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A framework for building teacher capacity and student engagement in STEM within school-university partnerships

Final report 2016

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List of acronyms used

AMSI	Australian Mathematical Sciences Institute
CSIRO	Commonwealths Scientific and Industrial Research Organisation
DEMO	Design and Evaluation Matrix for Outreach activities
HEPPP	Higher Education Participation and Partnerships Programme
HSC	Higher School Certificate
OECD	Organisation for Economic Co-operation and Development
OHS	Occupational Health and Safety
OLT	Office for Learning and Teaching
PICSE	Primary Industry Centre for Science Education
RUN	Regional Universities Network
STEM	Science, Technology, Engineering and Mathematics
SPERA	Society for the Provision of Education in Rural Australia
SPSS	Statistical Package for the Social Sciences

Executive summary

A framework for building teacher capacity and student engagement in STEM within school-university partnerships

Context

The declining participation rates in many Science, Technology, Engineering and Mathematics (STEM) courses at high school and university have been clearly identified. Low representation in STEM courses is particularly noticeable among young people from rural, regional and remote communities (Sheehan & Mosse, 2013), and among Indigenous populations. Science and mathematics subjects are often discontinued at Year 10 (Lyons & Quinn, 2010), where students select subjects in preparation for possible careers and further education, with the consequence that rural students are often excluded from higher education STEM courses and from careers that require STEM study (Sheehan & Mosse, 2013).

Increasing rural student participation and achievement in STEM requires skilled and qualified teachers who have links and investment in the long term target of higher education (Redman, Cooper & Bottrell, 2014). Studies indicate that higher education aspiration develops during the secondary years of education, yet secondary teachers are often not suitably qualified in science and mathematics, particularly in rural and remote schools (Lyons, Cooksey, Panizzon, Parnell & Pegg, 2006; Spielhofer, Golden & Evans, 2011). School-university partnerships have a demonstrated ability to meet education and social needs in rural, regional and remote Australia, but access is often severely limited. While governments have an obligation to support populations in all geographic areas, economic and political considerations influence the allocation of funds. Partnership programs in areas of low population density must demonstrate high impact to be competitive and sustainable, yet evaluations are often *ad hoc*, resulting in an inadequate evidential base.

Aims

This project sought to produce an evidence-based framework to inform the future design and evaluation of effective school-university partnerships and outreach programs that specifically build:

- The **capacities of regional secondary school teachers** to teach mathematics and science; and
- The **achievements and aspirations of regional secondary school students** to enrol in senior secondary school mathematics and science subjects and, subsequently, in STEM-related university courses.

Approach

The research methodology involved a number of data gathering and analysis strategies, which crossed sector and discipline boundaries:

- The **literature review** was designed to provide background context for the study and to create a lens through which to view the diverse factors that affect the educational outcomes and career aspirations of rural students. Models for the planning, development and evaluation of outreach programs were also investigated.
- A **national online survey** collected a range of data about STEM outreach programs. Survey responses were received from over 200 people working in this space, representing 38 Australian universities. The survey collected quantitative and qualitative data about program characteristics including aims, staffing and participant profiles, funding models, and evaluation strategies.
- Informed by the literature review and survey responses, a number of programs representing a diversity of structures, approaches and practises were selected as in-depth **case studies**. These programs involved eight universities in five states (New South Wales, Queensland, Tasmania, Victoria and Western Australia), and ranged in size from small niche programs to large, state-wide programs.
- The Design and Evaluation Matrix for Outreach activities (DEMO) generated by Gale, Sellar, Parker, Hattam, Comber, Tranter & Bills (2010) was adapted to form a **framework to guide the planning and design** of STEM outreach programs. The modified framework was refined after its application to effective STEM outreach programs identified during the case study phase.

Deliverables

This project has resulted in a number of presentations and publications, listed in Appendix A, and available on the project website at http://federation.edu.au/STEMoutreach

Key outputs include:

- A comprehensive national survey of STEM outreach programs;
- Case studies of effective university-school STEM partnerships, with a particular focus on rural and regional contexts;
- A framework to guide the review of existing STEM outreach programs and the planning and design of future programs; and
- A broad literature review, which considers the association between STEM skilled personnel and sustainable economic growth and the potential role of university outreach programs in building, supporting and maintaining STEM capability in regional, rural and remote areas.

Impact

The research methodology was designed to identify, build and foster relationships with those who work in partnerships across education and community sectors. Survey responses were received from over 200 people working in university outreach to schools, many of whom expressed a desire for ongoing involvement in STEM outreach research. Cross-fertilisation of ideas from industry, education and policy partners working in the rural and regional space can promote a national approach to collaboration.

Key findings

Findings suggest that there is no particular combination of program scale, target audience, activity-type or frequency that is optimal for sustained success. Neither were those outreach programs regarded as successful limited to particular locations, universities or faculties. Rather, the study concluded that an 'ideal' school-university partnership in STEM is one that:

- offers contextually relevant hands-on active learning;
- is conducive to the development of deep knowledge about STEM and STEM pathways;
- empowers students (and educators) towards critical reflection on aspirations and pathways;
- provides opportunities for reciprocal conversations among STEM experts, learners and education communities;
- builds relationships among educators and learners, education sectors and communities; and
- has a reasonable security of funding, year on year.

The national survey of university staff involved in STEM outreach programs highlighted that major impediments to program continuity were unclear aims, uncertainty of funding, reliance on a few key personnel, and perceived lack of institutional recognition.

While 90% of survey participants agreed that formal evaluation of programs was desirable, only a third reported that this was the case. Reasons given were varied, but resourcing issues were commonly cited, including lack of time, funding and expertise.

An evaluation model that can be applied consistently across different partnerships and settings is needed, thereby providing valuable comparative data for all levels of decision-making. Such a model could be used by parent organisations to guide program development and by funding bodies to inform allocation of funding. However, the requirement for longitudinal data and monitoring of student outcomes highlights the need for strategic links and collaboration between education sectors.

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Chapter 1: Aims, Approach and Outcomes

1.1 Aims and Context

While investment in Science, Technology, Engineering and Mathematics (STEM) enterprises is viewed as essential for sustainable economic growth (Education Council, 2015), STEM awareness and skills are sometimes lacking in regional and rural communities (Sheehan & Mosse, 2013). Declining participation rates in many Science, Technology, Engineering and Mathematics (STEM) courses at high school and university have been clearly identified (Dobson, 2013; Kennedy, Lyons & Quinn, 2014). The deficiency in numbers of STEM students is particularly noticeable in rural, regional and remote Australia, including Indigenous populations, where participation rates of students in higher education in general, and STEM specialist areas specifically, are low (Sheehan & Mosse, 2013). University outreach programs, developed in partnership with schools, can play an important role in regional, rural and remote areas by building, supporting and maintaining STEM capability. Science and mathematics subjects are often discontinued at Year 10 (Lyons & Quinn, 2010), a crucial time in preparation for careers and further education, the consequence is an issue of equity, that rural students are often excluded from higher education STEM courses and from careers that require STEM study (Sheehan & Mosse, 2013).

Increasing rural student participation and achievement in STEM requires teachers skilled in delivery, as well as teachers who have links and investment in the long term target of higher education (Redman, Cooper & Bottrell, 2014). Studies indicate that higher education aspiration develops during the years of secondary education, yet secondary teachers are often not suitably qualified in STEM, particularly in rural and remote schools (Lyons, Choi & McPhan, 2009; Spielhofer, Golden & Evans, 2011). University-school partnerships have a demonstrated ability to fill scholarly and social gaps in rural, regional and remote Australia, but access is often severely limited. While government has an obligation to support populations in all geographic areas, economic considerations drive allocation of funds. Programs in areas of low population density must demonstrate high impact to be competitive, but partnership evaluations are often *ad hoc*. Complexities arise due to the very different life experiences of those living in metropolitan, rural and remote settings; this intricacy becomes even more apparent when partnerships involve different education sectors.

To achieve positive impact, and to successfully meet outcomes, practitioners, policy makers and researchers working in the rural space must ensure that their work recognises and respects the rural context. Consistent with this premise, this project aimed to produce an evidence-based framework to inform the future design and evaluation of effective school-university STEM partnership programs that specifically build:

- the capacities **of regional secondary school teachers** to teach STEM subjects
- the **achievements and aspirations of regional secondary school students** to enrol in STEM-related study at secondary and tertiary levels.

1.2 Approach

The research methodology involved a number of data gathering and analysis strategies, which crossed sector-based and discipline-based units

An extensive **literature review** initially focussed on what were considered to be the key components of school-university outreach partnerships: teacher capability, educational outcomes and student aspiration. This was expanded to include models for planning, developmental and evaluation of outreach programs.

The **online survey** was designed to collect profile data about outreach program staff, the programs in which they are involved, their partners, and school participants. It also sought respondents' opinions about the aims and priorities of the programs, how these were evaluated, and the barriers to improving effectiveness and evaluation. The survey consisted of Likert-type rating items, multiple option items and open-ended items. It was launched in August 2014 and remained open until the end of November 2014. Quantitative data were analysed in SPSS using descriptive statistics and, where applicable, chi-square contingency table tests. The qualitative responses were coded thematically using the constant comparative method (Maykut & Morehouse, 1994).

Case studies, involving five school-university STEM partnership programs, were designed to identify aspects and mechanisms of programs that are effective, show promising practice, use evaluation or an evidence base for future practice and/or demonstrate a diversity of characteristics. Steps for identification, gathering and analysis of case studies were developed from the review of literature and applied to those school-university STEM outreach partnerships who provided contact details through the survey (n=63). Key features of each of these outreach partnerships including: type of activity; audience size; number of partners; and number of presenters were entered into a proforma. This allowed each program to be placed on a continuum, ranging from niche local program to national program across multiple locations. Members of the research team and reference committee settled on five partnerships that demonstrated diversity in geography, systems and structure. The study investigated school-university outreach partnerships in NSW, Victoria, Tasmania, Queensland and Western Australia using the categories: (a) assembling resources (b) engaging learners (c) working together, (d) building confidence, and (e) equity disposition modified from research by Gale *et al.* (2010) into equity in educational opportunity in Australia. Punch's (2005) work provided a format for case description, allowing similarities and differences to be made clear while contributing rich descriptive data to complement the analysis of data gathered through the national school-university partnership survey.

1.3 Linkages and Outputs

This project addressed the Innovation and Development Program priority *Improving Tertiary Pathways: developing and modelling programs that work with schools to improve student participation in higher education* and has direct relevance to the National STEM School Education Strategy, 2016-2026 (Education Council, 2015), which stresses the economic imperative for building national STEM capacity and highlights the overall trend away from

STEM subject choices in Australia, a trend that is particularly apparent in low SES, indigenous and non-metropolitan communities.

This project is related to two OLT National Teaching Fellowships investigating aspects of resourcing in urban, rural and remote settings: O'Shea's work[1], which investigates the impact of university outreach activities on productive partnerships with families in the higher education journey, and Mocerino's research[2], which aims to embed teaching skills in the laboratory across universities uses a similar methodology to the school-university outreach partnerships evaluation - trial, refine, enhance. Two HEPPP funded nationally significant projects to be run from the University of Melbourne between 2013 and 2017, the *Indigenous Academic Enrichment Program* and *Indigenous Engineers: Partners for Pathways*, which aim to provide an experience of university life that will broaden interests and raise aspirations, also share a philosophy and focus with this project.

Successful completion of this project can be attributed to the drive and persistence of the project team, and to the enthusiastic participation of the STEM outreach community. The latter was encouraged by personal contact, consistent follow-up and thoughtful, respectful interactions, rather than an unsolicited email with a survey link as is sometimes the case. The mobility of staff in the tertiary sector, both within and between institutions, affected both the project team and the reference group. The project team, who were committed to the project, worked hard to overcome these obstacles, however participation of all reference group members was sometimes limited.

This project has resulted in a number of presentations and publications, listed in Appendix B and available on the project website at http://federation.edu.au/STEMoutreach

Key outputs include:

- A comprehensive national survey of STEM outreach programs;
- Case studies of effective university-school STEM partnerships, with a particular focus on rural and regional contexts;
- A framework to guide the review of existing STEM outreach programs and the planning and design of future programs; and
- A broad literature review, which considers the association between STEM skilled personnel and sustainable economic growth and the potential role of university outreach programs in building, supporting and maintaining STEM capability in regional, rural and remote areas.

[1] Associate Professor Sarah O'Shea, University of Wollongong, Office for Learning and Teaching (OLT) National Teaching Fellowship 2015
[2] Associate Professor Mauro Mocerino, Curtin University, Office for Learning and Teaching (OLT) National Teaching Fellowship 2015

Chapter 2: Survey of university staff involved in STEM Outreach to Schools: Summary of results

2.1 Profiles of respondents

As shown in Table 2.1, valid responses were collected from 205 respondents in 38 universities, representing more than 100 STEM outreach programs (listed in Appendix C).

Table 2.1. Numbers of survey respondents by university (n=205) (Two respondents did not identify their universities)

	N	%		N	%
Australian Catholic University	3	1.5	Swinburne University of Technology	6	2.9
Australian National University	15	7.4	University of Adelaide	9	4.4
Central Queensland University	2	1.0	University of Canberra	3	1.5
Charles Darwin University	2	1.0	University of Melbourne	9	4.4
Charles Sturt University	5	2.5	University of Newcastle	5	2.5
Curtin University of Technology	20	9.8	University of New England	1	.5
Deakin University	7	3.4	University of New South Wales	6	2.9
Edith Cowan University	8	3.9	University of Notre Dame	1	.5
Federation University Australia	6	2.9	University of Queensland	6	2.9
Flinders University	4	2.0	University of South Australia	6	2.9
Griffith University	3	1.5	University of Southern Queensland	2	1.0
James Cook University	3	1.5	University of Sunshine Coast	3	1.5
La Trobe University	5	2.5	University of Sydney	4	2.0
Macquarie University	4	2.0	University of Tasmania	14	6.9
Monash University	9	4.4	University of Technology Sydney	5	2.5
Murdoch University	1	.5	University of Western Australia	8	3.9
Queensland University of Technology	5	2.5	University of Western Sydney	1	.5
RMIT University	1	.5	University of Wollongong	7	3.4
Southern Cross University	3	1.5	Victoria University	1	.5
TOTAL UNIVERSITIES 38			TOTAL VALID RESPONDENTS	203*	100%

Just under half of the respondents were associated with Faculties of Science or Mathematics, 10 per cent were associated with Faculties of Engineering, and 10 per cent with Faculties of Education. The number of responses from individual universities varied from one to 20, with the potential for survey results to be skewed in cases where multiple respondents referred to the same outreach program. However, follow up checks with universities with high response rates revealed that these responses represented multiple programs, with no more than two or three respondents reporting on the same program.

Tables 2.2 to 2.5 provide a profile of the respondents. Around 49 per cent were from Faculties or Schools of Science or Mathematics. A similar proportion consisted of full-time

academics. The majority (55 per cent) were Program Coordinators or Moderators, and most had been involved in the program for three years or less (55 per cent).

Table 2.2. With which faculty or school (or organisation) are you most closely associated?

	N (*n* = 205)	Valid %
Faculty or School of Science or Mathematics	101	49.3
Faculty or School of Engineering	20	9.8
Faculty or School of Education	21	10.2
Faculty or School of Health	10	4.9
Other	53	25.9

Table 2.3. How long have you been involved in this program?

	N (*n* = 203)	%
Less than one year	33	16.3
1 to 3 years	79	38.9
4 to 6 years	54	26.6
7 to 10 years	16	7.9
More than 10 years	21	10.3

Table 2.4. What are your roles in this program?

	Responses		Per cent of
	N	Per cent	Cases
Program Coordinator or moderator	111	31.4%	54.7%
Program Partner	45	12.7%	22.2%
Program Committee Member	22	6.2%	10.8%
Facilitator/Helper	44	12.5%	21.7%
Presenter	86	24.4%	42.4%
Evaluator	26	7.4%	12.8%
Other	19	5.4%	9.4%

Note: Per cent of cases may sum to more than 100 due to some respondents selecting more than one option.

Table 2.5. What is your main role within the university (or within the partner organisation)?

	N (*n* = 204)	Valid %
Full time academic	100	49.0
Part time academic	11	5.4
Sessional or casual staff member	2	1.0
Adjunct	2	1.0
School liaison	3	1.5
Project manager or project officer	36	17.6
Marketing and recruitment	5	2.5
Student (undergraduate or postgraduate)	9	4.4
Other	36	17.6

2.2 Profiles of the Outreach programs

The respondents represented a wide variety of STEM outreach programs. As shown in Table 2.6, more than half of respondents (53 per cent) indicated their programs had been running for more than five years, while 24 per cent indicated these had been running for more than a decade. Table 2.7 reports the frequency of program activities, with around 59 per cent of respondents indicating that their program runs at least once a year. (Respondents who were unfamiliar with such details did not respond.)

Table 2.6. How long has this program been running at your university?

	N (*n* = 171)	%
Less than 2 years	28	16.4
2 to 4 years	53	31.0
5 to 9 years	49	28.7
10 to 20 years	32	18.7
More than 20 years	9	5.3

Table 2.7. How often does this program run?

	N (*n* = 174)	%
More than once per year	61	35.1
Once per year	41	23.6
Once every two years	1	.6
When demand requires	28	16.1
Other	43	24.7

2.2.1 Staffing

Table 2.8 and Table 2.9 summarise respondents' reporting of the numbers of university employees and students engaged in running the program. Nearly 60 per cent of respondents reported that no more than three staff were involved in their program, while around 25 per cent reported that more than ten staff were involved. Around a quarter of respondents reported that no university students assisted with program delivery.

Table 2.8. How many university employees are involved in the delivery of this program?

	N (*n* = 164)	%
None	27	16.5
1 to 3	71	43.3
6 to 10	25	15.2
More than 10	41	25.0

Table 2.9. How many university students are involved as facilitators/helpers each time this program is run?

	N (*n* = 166)	%
None	41	24.7
1 to 3	29	17.5
4 to 9	45	27.1
10 to 20	28	16.9
More than 20	23	13.9

2.2.2 Types of outreach programs

As shown in Table 2.10, the most commonly reported outreach formats included visits to schools by university staff and/or students (62 per cent of respondents), and visits to the university by school students (nearly 60 per cent of respondents).

Table 2.10. Which of the following describe(s) the main format of your outreach program? (NB. some programs have more than one main format)

	Responses		Per cent of
	N	%	173 Cases
Visits to schools by university staff and/or students	108	26.3%	62.4%
Visits to the university by school students	103	25.1%	59.5%
Visits to the university by teachers	63	15.4%	36.4%
Activities or competitions supervised by teachers at school	31	7.6%	17.9%
Web-based activities	25	6.1%	14.5%
Excursions with school students/teachers to an off campus site	38	9.3%	22.0%
Other	42	10.2%	24.3%

Note: 'Per cent of cases' may sum to more than 100 due to some respondents selecting more than one option.

2.2.3 Profiles of program participants

According to respondents, some programs target specific Year levels or types of school students, while others cater for broader groups, including primary and secondary teachers. Table 2.11 summarises the broad participant categories. It appears that the majority of programs target secondary students, with around 64 per cent of respondents identifying junior secondary and 72 per cent identifying senior secondary students as the target group. Table 2.12 outlines the specific types of participant catered for by the programs, where relevant.

Table 2.11. What are the broad target groups for this program?

	Responses		Per cent
	N	Per cent	of Cases
Early childhood or lower primary school students	31	6.6%	19.3%
Upper primary school students	72	15.2%	44.7%
Primary school teachers	51	10.8%	31.7%
Junior secondary school students	103	21.8%	64.0%
Senior secondary school students	116	24.5%	72.0%
Secondary school teachers	77	16.3%	47.8%
Other	23	4.9%	14.3%

Note: N = 160. 'Per cent of cases' may sum to more than 100 due to some respondents selecting more than one option.

Table 2.12. Is this program designed primarily to cater for specific types of participant?

	Responses		Per cent
	N	Per cent	of Cases
Primarily for female students	12	4.4%	7.8%
Primarily for male students	5	1.8%	3.3%
Primarily for senior math students	18	6.6%	11.8%
Primarily for senior science students	34	12.5%	22.2%
Primarily for rural/remote students	39	14.3%	25.5%
Primarily for Indigenous students	19	7.0%	12.4%
Primarily for gifted and talented students	17	6.2%	11.1%
Primarily for low SES students	39	14.3%	25.5%
Not for specific types of students	56	20.5%	36.6%
Primarily for students with a disability	0	0%	0%
Other	34	12.5%	22.2%

Note: N= 153. 'Per cent of Cases' may sum to more than 100 due to some respondents selecting more than one option.

Over a quarter of respondents reported that their programs catered primarily for low SES students, while a similar proportion indicated their programs catered primarily for rural/remote students. Around 37 per cent of respondents indicated that their program did not specifically target any of the suggested categories. Programs focusing on female students were reported by around eight per cent of respondents, while no programs catered primarily for students with a disability. Participant types recorded in the "other" category included engineering science students, middle year students, and ICT students.

The scale of participation varied considerably. Thirty-three respondents indicated that their programs generally attracted fewer than 50 students, while 14 respondents reported more than 5000 program participants. The most common ranges were between 100 - 200 students (26 respondents) and 200 - 500 participants (24 respondents).

2.3 Partners and funding

As shown in Figure 2.1, the federal government and respondents' own universities appear to be the two major funding sources for outreach activities. Around 43 per cent of respondents reported that three quarters or more of their funding came from federal

government bodies, with 70 per cent of respondents indicated that more than a quarter of their funding is from this source. By contrast, only around 15 per cent of respondents reported that state, territory or local governments funded their programs to a similar extent. While it appears to be less common for private organisations to fund more than three quarters of a program, around 42 per cent of respondents agreed that private organisations contribute more than a quarter of their funding.

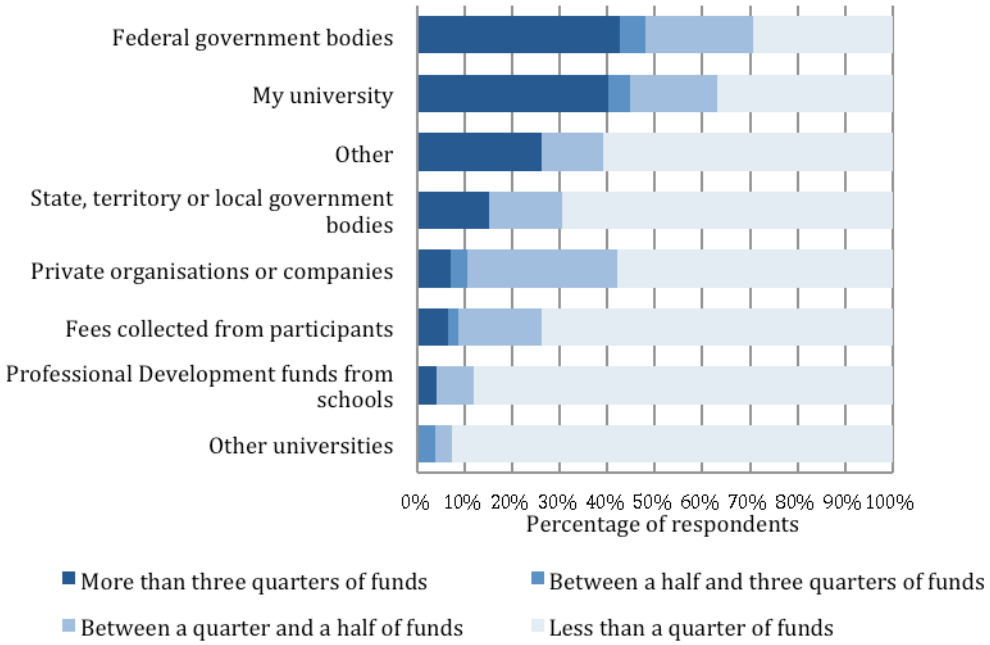

Figure 2.1. Sources and proportions of funding reported by respondents

2.3.1 Security of funding

Respondents were asked to rate the security of funding for their programs over the next two years. As shown in Table 2.13, around 30 per cent considered the funding to be reasonably or very secure, while 35 per cent believed it to be reasonably insecure or not at all secure.

Table 2.13. How secure is the funding for this program over the next two years?

	N (*n* = 163)	%
Not at all secure	38	23.3
Reasonably insecure	19	11.7
Don't know	57	35.0
Reasonably secure	35	21.5
Very secure	14	8.6

Overall, uncertainty about funding was a major concern of respondents. When asked via an open-ended question to identify the biggest barriers to improving the effectiveness of their programs, 52 respondents (41 per cent) nominated the insecurity of ongoing funding.

2.4 Aims and priorities of the programs

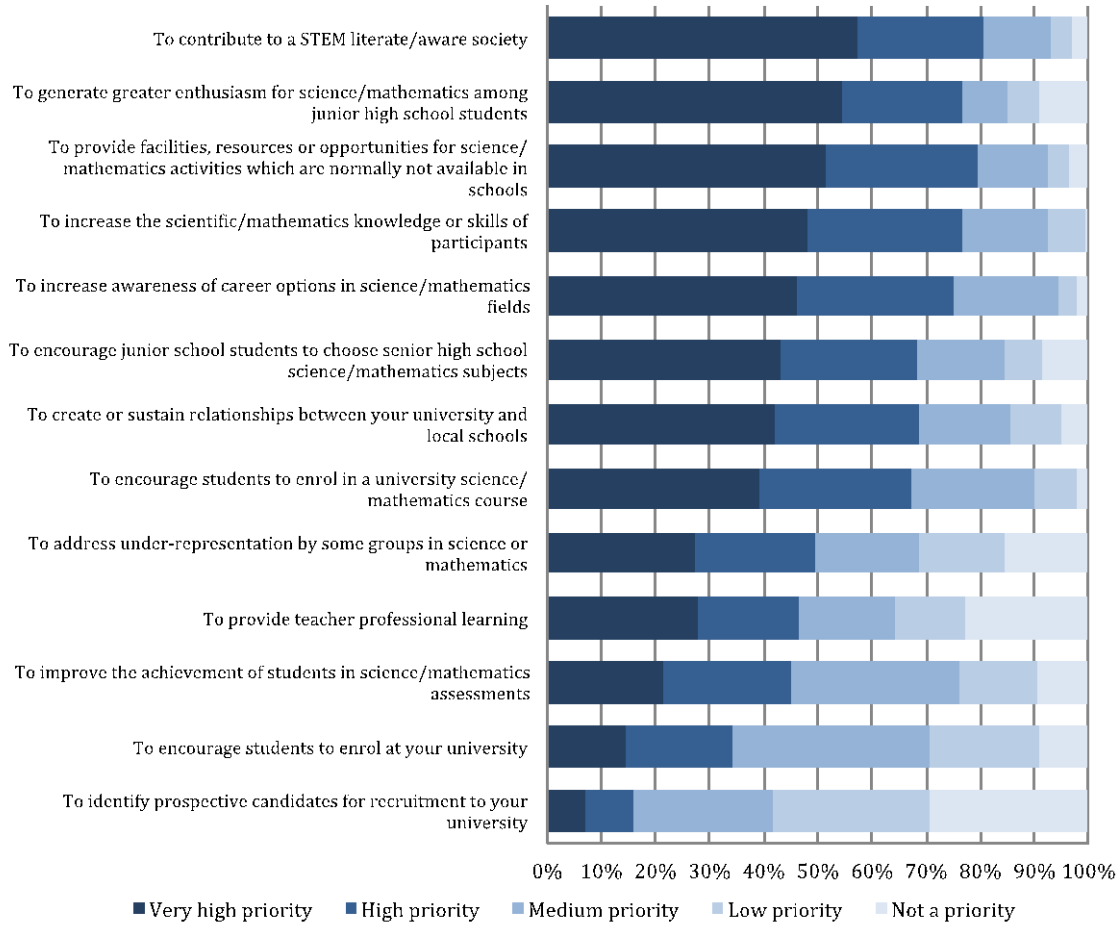

Figure 2.2. Respondents' ratings of the priorities given to particular aims of their outreach programs (N=153).

Figure 2.2 summarises respondents' opinions about the aims and priorities of their outreach programs. The figures shows that overall, more than half of respondents rated as very high priorities 'contributing to a STEM literate/aware society' (57 per cent), 'generating enthusiasm for science/mathematics among junior high school students' (54 per cent), and 'providing facilities, resources and opportunities to schools' (51 per cent). In contrast, 'identifying prospective candidates for their universities', 'encouraging students to enrol in their universities' and 'improving achievement in science and mathematics assessments', were relatively low priorities. In general, it is apparent that respondents considered those aims around increasing awareness, enthusiasm and subject knowledge to be a higher priority than more specific aims around university enrolment.

2.5 Evaluation of the program

As a follow-up question, participants were asked to identify the extent to which evidence had been collected to establish whether the aims depicted in Figure 2.2 had been achieved.

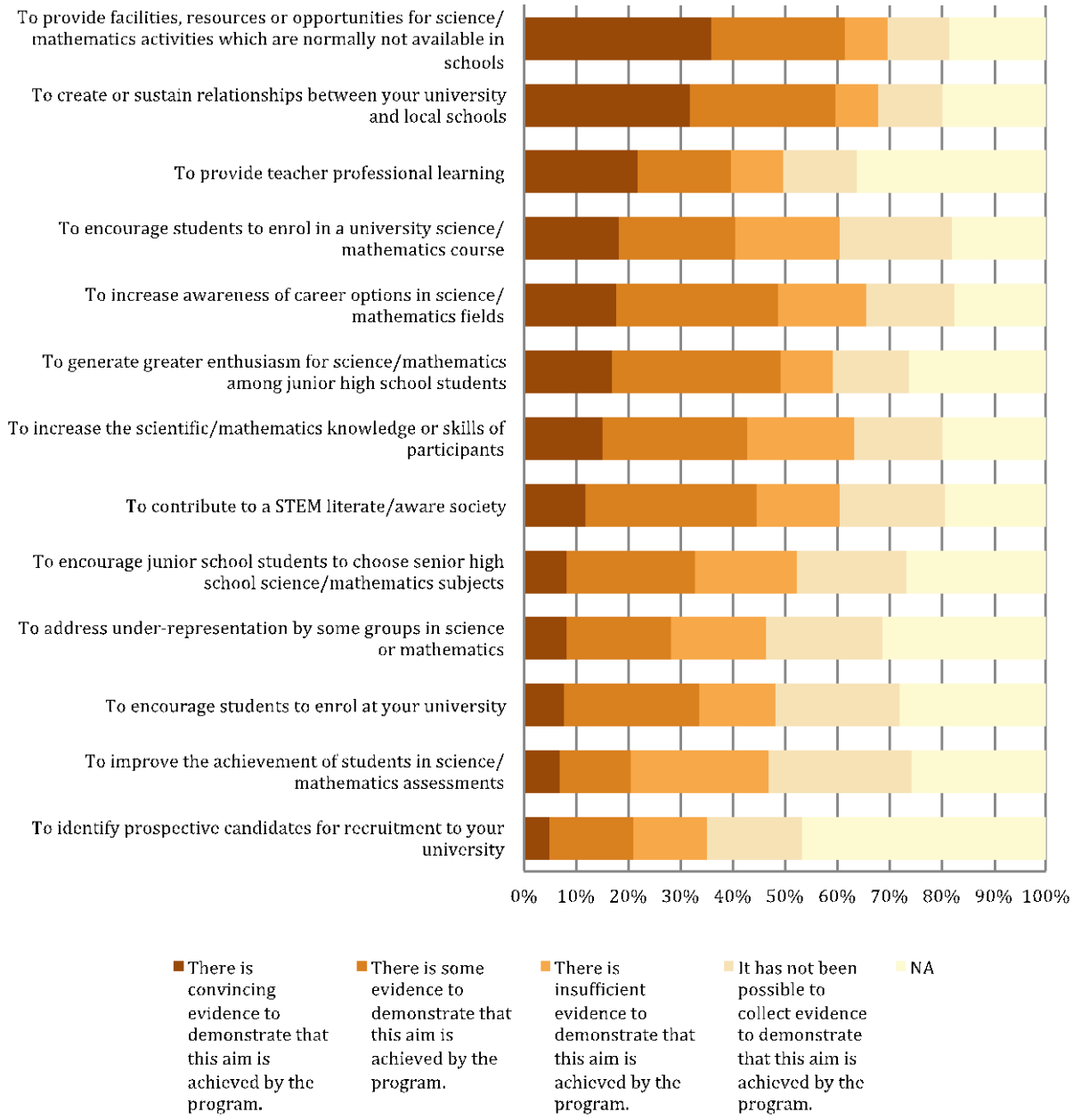

Figure 2.3. Respondents' views of the extent to which evidence had been collected to establish whether the aims listed in Figure 2.2 had been achieved (n = 144).

Figure 2.3 shows that around 36 per cent of respondents believed there was convincing evidence that their program provided facilities and resources normally unavailable to schools, while 32 per cent considered there was convincing evidence that their programs had created or sustained relationships with schools.

2.5.1 Degree of evidence that high priority aims have been achieved

Figure 2.4 compares the high and very high priority aims identified by respondents as a group (from Figure 2.2) with their perceptions of the extent to which evidence has been collected about the achievement of those aims (from Figure 2.3).

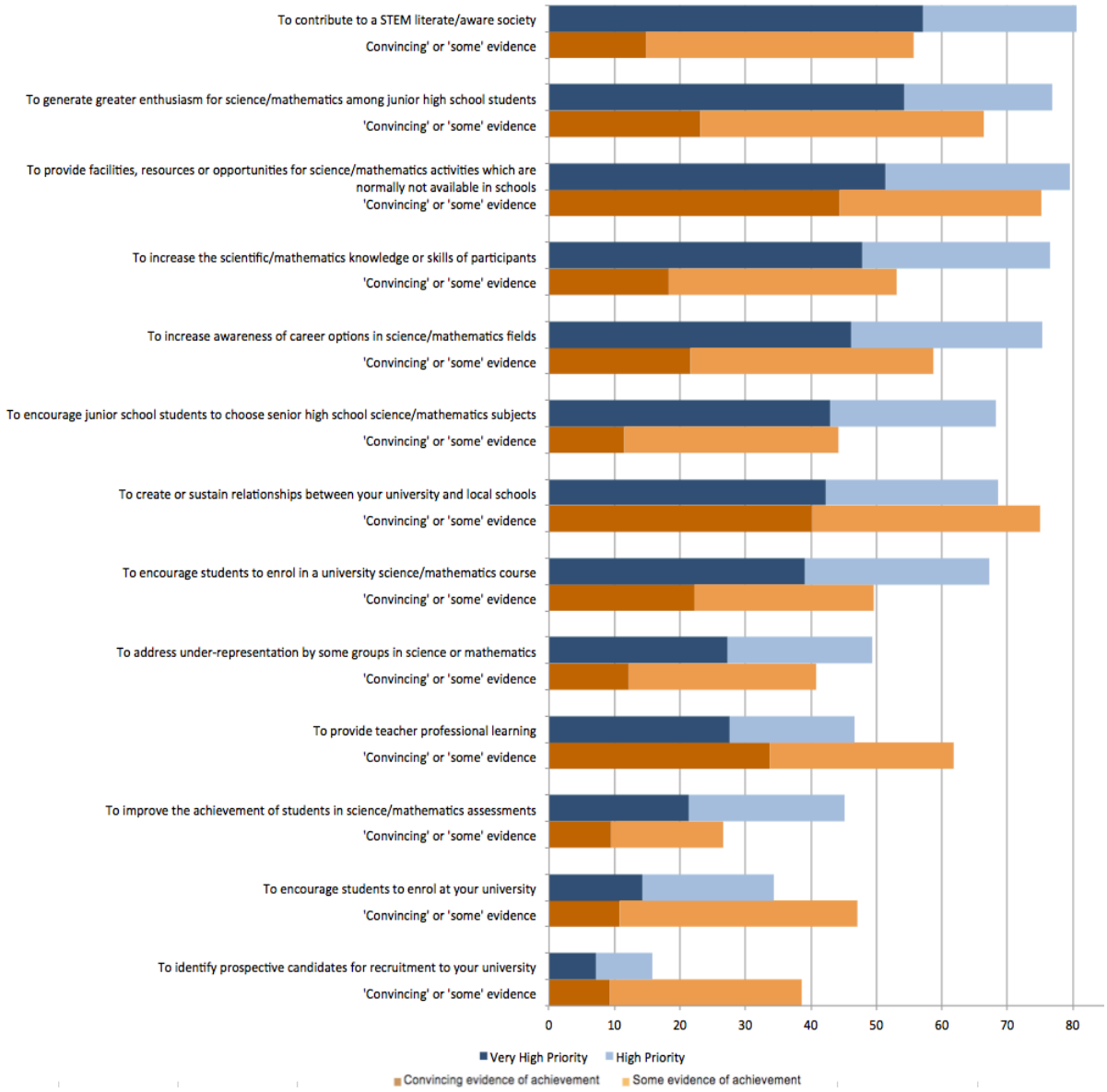

Figure 2.4. Comparison between the high priority aims identified by respondents and the degree of evidence collected about their achievement (n=117). (Excludes respondents who regarded the collection of evidence as 'not applicable' to the aims of their program.)

Figure 2.4 highlights some alignments and misalignments between stated aims and the extent of evidence that those aims have been achieved. The greatest degree of alignment is found among five items: 'providing teacher professional development', 'creating or sustaining relationships between your university and local schools', 'providing facilities, resources or opportunities not normally available to schools', encouraging students to enrol at your university' and 'identifying prospective candidates for recruitment to your university'. It is unsurprising that evidence has been collected about the latter two aims, since universities would be able to capture such evidence from newly enrolled students. Likewise, it would not be difficult to collect evidence about whether teacher professional learning or facilities and resources had been provided, or whether relationships exist with schools, since these would be a matter of record.

The greatest contrasts across the priorities attributed to particular aims and the extent of evidence that these have been achieved can be found among the broader or longer-term aims, such as:

- contributing to a STEM literate/aware society;
- generating greater enthusiasm for mathematics and science among junior high school students;
- increasing the scientific/mathematical knowledge of participants;
- encouraging junior students to choose senior high school science or mathematics;
- encouraging students to enrol in a university science/mathematics course;
- addressing under-representation in these subjects; and
- improving the achievement of students in science/mathematics assessments.

Of greatest concern is that such misalignments are found among five of the six highest priority aims. It appears that insufficient evidence (particularly 'convincing' evidence) is being collected to determine whether many, or any, of the highest priority aims of these programs are being achieved.

2.5.2 Perceptions about the achievement of aims

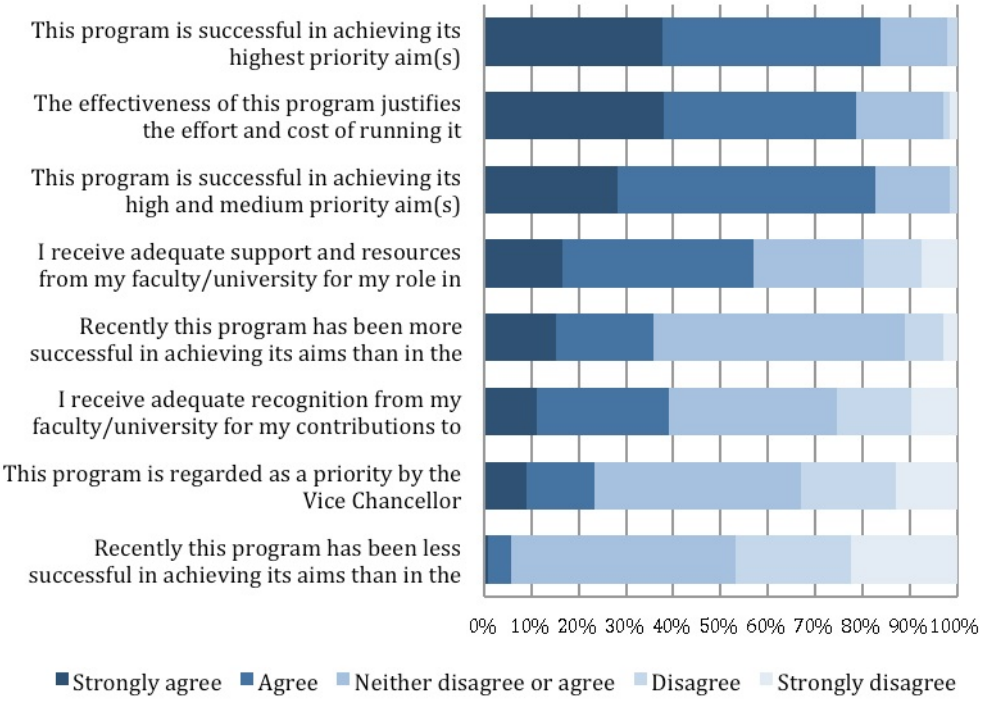

Figure 2.5. Perceptions about the success and recognition of outreach programs (n=147)

Respondents were asked about the success of and recognition for their program. Despite the misalignments between aims and evaluation, evidence presented above shows that around 83 per cent of respondents nevertheless agreed (46 per cent) or strongly agreed (38 per cent) that their program was successful in achieving its highest priority aims.

Around 83 per cent also agreed (55 per cent) or strongly agreed (28 per cent) that their program was successful in achieving its medium and high priority aims. These perceptions contrast with respondents' reports about evidence, suggesting that many respondents are confident the aims are being achieved regardless of the relatively small amount of convincing evidence. This highlights the need for collection of independent evidence, rather than self-reporting.

2.5.3 Evaluation strategies currently undertaken

Participants were asked to identify the types of informal (Table 2.14) and formal evaluation (Table 2.15) currently undertaken in their programs. The tables show that informal evaluation is far more common than formal evaluation. The most commonly reported types of informal evaluation were anecdotal comments from teachers and students, reported by 85 per cent and 76 per cent of respondents respectively. The most commonly reported types of formal evaluation included surveys distributed to teachers and to all students, reported by 42 per cent and 38 per cent of respondents respectively. Around 32 per cent of respondents reported that no formal evaluation was undertaken at all.

Table 2.14. Types of informal evaluation undertaken.

	Responses		Per cent of
	N	Per cent	Cases
No informal evaluation	7	1.5%	4.9%
Anecdotal comments from teachers	121	25.7%	84.6%
Anecdotal comment from students	109	23.2%	76.2%
Anecdotal comment from facilitators and organisers	75	16.0%	52.4%
Email feedback from teachers	90	19.1%	62.9%
Email feedback from facilitators or organisers	57	12.1%	39.9%
Other	11	2.3%	7.7%
Total	470	100.0%	328.7%

Note: N= 143. 'Per cent of Cases' may sum to more than 100 due to some respondents selecting more than one option.

Table 2.15. Types of formal evaluation undertaken

	Responses		Per cent
	N	Per cent	of Cases
No formal evaluation	45	16.5%	32.4%
A survey distributed to all students after the program	53	19.5%	38.1%
A survey distributed to a sample of students after the program	16	5.9%	11.5%
A survey distributed to students before participating in the program	20	7.4%	14.4%
Formal interviews with students after the program	12	4.4%	8.6%
A survey distributed to teachers after the program	59	21.7%	42.4%
Formal interviews with teachers after the program	17	6.3%	12.2%
A survey distributed to facilitators and organisers after the program	22	8.1%	15.8%
Other	28	10.3%	20.1%
Total	272	100.10%	

Note: N= 139. 'Per cent of Cases' may sum to more than 100 due to some respondents selecting more than one option.

2.5.4 Evaluation strategies that should ideally be undertaken

Participants were asked to identify which formal evaluation strategies they believed should be included as part of their outreach programs. Figure 2.5 compares the percentages of

respondents reporting particular types of formal evaluation currently undertaken, with the percentages that believe these types of evaluation should ideally be undertaken.

Whereas 32 per cent of respondents reported that no formal evaluation of their program is undertaken, only 10 per cent believed this should ideally be the case. For all types of evaluation, the reported actual rates were lower than those respondents believe are required, though the differences varied. The biggest contrasts between actual and ideal strategies were for the use of student surveys before the program, formal interviews with students after the program, formal interviews with teachers after the program, and surveys distributed to facilitators and organisers after the program. The percentages of respondents who believed each of these strategies should be undertaken were around double the percentage reporting that these were undertaken in practice.

In terms of reporting evaluation results, around 42 per cent of respondents indicated that neither they nor other program organisers had formally reported any evaluation results to stakeholders. Of those who did report results, the most common formats were a report to the faculty or university (37 per cent of respondents) and/or a formal report to schools or program partners (28 per cent).

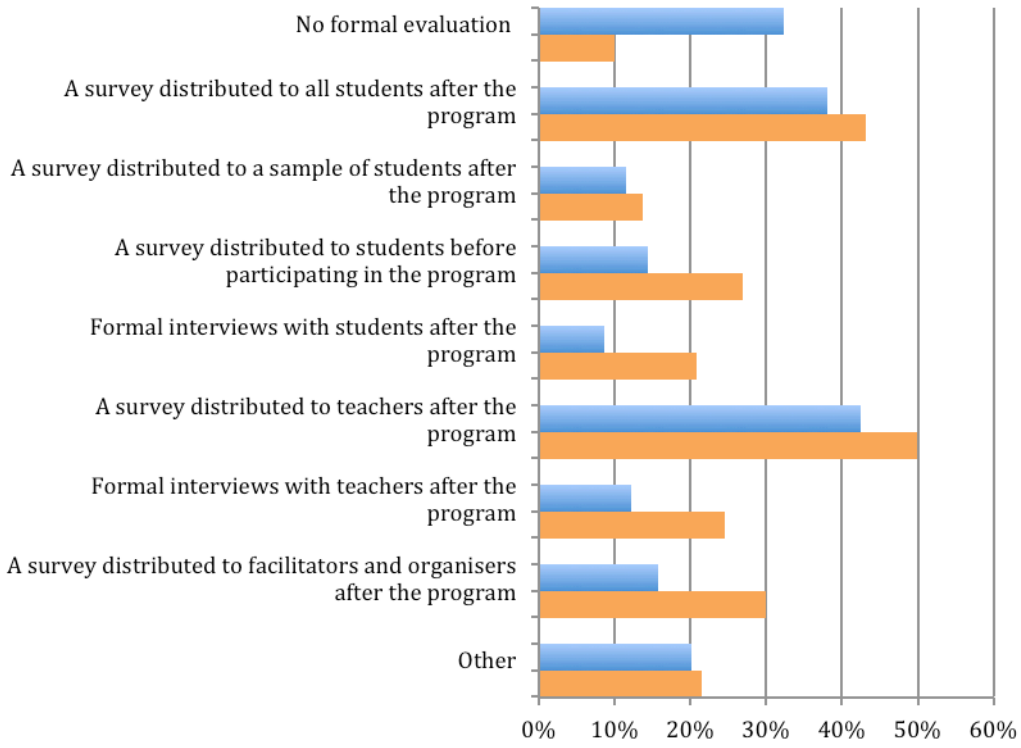

Figure 2.5. Comparison between the percentages of respondents reporting that particular types of formal evaluation are currently being undertaken (blue), and the percentages of respondents who believe these types of formal evaluation should be undertaken (orange) (n=139).

2.6 Barriers to more effective evaluation

Respondents were asked via an open-ended question to identify the best way of measuring the success of their programs. There were 120 separate recommendations from 108 respondents. The most common recommendation (41 respondents) was for longitudinal tracking of program participants (and non-participants for comparison), while the second most common recommendation was for the use of pre- and post-outreach surveys (18 respondents). Both recommendations would involve a relatively high degree of evaluation design, organisation, time and resources.

Consistent with this, respondents reported that the greatest impediments to more effective evaluation of programs were the lack of resources - including time, expertise and funding – and a range of impediments to data collection, including the generation of survey and longitudinal data. When asked to identify the specific resources they would require to more effectively evaluate their programs, the most frequent response (39 per cent) was additional funding, particularly to free up academic staff to design and carry out the evaluation. Around 22 per cent of respondents identified a need for additional expertise in evaluation design, while 21 per cent identified a need for strategic links with education sectors to monitor student outcomes and share data.

Chapter 3: Developing a framework to guide planning and design of STEM outreach partnerships

Partnerships between universities and schools can be very powerful. Five in-depth case studies were conducted, aimed at identifying the characteristics of effective outreach programs. Informed by the literature review and by findings from our national STEM outreach survey, focus questions were designed to address and capture the diversity of school-university outreach partnerships.

Case studies relied on four sources of data: observation, interviews with key stakeholders, artefacts and site visits. Individual and and focus group interviews gathered information on the initial development of the program, its purpose and philosophy, as well as program structure, program partners and aspects of resourcing. The nature of the audience, partnerships, relationships and the impact of these on evolution of the program were explored, with a specific focus on student aspiration and teacher capacity. Tangible aspects such as structure, resourcing and evaluation were also further investigated through data mining, document analysis and site visits. Triangulation and analysis of data provided descriptive narrative, available on the project website: http://federation.edu.au/STEMoutreach.

The case studies were deliberately selected to validate and/or expand on existing literature and survey findings, and to illustrate the complexity identified by survey responses in planning, delivering and evaluating school-university outreach partnerships in rural and regional Australia. This study identified three emergent themes that determine the success or otherwise of school-university outreach partnerships: impact, resourcing and access.

3.1 A Framework for Successful Practice

One purpose of this study was to identify 'successful practice' in relation to STEM university school partnerships in regional settings, which can be a challenging exercise as STEM outreach programs have significant differences in content, process and purpose. The five case studies were selected to reflect this diversity, as summarised below. Program content ranged from activities directly aligned with curriculum content through to creative workshops and independent-discovery programs. Some programs focus on development of subject specific attitudes, knowledge and skills, whereas others aim to develop scientific literacy and build aspiration.

> ***Case one:*** Part of a national program involving six regional Universities, 21 high schools and 20 primary schools, PICSE, AMSI, CSIRO; this Regional Universities Network (RUN) Maths & Science Digital Classroom is located in north Queensland. One researcher has partnered with local educators and developed a responsive program that has involved 250 students and 14 school staff over a 12 month period. The aim is to excite young people about STEM using local expertise and specifically designed digital resources.

Case two: This outreach partnership between a regional university and the regional Science Teachers' Association has been running for more than 20 years. The program comprises a full day related to HSC Chemistry, providing access to equipment unavailable in most parts of rural Australia. Active participation in experiments, opportunities to interview scientists, and engaging with university life are core to this day, which runs up to five times in a single week to meet audience demand.

Case three: This partnership between university Science and Engineering faculties and schools across one state delivers five individual outreach programs. Large numbers of academic staff, university and school students, educators and a broad range of community involvement from volunteers and participants are involved. One partnership, which overarches the other four, involves scientists travelling to rural and regional areas of the state where they work with individual classes or whole school communities. Some programs are responsive to community needs; others tailor national programs to a particular place and audience.

Case four: This program, a partnership between one secondary school and scientists at a regional campus, has run for two years. The program was funded by a joint grant application to develop and deliver an ecology-centred curriculum unit that is co-taught by university higher degree students, a school staff member and a university researcher.

Case five: This case study included interviews with personnel from four of five universities in the one state. The diverse outreach partnerships, which are not always solely STEM, offer models from niche programs evolving to address place based need, through to state-wide and national partnerships negotiated to best meet local requirements. The realities of the post compulsory education sector mean that there is always some competition to attract pathways students to courses. However, there is a remarkable degree of communication and support between these four Universities, who provide complementary STEM outreach offerings.

The DEMO framework (Gale *et al*, 2010), which captured common features while allowing information that reflected the unique nature of each program to be gathered, was applied to each of the five case study sites. Summary data for two very different sites are shown in Table 3.1, overleaf. Case A involved a series of outreach programs delivered by one university (four programs are presented) while Case B involved a single niche outreach program.

Viewing each outreach partnership through the DEMO lens, combined with the national survey data and the deeper case study investigations, highlighted the complexities inherent within programs that are often multidisciplinary, involve several partners and cross education sectors. Although the programs investigated had significant differences in content and purpose, a number of design or concept elements were identified that, taken together, might constitute a successful practice framework. However, the term 'successful practice' needs to be used with some care, as it is not suggested that each school-university outreach program should include all elements.

Table 3.1 Summary analysis of two case study sites using a modified DEMO framework (Gale *et al*, 2010)

Criteria (adapted from Gale *et al*, 2010)	Case A Multiple Outreach programs				Case B
	A1	A2	A3	A4	
People-rich	VS	M-S	S-VS	M	M
Financial support & resources	W	W	S	W	S
Early or sustained (Sus)	Sus	Sus	Sus	Sus	Early
Recognition of difference	VS	S	M	M	S
Enhanced academic curriculum *includes PL opportunities*	S	M-W	S-VS	S-VS	VS
Research driven	M	M	S	S-VS	S-M
Collaboration/ Partnership	S-VS	M	M	M-S	S
Cohort-based	S-VS	M-S	S	M-S	M
Communication + information	VS	S	S-VS	M-S	M
Familiarisation + site experiences	S	NF	S	NF	M-S
Unsettling deficit views	S	S	S-VS	NF	S
Researching local knowledge, negotiating local interventions	S	NF	VS	S	S
Building capacity in schools, communities, universities	S	S	VS	VS	S

Codes: VS Very strong S strong Sus Early or sustained M medium W weak NF not a focus

The five sites provided insight into environments that support and sustain school-university outreach partnerships. Processes that can be used to assess what is currently happening, to recognise what needs to happen and to determine how to make this happen, were also identified. Consistent with national survey data indicating that outreach partnerships were not explicitly focused on building university enrolments, case study responses indicated a primary focus on improving equity of opportunity for rural and regional young people; most programs were designed to meet identified local needs and to address specific resourcing issues. Case study interviews provided additional evidence about the characteristics of successful outreach partnerships and programs.

Successful *programs:*

- offered active, contextually relevant, hands-on learning;
- were conducive to the development of deep knowledge about STEM and STEM pathways;
- empowered students (and educators) towards critical reflection on aspirations and pathways;
- provided opportunities for two-way communication between STEM experts, learners and education communities; and

- built relationships between educators and learners, education sectors and communities.

Consistent with this, successful *partnerships* were:

- sustainable: encouraging deeper, more permanent practice;
- designed collectively: providing joint impact to change culture, rather than a series of atomistic programs;
- transformative: building confidence and competence in partnership management and relationships; and
- capacity building: systematically gathering evidence in order to influence funding, resourcing and organisation.

When discussing the ways in which school-university partnerships operated, the effectiveness of having a champion or manager removed from the day-to-day activities of the program became apparent. The support of key personnel within the university was also considered significant. Equally important was having access to strategies, tools and expert knowledge for measurement and evaluation that are seen as crucial for capacity building and targeted, embedded impact.

Dominant themes that emerged during the analysis of case study interviews included: Place; Communication; Impact; Resourcing; and Access. Place, the geographic location and community context within which each program is situated, strongly influences and sometimes controls outreach partnerships.

> *"When we go to some communities it is whole school immersion, as well as an OHS issue, as there are no shoes! When we head to the inner city suburb on the east coast it (the program) is an astounding disruption there. Continued demand from these really different locations indicates how the program has been expanded. While age appropriate adjustments need to be made in delivery and content it is all about PLACE – each one is a very different experience for us as well as the young people and communities"* (Case Study, participant 11)

The themes of Communication, Impact, Resourcing and Access, interact with one another and are strongly dependent on the Place where the partnerships reside and are delivered.

A distinction needs to be made between the term 'resources' in outreach partnerships and 'resourcing' as identified by participants in the outreach survey. While resources are tangible, such as time, funding or materials, resourcing relies on a range of interactions between institutions, systems, individuals and groups. The importance of making a clear distinction between how terms are understood and used, in theory and in practice, has been recognised as very important throughout this research. Language can be a barrier to the effectiveness, impact and sustainability of a partnership activity. Existing literature and research into outreach partnerships, when examined alongside responses from survey and case study participants, highlight the importance of clarity and shared understanding of terminology and concepts. A similar understanding by developers, planners, presenters and those whose role it is to fund and evaluate outreach partnerships is equally important.

Examining research literature, patterns detected in the descriptive data from the case studies and the responses of national STEM survey participants has enabled factors that impact on the development and delivery of quality partnerships to be identified.

School-university outreach partnerships can be considered as having four phases, depicted in Figure 3.1: the **assembly phase**, where time is required to identify needs and to plan a contextually relevant response, to seek partners and then to negotiate roles within the partnership; the **engagement phase** during which actions are prioritised, resourcing issues are addressed and new content structures are formed and developed; the **building** of social, environmental and economic value through relationships and implementation of activities, and **reflection**, where the impact of the programs is measured and the adjustments necessary for sustainable practice determined. The degree of collaboration required to operate and assess the impact of each stage highlights the complexity of factors that need to be included if the impact of outreach partnerships is to be accurately and rigorously measured.

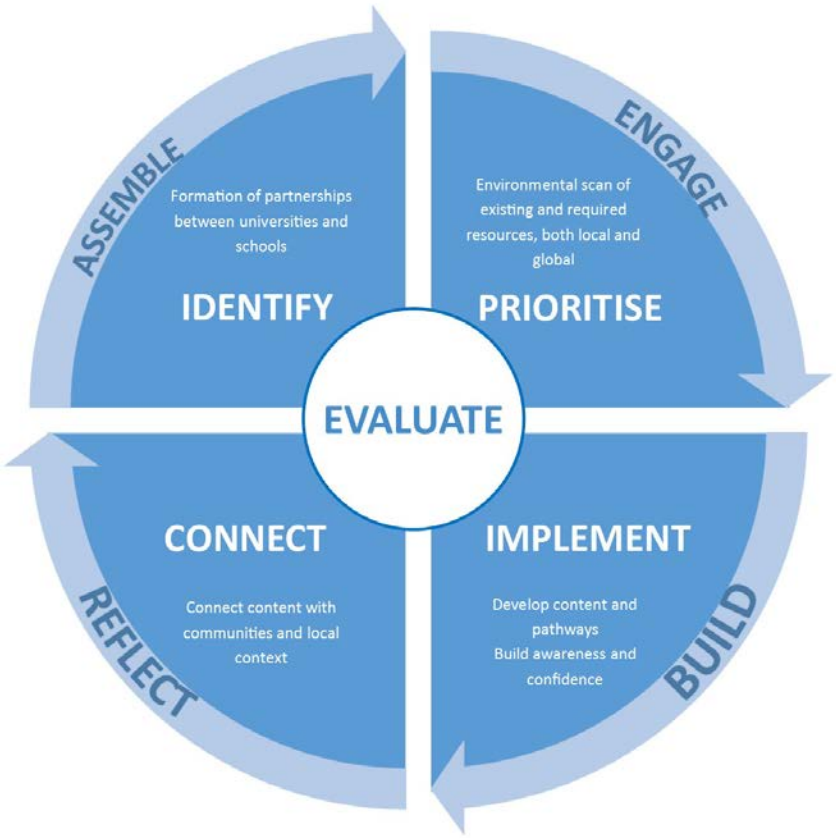

Figure 3.1: Model for the development of school-university outreach partnerships

Information from over 200 survey responses, 27 case study participants and a review of research literature all indicate that the security of resourcing is uppermost to STEM outreach partnership practitioners. There is an underlying conflict, where the longer-term range of potential impacts of education interventions cannot be measured within the 3-4 year political cycle that drives policy and funding.

"… the fact that results (of Outreach) are expected in the short term is a barrier to success. A longer term is needed to see if these outreach programs translate to increased interest in Science through university enrolments and career paths." (respondent 96, survey).

3.1.1 What doesn't work

The themes extracted from related research literature, the national survey of STEM outreach partnerships and case studies were consistent in identifying what contributed to the successful establishment and maintenance of outreach partnerships; equally strong responses indicate the actions or behaviours that negatively affect the establishment and sustainability of outreach partnerships.

Data from the national survey and case studies indicate that participants perceive that the following strategies are not useful in the engagement of partners, and do not contribute to improved academic achievement or school completion rates in STEM:

- Misinformed approaches, including those that assume regional, rural and remote students are either the same as metropolitan students, or identical to each other, and interventions that are imposed without collaboration with schools and/ or local communities;
- Inadequate funding, leading to short-term, piecemeal interventions that are not implemented for long enough to make a significant impact;
- Attempts to find solutions to problems including low aspirations and enrolments, without addressing the causes or underlying equity issues; and
- Methodological shortcomings, such as failure to design an evaluation strategy that allows progress towards attainment of program goals to be measured.

3.2 The Future: towards a working model for evaluation of outreach partnerships

The complexities involved in satisfactorily and rigorously tackling the evaluation of initiatives in STEM outreach partnerships contributes to a culture of evaluation avoidance. In Australia, STEM outreach programs are offered across states and territories, across education sectors, over short and long periods of time and in diverse localities. The unique nature of each outreach program environment contributes further to the difficulty in developing systematic evaluation and gathering evidence that takes into account the geographic and cultural diversity in urban, rural, remote and regional Australia. While policy developments in Australia have genuinely encouraged the development of a partnership approach to education delivery, a 'one size fits all' model will not provide the systematic and evidence-based approach to reforms required to improve educational outcomes.

Relationships underpin outreach partnerships, beginning at the initial concept stage, and communication is a vital common thread that impacts on the day to day running of outreach partnerships, as well as their longer-term sustainability. Evaluation, therefore, must be viewed as a process that is designed from the beginning to examine holistically the inputs, outputs, outcomes and impact of a partnership, using varied measurement processes, rather than a *post-hoc* process of simplistically analysing individual components or identifying what happened in an activity. Using items that gather numerical data as well as those designed to prompt open-ended responses will address the holistic nature of STEM outreach partnerships.

Any model for evaluation of STEM outreach partnerships needs to be grounded in systematic, ongoing data gathering and must include measurement of:

- changes in student STEM ability, engagement, participation and aspiration;
- changes in STEM teaching capacity;
- growth in STEM opportunities within and across education sectors; and
- efficient identification and utilisation of STEM expertise in the community.

Structured evaluation is important for two reasons. Firstly, it allows those involved in partnerships to determine what has worked well and what might need changing or remediation. Secondly, evaluation data provides evidence regarding the effectiveness of STEM partnerships; evidence that can be conveyed to funding sources (government/ university/ industry/philanthropic organisations) in support of applications to resource future projects.

An OECD report (2015) discusses the complexities associated with structural change in education systems. While successful education reform is typically characterised by improved student outcomes, how these outcomes are measured and the amount of time it takes for a whole cohort to go through a reformed school system must be figured into evaluations. But rigorous evaluation of education reforms requires a control or comparison group, which has ethical implications and confounds program implementation (OECD, 2015).

> *"Outcomes such as increased engagement in science and maths are long-term and not easily measurable" creating "a potential dissonance between the University objectives of driving enrolment in science and maths and the broader objective of stimulating general engagement with science and maths'' (respondent 107, survey)*

There are implications for the current situation of education evaluation in Australia where the political cycle often requires shorter time frames than do effective educational interventions. As discussed previously, effective outreach partnerships that require a planning and negotiation phase, a set-up period during which new structures are developed and trialled, and then subsequent reflection and adjustment, take considerably more time to evaluate than an election cycle provides.

The data gathered through this project have identified a lack of appropriate evaluation mechanisms in the implementation and subsequent sustainability of school-university STEM outreach partnerships. Results of this national survey, which was completed by 38 of the 39 Australian Universities offering STEM outreach programs, indicate only 30% of partnerships had been evaluated in some way, with only a few of these being a strong or meaningful evaluation. Further, university personnel interviewed supported these survey findings and indicated that outreach program partners required guidance and support to develop and implement a strategy for evaluation. Moreover, this evaluation must be planned and resourced at the beginning of the outreach program, rather than being tacked on at the end of the program as an afterthought if resources are available.

3.3.1 The evaluation instrument

Given the diversity of programs operating nationally (Office of the Chief Scientist, 2016), identifying the type of outreach partnership is a really important initial step in the evaluation process. A model such as that suggested by Barrett and Bull (2015), included below, provides appropriate distinction between types of outreach partnerships and aligns closely with the perceptions of participants in this study.

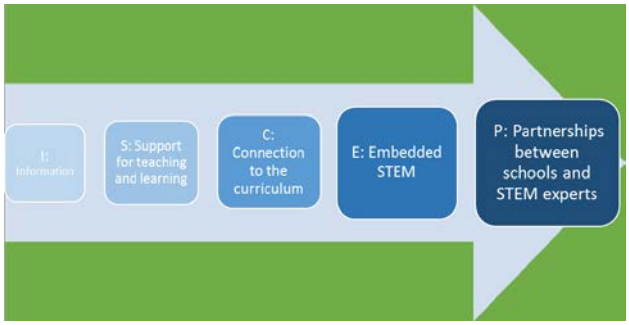

Figure 3.2 Continuum model for STEM school outreach and engagement (Barrett and Bull, 2015, p.11)

The evaluation instrument should include items designed as rating scales and items designed to prompt open-ended responses and must also be flexible enough to contain sample items that can be adapted to particular situations, so that participants can identify issues relevant to their own requirements and contexts. Analysis of site-specific data could be conveyed to funding bodies to highlight examples of effective solutions and/ or barriers to implementation and can also be included in funding applications to support system-wide comparative data.

Critical mass in urban areas may make outreach programs appear more cost effective if evaluation is focused only on measuring numbers of participants and occurrence. However, the deficiency in numbers of STEM students is particularly noticeable in rural, regional and remote Australia and must be addressed. Measuring the inputs, outputs, outcomes and impact of outreach programs and partnerships in a systematic way will provide a better understanding of the costs and benefits of outreach initiatives in non-metropolitan settings.

> *"… being able to access solid funding with provision for evaluation is a necessity for survival. To then be able to tap into [evaluation] expertise to guide our team and influence the future of the partnership would be great"* (Case Study respondent, 7)

Data should be gathered around issues including:

- Communication: clarity, interactions and engagement;
- Impact: individual, community and environmental;
- Resourcing: time, people, content knowledge and existing corporate knowledge;
- Access: relationships, culture, equity and context; and
- Measurements that include program frequency, numbers of participants and other interactions.

Future evaluations should also analyse aspects of school-university outreach partnerships (summarised in section 3.1) identified as crucial for monitoring improvement or change and contributing to program sustainability. Data from the partnership evaluation can then be connected to other existing data, thus building a stronger evidence-based proposal for funding. Though partnerships have unique characteristics, an overall picture of STEM school-university partnerships makes good sense. Government and funding bodies require evidence that is comprehensive and comparative across sites and settings, and key stakeholders need to understand what works and what may need adjustment.

Investment in measuring the performance of existing education initiatives and inputs rigorously and effectively allows tracking of outputs and effective measurement of outcomes – for students, educators and partnership members. Acknowledgement that the cost of provision of programs in rural and remote areas is higher per capita can be balanced by the identification and use of local resources. Measuring impact and systematically gathering data will provide equity for students and schools, and will also indicate where success happens and will address potential waste. Having an evaluation model based in evidence, suitable for use across sectors and partners, is a good investment.

Chapter 4: Project evaluation, dissemination and impact

This project involved both formative and summative evaluation. The evaluator, Léonie Rennie, has a longstanding interest in community science awareness and science literacy, so was able to act as a 'critical friend' thereby contributing to the project as it evolved. The evaluator's report is included in Appendix D.

The science outreach community is diverse, comprising academics from a range of faculties (Science, Engineering, IT, Mathematics, Health and Education), professional staff, industry and community representatives, so was difficult to target. Presentations at relevant practitioners' conferences (Australian Conference on Science and Maths Education, Engagement Australia, Country Education Partnership, STEM Education Conference, SPERA conference) enabled interactive discussions with a wide range of relevant personnel to occur, as will current and planned journal publications.

An email list for contact of all identified Australian STEM outreach programs was created in the early stages of the project and is currently maintained. Telephone and email interaction with outreach program coordinators was informative and responsive and an informal network of program coordinators from across Australia emerged. This has facilitated sharing of experiences that have strengthened the project's foundations.

Data from the on-line survey has been analysed and a full report sent to outreach and equity practitioners at all participating universities and available on the project web-site. Representatives of the project have met with the Assistant Science Minister, Mrs Karen Andrews and been in contact with the Office of the Chief Scientist, both of whom have requested a copy of our report: "*University STEM outreach programs across Australia: from niche to national*". Given the emphasis on facilitating effective partnerships between schools, universities, business and industry and the acknowledged need to establish a strong evidence base so that initiatives that improve STEM outcomes can be identified (Kudenko, Simarro & Roser, 2015; OECD, 2015), this report is both timely and valuable.

During the process of data gathering for this project, individuals and groups working in STEM outreach indicated that evaluating and measuring impact of these partnerships was problematic. A recent OECD Education Policy Outlook, *Making Reforms Happen*, states that only a tenth of education reforms carried out around the world since 2008 have been analysed by governments for the impact they have on children's education (OECD, 2015). While this particular OLT research is specifically related to school-university STEM outreach partnerships in rural, regional and remote Australia, there is evidence to indicate that the findings are relevant to education sector outreach partnerships across diverse disciplines and geographies. The development of an accessible framework for STEM outreach program evaluation will be an essential step towards developing a culture of evaluation that will, in turn, contribute to building a strong evidence base to inform the design and implementation of effective STEM outreach partnerships.

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Appendix A: Certification by Deputy Vice-Chancellor (or equivalent)

I certify that all parts of the final report for this OLT grant provide an accurate representation of the implementation, impact and findings of the project, and that the report is of publishable quality.

Name: ……Date: ……

Appendix B: STEM outreach programs contributing to this study

Australian Catholic University	MyScience
	Maths Outreach
Australian National University	Maths Outreach
	Australian National Centre for the Public Awareness of Science
Central Queensland University	Visualising the Human Body
Charles Darwin University	STELR (Science and Technology Education Leveraging Relevance)
Charles Sturt University	HSC Chemistry Day
Curtin University	Mildew Mania
	Focus on Mining Camp
	Fireballs in the Sky
	Electrical Engineering Autumn Camp
Deakin University	Science and Engineering Challenge
Edith Cowan University	Old Ways New Ways
Federation University	GAP (Gippsland Access and Participation) project
Flinders University	Smart Science Initiative
Griffith University	Science on the Go
James Cook University	The Science Place
Latrobe University	FARlab (Freely Accessible Remote Laboratories)
	SC 301 Ecology Unit
	Murray Darling Easter Science School
	Get into Genes - rural & regional Outreach
Macquarie University	NISEP (National Indigenous Science Education Program)
Monash University	LEAP (Learn Experience Access Professions)
	SEAMS (Strengthening Engagement and Achievement in Mathematics and Science)
Murdoch University	MAP4U (Murdoch Aspirations and Pathways For University)
Queensland University of Technology	Robotics@QUT
	Extreme Science
	YuMi Deadly Maths
	PRIME Futures (mathematics)
RMIT University	Science Outreach
	CNBP (Centre of Excellence for Nanoscale BioPhotonics)
Southern Cross University	RUN Digital Classroom Project
	Community Outreach and Education
	Uni-Bound
	STELLAR (Get Into Uni)
Swinburne University of Technology	SIS Physics
University of Adelaide	CS4HS (computer science)
University of Canberra	INSPIRE

	Towards Place-Conscious Education in the Murray Darling Basin
University of Melbourne	Telescopes in Schools
	Lab in a box -VCE kits for hire
	University of Melbourne Physics Outreach Programmes
	Choose Maths
	Times online modules - Building teacher content knowledge
	SAM (Supporting Australian Mathematics) Middle Years
	SAM (Supporting Australian Mathematics) Senior Years
	ICE-EM Mathematics program textbooks
University of New England	S& E Challenge, Discover Da
	SiMERR (National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia)
	School of Ants - Citizen Science
University of New South Wales	Physics Outreach
	Astronomy Outreach
	Chemistry Outreach
University of Newcastle	Aim High Program
	Year 4 - Careers Through Science
	Year 9 - Girls' Choices Summer School and LIVE IT!
	Year 6 - Digital Day Out (on campus) or Hour of Code (in school)
	Experiment Fest
	CS4HS (computer science)
	Inspiring Mathematics and Science In Teacher Education
	National Schools Poster Competition
	Newcastle Maths Educators Community
	CARMA (Computer Assisted Research Mathematics and its Applications)
	Newcastle Young Mathematicians Project
University of Queensland	Wonder of Science
	SPARQ-ed (Students Performing Advanced Research Queensland)
	Women in Engineering
University of South Australia	UniSA Connect Programs
	Maths & Science Digital Classroom
	Australian Technology Network
University of Southern Queensland	RUN (Regional Universities Network) Maths and Science Digital Classroom
University of Sydney	NISEP (National Indigenous Science Education Program)
	CAASTRO in the Classroom (Australian Research Council Centre of Excellence for All-sky Astrophysics)
	Science 50:50
University of Tasmania	Young Tassie Scientist
	Science week (month)
	The Science Experience
	Science & Engineering Challenge
	RoboCup Junior
	UTAS Science Investigation Awards
	STAR CoP (STudent Aspiration Raising Community of Practice)
University of Technology Sydney	Sparks Ignite

	Collabor8 (Women in Engineering and IT)
University of the Sunshine Coast	Biodiversity Field Guide App Project
	Panboola Blitz
	International Centre for Radio Astronomy
University of Western Australia	Aspire UWA
	SPICE Physics ICRAR Internet Telescope Project (SPIRIT)
	Travelling Scientist
	International Centre for Radio Astronomy
University of Western Sydney	Program not named
University of Wollongong	Science Centre
	Planetarium
Victoria University	FARlab (Freely Accessible Remote Laboratories)
	Partnerships
Other	National Youth Science Forum
	iSME (Inspiring Science and Mathematics Education)
	Australian Science Olympiads
	Robogals (Victorian Regional)
	Primary Connections
	Scientists, Mathematicians & ICT in Schools
	RACV Engineering Challenge
	Australian Mathematics Trust

Appendix C: Publications & communication

Invitations and presentations

Bottrell, C. 2015, Meeting with the Assistant Science Minister, Mrs Karen Andrews, OLT Project discussion, November 9th, Canberra: Australia.

Bottrell, C. 2015, *Partnerships, Policy & Complexities.* Mapping Education Policy Landscapes: rurality & rural futures, Society for the Provision of Rural Education, Annual Conference, November 4-6, Geelong: Australia.

Bottrell, C. 2015, *Dynamic Aspirations,* Country Education Partnership (CEP) Annual Conference, Rural Learning- Raising the Potential, May 28-29, Melbourne: Australia.

Mosse, J. 2014, Gippsland Secondary Principals' Group, Discussion with attending Principals around the changing professional development needs for science teachers and how universities can respond to those needs. September 5, Traralgon: Australia.

Bottrell, C. & Hall, R. 2014, *Engagement a promise: nurturing innovation in STEM partnerships,* Roundtable, Engagement Australia Annual Conference, Charles Sturt University, July 21-23. Wagga Wagga: NSW, Australia.

Bottrell, C. 2014 *Aspirations of Rural Young People*, Country Education Partnership (CEP) Annual Conference. September 4-5, Melbourne: Australia.

Mosse, J. 2014 *STEM education in regional, rural and remote areas,* Inaugural STEM Education Conference: Advancing innovation and research in STEM education and practice. August 20-21, Melbourne: Australia.

Mosse, J. & B. Panther 2013 *Evaluating the effectiveness of STEM related school-university partnerships.* ACSME: Australian Conference on Science and Mathematics Education. September 19-21, Canberra: Australia.

Publications

Mosse, J. & Bottrell, C. 2015 The importance of place in engagement for partnerships in STEM between Universities and Schools in rural, remote and regional Australia. *The Australasian Journal of University-Community Engagement*, vol.10, no.2.

Appendix D: Project evaluator's report

Evaluation of *A Framework for Building Teacher Capacity and Student achievement in STEM within School-University Partnerships*

Léonie J Rennie

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Aims of the Project

A Framework for Building Teacher Capacity and Student achievement in STEM within School-University Partnerships (the Project) was funded by the Australian Government Office for Learning and Teaching (OLT) (Project ID: ID13-3103) from June 2013 to February 2016. The lead institution is Federation University Australia, partnership institutions are Queensland University of Technology and Deakin University. The project leader is Associate Professor Jennifer Mosse and the team members are Associate Professor Terry Lyons, Dr Andrew Skourdoumbis and Dr Christine Bottrell.

The Project's overall intended outcome is an evidence-based framework to inform the future design and evaluation of effective school-university partnership programs, that specifically build the *capacities* of regional secondary school teachers to teach mathematics and science; and the *achievements* and *aspirations* of regional secondary school students to enrol in senior secondary school mathematics and science subjects and, subsequently, in STEM-related university courses. This overall outcome will be achieved by four specific outcomes:

- a **meta-analysis** of the research literature describing regional school-university partnership programs in STEM in a regional context, both in Australia and overseas,
- a **summary** of existing Australian STEM school-university partnership programs,
- **case studies** of successful STEM school-university programs in regional Australia, and
- a **framework** for the design and evaluation of school-university programs specifically focused on building teacher capacity and student achievement/aspirations in relation to STEM.

Approach Taken in the Evaluation

OLT projects are required to have an independent external evaluation and the Project Proposal documented that the Evaluator would take both formative and summative roles, providing feedback to the team at each project stage via conversations with the Project Team and Reference Group, and providing a summative report on the conduct of the project towards its end. The OLT has an Evaluation Resource to provide guidance[3] and this evaluation was planned according to relevant sections of this Resource in the context of the Project Proposal.

The Evaluator worked with the Project Team and Reference Group to develop and implement the evaluation plan shown in Table 1. While this report is summative, the evaluation was ongoing via communication between the Project Team and the Evaluator to provide formative comment and other contributions during each stage of the project. The main summative question to be answered in the evaluation is "To what extent were the intended project outcomes achieved?"

[3] ALTC Project Evaluation Resource retrieved from http://www.olt.gov.au/system/files/Project_Evaluation_Resource.pdf

Table 1. Evaluation Sub-questions and Data Sources

Evaluation Sub-questions	Data Sources			
	Communication with Project Team	Communication with Reference Group	Documentation and documents produced	Communication with case study participants
How effective and efficient were the proposed project processes that led to the outcomes?	✓	✓	✓	✓
Were any arising ethical issues appropriately addressed?	✓		✓	✓
What were the facilitating and hindering factors and how were the latter overcome?	✓		✓	
How effective were the strategies used for dissemination of the outcomes?	✓	✓	✓	✓
What lessons learned could assist others in similar projects?	✓		✓	✓
Overall, how successful was the project in achieving its outcomes?	✓	✓	✓	

Data Collection from the Project Team

Data were collected in the following ways. The Evaluator attended two of the four Reference Group meetings (held on 21-08-14 and 19-06-15) either in person or via telephone. Unfortunately, attendance at the first meeting on 19-02-14 was cut off due to telecommunication failure. She was overseas at the third meeting held on 20-11-2014 but had a follow-up phone call with the Project Leader (on 24-11-14) to replace this meeting. One formal team meeting was attended on 27-06-14. Other meetings, teleconferences and email exchanges were had with Project Team members on a semi-regular basis, to determine progress on the stages of the Project and to offer feedback on drafts of the survey, interview questions for case study visits, draft case study reports and the draft report describing outcomes of the Project.

Towards the end of the project, each team member was contacted by email and asked to respond to a series of questions relating to the project operation and their participation, as below:

1. How well did the Project team function?
2. How helpful was the input from the Project Reference Group?
3. What factors facilitated Project processes? Why?
4. What factors hindered Project processes, and how were these overcome?
5. How effective were strategies for disseminating information about the project?
6. What lessons were learned that could assist others in similar projects?
7. Do you believe you have gained in a personal way from participating in this Project? If so, in what way?

In addition project team members were asked to estimate, or a 0 to 3 scale, the extent to which they thought each of the four specific outcomes was achieved, and to provide a reason for their ratings.

Written responses were received from all four team members.

Data Collection from Reference Group

The Reference Group originally comprised five persons with diverse but relevant backgrounds in teacher education and professional development, and who were specialists in science communication and science enrichment programs (Longnecker), the provision of equity programs in the tertiary sector (Tranter), rural and regional STEM education (Tytler), school-community partnerships and teacher training for regional service (White), and a past president of the Australian Science Teachers' Association with outreach experience (Zander). Unfortunately, Zander became ill and could not continue. In addition, a sixth person (Hall) with expertise in school science enrichment projects joined the Reference Group to cover a gap left by John, one of the original Team Members.

Due to a technology failure, attendance at the first reference group meetings was limited to those who could attend in person. Three further meetings were scheduled. Difficulties were experienced in finding a time when all members were available (particularly those in a different time zone) so no member was able to attend all of the meetings; however, all members received documentation for the meetings and their minutes, and a copy of the draft project report inviting their comment.

Towards the end of the Project, an email was sent to each member asking the following questions:

1. What is your view of the effectiveness and efficiency of the project processes that led to the outcome of the evidence-based framework for effective school-university partnership programs?
2. What lessons do you think may be learned that could assist others in similar OTL projects?
3. From what you were able to learn from the various documentation, any meetings attended, and the draft report, how well do you think the project has achieved its intended outcomes?

4. What aspects of this project influenced your decision to join the reference group?
5. In what way(s) do you think you were able to contribute to, or offer advice about, this project?
6. Were you able to contribute to the project as you had hoped? If not, what were the major barriers to your participation?

Responses were received from four of the five Reference Group members, three in writing and one by telephone. The fifth member reported she was working outside the sector and was unable to respond at the time.

Examination of Documentation and Documents

The documentation examined as part of the formative and summative evaluation included

- the original OLT Project proposal,
- the proposal requesting ethics approval (which was granted),
- minutes of all formal meetings,
- the Evaluator's email exchanges with Project Team members,
- drafts and final copies of the survey and interview questions,
- the Evaluator's notes for all meetings and teleconferences with team members,
- progress reports of the analysis of the survey and case studies,
- final Survey analysis,
- draft case study reports, and
- the draft of the final Project Report.

Communication with Case Study Participants

The five case studies varied considerably, with between one and 20 key informants. An email was sent to one or two of the informants from the four case studies who gave permission to my asking several questions in the context of data collection from their program(s).

1. How effective and efficient did you think the survey and the interview were in terms of gathering information about your program?
2. Do you think the case study report (sent to you in December last year) provided a fair description of your program? Please explain.
3. Were there any ethical issues that arose during the process? Is so, were they appropriately addressed?
4. The aim of this OLT project was to develop a model including strategies and proposed guidelines for sustainable Outreach partnerships. As a result of it, your case study, with the other four case studies, will be placed online together with the model and strategies developed.
   How effective are the planned strategies for using the data to assist others with similar projects?

Responses were received from five case study informants representing all four of the case studies that invited contact.

Answers to the Evaluation Questions

The six evaluation questions were answered by collating information obtained from the several data sources described above. All can be answered in a positive way and there are some potential learnings that can inform other research of this kind.

1. How effective and efficient were the proposed project processes that led to the outcomes?

The proposed project processes were sequential: The project began with a synthesis of relevant literature to provide a comprehensive background to the development of the national survey, ensuring that it covered the diversity of school-university partnerships, their implementation, and evaluation, if any. This successfully informed the survey.

The national survey achieved an impressive coverage, with responses from over 200 people in 38 Australian universities. The outcomes provided a thorough overview, and profiles of the nature of the outreach programs, their staffing, funding, priorities, aims and achievement thereof. The finding that few partnerships have any systematic evaluation is consistent with other research findings, even though the majority of respondents thought this was important. One case study respondent described the survey as “very well written” but “restrictive when capturing the scope of complex projects”. This feature was well-recognised by the project team, and endorses the decision to conduct follow-up case studies.

The five case studies selected on the basis of survey responses provided a view of programs diverse in aims, target audiences, structure, and geographic location. The carefully crafted interview questions, developed from the preceding processes and the expertise of team members, together with the professionalism and approachability of the team member conducting the interviews (“a great balance of active listening and insightful, prompting questions” as one case study respondent wrote), enabled a large amount of data to be collected for each case study. Details of these, when made available online in due course, should be a valuable contribution to the field.

The culmination of the project was the development of the framework for the design and evaluation of school-university programs that specifically focused on building teacher capacity and student achievement/aspirations in relation to STEM. To begin, the case studies data were mapped onto the DEMO matrix generated earlier by Gale and his colleagues (2010). Subsequent analyses identified characteristics of successful programs and partnerships and these results fed into the development of the final framework described in the report.

Overall, the project proceeded steadily, met appropriate timelines, and was concluded successfully. Apart from meeting the stated objectives, the project outcomes also indicated questions and directions for further exploration in the field.

2. Were any arising ethical issues appropriately addressed?

The application for ethics approval was submitted to Deakin University and approved (HAE-14-006) prior to the beginning of data collection. This application described the research

design as proposed and guaranteed anonymity in use of data and reporting of results. Another ethics application was approved by the Victorian Education Department (#2014-002). No ethical issues arose during the Project, and none were reported by Case Study informants.

3. What were the facilitating and hindering factors and how were the latter overcome?

The main facilitating factor was the consistency and enthusiasm of the Project Team members who ensured that progress continued and remained on track. Mosse, the project leader, had continual oversight, and worked hard to ensure effective communication among team members and the project continued as planned. Lyons, building on his considerable previous experience, undertook responsibility for leading the development, implementation and analysis of the online survey. Skourdoumbis dealt with the ethics applications and remained active and responsive throughout the project. All members were adaptable to situations as they arose, and their flexibility kept the project moving along in parallel with the ebb and flow of their other university work commitments. Bottrell, the research associate who prepared the literature review, worked hard to achieve a high response rate to the survey, personally collected the case study data and greatly assisted its analysis and writing of the case studies. In other words, team members knew their roles, communicated as needed, and got on with the job, effectively balancing their other commitments.

Several factors affected the progress of the Project.

Inauguration of Federation University, Australia. The Project Leader (Mosse) was employed by Monash University on the Gippsland Campus which was transferred to Federation University at the start of the project. Although Mosse was able to continue, there was a period of disrupted technological services due to change from Monash University to Federation University systems.

Movement of personnel. One member of the Project Team (Lyons) transferred from UNE to QUT at the beginning of the project. Despite delays caused by "settling in" Lyons continued as a key team member. In addition, Skourdoumbis, moved from RMIT to Deakin University early in the project, but remained a contributing team member. A third member of the original Project Team (John) was unable to participate due to a change in role, but he nominated a "deputy" (Hall) who became a valuable member of the Reference Group. Movement by two members of the Reference Group limited their participation (White moved from Federation University to Monash University, and Longnecker moved from the University of Western Australia to the University of Otago).

4. How effective were the strategies used for dissemination of the outcomes?

Throughout the project, every opportunity was taken to network with appropriate audiences, including the Assistant Minister for Science, and to present papers and workshops at relevant conferences and gatherings. Given the nature of the project, it was appropriate that there was a focus on rural locations. A current list of such presentations and meetings is given in Appendix C.

Another significant avenue for promulgating the research aspects of the project to an academic audience is the publication of papers. One has already been accepted for publication, and more are planned subsequent to the completion of the project report.

In addition to peer networking among peers and the university outreach community mentioned above, the project results need to be made available nationally and internationally. The plans for a website (nearing completion) upon which key outcomes are available, including full descriptions of the case studies and survey results will go a long way towards fulfilling this need.

At the time of writing, it is too early to comment on the effectiveness of dissemination, but the efforts to date, and the planned papers and website, should ensure wide access to the outcomes.

5. What lessons learned could assist others in similar projects?

Building on Team Members Strengths in Ways that Develop Each Other's Skills

One of the reasons for the success of this project is that each team member, including the leader, was assigned project tasks that were consistent with their particular strengths. This underlines the importance of carefully choosing team members and effectively allocating tasks. Regular, whole team meetings for sharing progress, maintains commitment to the project and also enables less experienced team members to grow and develop their own skills and expertise. This project demonstrated how the whole can be greater than the sum of its parts.

Use of Online Surveys for Data Collection

Online surveys are cheap to administer to a very wide target group, but they are successful only if they are well developed and widely "advertised", as in this project. Here, a good deal of care was taken to develop an instrument that was as broad as possible to cover the required information, but also as short as possible, to encourage completion. The drop down menus facilitated data analysis because they reduced coding, and the open-ended questions enabled participants to expand on answers. The joint analyses of responses to the open-ended questions by team members enabled the whole team to come to grips with the content. The time-consuming work by Bottrell in finding contact points in each university and her persistence in following up ensured an excellent response.

Nomination and Use of Reference Group Members

Issues relating to the movement of personnel and changes of role, particularly in the Reference Group, are quite common in most projects of this kind. Reference Group members must accept their nomination before the proposal is submitted, not knowing whether or not it will receive approval and they will be involved. There is an inevitable time lag before success is known, a contract signed and the project team can meet and organise its timetable, including reference group meetings. By this time the circumstances of some members have changed and their participation, or the extent of their participation, is compromised. It would be more efficient if funding bodies enabled Reference Groups to be chosen at the time project approvals are announced, then members could be invited to

participate with a clear indication of what their commitment would entail. For example, they are more likely to know when they are available for meetings and if they are able to commit to the task. Further, with clear knowledge of the project's purpose and direction, members are less likely to suggest off-focus directions related to their own interests. Once in operation, it is important to exploit the expertise of Reference Group members, and this is easier to do if firm plans for their involvement can be made closer to the time that their input is needed. In this project, all members of the Reference Group who provided evaluation data were initially keen to be involved in the project, however, their personal circumstances meant that most were unable to attend meetings, despite the best efforts of the Project Manager to find convenient times. Near the end of the project, only one member was able to find time to provide feedback on the draft report which was circulated to all members. Perhaps the lesson to be learned is that if funding bodies facilitated the nomination of Reference Groups when the project is approved (rather than proposed), Project Teams could negotiate the membership to maximise the benefit to the project through both scheduled meetings and whatever other contact is convenient for both Project Team and Reference Group members.

6. Overall, how successful was the project in achieving its outcomes?

There were four intended outcomes of the Project and all were achieved as described below. In response to the evaluation questions, three of the project team members rated the level of achievement of all outcomes as 3, on a scale from 0 to 3. The fourth team member rated the second and third of the outcomes listed below as 3, and the first and last of the outcomes as 2.5. These two require considerable synthesis and were the most challenging tasks, nevertheless, the evidence reviewed above suggests they were well-done.

6.1. A meta-analysis of the research literature describing regional school-university partnership programs in STEM.

The literature review was ongoing, but began early in the study to provide direction for subsequent stages in the Project and to achieve consistency in the use of terms used to define rurality, aspirations and so on. The review drew heavily on recent Australian reports but was informed by relevant international studies. (The review is better described as a synthesis rather than a meta-analysis which usually focuses on quantitative measures.) Access to this review via the website and publications will be of assistance to other researchers in the field.

6.2. A summary of existing Australian STEM school-university partnership programs.

This summary was built from the results of the survey. This achieved an exceptionally high response rate, obtaining at least one response from every university known to have any university-school partnerships except one. The project report provides a synthesis of the findings (some of which, such as the need for, but lack of, formal evaluation of projects) are not surprising, but others (such as the need for security of funding) are new, and should be publicised widely.

6.3. Case studies of successful STEM school-university programs in regional Australia.

A representative set of case studies was chosen from survey respondents to cover a diverse range of objectives, nature of partnerships, and geographic location. These provided ample data to build the framework described in 6.4.

Feedback from case study participants revealed their appreciation of face-to-face data collection by the researcher. This allowed a more detailed exploration of their program, particularly as this could be done as a group discussion and several viewpoints aired. They also appreciated the opportunity to provide input to the completed draft of their case study, which enabled the correction of small details. Hope was expressed that the publication of the case studies would assist university administration to recognise that although a lot can be done with even minimal resources there remains a need for appropriate resourcing. As a case study informant wrote: “One of the challenges of outreach is time availability, and funding, and hopefully people high up at Uni will realise that while anything is possible, they need to support the staff involved in those Programs. It is one thing to demand more outreach, but another to actually enable the staff to be involved in more outreach.”

6.4. A framework for the design and evaluation of school-university programs specifically focused on building teacher capacity and student achievement/aspirations in relation to STEM

The framework was informed by the review of previous effective partnerships, the results of the survey and the findings from the case studies. The resultant framework is presented as a model in Figure 3.1 of the project report. It makes clear what needs to be done to develop and maintain school-university outreach partnerships and that this takes time and effort. In addition, some overview guidelines to structure partnership evaluation, something for which a need was recognised but rarely fulfilled. The promulgation and use of the model deserves monitoring in the future.

Conclusion

Based on my participation throughout the project (as described earlier) and from reviewing the project outcomes, it is clear that those outcomes have been achieved in a manner that has contributed to the OLT mission to support change in higher education administration for the enhancement of learning and teaching. The project functioned in a way that both exploited and enhanced the team members’ capacities and demonstrated that the project was conducted to the highest academic standards.

References

Gale, T., Sellar, S., Parker, S., Hattam, R., Comber, B., Tranter, D. & Bills, D. (2010) *Interventions early in school as a means to improve higher education outcomes for disadvantaged (particularly low SES) students,* National Centre Student Equity in Higher Education, Underdale, S. Aust.