following aspects of the Wonder of Science Challenge (you might consider the value to you, personally, or to your students).

| | High value | Medium value | Low value | Of no value | Undecided | Did not do this |
|---|---|---|---|---|---|---|
| Attending the Wonder of Science Professional Development Day | | | | | | |
| Wonder of Science curriculum resources | | | | | | |
| Working on the Wonder of Science Challenge in science classes | | | | | | |
| Working with a Young Science Ambassador | | | | | | |
| Attending the student conference day | | | | | | |
| Attending the Wonder of Science dinner | | | | | | |

4. What did you enjoy the most about the Wonder of Science Challenge?

5. What did you enjoy least about the Wonder of Science Challenge?

6. Would you have liked anything else to have been included in the Wonder of Science challenge?

7. Are there any parts of the Wonder of Science Challenge that you would like to see changed or improved? If so, how?

8. In your opinion, what were the most effective/valuable aspects of the Wonder of Science Challenge, and why?

9. In your opinion, what were the least effective/valuable aspects of the Wonder of Science Challenge, and why?

10. Were any resources provided by ATSE to support your implementation of the Wonder of Science Challenge? If so, what were they, and briefly summarise how they were utilised.

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

11. Please indicate the extent to which you agree with the following statements.

| | **Strongly agree** | **Agree** | **Neither agree or disagree** | **Disagree** | **Strongly disagree** |
|---|---|---|---|---|---|
| a. Overall, the Wonder of Science Challenge aligned with the Australian Science Curriculum. | | | | | |
| Briefly explain your response: | | | | | |
| b. I will use ideas that I learned from the Wonder of Science Challenge again in my future teaching practice. | | | | | |
| Briefly explain your response: | | | | | |
| c. The Wonder of Science Challenge engaged my students. | | | | | |
| Briefly explain your response: | | | | | |
| d. My students learned a lot about science from the Wonder of Science Challenge. | | | | | |
| Briefly explain your response: | | | | | |

**Section 2. Preparedness to enact the Wonder of Science Challenge**

1. Please respond to the following question:

| | Very effective | Somewhat effective | Not effective at all | Undecided |
|---|---|---|---|---|
| Looking back at the Wonder of Science professional development day, how effective was the professional development in preparing you to implement the Wonder of Science challenge at your school? | | | | |
| Briefly explain your response: | | | | |

2. Please identify significant **enabling factors** that supported the implementation of the Wonder of Science Challenge in your class/school.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

3. Please identify significant **constraints** that challenged the implementation of the Wonder of Science Challenge in your class/school.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**Section 3. Your views about teaching science following the Wonder of Science Challenge**

1. In reference to the first three columns in the table below, please indicate whether you feel that **your participation in the Wonder of Science challenge has impacted on your confidence in developing the following science inquiry skills in your students**.

*In the final column, please **rate your view on your level of confidence in developing these science inquiry skills in your students on scale from 1-10**, where **1** equates to a belief that you have **no confidence** in developing a particular skill, and **10** equates to a belief that you are **extremely confident** in developing a particular skill.

| | **I feel more confident than I did before** | **I feel less confident than I did before** | **My confidence has not changed** | ***My level of confidence** |
|---|---|---|---|---|
| Questioning and predicting | | | | |
| Planning and conducting investigations | | | | |
| Processing and analysing data and information | | | | |
| Evaluating | | | | |
| Communicating | | | | |

2. In reference to the first three columns in the table below, please indicate whether you feel that **your participation in the Wonder of Science challenge has changed your views about the importance of the following approaches to teaching science**.
***In the final column, please **rate your view on the importance of each teaching science approach on scale from 1-10**, where **1** equates to a belief that the approach is of **no importance** to successful science teaching and **10** equates to a belief that the approach is **extremely important** to successful science teaching.

| | **I feel that this approach is more important than I did before** | **I feel that this approach is less important than I did before** | **My views about this approach have not changed** | ***Importance of this approach** |
|---|---|---|---|---|
| Students are given opportunities to explain their ideas | | | | |
| Students identify science questions that could be investigated | | | | |
| Students design their own experiments | | | | |
| Students have discussions about the science topics | | | | |
| Students do investigations to test their own ideas | | | | |
| Students spend time in a laboratory during science experiments | | | | |
| Students spend time in outdoor learning spaces during science experiments | | | | |
| Students draw conclusions from a science experiment they conducted | | | | |
| Students choose their own investigations | | | | |
| Students do experiments by following the instructions of the teacher | | | | |
| The teacher uses real examples of science and technology to show how school science is relevant to society | | | | |

# Appendix 6: End-of-project student survey

**ATSE Wonder of Science Challenge**
**Student Survey**

The purpose of this survey is to find out your experience of the Wonder of Science Challenge, and your views about science. You do not put your name on the survey so please answer as honestly as possible.

**Section 1. All about you**

1. What grade are you in? Year …………
2. In what year were you born? ……………
3. Are you a: □ boy □ girl?
4. In what country were you born? ……………………………………

   If you were not born in Australia, how old were you when you arrived in Australia? If you were less than 12 months old, please write zero (0).

   ………… years
5. Do you speak English at home most of the time? □ Yes □ No

   If not, please state the language that you speak at home: ………………………………………………
6. What is your favourite subject in school? ………………………………………………

**Section 2. Your experience of the Wonder of Science Challenge**

1. Please indicate how much you agree with the following statements. Please tick only one box in each row; do not tick in between boxes.

| | Strongly agree | Agree | Neither agree or disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| a. The Wonder of Science Challenge was fun | | | | | |
| b. I learnt a lot about science from the Wonder of Science Challenge | | | | | |
| c. The Wonder of Science Challenge has made me think about a career in science and engineering | | | | | |
| d. I did not learn anything new from the Wonder of Science Challenge | | | | | |

2. How much interest did you feel were you while you were involved in the Wonder of Science Challenge?

| High interest | Medium interest | Low interest | No interest | Undecided |
|---|---|---|---|---|
| | | | | |

3. What did you enjoy the most about the Wonder of Science Challenge?

___

___

___

___

4. What did you enjoy least about the Wonder of Science Challenge?

____________________________________________________________________________________

5. Please **rate your enjoyment** of the following aspects of the Wonder of Science Challenge. Please tick only one box in each row; do not tick in between boxes.

| | High | Medium | Low | Undecided | I did not get a chance to do this |
|---|---|---|---|---|---|
| Working on the Wonder of Science Challenge in science classes | | | | | |
| Working with a Young Science Ambassador | | | | | |
| Attending the Wonder of Science dinner | | | | | |
| Presenting and defending my team's findings at the student conference day | | | | | |
| Challenging the findings of teams from other schools | | | | | |
| Learning about other teams' solutions to the challenge | | | | | |

6. What was your most important achievement in the Wonder of Science Challenge?

7. Would you have liked anything else to have been included in the Wonder of Science challenge?

8. Are there any parts of the Wonder of Science Challenge that you would to see changed? If so, how?

**Section 3. Your views on science**

1. Please indicate how much you agree with the following statements. Please tick only one box in each row; do not tick in between boxes.

| | Strongly Agree | Agree | Neither agree or disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| a. I generally have fun when I am learning science topics | | | | | |
| b. I like reading about science | | | | | |
| c. I am happy doing science problems | | | | | |
| d. I enjoy acquiring new knowledge in science | | | | | |
| e. I am interested in learning about science | | | | | |
| f. Advances in science and technology usually improve people's living conditions | | | | | |
| g. Science is very relevant to me | | | | | |
| h. I find that science helps me to understand the things around me | | | | | |
| i. Advances in science and technology usually bring social benefits | | | | | |
| j. When I leave school there will be many opportunities for me to use science | | | | | |

**Section 4. Your views on careers and science**

1. Please indicate how much you agree with the following statements. Please tick only one box in each row; do not tick in between boxes.

| | Strongly Agree | Agree | Neither agree or disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| a. Studying science at school provides me with the basic skills and knowledge for a science related career | | | | | |
| b. I would like to work in a career involving science | | | | | |
| c. I would like to study science after secondary school | | | | | |
| d. I would like to spend my life doing advanced science | | | | | |
| e. I would like to work on science projects as an adult | | | | | |

**Section 5. Your views on learning science**

1. Please indicate how much you agree with the following statements. Please tick only one box in each row; do not tick in between boxes.

| | Strongly Agree | Agree | Neither agree or disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| a. Making an effort in school science is worth it because this will help me in the work I want to do later | | | | | |
| b. What I learn in school science is important for me because I need this for what I want to study later on | | | | | |
| c. I study science because I know it is useful for me | | | | | |
| d. Studying school science is worthwhile for me because what I learn will improve my career prospects | | | | | |
| e. I will learn many things in school science that will help me get a job | | | | | |

**Section 6. Your experience of science in school**

1. Please indicate how much you agree with the following statements. Please tick only one box in each row; do not tick in between boxes.

| | Strongly Agree | Agree | Neither agree or disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| a. Science lessons are fun | | | | | |
| b. I look forward to my science lessons | | | | | |
| c. Solving science problems is enjoyable | | | | | |
| d. We learn interesting things in science lessons | | | | | |
| e. I only like science when I am doing practical work | | | | | |
| f. We do too much written work in science | | | | | |
| g. We learn science better when we do practical work | | | | | |
| h. In science, I can talk to other students about the work we are doing more than in other subjects | | | | | |
| i. We don’t do enough practical work in science | | | | | |
| j. I find science difficult | | | | | |
| k. I get good marks in science | | | | | |
| l. I find it difficult to understand science results | | | | | |
| m. Science is one of my best subjects | | | | | |

2. In general, how important do you think it is for you to do well in school science?

| Very Important | Important | Of little importance | Not important at all |
|---|---|---|---|
| | | | |

3. Compare the science that you have done this term as part of the Wonder of Science Challenge, to the science you did in Term 2. **When learning science this term**, how often did the following activities occur? Please tick only one box in each row; do not tick in between boxes.

| | **A lot more this term** | **A little more this term** | **The same as Term 2** | **A little less this term** | **A lot less this term** |
|---|---|---|---|---|---|
| a. Students are given opportunities to explain their ideas | | | | | |
| b. Students spend time in a laboratory doing practical experiments | | | | | |
| c. Students are required to design how a question could be investigated scientifically | | | | | |
| d. Students are asked to draw conclusions from an experiment they have conducted | | | | | |
| e. Students are allowed to design their own experiments | | | | | |
| f. Students are given the chance to choose their own investigations | | | | | |
| g. Students have discussions about the topics | | | | | |
| h. Students do experiments by following the instructions of the teacher | | | | | |
| i. Students are asked to do an investigation to test out their own ideas | | | | | |
| j. The teacher uses examples of technological application to show how school science is relevant to society | | | | | |

**Thank you for completing this survey!**

## Appendix 7: Young Science Ambassador survey

**ATSE Wonder of Science Challenge**
**Young Ambassador Survey**

The purpose of this survey is to find out your experiences of and views about the Wonder of Science Challenge. Please answer as honestly as possible.

**Your help in completing this survey is very much appreciated!**

**Section 1. Information about you**

10. Please indicate your gender: □ male □ female
11. Please indicate your age: ……………… years
12. Please indicate your highest qualification:
    □ TAFE Certificate □ Diploma □ Bachelor degree □ Masters □ Ph.D.
13. Please indicate your field of expertise: ……………………………………………………………………
14. How did you find out about the ATSE Young Science Ambassador Program?

______________________________________________________________________

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______________________________________________________________________

15. Why did you apply for the Program?

______________________________________________________________________

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______________________________________________________________________

**Section 2. Your experiences of the ATSE Young Science Ambassador Program**

6. How many schools did you work with? □1 □ 2 □ 3 □ More than 3. Specify: …………….
7. How many classes did you work with? □1 □ 2 □3 □ More than 3. Specify: …………….
8. Please outline your involvement in the program (i.e. what you did).

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**Section 3: Satisfaction with the ATSE Young Science Ambassador Program**

1. Has the program met your initial expectations? □ No □ Yes

   Please explain:

   ______________________________________________________________

   ______________________________________________________________

   ______________________________________________________________

   ______________________________________________________________

2. How valuable do you think your participation in the program was for the following people? Please give reasons for your response.

| | Very valuable | Somewhat valuable | Not valuable at all | Undecided |
|---|---|---|---|---|
| For you, personally | | | | |
| Briefly explain: | | | | |
| Teachers | | | | |
| Briefly explain: | | | | |
| Students | | | | |
| Briefly explain: | | | | |
| Your industry | | | | |
| Briefly explain: | | | | |

3. Please respond to the following question:

| | Strongly agree | Agree | Neither agree or disagree | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| Overall, the Wonder of Science Challenge was an excellent opportunity for industry to engage with schools | | | | | |

## Appendix 8: An excerpt from the Year 5 to Year 10 Scope and Sequence from the F-10 *Australian Curriculum: Science* (ACARA, 2012c)

The Australian Curriculum

acara AUSTRALIAN CURRICULUM, ASSESSMENT AND REPORTING AUTHORITY

### Science Scope and Sequence: Year 5 to Year 10

| | | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|
| Science Understanding | Biological sciences | Living things have structural features and adaptations that help them to survive in their environment | The growth and survival of living things are affected by the physical conditions of their environment | There are differences within and between groups of organisms; classification helps organise this diversity<br>Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions | Cells are the basic units of living things and have specialised structures and functions<br>Multi-cellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce | Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment<br>Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems | The transmission of heritable characteristics from one generation to the next involves DNA and genes<br>The theory of e volution by natural selection explains the diversity of living things and is supported by a range of scientific evidence |
| | Chemical sciences | Solids, liquids and gases have different observable properties and behave in different ways | Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting | Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques | The properties of the different states of matter can be explained in terms of the motion and arrangement of particles<br>Differences between elements, compounds and mixtures can be described at a particle level<br>Chemical change involves substances reacting to form new substances | All matter is made of atoms which are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms<br>Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction mass is not created or destroyed<br>Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer | The atomic structure and properties of elements are used to organise them in the Periodic Table<br>Different types of chemical reactions are used to produce a range of products and can occur at different rates |
| | Earth and space sciences | The Earth is part of a system of planets orbiting around a star (the sun) | Sudden geological changes or extreme weather conditions can affect Earth's surface | Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon<br>Some of Earth's resources are renewable, but others are non-renewable<br>Water is an important resource that cycles through the environment | Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales | The theory of plate tectonics explains global patterns of geological activity and continental movement | The universe contains features including galaxies, stars and solar systems and the Big Bang theory can be used to explain the origin of the universe<br>Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere |
| | Physical sciences | Light from a source forms shadows and can be absorbed, reflected and refracted | Electrical circuits provide a means of transferring and transforming electricity<br>Energy from a variety of sources can be used to generate electricity | Change to an object's motion is caused by unbalanced forces acting on the object<br>Earth's gravity pulls objects towards the centre of the Earth | Energy appears in different forms including movement (kinetic energy), heat and potential energy, and causes change within systems | Energy transfer through different mediums can be explained using wave and particle models | Energy conservation in a system can be explained by describing energy transfers and transformations<br>The motion of objects can be described and predicted using the laws of physics |

## Appendix 9: An example of a guide to making judgment provided by the ATSE to assess the student research projects in classes

# Curriculum into the Classroom

| Wonders of Science modification | Year 9 | Unit 6 |
|---|---|---|

**Assessment task: Scientific research investigation Consider the following task, basing the investigation on whether changing salt levels have an impact on an eco system.**

### Introduction

Queensland has recently experienced large population growth. The increase in the number of people living in the State has impacted on the natural balance of many ecosystems.

A committee responsible for natural resource management is developing a plan for ensuring ecosystems are maintained. The committee has called for contributions that identify ecosystems that have been affected by change and wish to focus on those that are possibly impacted by salt.

**Purpose:** To research and evaluate the impact of change on an Australian ecosystem and use the findings to create a presentation outlining the interrelationships of the ecosystem, whether changing salt levels have an impact on the ecosystem, and recommendations for its future management.

In **conducting** this investigation you will:

- **identify and describe an Australian ecosystem** including biotic and abiotic components, interrelationships and changes that have impacted on these (Part 1)
- **generate key questions to guide the investigation** into the impact of changes on the interrelationships of the ecosystem (Part 2) focusing on the possible effects of increasing salt levels.
- **develop a plan** to guide the progress of the investigation (Hint: Refer to student progress checklist.) (Part 3)
- **research** data to answer your key questions (Part 4)
- **analyse and evaluate your data** (Part 5)
- **propose recommendations** for future management of the ecosystem (Part 6)
- **create a presentation** to the committee describing the impact of change on interrelationships, and recommendations for its future management justified by your research (Part 7).

**Note: The parts identified above relate to the *Student investigation guide.***

Your assessment will be **based on** information from your **science journal** and **presentation.**

**Task conditions:**

- **checkpoints** in the student investigation guide must be signed off before proceeding to the next phase of the investigation
- class time allotted **6 x 70** minute lessons.

Year 9 Science: Unit 6: Guide to making judgments — Responding to change | Name:

**Purpose of assessment:** To identify, develop, research, evaluate and report on an investigation into the impact of change on an ecosystem.

| Knowledge and Understanding | Investigating | Investigating | Investigating | |
|---|---|---|---|---|
| Science understanding – Describes interrelationships within an ecosystem and the impact of changing salt levels | Questioning and predicting — Poses questions that can be investigated | Process and analysis – Analyses data and develops related recommendations | Communicating — Discusses the effectiveness of the investigation using scientific language and representations | |
| Explains the impact of salt levels on interrelationships and the future of the ecosystem | Generates a logical sequence of researchable questions to gather key data | Analyses data and infers trends to generate recommendations linked to these trends | Purposefully selects and uses scientific language and representations | A |
| Discusses the impact of salt levels on the interrelationships in an ecosystem | | Analyses data and indentifies patterns | | B |
| Identifies and describes relevant interrelationships within an ecosystem and an impact of a changing salt levels | Poses different types of questions that can be investigated | Analyses data and develops a related recommendation | Communicates recommendations meaningfully using scientific language and representations | C |
| Describes an ecosystem and states a relationship between components | | | Communicates using scientific language | D |
| States information about an ecosystem | States a question related to an ecosystem | States a recommendation | | E |

## Appendix 10: Challenge booklet

ATSE
Queensland Division


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## Rationale

### *STATUS OF SCIENCE EDUCATION*

It is with great concern that we read reports about the lack of interest in science shown by students in both industrialised and developing countries. Unfortunately, this disinterest comes at a time when demand for scientists, mathematicians, technologists and engineers is at its greatest. The Australian Council of Deans of Science commissioned an Australia-wide review which showed a drop in Year 12 enrolments in science subjects from 21% of the cohort in 1986 to just 15.2% in 2002.

Sadly, it appears that students are being turned off science at an early age. In Australia, according to *Australian Social Trends, 2009*, while 78% of Year 4 students declared a positive attitude towards science (a percentage comparable to the international average), by Year 8 only about 47% per cent of Australian students retained a positive attitude (compared with an international average of 65%). What is happening in these four years of schooling to cause this decline? Many of the 143 submissions responding to the Australian Government's discussion paper, *Review of Teaching and Teacher Education Strategies to Attract and Retain Teachers of Science, Technology and Mathematics* identified the shortage of suitably qualified teachers as a major cause of the waning interest in studying science. In 2007, only 12% of students in Year 4 were taught by a teacher with a specific qualification in science. This rose significantly for Year 8 students, 85% of whom had a teacher with a science-specific qualification. Furthermore, only one-third of Year 4 teachers and half of Year 8 Science teachers reported participating in professional development activities concerned with improving students' critical thinking or problem solving skills.

Research has shown that teachers adopt content-oriented, textbook-driven approach to topics when teaching outside their area of expertise, and it is obvious that poor content knowledge and weak pedagogy are not conducive to innovation in a science classroom. Nor is the fact that many schools have such poor physical resources that they struggle to accommodate contemporary developments in science and technology education. Other causes for the decline is a lack of appeal to girls and that the sciences are too intellectually challenging for students, who prefer the satisfaction gained from high marks rather than that achieved by rising to a challenge. It is clear that all of these factors in combination can lead to a lasting aversion to science which in turn leads to fewer graduates, a shortage of qualified teachers and so the cycle is perpetuated.

### *GOALS OF SCIENCE EDUCATION*

The goals of science education should be to learn science, to learn to do science, and to learn about science. There is widespread conviction that an important way for students to achieve these goals is for them to be given opportunities to practise science as professionals do. This is consistent with those who argue that the culture of science is concerned with cooperation within a stringent code of conduct that is probably best appreciated from working within the discipline or in a context that replicates it as nearly as possible. However, it is not always easy to convert this conviction into a workable curriculum.

The aim is to develop a curriculum to conquer the disparity between the working lives of professional scientists and the educational experiences of students of science. Some degree of enculturation should be achieved by granting students access to the socio-cultural elements that are active in professional practice and by giving them the opportunity to amass relevant cultural tools through the sort of problem-solving activity that is common to the culture. The search to find a task that could make the transition from expert to novice practice is complicated.

### *SCIENCE INQUIRY*

Numerous reviews of science education suggest that the way to increase student interest in science is to facilitate the integration of authentic inquiry approaches into science classrooms. Of course, this suggestion is not new and the fact that seasoned educators are, after so many years, still calling for the prioritisation of effective inquiry at all levels of science education is testimony to the difficulty associated with integrating inquiry into classroom practice.

The reason it is so difficult to deploy effective inquiry strategies in schools is because of the need to get everything right. Apart from well-credentialed teachers with good pedagogical and technological skills and the contemporary resources to support them, we also need to teach students to welcome the intellectual challenge of interpreting complex or controversial problems, posing solution pathways, taking the wrong path and emerging to try another, dealing with the issues that arise when working in teams, reflecting on their own understanding, and taking responsibility for their progress. Indeed, they need to be able to thrive in a culture of uncertainty – a very different culture from that which pervades a large number of science classrooms today. Students need to be exposed, not only to the physical experiences that define the culture, but also to the concepts and models of conventional science and the nature and status of scientific knowledge. They also need to be able to make, support and rebut a case, collect empirical data to be used as evidence, and use explanatory models as a theoretical means for accounting for what has been observed.

The culture of science education is at best only an approximation of expert practice, with the very nature of schooling causing a distortion in the cultural transmission from professional to school practice. Without considerable planning, teachers can transform the complex, socially-embedded processes of scientific sense-making into traditional, easily-managed, teacher-centred school tasks. Students need to engage in 'authentic' tasks, which are characterised by (a) the construction of new knowledge, (b) the use of disciplined inquiry to construct this knowledge, and (c) an outcome that has personal, aesthetic or utilitarian value.

### *ATSE WONDERS OF SCIENCE*

The *ATSE Wonders of Science* program was created to foster scientific research through authentic inquiry. It is an annual competition for students in Years 6 to 9. A few months prior to the competition, each year level is supplied with a problem which must be theoretically and experimentally researched to arrive at a presentable 'solution'. At the conclusion of their research, participating schools will select a team of a maximum of four students to represent them at the *ATSE Wonders of Science* - *Science Challenge.* At this competition, each team presents and defends the validity of their solution against a team from another school. Jurors with expertise in science rate the teams' reports and the discussion that those reports generate.

The competition promotes real research into authentic problems. The research carried out is open-ended and challenging in an age-appropriate way. The students "do science" rather than traditional school laboratory activities and have to utilise higher order thinking skills to make progress. The research takes students away from their comfort zone as they try to understand new concepts and incorporate them into their proposed solutions. The validity of a student's research must be justified and defended against the criticism of their peers in a manner reminiscent of the processes employed by practising professional scientists to publish their research.

It is hoped that completing these authentic tasks will help, not only those who are selected to compete in the Science Challenge, but all of the students who formed the research community at the participating schools. Through their engagement with this process, these students should acquire a body of knowledge while developing an understanding of the nature of scientific knowledge and how it is constructed and incorporated into a wider theoretical network. There is often a tension between these two agendas because, during inquiry sessions, students can conduct investigations and construct explanations that are not consistent with those of scientists. Inconsistencies of this type are almost always due to the interference of prior knowledge or the use of poor inquiry strategies. Performing authentic research tasks can help students understand that the scientific community has ways of dealing with less than rigorous strategies and, if well-mentored, improved rigour during scientific investigations should permeate Science programs at all levels.

One of the most remarkable changes that should result from a school's involvement with the *ATSE Wonders of Science - Science Challenge* is the repression of the "illusion of certainty" during laboratory investigations and the acceptance of scepticism and uncertainty as being right and healthy. Students should become better able to reflect on the selection, utilisation, and outcomes of their strategies and to continue working until they achieve some sort of confidence in their results. Past practices rarely set aside time for this to happen. The shift in science schooling from a culture of certainty to one of uncertainty should improve the rigour of any school-based inquiry for all those involved.

# The ATSE *Wonders of Science* – Science challenge

### *PROBLEMS*

| | |
|---|---|
| Year 6 | Earthquakes may or may not produce a Tsunami: Investigate. |
| Year 7 | Design a solar powered vehicle to complete a revolution of a circle in 10 seconds. |
| Year 8 | Design a Rube Goldberg machine to pop a balloon. |
| Year 9 | Investigate whether changing salt levels have an impact on an eco system. |

The problems can be presented in whatever format the students believe will cover and explain the results of their investigation or design. For example power point, models, posters, video, or any combination.

# Scientific vs Engineering Project

| The Scientific Method | The Engineering Design Process |
|---|---|
| State your question | Define the problem |
| Do background research | Do background research |
| Formulate your hypothesis, identify variables | Specify requirements |
| Design experiment, establish procedure | Create alternative solutions, choose the best one and develop it |
| Test your hypothesis by doing an experiment | Build a prototype |
| Analyse your results and draw conclusions | Test and redesign as necessary |

| | |
|---|---|
| Communicate results | Communicate results |

## What are the roles in the Science Challenge?

The Science Challenge is structured so that each team will take two roles in turn - Presenter and Informed Colleague.  Each team will have a maximum of 4 students. The team may choose to have a single Presenter and Informed Colleague or may use a group approach.

### THE PRESENTER

**What is the role of the Presenter?**

The Presenter is the student or group of students in the team who have researched and prepared a solution to the problem. S/he/they prepare then present a report of her/his/their solution to the problem. The team may use one or more presenters.

- have 2 minutes to set up the presentation.
- present the report for a maximum of 10 minutes depending on the yr level(refer to table below).
- are questioned by the Informed Colleague for a maximum of 2 minutes.
- have to discuss with the Informed Colleague the points raised by the latter for up to **to the maximum total allocated time by year level (refer to table stage 5).**
- have two minutes to make concluding remarks if they so wish
- Clarifying questions from the Jury

### THE INFORMED COLLEAGUE

**What is the role of the Informed Colleague?**

The Informed Colleague listens carefully to the Presenters' presentation and prepares and delivers a critical response. S/he/they: (There may be more than one informed colleague.)

- question the Presenter for up to 2 minutes on completion of presentation.
- have up to 4 minutes to prepare a response.
- present her/his/their response for up to 50% of the total allocated time and then may have a discussion with the presenter for the remainder of the time allocated per year level if required.
- do not give her/his/their own ideas.
- have to discuss with the Presenter the points raised  up **to the maximum total allocated time by year level.**
- Clarifying questions from the Jury

## Structure of the Science Challenge

When describing time allocated it is suggested that the use of the term "up to". The students can make their points and then finish they do not have to stay on stage for a entire time.

| **The performance order in each stage:** | **Maximum time in minutes** |
|---|---|
| 1. Preparation of Presenter | 2 |
| 2. Presentation of the report | Yr6 5min, Yr7 6 min,<br>Yr8 8 min Yr9 10 min |
| 3. Questions from the informed Colleague to the Presenter and answers of the Presenter | 2 |
| 4. Preparation of the informed Colleague | 4 |
| 5. The Informed Colleague takes the floor for a maximum of 50% of the total allocated time **and** then may have a discussion with the Presenter for the remainder of the time allocated. | **total allocated time by year level**<br>Yr 6 5min<br>Yr 7 5 min<br>Yr 8 8 min<br>Yr 9 10 min |
| 6. Concluding remarks of the Presenter | 2 |
| 7. Clarifying questions from the Jury | 3 |
| 8. Awarding of Marks | 2 |
| **Total time of stage** | **Will vary with age group up to a maximum of 35** |
| 9. Break between stages | 10 |
| 10. Stage 2 | Will vary with age group up to a maximum of 35 |
| 11. Juror feedback to the teams | 5 |
| **Total time of Round for 2 teams** | **85** |
| **Total time of Round for 3 teams** | **130** |

## The Scoring System

- Each Jury member shows marks from 1 (low) to 10 (high).
- The mean mark of the jurors is calculated so that the weighting for the Presenters performance will be double that of the Informed Colleagues role:
  - 2.0 for the Presenter
  - 1.0 for the informed Colleague
- Each team's scores for Presenter and Informed Colleague are totaled and the highest total score wins the round.

| Stage 1 | Juror 1 | Juror 2 | Juror 3 | Average | Stage 2 | Juror 1 | Juror 2 | Juror 3 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Presenter | | | | | Informed Colleague | | | | |
| Informed Colleague | | | | | Presenter | | | | |
| | | | | | | | | | |

| **Stage 1** | **Juror 1** | **Juror 2** | **Juror 3** | **Average** | **Stage 2** | **Juror 1** | **Juror 2** | **Juror 3** | **Average** |
|---|---|---|---|---|---|---|---|---|---|
| A Presenter | 8 | 7 | 7 | 7.3 | A Informed Colleague | 8 | 8 | 7 | 7.7 |
| B Informed Colleague | 7 | 6 | 7 | 6.7 | B Presenter | 7 | 7 | 8 | 7.3 |

| Team | Weighting | Total Score |
|---|---|---|
| A | (7.3 x 2) + 7.7 | 22.3 |
| B | 6.7 + (7.3 x 2) | 21.3 |

Team A is the winner.

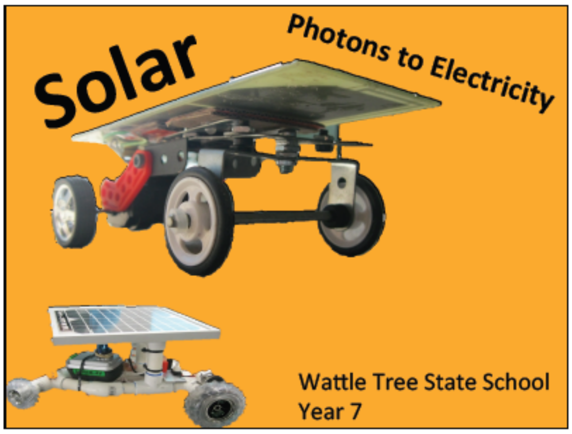
- For each Year level, the teams with the two highest scores compete in the final.

| Presenter | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Theoretical Solution | | Experimental Evidence | | Modified by Defence of Solution | | Interim Total | Modified by Communication | | Score |
| The Presenter<br>• provides a clear interpretation of the problem which demonstrates significant breadth<br>• fully specifies key assumptions<br>• provides comprehensive solution<br>• demonstrates a deep understanding of relevant concepts<br>• includes detailed scientific modeling in the solution | 3 | The Presenter<br>• employs stringent experimental design strategies<br>• presents data in appropriate form<br>• undertakes insightful data analysis<br>• draws appropriate conclusions<br>• aligns theory and data | 3 | The Presenter<br>• demonstrates a deep understanding of science in defence of solution<br>• acknowledges and integrates alternative perspectives into solution when appropriate | 3 | 9<br>8<br>7 | The Presenter<br>• communicates understanding in clear and logical manner<br>• enhances the report with well-prepared, relevant resources<br>• uses impromptu visual aids with clarity where appropriate | +1 | 10<br>9<br>8<br>7 |
| The Presenter<br>• provides a reasonably clear interpretation of the problem and shows appropriate breadth of solution<br>• outlines some key assumptions<br>• provides quite detailed solution<br>• demonstrates a sound knowledge of science<br>• uses simple scientific modeling in the solution | 2 | The Presenter<br>• undertakes partial experimental verification<br>• presents data in appropriate form<br>• considers validity of results<br>• draws appropriate conclusions<br>• compares data and theory | 2 | The Presenter<br>• demonstrates some understanding of science in defence of solution<br>• acknowledges alternative perspectives but is unable to integrate them into solution when appropriate | 2 | 6<br>5<br>4<br>3 | The Presenter<br>• communicates understanding in a reasonably clear and logical manner<br>• produces a report that is somewhat enhanced through the use of relevant resources<br>• uses impromptu visual aids with some success | 0 | 6<br>5<br>4<br>3 |
| The Presenter<br>• provides a poor, shallow interpretation of the problem<br>• does not outline key assumptions<br>• provides a solution which lacks detail<br>• is unable to demonstrate a sound knowledge of science<br>•makes little attempt to use scientific modeling | 1 | The Presenter<br>• uses flawed experimental design strategies<br>• presents insufficient data<br>• shows little consideration for validity of results<br>• fails to draw appropriate conclusions<br>• makes little attempt to align theory and data<br><br>The Presenter<br>• provides no experimental evidence | 1 | The Presenter<br>• demonstrates little ability to use science to defend solution<br>•is unwilling or unable to acknowledge alternative perspectives when appropriate | 1 | 2<br>1 | The Presenter<br>• demonstrates little ability to communicate understanding of science concepts<br>• produces a report that lacks supporting resources<br>• uses impromptu visual aids with little success or not at all | -1 | 2<br>1 |

## Informed Colleague

| Presentation of Informed Colleague: Critique of Theory Presented | | Critique of experimental work | | Interim Total | Discussion | | Modified by Communication | | Score |
|---|---|---|---|---|---|---|---|---|---|
| The Informed Colleague<br>• provides a clear analysis of the strengths and weaknesses of the Presenter's interpretation of the problem<br>• makes insightful comments about the key assumptions of the report<br>• demonstrates a deep understanding of relevant concepts<br>• presents a critical analysis of the science modeling used in the report<br>• asks appropriate questions to give direction to the discussion that follows | 3 | The Informed Colleague<br>• recognises the strengths and limitations of the experimental work<br>• recognises uncontrolled variables<br>• comments effectively on the validity of the data collected<br>• asks appropriate questions to give direction to the discussion that follows | 3 | 6 | The Informed Colleague<br>• concentrates on reporter's solution and does not introduce own research<br>• is focused on flaws in the science<br>• recognises valid points of the Presenter<br>• asks relevant questions<br>• works to uncover the strengths and weaknesses of the report<br>• demonstrates a deep understanding of key science concepts in discussing the solution | 3 | The Informed Colleague<br>• communicates understanding in clear and logical manner<br>• enhances critique with well-presented, relevant resources<br>• uses impromptu visual aids with clarity where appropriate | +1 | 10<br>9 |
| | | The Informed Colleague<br>• fails to recognises the strengths and limitations of the experimental work<br>• does not discuss the measures to control variables<br>• does not discuss the validity of the data collected<br>• asks trivial questions that fail to give direction to the discussion that follows | 2 | 5 | | 2 | The Informed Colleague<br>• communicates understanding in a reasonably clear and logical manner<br>• supports critique with some well-presented, relevant resources<br>• uses impromptu visual aids with some success | | 8<br>7 |
| | 2 | | | 4 | The Informed Colleague<br>• discusses own results<br>• is focused on trivial features<br>• fails to acknowledge good points raised by the Presenter<br>• makes little attempt to discuss scientific concepts<br>• asks irrelevant questions<br>• is overly aggressive<br>• continuously repeats similar points | | | | 6 |
| The informed Colleague<br>• provides a limited analysis of the strengths and weaknesses of the Presenter's interpretation of the problem<br>• makes insightful comments about the key assumptions of the report<br>• demonstrates little understanding of relevant concepts<br>• fails to address the science<br>• shows little understanding of the science presented<br>• asks trivial questions that fail to give direction to the discussion that follows | | | 1 | 3 | | 1 | The Informed Colleague<br>• demonstrates little ability to communicate an understanding of science concepts<br>• presents a critique which lacks supporting resources<br>• uses impromptu visual aids with little success or not at all | 0 | 5<br>4 |
| | 1 | The Informed Colleague<br>• does not give a critique of the experimental work | | 2 | | 0 | | | 3<br>2 |
| | | | 0 | 1 | | | | -1 | 1 |

## Appendix 11: The slideshow presented by Year 7 students from Wattle Tree State School at the student challenge day




**Task:**
**To design, plan and conduct fair tests on a solar powered vehicle to complete a revolution of a circle in exactly 10sec**

### Define how solar powered vehicles operate

1. Photons come from the sun
2. Then hit the solar panel, which is then converted into electricity
3. Electricity runs through the wire, which is made of metal
4. It contacts the motor giving the motor power
5. The gear box starts spinning
6. Makes the axel spin, making the wheels spin

### How the solar panel works

### How the motor works

- The current runs through the insulated wire
- While that, the magnet south is pushing the positive current away and magnet north is pulling the positive towards it
- Then the coil starts spinning and with the momentum, the process starts all over again

### Methodology- Investigation

1. Identify the factors affecting the vehicle's motion
2. Select the specific research question
3. Design the vehicle in which the factors can be varied
4. Compose the vehicle based on the design
5. Test the vehicles motion and record our observation
6. Analyse data

## Identifying the factors affecting the vehicle motion

- Surface area of wheels
- Wheel tread pattern
- Surface type of testing
- Intensity of photons (sunlight)
- The mass of vehicle
- Degrees of the axle
- Size of solar panel
- Angle of the wheels

## Specific research question to investigate

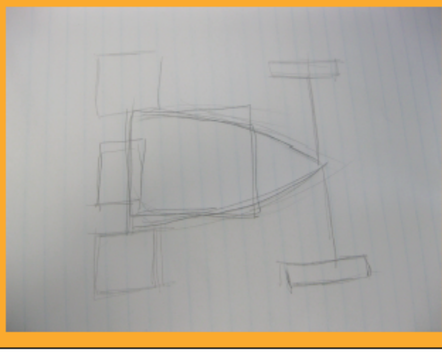
- How does the axles' angle affect the time to do one revolution ?

- Change: Angle of wheels
- Measure: The time
- Same: Retain all of the other variables the same

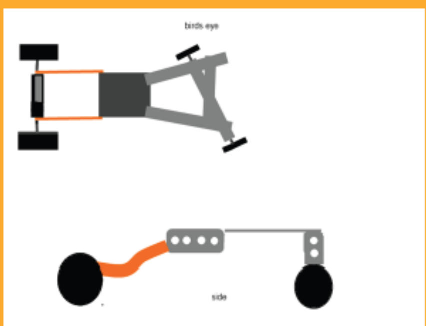
## Designing the vehicle

- Drew the 1st sketch and discussed the design of the car (and if it was going to be a car)e.g. Where the motor, solar panel and the wheels would be
- Made an equipment list
- Made the 2nd sketch on paint.net (still rough)
- Made the 3rd and final sketch on paint.net

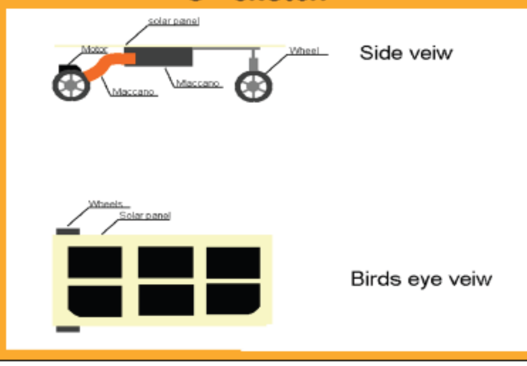
## 1st sketch



## 2nd sketch




## 3rd sketch

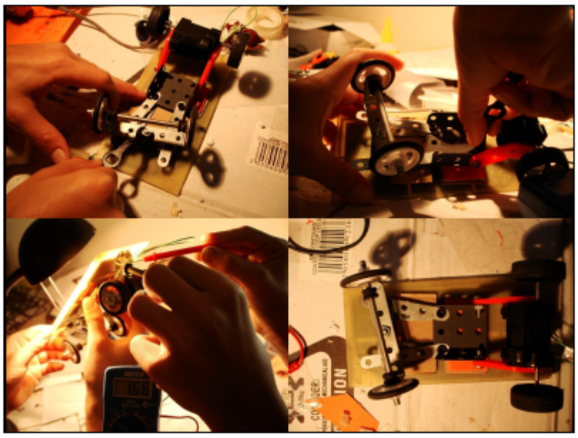


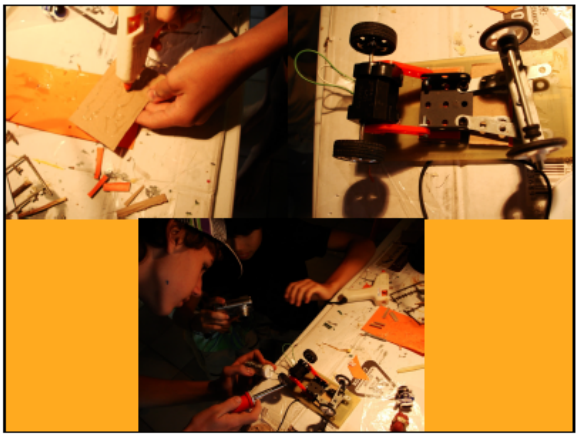

## Component List

- Meccano
- Conductible wire
- Electric motor
- Rubber wheels
- Nuts and bolts
- Solar panel
- Axles
- Card board

## Methodology-Construction (Basic)

1. Construct a base that is substantially secure
2. Meld the motor to the back of the base
3. Put cardboard on to the top of the base so that the solar panel will stick firmly to the base





## Issues to over come

- Our construction methodology did help but we had to put more thinking into it.
- The size of the motor was a overly sized which made the meccano bend out of its place.
- The wiring always came off the motor because of it hanging out of the car and getting dragged on the ground
- Use a stronger glue to stick things together

## Testing and timing the vehicle

**1.6v**

- Tested the velocity of the solar car, to test the acceleration we differed the degree of the front axle of the vehicle to 0 degrees and measured out 5m on the ground and then recorded the car. Then divided it by 5 to get the answer of how fast the car goes (m/s). The answer that we got was 0.56m/s
- Tested how different the angle has to be for the front axle to get the car to go in a revolution in 10 sec, to test this we first started off with an acute angle for the front axle of 20 degrees and tested how long it would take to go around in a circle, it took 4.65sec. So we tried……

## Table of wheel angle of solar powered vehicle and time for one revolution

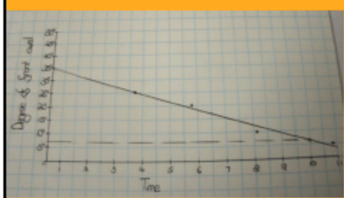
| Voltage | Angle | Time |
|---|---|---|
| 1.6 | 20 | 4.65 |
| 1.6 | 10 | 5.45 |
| 1.6 | 5 | 9.80 |

We have kept all of the other variables the same and changed the angle of axle to get the target time (10sec)

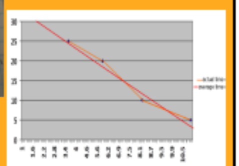

## Table of wheel angle of solar powered vehicle and average time for one revolution

| Degree of front axel | Test 1 | Test 2 | Test 3 | Test 4 | Average |
|---|---|---|---|---|---|
| 25 | 3.62 | 3.78 | 3.51 | 3.49 | 3.6 |
| 20 | 5.53 | 5.59 | 5.78 | 5.91 | 5.78 |
| 10 | 8.19 | 8.54 | 7.97 | 7.94 | 8.16 |
| 5 | 11.22 | 11.09 | 11.09 | 10.13 | 10.88 |

## Graph of wheel angle of solar powered vehicle and time for one revolution




7.75 degrees would get us a revolution in 10 seconds



## Analysis

| + | - | Interesting |
|---|---|---|
| The solar cells gives us the voltage we need. | The bolt that keeps the axle in place becomes loose when moving on rough surfaces | How cogs effect the axel in motion |
| Our motor has a big cog connecting to a small cog, there for benefiting the speed. | The sun is not controllable so we are having it difficulties for a fair test. | Kye's lamp gives 1.6 volts (if you put the solar panel right up to it) but… the sun (at mid day) gives 1.6 volts as well but it is millions of kilometres away. |
| We have good photons (sun shine) every day. | | Motors use magnets to operate |
| Our vehicle is strong and sturdy | | |
| We could test and time our vehicle easily | | |

## Recommendations

- Use a controllable light
- Change the degrees of the front axel more accurately
- Less damage to the vehicle making it a fair test
- A motor that has more durability

## Conclusion

This opportunity has provided as with knowledge that we will use in our future. Solar maybe renewable and Eco friendly but it is not reliable yet as a main source of power to generate our electrical jungle that we are using. It will be hard to figure out a good plan for the future. So would you like to have a rough, bumpy, stinky ride on a petrol running car rather than a smooth healthy ride on a Solar powered car? If you don't want to, this was a small push for the future. Take our plan to a bigger plan.

# The End

## Appendix 12: Samples of work taken from a Year 9 students' science notebook at Melaleuca State High School

Experiment proposal

Experiment title:

Purpose: To test which type of soil effect the process of salinity and how it impacts biodiversity

Hypothesis: If the soil is sandy then the water table will rise, due to the effects of salinity. However, if the soil contains clay, then the watertable will remain low because the salt water will be absorbed.

Materials:
↳ x4 cups (one sand, one clay, one mixed)
↳ clay
↳ sand
↳ potting mix
↳ x8 long-rotted plants (4 per pot) - seedlings
↳ x4 shallow container (watertable)
↳ saltwater for watertable
↳ rainwater 30ml every 3rd day

Good Copy Method:
Step 1: Fill cup with sand 2cm from top of cup.
Step 2: Repeat step 1 for mix soil, clay soil and normal garching soil.
Step 3: Plant two long rooted seedlings in each cup.
Step 4: Get four tachaway containers and cut out one hole in each of the lids so that the cup can sit in.
Step 5: Mix salt water - 10mg per 1L.
Step 6: Fill containers with 2cm of water.
Step 7: Mark the height of the water table on the side of the container.
Step 8: Put the lid on the container and place the cup with seedlings into container. Don't let the bottom of the cup touch the water table.
Step 9: Water the plants every three days - 30mL. Re-mark the height of water table each watering.

Dependent Variables:
The variable that is measured:
- plant height
- height of water table.
- salinity of water table.
- root depth.
- plant health (not quantitative)

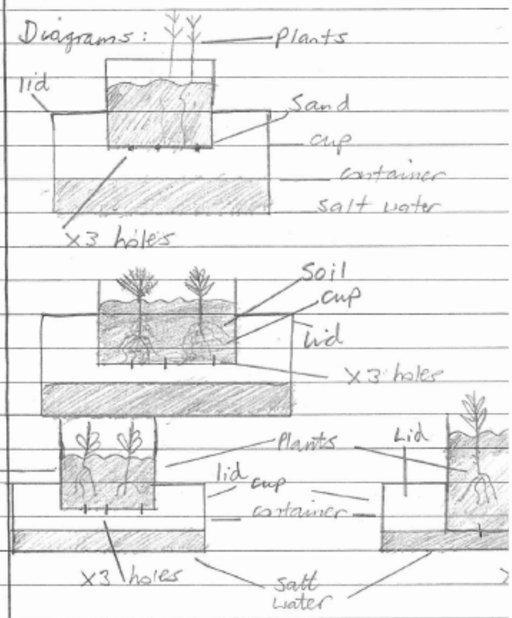
Plant height (cm)

| | Week Number | | | | |
|---|---|---|---|---|---|
| Plant | 1 | 2 | 2.5 | 3 | AV |
| 1 | 11cm | 15.5 | 16 | | |
| 2 | 7 | 8 | 7.5 | | |
| 3 | 8.2 | 12 | 11.5 | | |
| 4 | 10 | 13 | 14 | | |

Height of water table

| | Week Number | | | | |
|---|---|---|---|---|---|
| Plant | 1 | 2 | 3 | 4 | AV |
| 1 | 1 | 1.4 | 1.4 | | |
| 2 | 0.9 | 1.3 | 1.7 | | |
| 3 | 1 | 1.3 | 1.3 | | |
| 4 | 1 | 1.3 | 1.2 | | |

Diagrams:



ATSE
Queensland Division


# Teacher Information Material

- Organisational information
- Preparing students for the challenge

Our Sponsors

James Cook University Australia | Queensland Government Education Queensland | The University of Queensland Australia | QIC Dynamic Investment Solutions | QR National | xstrata community program North Queensland

# Draft Program

***WELCOME: 0915-0945***

**Year 6 & 7**

| | |
|---|---|
| Prep Round 1 | 0945-1000 |
| Round 1 | 1000-1035 |
| Morning Tea | 1035-1100 |
| Prep Round 2 | 1110-1125 |
| Round 2 | 1125-1200 |
| Prep Round 3 | 1200-1215 |
| Round 3 | 1215-1250 |
| **Lunch** | **1300-1345** |
| Site visits | 1345-1700 |

**Year 8 & 9**

| | |
|---|---|
| Site visits | 0945-1300 |
| **Lunch** | **1300-1345** |
| Prep Round 1 | 1345-1400 |
| Round 1 | 1400-1435 |
| Prep Round 2 | 1435-1500 |
| Round 2 | 1500-1535 |
| Prep Round 3 Refresh | 1535-1600 |
| Round 3 | 1610-1645 |

| | |
|---|---|
| Free time | 1700-1800 |
| Dinner and presentations | 1800-2100 |

# PROPOSED DRAW

### *3 SCHOOLS – YEAR 6, YEAR 8*

3 rounds, 1 room

| | | |
|---|---|---|
| A | C | B |
| C | B | A |
| (B) sits out | (A) | (C) |

### *5 SCHOOLS –YEAR 9*

3 rounds, 2 rooms

| | | |
|---|---|---|
| A | D | C |
| B | A | B |
| | | |
| C | B | D |
| D | E | E |
| | | |
| (E) sits out | (C) | (A) |

### *6 SCHOOLS – YEAR 7*

3 rounds, 3 rooms

| | | |
|---|---|---|
| A | D | A |
| B | A | C |
| | | |
| C | B | F |
| D | E | B |
| | | |
| E | F | D |
| F | C | E |

Notes:

The specific schools to be associated with each designator will be randomly drawn in the near future and communicated to all schools.

## ROOM ALLOCATION FOR PRESENTATIONS

| | | | | | |
|---|---|---|---|---|---|
| | | | **ROOM** | | |
| | | **W** | **X** | **Y** | **Z** |
| (morning) | **1** | 6 | 7 | 7 | 7 |
| | **2** | 6 | 7 | 7 | 7 |
| **ROUND** | **3** | 6 | 7 | 7 | 7 |
| | | | | | |
| (afternoon) | **1** | 8 | 9 | 9 | |
| | **2** | 8 | 9 | 9 | |
| | **3** | 8 | 9 | 9 | |

# Preparing students for the challenge

The intent of the following guide is to provide guidance to teachers in their preparation of students for the challenge.

It is intended that participating teachers discuss all of the guidelines material below so that students are aware of the expectations. The guideline material specific to the challenge (report presentation, informed colleague response and the following reporter/informed colleague discussion) was modelled to reflect the grading criteria to be used by the challenge competition judges.

## Code of conduct

The participants as representatives of their school will be required to wear school uniforms during their presentations.

As the program will include industry and university site visits, the wearing of uniform will address duty of care issues and also the sites' WH&S requirements for visitors to wear enclosed shoes.

The behaviour of the participants should always be politely respectful and tolerant of the diversity in participants' backgrounds and capabilities.

During the competition, teams may draw ideas from presentations of other competing teams, however proper citing is essential.

## Student team leader responsibility

Each school team entered must nominate a student team leader.
The student team-leaders, in conjunction with the supervising school teachers, are responsible for:

- the preparation and correct participation of their teams in the challenge
- appropriate conduct of team members during the whole period of the tournament
- being the nominated person for any communication required by tournament officials.

## Reporting Overview

The reporting team researches and prepares a solution to its assigned problem. The reporting team is required to deliver a presentation that clearly communicates its members' understanding of the problem and their journey to the solution, including addressing the following points. It should also be remembered that all published work referred to in the presentation must be cited. Financial, material or other support should be acknowledged by the team as part of the presentation.

*The Reporting team's presentation should include :*

- Introductions – school, student team members and supervising teacher
- a brief description/interpretation of the problem
- difficulties/obstacles to finding a solution
- presenting appropriate **concepts, theories and principles** relating to the problem
- outlining any key assumptions made in solving the problem
- an **application** of **appropriate mathematics, investigative methodology or modelling**
- appropriate **experimental technique** to **gather** and **record data** (or **demonstrate** the **phenomena** if appropriate)
- an **explanation** of the data obtained or **observed phenomena**
- linking of **theoretical** and **experimental findings** to draw **suitable conclusions**
- consideration to solutions from **alternative perspectives**
- communicating **difficult** or **complex** ideas in an **effective** and **understandable** manner

## Informed Colleague Overview

The Informed Colleague listens carefully to the presented report and prepares and delivers a critical response to the report. **The Informed Colleague** puts questions to the Reporter and critiques the report, pointing to possible inaccuracies and errors in the understanding of the problem and in the solution. "Critiquing" can also involve making commendations where appropriate. The Informed Colleague analyses the advantages and drawbacks of both the solution and the presentation from the Reporter.

*The Opposition team should include, where relevant:*

- reference to the strengths and weaknesses of the reporters' interpretation of the problem
- agreeing or disagreeing with the reporters' assumptions.
- any appropriate **concepts, theories and principles** relating to the problem that the reporter may have not covered appropriately
- comments on the reporters' **application** of **appropriate mathematics, investigative methodology or modelling**
- questioning the **validity** of the **data** (how data was collected, reliability of equipment)

## Informed Colleague and Reporter discussion Overview

The discussion by the Informed Colleague should not become a presentation of his/her own solution. In the discussion, the solution presented by the Reporter is discussed.

*The Opposition team* should:

- concentrate on reporters' solution (no reference to own report allowed)
- the informed colleague recognizes and highlights valid points by the reporter
- attempt to clarify strengths and weaknesses of the report
- ask relevant questions
- demonstrate understanding of the concepts, theories and principles when discussing the solution

*The Reporting team* should;

- be able to defend their solution by reference to science
- acknowledge solutions from alternative perspectives.

# Informed Colleague checklist

## Teacher notes.

The intent of the Informed Colleague checklist is to provide students in the role of Informed Colleague with a range of points to consider for their response to the Reporters presentation (refer to section 4 and 5 of Structure of the Science Challenge).

It is intended that teachers assist students in their understanding of the checklist points by discussing/interpreting the statements in the context of the students assigned problem task.

The process and strategy of learning how to critique a presentation should actually assist students with their own presentation and defence during the discussion section (refer to section 5 of Structure of the Science Challenge).

On the challenge event day in Townsville it is recommended that students have copies of the checklist to refer to and write notes as they listen to other schools' Reporters' presentation. Students can then refer to their checklist notes during their Informed Colleague response.

## Informed Colleague Checklist

Reference to the strengths and weaknesses of the reporter's interpretation of the problem.

You are to point out one positive (strength) and one negative (weakness) in the presentation.
Points to consider: Has the reporter:

- defined their scientific terms
- defined any relevant criteria
- distinguished fact from opinion
- thought about or asked relevant questions in their planning
- cited the sources of supporting information

Agreeing or disagreeing with the reporter's assumptions
You are to agree or disagree with the reporter's assumptions.

Points to consider: Has the reporter:

- presented any relevant **concepts, theories and principles** relating to the problem that may have not been covered appropriately
- rejected information that is incorrect or irrelevant
- identified information that has been omitted or not collected

Application of appropriate mathematics, investigative methodology or modelling

You may state the strengths and limitations in the work of the presenter

Points to consider: Has the reporter:

- chosen an appropriate scientific method/approach (investigation or modelling) to solve the task

- discussed (for investigation) the independent and dependent variables chosen

- discussed other variables not considered

- described in detail their method (design, equipment, materials used, data collection (how, what)

Questioning the validity of the data (how data was collected, reliability of equipment)

Points to consider: Has the reporter

- commented on data validity (how data was collected, reliability of equipment, made detailed and accurate observations

- presented their observations clearly and in a scientific format

- covered adequately relevant questions about their observations or results.

- identified any information that has been omitted or not collected.

Research Findings

Points to consider: Has the reporter:

- analysed the data(observations) to make reasonable conclusions

- stated a clear conclusion

- made claims or statements based on solid evidence and sound logic.

- adjusted opinions when new facts were found

- admitted a lack of understanding or information when necessary

- considered a variety of explanations (any contradictory data)

# Elements of Critical Thinking

Elements of Critical Thinking:

- Identification of premises and conclusions. Critical thinkers break arguments into basic statements and draw logical implications.
- Clarification of arguments: Critical thinkers locate ambiguity and vagueness in arguments and propositions.
- Establishment of facts: Critical thinkers determine if the premises are reasonable and they determine if the implications are logical and search for potentially contradictory data.
- Evaluation of Logic: Critical thinkers determine if the premises support the conclusion. In deductive arguments, the conclusions must be true if the premises are true. In inductive arguments, the conclusions are likely if the premises are true.
- Final evaluation: Critical thinkers weigh the evidence and arguments. Supporting data, logic and evidence increase the weight of an argument. Contradictions and lack of evidence decrease the weight of an argument. Critical thinkers do not accept propositions if they think there is more evidence against them or if the argument is unclear, omits significant information, or has false premises or poor logic.