DEAKIN UNIVERSITY

Building Productive Partnerships for STEM Education

Evaluating the model & outcomes of the Scientists and Mathematicians in Schools program 2015

A report from the Deakin University team:

Professor Russell Tytler (Project Leader)
Professor David Symington
Dr. Gaye Williams
Dr. Peta White
Associate Professor Coral Campbell
Dr. Gail Chittleborough
Mr. Garrett Upstill
Dr. Elise Roper
Ms. Nicola Dziadkiewicz

STEME Research Group
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1. EXECUTIVE SUMMARY

The Scientists and Mathematicians in Schools (SMiS) program is a major Australian initiative funded by the Australian Government Department of Education and Training in conjunction with CSIRO, which delivers the program through a national SMiS program team. The program involves volunteer science, mathematics, engineering and technology (STEM) professionals working in partnership with teachers in primary and secondary schools to engage students in quality learning in the STEM disciplines. Since its inception as Scientists in Schools in 2007 it has expanded to formally include Mathematicians in Schools and more recently ICT in Schools. Up to June 2015 it has brokered in excess of 4600 individual teacher-STEM professional partnerships and the program represents a major innovation in the national STEM education scene.

Since 2007 the program has been evaluated three times, leading to affirmation of the success of the model in terms of outcomes for students, teachers and the STEM Professionals, and recommendations for expansion. The evaluations have informed the development and expansion also of the SMiS program team which arranges the matches of the STEM professionals and teachers, provides support and advice for partnerships through project officers in each state, and organises workshops, online support and a website.

SMiS can be viewed as one of a suite of models of partnerships between STEM professionals and schools, which have achieved increasing prominence as concern with lack of engagement of students in STEM subjects and futures increases.

A number of key strengths characterise SMiS as distinctive amongst these initiatives: first, the partnerships involve a collaborative arrangement between an individual STEM professional and a teacher; second, the partnerships are flexible enabling response to local contexts; third, the partnerships are ongoing; and fourth, the program has significant national reach.

This evaluation

This assessment distinguishes itself from previous evaluations in its intent to probe more deeply into partners' experiences in order to:

- identify the affordances and challenges of the model and provide advice concerning improving its operation and its effectiveness to enable it to continue to lead practice, and
- provide an economic assessment of the return on investment of government resources into SMiS.

The assessment methodology included:

- analysis of previous evaluations,
- utilisations of data sources and literature around STEM participation and partnerships,
- surveys of STEM professionals, and teachers, in existing, closed and withdrawn partnerships,

- interviews with selected members of the SMiS team, and
- interviews with STEM professionals, teachers and students to construct partnership case studies.

The questions driving the evaluation are:

1. What are the outcomes for students, teachers, and STEM professionals as a result of the Scientists and Mathematicians in Schools program?
2. How is the Scientists and Mathematicians in Schools Program changing students' and teachers' engagement with, and knowledge and understanding of STEM practices?
3. What are the similarities and differences among the partnerships developed by teachers and scientists, teachers and mathematicians, and teachers and ICT professionals?
4. What are the strengths of the Scientists and Mathematicians in Schools model? What significant attributes of the SMiS model are highlighted when considering an overview of a range of initiatives involving STEM professionals, including university and industry working with schools?
5. In what ways could the Scientists and Mathematicians in Schools model be implemented which would result in it being ahead of leading practice and which would enhance program outcomes and impact?

Outcomes for students, teachers and STEM professionals (Qs1 and 2)

Both teachers and STEM professionals identified substantial benefits from the partnerships for students, and themselves.

For students the data point to a range of very significant benefits in increasing engagement with science, mathematics and ICT learning and reasoning, increased interest and enjoyment and knowledge and confidence in STEM subjects, awareness of how scientists and mathematicians think and work, increased appreciation of STEM professionals as people, and knowledge of, and enhanced attitudes towards, STEM pathways and careers.

Judgments of student outcomes were mainly based on informal/ anecdotal evidence. However a solid minority of teachers claimed evidence that involved judgments of the quality of student work. The SMiS team could usefully explore ways that evaluation of knowledge outcomes, improvements in inquiry and problem solving capability and attitudinal changes might be supported to help teachers and STEM professionals conceptualise appropriate outcomes.

For teachers the outcomes were improved motivation and engagement in science and mathematics teaching, the enjoyment of working with STEM professionals, increased engagement of their students, improved teaching processes and, for primary teachers especially, increased confidence with teaching.

For partnerships in primary schools there was evidence of substantial benefit flowing to the school more widely as an outcome of the partnership, involving improved teaching, and increased profile for STEM.

For STEM professionals the outcomes included enjoyment of promoting their commitments and knowledge to a new generation of students, increased understanding of, and confidence in, promoting public understandings of STEM, and gaining an alternative perspective on their own work.

The nature of the partnerships - similarities and differences (Q3)

A key feature of the SMiS model is the flexible, negotiated nature of the partnership, and partnerships vary considerably across dimensions of focus, time commitment, structure, and relation to the curriculum.

Some partnerships involve quite focused activities over a short period of time, recurring annually, while others involve considerable ongoing time commitment of both STEM professionals and teachers with the mode of engagement adjusting and growing over a period of years as both partners learn how to frame benefits emerging from their respective expertise.

In many cases, particularly with primary schools, the activities extend to multiple teachers or even the whole school, an additional benefit of the open nature of the model.

Curriculum is an important consideration in framing the partnership focus. The findings suggest significant variation in the nature of partnerships at different grade levels, and between the different subject areas, in the ways in which curriculum features in the partnership focus. A strength of the model is its flexibility to accommodate these contextual differences.

In senior secondary science classes the partnership often has a very distinct topic focus. At the primary and lower secondary levels, the flexibility of the model is utilised, and the partnership can enrich and lead curriculum practice with significant support in particular for the Inquiry Skills and Science as a Human Endeavour strands of the science curriculum.

In mathematics, where the curriculum is more highly organised and a central feature of practice in primary schools, mathematicians were often called upon to help design and implement problem solving and inquiry activities.

In both subjects the program exposed students to authentic models of thinking and working in the discipline.

While there were too few responses to the survey from ICT teachers and professionals to draw conclusions, it seems likely that over time these partnerships could be generative in supporting significant and authentic ways of working with digital technologies.

The strengths of the model (Q4)

The model is distinctive from other STEM partnership arrangements in three particular aspects; the individual and collaborative nature of the partnerships, their flexibility in responding to local contexts, and their ongoing intent.

The flexibility of the partnership arrangements, supported by the SMiS program team, allowed distinctive activities and programs to develop that drew on partners' strengths, accommodated local needs and made use of local resources.

Many of the partnerships explored in the study had a history over 3 and up to 7 years, and partners described the development of relationships, and initiatives, that morphed over time in response to growing understanding of what the STEM professionals could offer and what activities were particularly productive.

The study showed the potential for STEM professionals to bring to the partnerships a set of knowledge, skills and perspectives that are distinctly different to what the teachers themselves can offer. Teachers brought strengths in curriculum and teaching expertise. The collaborations in many cases opened up enriched learning opportunities for both partners, and for students.

The model has significance in bringing together school and professional practice communities to develop an experienced curriculum with a strong focus on STEM inquiry and reasoning.

Return on investment in the SMiS program

Analysis of the nature of SMiS partnerships demonstrates outputs and outcomes for students, teachers, and STEM professionals that represent a strong return on investment for the program.

First, SMiS leverages considerable volunteer STEM professional resources to address the important national problem of student engagement. For the partnerships reported on in the survey, each partnership represents an estimated annual commitment of $1250 from the Australian Government Department of Education and Training and CSIRO. This funding input leverages however the equivalent of almost three times this amount through the commitment of STEM professionals dedicated to improving STEM teaching and learning in schools.

Each science partnership involves on average an estimated 192 student interactions each year, amounting to 326 000 annual interactions across the program currently. Scientists spend on average 29 hours in contact at schools per year, 13.5 of which are spent working with small groups or individual students, representing focused learning experiences.

Second, to deliver the outcomes of the program by alternative means would be expensive. For instance, using proxy measures to estimate the cost of a subset of equivalent outcomes by other means yields $3700 per partnership for enhanced student enthusiasm for STEM learning, $1080 for increased STEM knowledge, and another $4000 for equivalent teacher development.

Third, the outcomes of the program are substantial, and significant. Teachers involved in the partnerships engage in significant professional learning through planning with the STEM professional and working with and observing their interactions with students. These professional learning opportunities and activities are consistent with current thinking about effective teacher development as being action oriented, collaborative, and grounded in local practice.

The types of experiences and learning for students brought by STEM professionals, focusing as they do on authentic practice and offering role models of thinking and working in the disciplines, are consistent with current thinking concerning best practice in supporting engagement with learning in science and mathematics and student choice of STEM futures.

Outcomes for STEM professionals include increased commitment to educating future generations, and skills in interpreting their practice for a wider audience.

Fourth, there are valuable longer-term impacts attributable to the SMiS program because of its distinctive and central role as a STEM outreach activity. The impact of the SMiS program relates to its status within Australia as emblematic of the incorporation of contemporary STEM practice into school curricula, its focus on ways of thinking and working in the STEM disciplines, and its alignment with contemporary directions in science, mathematics and ICT curricula.

Discontinuation of the program would represent a significant loss to innovation in contemporary thinking in STEM teaching and learning. Continuing and scaling up the program would open the possibility of establishing in Australia a significant new direction in teaching and learning in STEM subjects.

Forging ahead of leading practice (Q5)

The SMiS program can legitimately claim to be a major feature of the school-STEM community partnership landscape in Australia. This evaluation has shown that the model underpinning SMiS is distinctive through its capacity to adjust to local context, and the depth and longevity of the partnerships that can develop.

The flexible and negotiated nature of the program however brings with it challenges, and this study revealed problems with some partners not understanding their roles, not appreciating the potential of the program, and finding it difficult to undertake the negotiation and understandings needed to make the partnership work. Almost one quarter of partnerships are 'withdrawn' before starting joint activity.

SMiS partnerships involve professionals from quite different communities of practice learning to understand and appreciate each other's perspectives, and the 'border crossing' that is required needs patience and support. Both STEM professionals and teachers describe key aspects of partnership sustainability as involving willingness to be flexible, a capacity to understand each other and develop a shared view, and a commitment to develop a quality relationship focused on making the partnership work.

Matching partners thus becomes understood as a key aspect of setting up sustainable partnerships. The SMiS team has developed an impressive variety of processes – personal contact, workshops and resources, and on-line supports – to support the matching of partners and support of ongoing partnerships. However, the pressure of numbers and the complexity of providing support for the varied personal and professional relationships that are initiated mean there are inevitable tensions between the need to initiate new partnerships, and the need to support them at key points.

There is an opportunity, if SMiS continues to grow to be a major influence on innovative STEM practice in schools, to more systematically articulate and support the needs of partners to understand the roles that are implied by such partnerships and the potential experiences and expertise that can be productively brought into them. If resources could be effectively developed to do this, SMiS has the potential to become an even more significant catalyst for major innovation in school STEM curricula in Australia and beyond.

2. INTRODUCTION

The CSIRO Scientists and Mathematicians in Schools Program including ICT in Schools, is a partnership program in which volunteer STEM (Science, Technology, Engineering, and Mathematics) professionals partner with teachers in Australian schools to promote science, mathematics and ICT among Australian students. The program is funded by the Australian Government Department of Education and Training and CSIRO. Initially this started as "Scientists in Schools" (2007), then incorporated "Mathematicians in Schools" (2009) and finally included "ICT in Schools" (2014). The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has managed the project over the last eight years (2007-2015). Across this time, the program has undergone three formal independent evaluation processes, the first of the program pilot in 2007, and subsequently in 2008-9 and in 2011-12.

SMiS program aims

The aims of the program have essentially remained the same since the beginning, although they have been expanded to recognise mathematics and ICT partnerships. The aims are for the partnerships to:

- bring the practice of real world science, mathematics and the ICT profession to students and teachers;
- inspire and motivate teachers and students in the teaching and learning of science, mathematics and ICT;
- provide teachers with the opportunity to strengthen their knowledge of current scientific practice, mathematical and ICT applications;
- enable scientists, mathematicians and ICT professionals to act as mentors or role models for students;
- broaden awareness of the types and variety of careers available within the mathematics, science and ICT fields;
- enable teachers, scientists, mathematicians and ICT professionals to share ideas and practices with other teachers, scientists, mathematicians and ICT professionals; and
- increase scientists', mathematicians' and ICT professionals' engagement with the broader community, thus raising public awareness of their work and its social and economic importance.

SMiS model and growth trends

The SMiS model refers to the development of a voluntary partnership between a teacher and a STEM professional who work together to provide a program of value and interest to the students and which achieves the aims of the SMiS program. Partnerships can be:

- assigned – where the teacher and STEM professional have been assigned to each other and are in the process of planning their activities;
- active – where activities are currently running;
- closed – have previously been active and achieved some outcomes, but are no longer active ; and
- withdrawn – where no activity at all has occurred after a reasonable time of being assigned.

Data about the partnerships over the last four years provides a means of tracking the number and the duration of the four types of partnership. Over the last 4 years, there has been a steady annual increase in the number of assigned and active partnerships (see Table 2.1). The Scientists in Schools (SiS) partnerships have grown by approximately 4% per year, and the Mathematics in Schools (MiS) partnerships have averaged an annual growth of 12% over the last four years.

Table 2.1: Number of Active and Assigned partnerships in the SMiS programs from 2012 to 2015

Years	Partnerships (active and assigned)	Science	Maths**	ICT*	Schools involved
June 2012	1469	1291	178	NA	1119
June 2013	1539	1348	190	NA	1159
June 2014	1650	1400	250	NA	1177
June 2015	1799	1460	263	76	1263

** Mathematicians in Schools program began in 2009*
*ICT in Schools program began in 2014
Source: SMiS - Summary 30 June 2012-2015

The nature of each partnership is varied and dependent on a range of factors, such as the requirements of the individual teacher or STEM professional, the curriculum requirements, the geographical location, structure of the school, flexibility of the school timetables, facilities in schools, and availability of the teacher and STEM professional. While these factors make the task of managing the partnerships quite complex, it is clear from the data that the strategies put in place to increase both the Mathematicians in Schools and the ICT in Schools partnerships are having a positive effect on their increasing numbers.

Over the last few years there has been an increase in funding for the SMiS program which has resulted in a growth in the numbers of team members (including Project Officers). This has enabled the team to successfully focus on increasing the MiS and ICT in Schools partnerships. For example, significant team time has been put into increasing ICT in Schools through a number of Network and Stakeholder engagement strategies (SMiS ICT Updates 2014-2015). The growth of the SMiS team made possible by funding increases has supported an increase in quantity of partnerships and also attention to quality through enhanced support processes. The growth in funding has allowed structures to be put in place for advancing the mathematics and ICT arms of the program, for more sophisticated communication measures to prepare for future recruitment, and for effectively supporting quality in partnerships.

Purpose of this evaluation

The purpose of the evaluation is to:

- Provide a summary of the current context in which the Scientists and Mathematicians in Schools Program operates and an overview of the impact and value created to date against the Program objectives using all past evaluations conducted on the Programs.
- Report on the current state of the Scientists and Mathematicians in Schools Program, using data collected and analysed across 2015.
- Provide a contemporary economic assessment of the return on the investment in the Scientists and Mathematicians in Schools Program and contextualise this in the overall value of STEM outreach programs.

In developing the understanding of the impact and value of the SMiS program, the gathering of data and analysis was focused around the following five questions:

Q.1 What are the outcomes for students, teachers, and STEM professionals as a result of the Scientists and Mathematicians in Schools program?

Q.2 How is the Scientists and Mathematicians in Schools Program changing students' and teachers' engagement with, and knowledge and understanding of STEM practices?

Q.3 What are the similarities and differences among the partnerships developed by teachers and scientists, teachers and mathematicians, and teachers and ICT professionals?

Q.4 What are the strengths of the Scientists and Mathematicians in Schools model? What significant attributes of the SMiS model are highlighted when considering an overview of a range of initiatives involving STEM professionals, including university and industry working with schools?

Q.5 In what ways could the Scientists and Mathematicians in Schools model be implemented which would result in it being ahead of leading practice and which would enhance program outcomes and impact?

Methodology of the evaluation

As part of the process for this assessment, the research team undertook a number of steps and activities. These included:

- Consulting the education literature around partnerships between the STEM professional community and schools, to place the SMiS model in a national and international context.
- Analysing previous evaluation reports to identify key issues and trends relevant to the current assessment.
- Accessing and interpreting CSIRO SMiS data with the collaboration of the SMiS team leadership.
- Interviewing SMiS team members concerning their experience of the program.
- Arranging ethical clearance for the assessment as well as permission to collect data with education authorities (32 jurisdictions including state and territory Departments of Education and Catholic Diocese) and principals.
- Surveying teachers and STEM professionals.
- Based on a preliminary analysis of the survey data, selecting and developing through interviews, case studies of partnerships that represent characteristics of particular interest.
- Developing an analysis of the return on investment for the program using data from the survey, comparing to equivalent STEM practices.

With any assessment of a program as extensive and complex as SMiS there are methodological challenges in capturing information and narratives from partnerships that are representative, yet capture the range of experiences of the different partners. This is particularly the case given the SMiS model is distinct in involving an individually negotiated set of arrangements between the partners.

In capturing the breadth of experience the survey has been the key instrument. All partners from assigned, active, closed and withdrawn partnerships at 28 May 2015 were invited to respond to the survey. The survey was designed to probe in some depth the profile of teachers and their context, STEM professionals and their context, motivations and information concerning their entry into the program, the nature of the partnership, outcomes and changes from the partnerships, and comments on the SMiS model and its operation.

In many cases the survey questions were based on those from previous evaluations, however there was an attempt to probe more deeply into the nature of participants' experience including hours spent in various activities or the nature of changes to partnerships over time. Questions which previously had two point responses were expanded to four point scales (e.g. that potential outcomes were: 'not a relevant benefit', 'a somewhat relevant benefit', 'a relevant benefit' and 'a very significant benefit'). There were many opportunities for comment within the survey and these have been collated and presented in this final report.

A representative sample of CSIRO SMiS team members with relevant experience were interviewed either individually or in pairs, to provide insight into the operation of the program.

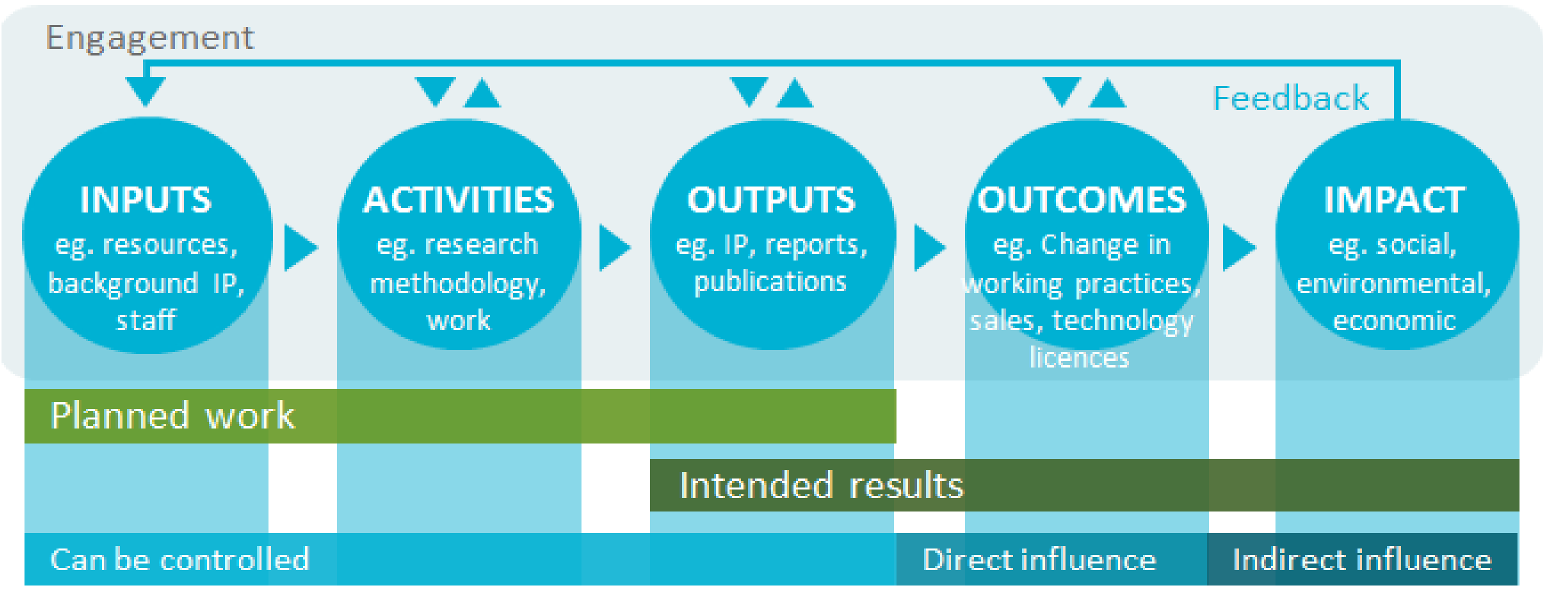
Selected partnerships were probed through interview and focus group to develop narrative descriptions of case experiences. Cases present data from interviews with teachers and STEM professionals, as well as focus groups with students participating in the program. These cases illustrate, in more depth than is possible through survey, the experience of partners and students and particular aspects of the nature of the partnership. These cases have undergone a separate qualitative analysis.

All data sources were used in a series of analyses to address the assessment questions.

Performance evaluation

The terminology of the Kellogg Logic Model (Figure 2.1) was adopted in evaluating the program (W.K. Kellogg Foundation, 2004). The inputs, activities, outputs, outcomes, and impacts of the SMiS program were identified and analysed. Primary attention focused on the outcomes of the program, namely the changes in behaviour and performance of students, teachers, and STEM professionals attributable to the program.

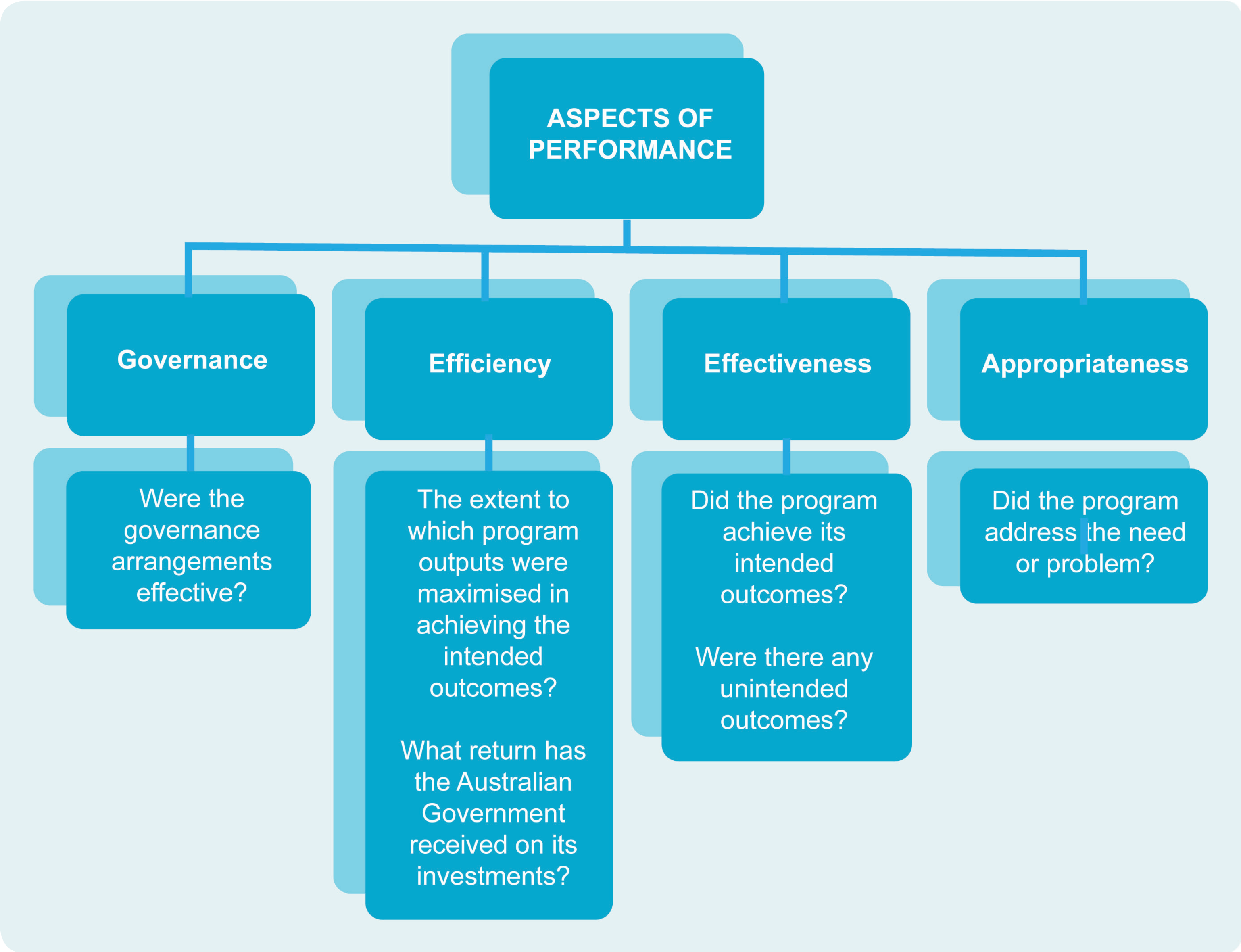
Figure 2.1   Kellogg Evaluation Logic Model



This provided the basis for analysis of the efficiency and effectiveness of the program (see Framework, Figure 2.2). Both the cost efficiency in delivering its range of outputs, and the effectiveness in achieving intended outcomes were considered (see Performance Evaluation Framework, Figure 2.2). A combination of quantitative and qualitative analysis was thereby used to evaluate the return on investment in the SMiS program.

Governance and Appropriateness, the other major categories in the Performance Framework, were addressed separately in the report. The question of the effectiveness of governance arrangements for the SMiS program are considered in Chapter 7, and questions of appropriateness in Chapter 10.

Figure 2.2: Performance Evaluation Framework (SMiS, CSIRO, 2015)



3. SUMMARY OF OPERATING CONTEXT AND LONGITUDINAL SUMMARY OF IMPACT

The context of SMiS and the evaluation

The CSIRO administered Scientists and Mathematicians in Schools (SMiS) program is a major, high profile initiative in which STEM professionals including also ICT professionals and engineers interact with teachers in schools under a local partnership arrangement that is ongoing and negotiated. The program is funded by the Australian Government Department of Education and Training, with a financial contribution from CSIRO.

It was first instituted in 2007 on the advocacy of the then Chief Scientist of Australia Dr Jim Peacock in order to address concerns within the scientific community about decreasing engagement and involvement of Australian students in STEM post compulsory education, and concern to support teachers to better represent contemporary scientific practices in school education. Since that time the program has expanded considerably in size, to have created a cumulative total of 4619 teacher-STEM professional partnerships with currently 1799 active partnerships at 30 June 2015 involving not only scientists, but since 2009 mathematicians, and since 2014, ICT professionals.

The program has been evaluated three times: in 2007, 2008-9 and again in 2011-12. An overview of these evaluations is given in the second part of this section, describing findings and recommendations, and the way the project has responded. In brief, these evaluations have been very supportive of the SMiS model and its outcomes, and the main recommendations have dealt with issues around management, publicity, support processes, and needs associated with expansion.

The current evaluation offers the opportunity to take a fresh look at the aims and affordances of the SMiS model taking account of the changing context of STEM education in Australia and internationally. As part of this investigation, the assessment will look carefully at the findings of these previous evaluations to identify areas where a close and critical examination of the model might afford an opportunity to apply a fresh perspective. It will explore for instance whether in Mathematicians in Schools the partnerships take students into unfamiliar territory to explore and develop new mathematical knowledge.

Since 2012, the last evaluation, there has been accelerating concern with participation in STEM and in the performance of Australian students in this area, changes in the curriculum context in the STEM disciplines in schools, and a proliferation of models of partnerships, which put schools in touch with the professional STEM community. All of these factors justify a fresh look at the SMiS program model and operation, its intent, and its impact in this changing environment.

Current concerns about declining participation in STEM are well documented in Australia (Australian Industry Group, 2015; Office of the Chief Scientist, 2012, 2013, 2014) and across a range of high profile publications representing the views of governments across the globe (Freeman, Marginson & Tytler, 2015; Marginson, Tytler, Freeman, & Roberts, 2013; Tytler, 2007). In these, the concern is that youth in contemporary society are not choosing the STEM subjects of science and mathematics in sufficient numbers to attend to a supply of STEM professionals that are needed in contemporary technological societies. While there is some controversy about the extent of this 'crisis', there is general agreement that declining participation in advanced level mathematics and physical sciences, for instance, means that many young people are cutting themselves off from future productive pathways, from understandings of science and mathematics that will enable them to function effectively as adults (Marginson et al., 2013). There have also been concerns in Australia at evidence of declining performance of Australian students on international comparative tests (Martin, Mullis, Foy, & Stanco, 2012). At the societal level, there is a need to have a general population with the disposition and capacity to engage with STEM issues, and to bring STEM related skills to bear on both personal and community decision making (Marginson et al., 2013; Tytler & Symington, 2006). A key aim of governments around the globe is to have, as an outcome of school education including STEM education, adults who are flexible and imaginative problem solvers[1].

The constructs of scientific and mathematical literacy, broadly applied to curriculum frameworks globally, emphasises the need for all students, and not simply a STEM elite, to develop these dispositions and skills. Yet in advanced societies there is evidence that many students develop increasingly negative attitudes to school science and mathematics across the primary and early secondary school years (Goodrum, Hackling, & Rennie, 2001; Tytler, 2007). Student engagement with science and mathematics, and the development of dispositions towards STEM knowledge and perspectives, is thus an increasing focus. In research into students' attitudes and aspirations there is increasing interest in the construct of identity, representing questions such as 'Is this scientist the sort of person I want to become?' or 'Am I the sort of person who is interested in this problem?'.

In mathematics there is evidence that resilience is required if students are to be inclined to explore unfamiliar territory. Thus, in curriculum framing and in advocacy of teaching and learning approaches, there is increasing interest in student engagement with reasoning, problem solving, and learning as distinct from developing procedural fluency. The representation of scientific and mathematical practices and the nature of science and the power of mathematics are critical to retaining student interest in mathematics and science and drawing more students towards such interests. Working as scientists and mathematicians during learning in these domains is crucial to attaining this.

In science and mathematics, an emphasis on the relevance of knowledge to students' lives, and a realisation of student capacity to use it, and representation of the work of scientists' and mathematicians, and student recognition that they can operate in these ways are key curriculum emphases. The power of ICT is crucial to bringing about such realisations. Students need to be familiar with the options they have for exploratory activity.

These ideas are represented in the Australian Curriculum in Science in the two strands 'Science Inquiry Skills' and 'Science as a

1 See for instance: http://pwc.blogs.com/psm_globally/2015/05/the-stem-imperative-future-proofing-australias-workforce.html

Human Endeavour' which focus on the way scientists work, the nature of evidence, and how science is practiced both in the laboratory, and in the context of societal needs and issues. The proficiency strands in mathematics (Understanding, Fluency, Problem Solving, and Reasoning) are intended to be integrated into every content domain for the purpose of bringing mathematics to life and emphasising the power it has for exploration, and the beauty of the analysis techniques and proofs that can result.

These ideas, concerning the state of STEM participation and education, are represented strongly in a series of seminal reports coming out of the Office of the Chief Scientist in Australia concerning the state of Australian science including mathematics and policy directions that Australia needs to commit to (Hackling, Murcia, West, & Anderson, 2013; Office of the Chief Scientist, 2012, 2013, 2014). In particular, in these writings there is a strong recognition of the importance of STEM thinking and skills for all students, and an advocacy of the need to bring school science and mathematics closer to the way science and mathematics are practiced in contemporary settings. There is thus contained in these important policy writings an argument for school science and mathematics to better represent the practices of scientists and mathematicians, and not simply their historical products, and an implication that there is an important role for practicing scientists and mathematicians to become involved in re-engineering the STEM curriculum. This view was presaged by Dr Jim Peacock (Peacock, 2007), a former Chief Scientist and initiator and patron of the SMiS program, who argued that profound changes in the way contemporary science is practiced have significant implications for how we conceptualise school science, and in particular that we can no longer put our entire faith in knowledge products that will inevitably be outdated over the lives of our students. These ideas and the context that has given rise to them align significantly with the SMiS program.

School-STEM professional partnerships

Allied to these perspectives there has been increasing interest in school partnerships with community and professional scientific organisations and individuals as a way of opening up the school curriculum to scientists and their practices. This is true of a raft of such initiatives in Europe, the US, and in Asia (Marginson, Tytler, Freeman, & Roberts, 2013). There have also been significant partnership programs in Australia (Tytler, Symington & Smith, 2011) and many locally negotiated partnership initiatives that can involve professionals practicing science in a variety of ways (Symington & Tytler, 2011; Tytler, Osborne, Williams, Tytler, & Cripps Clark, 2008).

Some major questions emerge out of research into these partnership initiatives:

1. how might we describe the different partnership models that are operating?
2. what potential do these offer for enhancing student engagement with learning?
3. what knowledge and experience can STEM professionals most powerfully bring to these partnerships?

For mathematics, we might ask if there are partnerships with mathematicians that encourage students to think like mathematicians during creative and innovative development of deep mathematical knowledge that also increases student inclination to explore unfamiliar mathematical ideas in the future?

With regard to Question 1, concerning a need to map partnerships to better understand the scope and potential of this field (Cripps Clark ,Tytler, & Symington, 2014; Tytler, Symington & Cripps Clark, in press), there is considerable current interest in Australia in understanding what is going on. The Office of the Chief Scientist in Queensland (2014) has undertaken such an exercise and currently the Australian Industry Group is undertaking a national study to explore the variety of ways industry is involved with the STEM school curriculum.

For the current evaluation exercise a key question concerns how the SMiS partnership model sits alongside other partnership models, and in particular what the particular affordances of this model might be. Later in this section we describe a significant mapping exercise in which the different dimensions of partnership programs are explored and compared.

With regard to Question 2, that of the impact of partnerships on school science and mathematics and ICT, we can see from the discussion above that the SMiS program can be viewed not simply as an exercise through which STEM professionals work in schools to top up teachers' and students' knowledge and skills, but more significantly as part of a more concerted attempt to bring the practices of school science and mathematics closer to those of practicing STEM professionals. This latter view is supported by the significant appetite that currently exists in the STEM community to help in schools, in what must be seen as an interesting, perhaps exciting intervention. The question is: how can such partnerships be framed to have maximum beneficial impact in schools?

Question 3, concerning what scientists and mathematicians can bring to these partnerships (Cripps Clark ,Tytler, & Symington, 2014; Tytler, Symington & Cripps Clark, in press)will be an important focus for the assessmentThe original SiS program involved scientists, including engineers, and the curriculum argument for their involvement is represented above. The case for mathematicians is somewhat different in a number of respects:

1. curriculum arguments for relevant mathematics sit somewhat differently to those in science;
2. the mathematics curriculum is more sequentially structured, the content more prescriptive, the assessment more definite than the science curriculum, and the subject cultures differ (Hobbs, 2012) although arguably do not need to (Williams, 2014); and
3. mathematics sits in a somewhat different relation to professionals who use mathematics, to that for science.

Taking these points one by one, although three mathematical strands are listed for mathematics, it is expected that learning within these domains will be dynamic rather than static. This is represented in the expectation that the four mathematical proficiencies (Understanding, Fluency, Problem Solving, and Reasoning) be employed during mathematical activity associated with the three strands. This is not presently the approach taken by the majority of mathematics teachers (Williams, 2014). Mathematicians in partnerships who draw out such proficiencies could assist teachers in developing such approaches. There are differences again for

ICT. For these reasons, the assessment will examine differences in the way that different STEM professionals operate in the SMiS partnerships.

Partnership practices

In the SMiS program the teacher and the STEM professional collaborate in flexible arrangements, with a shared purpose of promoting STEM education among school children. The partnerships are dependent on growing these relationships between teachers and STEM professionals.

A partnership between a STEM professional and a teacher represents the coming together of two distinct communities of practice, with different languages and perceptions of the STEM field, different purposes, and different communication structures. The metaphor of 'boundary crossing' (Akkerman & Bakker, 2011) has been productively used to frame and investigate the issues associated with bringing together scientists and the school community (Cripps Clark, Tytler & Symington, 2014; Tytler, Symington & Cripps Clark, in press). From this perspective it becomes an interesting and significant question as to the nature of the practices that emerge at the boundary. What actually happens, when a STEM professional interacts significantly with teachers and students? Are the activities simply topping up of school activities, but better informed, or are they different activities that could not happen without the STEM professional's and teacher's presence?

Mapping STEM partnership models

The evaluation question —"What are the strengths of the Scientists and Mathematicians in Schools model? What significant attributes of the SMiS model are highlighted when considering an overview of a range of initiatives involving STEM professionals, including university and industry working with schools?" — implies a need to consider the SMiS model in relation to other STEM outreach models. To review models in Australia that specifically target STEM participation of students and schools an online search was undertaken covering in-school programs, competitions, awards and online resources. This work is of significant current interest, given the number of partnerships operating, and the enthusiasm of the STEM community for supporting school work. The programs vary considerably across a number of dimensions. The STEM partnerships table (Appendix) identifies the profiles of partnerships along key dimensions. These dimensions include whether the models incorporated an external partner such as a scientist, volunteer or mentor to assist the school and individual teachers and students. In addition, flexibility was a critical criterion whereby programs could be negotiated or provided scope for modification to cater for individual needs.

The table compares 44 representative programs covering a range of delivery methods. The majority focus is on Science Education but recognising that STEM expansion into other areas is occurring. Many of the programs operate on an annual basis allowing schools to plan student engagement and development of in-house skills necessary to roll out the programs. Large numbers of module or one-off programs were identified whereby teachers or schools can pick and choose components to be utilised that link directly to the Australian Curriculum.

While approximately 50% of the programs target both primary and secondary schools, many have a narrower focus working specifically with the upper primary and lower secondary classes thus influencing and engaging younger students, reflecting increasing realisation of this age as critical in forming attitudes and aspirations towards STEM (Tytler, Osborne et al., 2008; Tytler, 2014). Involvement in the programs tends to rely on schools nominating to participate, requiring a teacher within the school to act as the main contact for the program.

The analysis has suggested the following major program categories: In school programs including SMiS, and also In2 science, a scheme where undergraduate scientists spend time in classrooms; competitions and awards such as science fairs or the F1 in Schools technology challenge; and online and other resource production such as Primary Connections or iSTELR. From the analysis of dimensions across these programs (see Appendix) it becomes clear that the SMiS has a number of significant features that place it in a key strategic position with regard to influencing students, teachers and schools in the promotion of STEM. It is one of few programs with the flexibility and scope to work across the STEM area; almost the only program where schools can interact with STEM professionals longitudinally, thus allowing a relationship to develop; one of few programs where the content of the partnership is truly negotiated and flexible such that teachers' and schools' needs can be matched to the knowledge and skills of the STEM professional; and one of few programs which facilitate a focus on a range of capabilities such as teamwork, inquiry skills, engagements, problem solving, and contemporary science knowledge.

Thus, unlike competitions and resource development in particular, and other in-school programs to a lesser extent, the SMiS model sits in a special place in providing the flexibility to allow the STEM professionals space and support to bring their knowledge and capabilities into the partnership, and to allow the teachers to consider and negotiate their particular needs and those of their students. Also, alongside partnerships initiated by schools with local scientists and industries, such as those reported by Tytler et al (2008), the model allows teachers and students to interact with scientists from their local area, representing science, mathematics and ICT in contexts that students recognise as familiar and meaningful. An area of increasing interest is in universities partnering with local schools to implement learning opportunities for undergraduate and secondary students.

The challenge is, of course, for schools and STEM professionals to avail themselves of the strengths of the model. What is possible is not necessarily probable. Thus, key questions for this assessment are to ascertain whether the partnerships in general avail themselves of the potential offered by the flexible and important model of STEM partnerships to engage students and teachers in worthwhile activities, and whether the SMiS processes might be refined to better encourage the quality outcomes offered by the model.

An overview of previous evaluations and their implications

Since its inception evaluation of the SMiS program has been taken very seriously. There was an evaluation of the pilot program operating in 2007 (Howitt & Rennie, 2008), an evaluation carried out in 2008 (Rennie & Howitt, 2009), then an evaluation undertaken in 2011 (Rennie, 2012).

In the following sections we briefly examine the essential issues addressed by these previous evaluations as a background to the current evaluation.

Evaluation methodologies for SiS evaluations

There are two critical issues to be considered in relation to evaluating this program. The first arises from the nature of the model underpinning SMiS, which poses a significantly greater challenge for evaluation than some other models in terms of how the program impacts on students. The model is built upon matching a STEM professional and teacher to negotiate and manage a shared activity. For example, one scientist/teacher pair may choose to focus on increasing the students' understanding of what scientists do in their work while another pair may choose to focus on developments in a particular topic where the scientist has expertise. Hence, ideally, each partnership would require a unique evaluation to determine the outcome of the program.

Second, the impact of the program is conceived of more widely than simply gains in student knowledge, so the evaluations have needed to identify a wider set of program objectives, including improvement in student attitudes and perceptions, and benefits to the participating teachers, and STEM professionals. Naturally these considerations have shaped each of the program evaluations.

Further, the evaluations of the program have been carried out in changing circumstances each time, for example the introduction of Mathematicians in Schools and more recently ICT in Schools, and changes to Australian school curriculum settings. Hence, although there is a significant amount of consistency in the evaluation methods used there is some variation reflecting these changes.

However, the same key data gathering procedures have been used across the evaluations; a survey of the participating scientists and teachers, which has in each case achieved a sound response rate, which itself reflects the value that the participants place on the program, a set of case studies of partnerships, and interviews with SMiS staff employed in recruiting and managing partnerships.

Findings of past evaluations

The findings of the earlier evaluations of the SiS program tend to reflect the novelty and complexity of the operation. There is considerable discussion of management aspects of the program such as regionalisation, governance, and the number and nature of the partnerships. This emphasis on the management issues will be noted again in the following section, which reports on the recommendations of the evaluations. Table 3.1 describes the major focus of each of the evaluations.

Table 3.1: An overview of issues raised and findings of previous evaluations

Key : E1 = Evaluation 1 - Howitt & Rennie (2008)
E2 = Evaluation 2 - Rennie & Howitt (2009) - Rennie (2012)

Issue	Commentary
Number of partnerships	Each evaluation describes the growth in the number of participants in the program.
Nature of partnerships	The comments on the nature of the partnerships are quite varied. In E1 the emphasis is on the variety in partnerships. In E2, while noting the variety, commentary is made on the distribution of partnerships across the primary/secondary school divide, the subject matter dealt with, and the role played by the scientist. In E3 attention is given to closed or withdrawn partnerships and the reasons why they are not proceeding. There is reference in this section of E3 to some of the challenges listed below e.g. Communication.
Benefits to participants	A major but unsurprising focus in all of the evaluations is on the impact of involvement on all three groups of participants: all three evaluations identifying benefits derived by all groups of participants. In E2 the major emphasis is on the benefits to students but there is mention also of increased confidence amongst primary teachers as a result of SMiS. Benefits are a major focus for E3 .
Regionalisation	As the numbers of partnerships grew so the organisation appointed people regionally to establish and support the partnerships. The second evaluation report is the most comprehensive on this issue detailing challenges to this work: the dilemma inherent in working on establishing new partnerships at the expense of monitoring and sustaining existing partnerships; the pressure to meet targets, the feeling of isolation, and the difficulty some SMiS Project Officers experienced in dealing with both scientists and teachers, who work in quite different ways.
Effectiveness in managing partnerships	In the first two years symposia were held and E1 and E2 commented on the value of these as well as the ongoing networking and information sessions. The first two evaluations also comment positively on the database necessary to the running of the project and the importance of the, under-utilised by partners, website as a source of information and contact.
Challenges	The second evaluation report details some of the challenges to effective SMiS partnerships. For example, in that report communication is identified as a challenge in three areas: communication between the partners, communication from the school principal with all interested parties, and the ability of the STEM professionals to communicate with students. All of these are quite significant issues as they are ones which have arisen in other studies of school-STEM professional collaborations.

Each evaluation has reported on the outcomes of the program for all of the participants, and there is a consistent story of benefit across the life of the program. E3 described in some detail benefits for the three sets of participants; students, STEM professionals and teachers, that are broadly consistent with findings from E1 and E2. With respect to benefits for the students, Rennie (2012) reported that 'more than 90% of SiS partners perceive benefits to include the opportunity to see practicing scientists as real people, to experience science with them, and to increase their knowledge of contemporary science. More than 80% see students as having fun, increasing their awareness of the nature of scientific investigation, of science related careers, and their ability to recognise and ask questions about science-related issues in the world around them. Benefits for students perceived by MiS partners were similar but more muted'. (Rennie, 2012, p 77)

Rennie (2012) also reported the STEM professionals identifying benefits for themselves: 'For more than 90% of scientists/mathematicians, the most important benefit for themselves was the opportunity to work and communicate with students. More than 80% of scientists and around 77% of mathematicians also enjoyed working and communicating with teachers.' (Rennie, 2012, p. 78)

Further, Rennie (2012) reported that opportunities to communicate with scientists/mathematicians and to increase engagement of students in science/mathematics are seen as the most important benefits for themselves by more than 91% of SiS teachers and around 90% of MiS teachers.

In terms of impact, Rennie points out (2012, p. v): 'Finding "hard" data to demonstrate the impact of SiS is difficult, because establishing cause-effect relationships in the social sciences depends on building a body of evidence rather than using a carefully controlled experimental design. However, the strong weight of evidence suggests that SiS is a successful program with worthwhile benefits for its participants'. She bases this on the strong reported benefits, described above, and also on the finding that interviewees were clear that without the program support, the partnerships would languish, and new partnerships would not be created.

A further measure of impact emerging from these earlier evaluations is the impressive growth of the program since 2007, to the current point in 2015 where in excess of 13% of Australian schools are involved. Rennie estimated the number of interactions between scientists/mathematicians during 2011 to be 140 000 to 190 000, with the total number of students involved 42 000 to 50 000. These are impressive figures when coupled with judgments about the strong benefits accruing from interacting with STEM professionals. The recommendations of the 2012 evaluation largely focused on ways of expanding the program further, and on aligning it with the Australian Curriculum.

Recommendations of past evaluations

Consideration of the recommendations from the previous evaluations draws attention to the continuing focus on maintenance of the ways in which the program is managed. The 2011 evaluation recommendations however illustrate the growing size and importance of the SMiS program, in calling for expansion of the focus on coordination with the national curriculum, and increasing focus on online support and the media engagement plan. As part of the present evaluation of the program the SMiS team leadership provided data on the response of the program managers to each of the recommendations of the 2011 evaluation.

A detailed response was provided which is illustrated in Table 3.2 by reference to two of the recommendations.

Table 3.2: Two of the recommendations of the 2012 evaluation and a summary of the response of the SMiS management to these recommendations

Recommendation	Response
Continue to provide flexible, responsive support for partnerships, including using face-to-face events and online technology.	The program continues to provide flexible and responsive support for partnerships via face-to-face events such as: regional tours, school visits, networking sessions and recognition events and utilising on-line technology. The latter include conducting webinars for newly assigned partnerships; engaging with participants through Twitter handle (@CSIROSMiS) and hashtag (#CSIROSMiS); creating a presence for SMiS in the form of a CSIRO showcase page on the professional online network, LinkedIn, for participants and interested stakeholders; and piloting an Online Collaborative Space to allow invited participants to ask questions, share resources and report on partnership activities.
Continue and expand the focus on supporting partnerships to implement the Australian Curriculum: Science and Mathematics.	The SMiS team has enhanced its interactions with appropriate professional bodies in the three relevant areas of the curriculum, science, mathematics and ICT, to ensure that its partnerships reflect curriculum developments in these areas. Additional senior staff members were added to the team to provide expertise and capacity building for the project team in relation to Mathematics and ICT. A Mathematics and Engineering Coordinator commenced 16 December 2013 and an ICT Partnerships and Projects Coordinator, funded by the Making Career Connections initiative, commenced 20 January 2014. SMiS also collaborated with AITSL as part of their 'Mathematics and Science Illustrations of Practice' video project and four SMiS schools who demonstrate exemplary practice in science and mathematics education through their participation in SMiS were showcased in this project.

In summary

What must be stressed is the challenge of evaluating a program such as SMiS with its model of forming partnerships which develop in ways best suited to the needs of the school and the expertise brought by the STEM professional. Despite this challenge, the management of the SMiS program has made regular evaluation of the program a priority and the present evaluation is the fourth of a series. The findings of the evaluations have been congruent with the objectives of the program with strong endorsement from participating STEM professionals and teachers.

With respect to the recommendations of past evaluations, the response of the SMiS team as illustrated in Table 3.2, shows that the team has taken seriously the issues raised and acted decisively to address the issues. The period 2012–2015 has been one of expansion, including the introduction of the ICT in Schools initiative, and so the demands of managing such a program have increased. However, the response to the recommendations of the 2012 evaluation would appear to continue to be very relevant to what is an increasingly complex operation.

Previous evaluations have adopted a multi-method approach and effectively used a range of procedures – surveys, interviews and case studies. It was agreed that on the basis of the success of this mixed methods approach this would be the basis for the current evaluation. The current evaluation however has a particular focus that extends the scope of previous evaluations. It is charged with probing more deeply the nature and extent of outcomes of SMiS, the affordances of the SMiS model, the variation in its nature for the different discipline areas, and its significance and impact in relation to STEM partnership programs more generally. A particular extension is the evaluation of the return on investment for SMiS in terms of its overall impact.

4. PARTICIPANTS IN THE PROGRAM

Who is involved in the program?

The participants of the program are STEM professionals and teachers who are "matched" to form a partnership. As part of the partnership, STEM professionals visit schools and work with teachers and students. The status of a partnership is described as assigned, active, closed or withdrawn (Figure 4.1). This section seeks to provide a representation of the participants and schools in the SMiS and ICTiS programs across Australia.

Active and assigned partnerships

As of 30 June 2015, there were 1799 active and assigned partnerships in the SMiS and ICTiS programs, consisting of 1460 Scientists in Schools partnerships (SiS), 263 Mathematics in Schools partnerships (MiS), and 76 ICT in Schools (ICTiS) partnerships. There were 1515 teachers and 1424 STEM professionals active or assigned in the SMiS program participating in the 1799 partnerships. There are active and assigned partnerships in all states and territories of Australia (Table 4.1). The data in Table 4.1 shows that there are more partnerships than either teachers or STEM professionals. This difference occurs because STEM professionals and teachers may be in more than one partnership.

Figure 4.1: The status of partnerships in the SMiS and ICTiS program

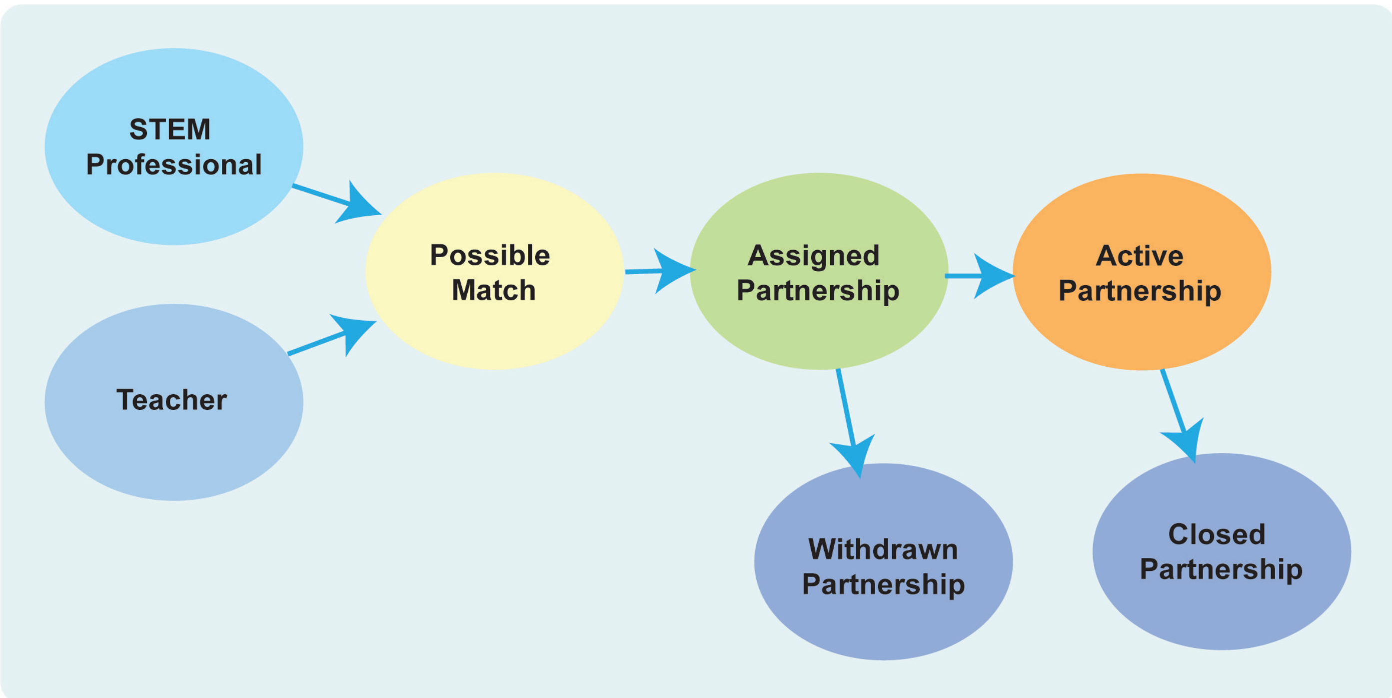


Table 4.1: Distribution of active and assigned partnerships (teams) as of 30 June 2015**

State / Territory	No. of Active and Assigned Partnerships (Teams)	No. Teachers	No. STEM profess-ionals	Schools involved	% of schools involved in partner-ships compared to the total number of schools for each state	% of schools in each state compared to the total number of schools in Australia*
ACT	89	77	72	55	42	1.4
NSW	525	436	420	373	12	32.8
NT	23	23	21	20	11	2.0
QLD	268	227	223	195	11	18.3
SA	142	132	113	109	14	7.7
TAS	128	99	75	61	22	2.7
VIC	447	368	369	316	14	23.6
WA	177	153	131	134	13	11.5
Totals	1799	1450	1373	1263	13 (Average)	

** Scientists and Mathematicians in Schools Statistics 30th June 2015 Assigned & Active

*Australian Bureau of Statistics, 2014

As of 30 June 2015, there were teachers from 1263 schools involved in active and assigned partnerships in SMiS and ICTiS programs. This represents 13.5% of schools in Australia (9389 schools). Of those schools, 65% were Government Schools, 18% Catholic, 17%, Independent Schools and 1% Special Schools. This distribution is very similar to the distribution found in Australian schools according to the Australian Bureau of Statistics that reports the ratio of Government, Catholic, and Independent schools to be 66:19:17.

The distribution of partnerships across the states shows that there are more partnerships in ACT, NT, SA, Tasmania, and WA than would be representative of the normal population of schools for those states, and less in NSW, Queensland and Victoria than would be representative of the normal population of schools for those states.

There are 1,263 schools in Australia involved in partnerships with assigned and active teachers and STEM professionals.

This equates to 13.5% of all schools (9,389) in Australia.

Of the 1263 schools 60% were primary schools, 39% secondary and 1% special schools. Of the 1424 STEM professionals listed as active and assigned as of 30 June 2015, 57% are male and 43% female, and 40% were aged between 20-35 years, 43% aged between 36-49 years and 17% over 50 years. Some schools have two or more partnerships.

Of all the partnerships, 81% are science, 15% Mathematics, and 4% ICT partnerships.

The majority of partnerships (67%) occur in major cities of Australia. As of 30 June 2015, 587 (33%) of all active and assigned partnerships (1,799) were located outside major cities, including 35 in remote or very remote locations (CSIRO Data:SMiS Progress Report 3 26 August 2015)

Withdrawn partnerships

As of the 28th May 2015, when the list of partnerships to be surveyed was drawn up, 1420 partnerships were listed as withdrawn – where no activity has occurred in the partnership after a reasonable time from when a teacher and STEM professional were assigned. The average percentage of withdrawn partnerships (1420) when compared to total assigned and active partnerships (5936) is 23.9%. The value of the time and effort in arranging the match of teacher and STEM professional and monitoring its progress is lost when the result is a withdrawal. The failure of partnerships to proceed has wider implications beyond the participants involved, such as reluctance to participate in future partnerships, and repercussions for other potential participants.

The withdrawn status is a substantial fraction (23.9%) of assigned partnerships and represents challenges for the matching and support processes of the SMiS model.

Data from the online surveys

All teachers and STEM professionals involved in the assigned, active, closed partnerships or withdrawn partnerships (after 2012) were invited to complete a survey. The surveys were designed to acquire feedback from the teachers and STEM professionals about their experiences in the program. Participants were categorised as being in an active, assigned or closed partnership, or being in a partnership that is classified as withdrawn. The surveys are an important part of the evaluation of the SMiS program that aims to maximise its effective operation. The number of invitations that were extended to participants and the number of responses is described here according to the categorisation of the partnership:

- 1893 teachers who are in active, assigned or closed partnerships were invited to complete the survey, and 193 completed it. This is a 10.2% response rate.
- 90 teachers who were in withdrawn partnerships - those for which participants had not engaged in any activity were invited to complete the survey, and 5 teachers completed it. This is a 5.6% response rate.
- 1717 STEM professionals who are in active, assigned or closed partnerships were invited to complete the survey, and 358 STEM professionals completed it. This is a response rate of 20.9%
- 81 STEM professionals who were in withdrawn partnerships were invited to complete the survey, and 10 completed it. This is a 12.3% response rate.

Noticeably twice as many STEM professionals responded (20.9%), as did teachers (10.2%).

There is variation in the total number of responses to individual items because respondents did not always answer every item in the survey.

Survey Responses from respondents of active, assigned, and closed partnerships

The survey data provides background information about the respondents and provides insight into the representativeness of the survey respondents to the whole cohort.

Geographic distribution

Table 4.2 overleaf shows the distribution of teacher and STEM survey respondents across the states and territories. The survey respondents, both teachers and STEM professionals are generally located in geographic areas representative of the distribution of the whole cohort, both with respect to the state and the size of the area where the partnership is located.

More than 86% of respondents to the survey are located in capital or regional cities, which is higher than the 67% reported as of 30 June 2015 for the whole cohort (CSIRO Data:SMiS Progress Report 3 26 August, 2015)

Distribution of the specialism

The teacher and STEM professional survey respondents, show a similar distribution in the specialism of the partnership to that reported for all participants in the program as seen in Table 4.3. The small response rate in the ICTiS program from teachers and STEM professionals is expected because this program only began in 2014.

Table 4.2: Survey Respondents: Teachers and STEM professionals' involved in assigned and active SMiS partnerships by state/territory

State / Territory	% Teachers who completed the survey (N=193)	% STEM Professionals who completed the survey (N=358)	Total Number of Partnerships in the state*	% Partner-ships *
ACT	4.1	7.8	89	4.9
NSW	28.5	27.7	525	29.2
NT	0.5	0.6	23	1.3
QLD	14.5	11.7	268	14.9
SA	8.3	7.8	142	7.9
TAS	4.1	7.0	128	7.1
VIC	28.0	25.7	447	24.8
WA	11.9	11.7	177	9.8
Totals	100.0	100.0	1799	100.0

Data: CSIRO Scientists and Mathematicians in Schools Statistics June 30th 2015, Active and Assigned

Table 4.3: Survey Respondents: Teachers and STEM respondents Involved in SMiS and ICTiS partnerships by specialism

	% Teacher respondents (N=199)	% STEM professional respondents (N=364)	No. of partner-ships *	% Partner-ships *
Scientists in Schools	83	81	1460	81.2
Mathematicians in Schools	15	15	263	14.6
ICT in Schools	2	4	76	4.2
Total	100	100	1799	100

Data: CSIRO Scientists and Mathematicians in Schools Statistics June 30th 2015, Active and Assigned

Types of Schools

The types of the schools represented in the survey data from teachers match closely the distribution of the whole cohort. For example 63% of teacher respondents were from, government schools and this compares with 65% for the whole cohort; 18% of teacher respondents were from catholic schools and this compares with 18% for the whole cohort and 19% of teacher respondents were from independent schools and this compares with 16% for the whole cohort. Fifty three percent of the teacher respondents work at primary level, and this compares with 60% for the whole cohort; 18% of teacher respondents work at lower secondary and 18% at upper secondary, and this compares with 39% of the whole cohort categorised as working at secondary level.

Professional experience of the participants who responded to the survey

The majority of teachers who responded to the survey were experienced, hold leading positions in schools and were well qualified. Over 60% of teacher respondents were highly experienced with over 15 years in teaching and 97% of teachers were at the proficient level or higher according to the AITSL Teacher Professional standards. Sixty-seven percent of responding teachers were highly accomplished or lead teachers in their schools. The teacher respondents were well qualified with 41 % having a bachelor degree and 55% having post-graduate degrees. Sixty two percent of the teacher respondents had no university qualification in the subject disciplines, science, mathematics or ICT, reflecting the large number of primary teacher respondents, while 24.7% had a bachelor degree, and 10.8% had a higher degree in Mathematics, Science or ICT.

Table 4.4: Survey Respondents: Number of years of professional experience of teachers and STEM professionals

Years of Experience	% Teacher respondents (N=192)	% STEM professionals (N=352)
1-2	0	10
3-4	3	11
5-10	20	19
10-15	14	18
15-20	10	12
20-30	35	16
>30	19	14
Total	100	100

Both teacher and STEM professional respondents are highly qualified and experienced. The STEM professionals work in diverse settings.

The STEM professionals who completed the survey were a highly qualified group, with over 60% having doctorates, and a further 16% with degrees higher than a bachelor award. The survey data shows a fairly even distribution of years of experience of the STEM professionals. The STEM professionals work mainly in government departments and universities (72%). The main role the STEM professional is that of the scientist/researcher (41.4%). Other roles include post-doctoral studies (7%), lecturer (11%), manager (9%), retired (8%) and engineer/technologist (7%). The STEM professionals work in diverse settings and with diverse roles for example, analyst, engineer, business-person, chemist, climate scientist, researcher, radio astronomer, horticulturist, statistician, medical researcher, and marine biologist.

Awareness of the SMiS program

The primary factor that contributed to both teachers' and the STEM professionals' awareness of the SMiS program was the publicity from CSIRO itself, either through publicity of the program or through contact with the SMiS team. The second major factor was the place of employment. Both teachers and STEM professionals sought advice from colleagues regarding participation.

For 84% of the teachers responding to the survey they personally made the decision to become involved, and for 19% the principal/leadership contributed to the decision. The STEM professionals responding to the survey reported that the decision to be involved with SMiS tended to be made at an individual level and only in a small percentage of cases (12%) was involvement the result of organisational endorsement/encouragement.

The STEM professionals and teachers both reported that the publicity by the CSIRO was instrumental in raising their awareness of the program. The decision to be involved was in almost all cases a personal one.

The number and the longevity of the SMiS partnerships

The survey data show that many teachers (41%) and STEM professionals (49%) are involved in multiple partnerships (Table 4.5). The longevity of the partnerships is demonstrated in Table 4.6 with some surprisingly enduring science partnerships of more than 7 years. The mathematics and ICT partnerships are younger, due to these programs beginning more recently. The modal length (most common) for the longevity of a Scientists in Schools partnership is 1-2 years and 2-12 months of the Mathematicians in Schools partnership (Table 4.6). There is insufficient data for the ICT in Schools element of the program.

Table 4.5: Survey Respondents: Teachers and STEM professionals report on the number of current partnerships in which participate.

Number of partnerships	% of Teacher (N=191)	% of STEM Professional (N=348)
1	59	51
2	20	30
3	14	10
4	4	4
5	1	2
>5	2	3
Total	100	100

The survey data reported that many participants, both STEM professionals (49%) and teachers (41%) were involved in more than one partnership.

The survey data also reported that the length of partnerships varied but some STEM professionals (13) and some teachers (9) reported being in a partnership for more than 7 years. The longevity among many partnerships indicates the resilience and robustness of the SMiS model.

Table 4.6: Survey Respondents: STEM professionals and teachers, report on the longevity of the partnerships in which they are involved.

Partner	Up to 2 months	2-6 months	6-12 months	1-2 years	3-4 years	5-6 years	7 + years	Total
Mathematician	3	10	10	9	9	3	0	44
Scientist	9	46	42	87	54	18	13	269
ICT Professional	0	3	2	1	0	1	0	7
Total	12	59	54	97	63	22	13	320
Teacher in a Maths partnership	1	5	4	7	4	1	0	22
Teacher in a Science partnership	4	20	22	36	42	13	9	146
Teacher in an ICT partnership	0	2	1	0	0	0	0	3
Total	5	27	27	43	46	14	9	171

Motivation to participate in the program

The eight items that were most commonly selected as very important on a scale of 1-4, by teachers and STEM professionals are shown in Tables 4.9 and 4.10. The data for teachers in an ICT partnership, was omitted from Table 4.9 because the sample size was too small, N= 3. Many teachers and STEM professionals expressed a desire to engage students and communicate and share their knowledge of science, mathematics and ICT with students in schools. It is clear from the responses of the STEM professionals to the survey, that enthusiasm and passion to share their STEM knowledge is their major motivation.

Many written comments mentioned a desire to promote the knowledge and understanding of STEM. For example: to educate teachers, to promote females in STEM by being a positive example, to promote careers in engineering science. Other lower order responses show more personal motivation factors such as to fulfil academic promotion requirements, and personal satisfaction, for the benefit of my Curriculum vitae and to be recognised as a scientist in the community. Written reasons for participation in the program by STEM

Table 4.7: Survey Respondents: The eight most important reasons for teacher participating in the SMiS program

	Science: % very important (N=159)	Maths: % very important (N=26)
Increased student engagement with Science/ Maths/ICT	86	73
To provide students with access to a Science/ Maths/ICT professional	79	62
Alert students to the importance of Science/ Maths/ICT in their lives	77	58
Students access to contemporary Science/ Maths/ICT knowledge	76	54
Raise the profile of Science/ Maths/ICT in the school	67	46
Alert students to contemporary Science/ Maths/ ICT careers	64	50
To provide an expert voice in this area of the curriculum	58	31
Engage in Science/ Maths/ICT linking to our community	52	38

professionals included 'Enlighten students to possibilities', 'Benefit from interacting with students in order to find what is useful for them', and 'Volunteering is a good thing for the community.'

Table 4.8: Survey Respondents: The eight most important reasons for STEM professionals participating in the SMiS and ICTiS program.

	ICT: % very important (N=12)	Science: % very important (N=281)	Maths: % very important (N=46)
Inspire and engage students in Science/ Maths/ICT	75	84	80
To share my passion of Science/ Maths/ICT	50	68	61
Alert students to the importance of Science/ Maths/ ICT in their lives	58	62	57
Raise the profile of Science/ Maths/ICT in schools	50	62	54
Promote contemporary Science/ Maths/ICT	42	46	33
Share information about my field	42	39	37
Alert students to the Science/ Maths/ICT related careers	42	38	43
Engage in service to the community	17	35	28

The survey data indicate that the primary motivation of the STEM professional volunteers is the desire to inspire and engage students in their discipline and the primary motivation of the teachers was to promote enthusiasm among their students and to have access to a Science/Maths/ICT professional. Teaching of traditional curriculum knowledge did not seem to be a high priority.

Involvement in STEM Outreach programs

In the online survey the teachers reported on their involvement in STEM outreach or resource programs responding to the question:

'Are you involved in any other STEM outreach or resource programs (e.g. CREST, Science by Doing, F1 challenge, Science competitions, Code the Future, FIRST, EngQuest, STELR, Australian Informatics Olympiad Program)'.

Three of the 4 survey respondents who participate in the ICTiS program confirmed they were involved in other STEM programs. The data show that 58 of the 165 teachers in the SiS programs, reported having involvement in multiple outreach programs and 2 of the 30 teachers participating in the MiS programs, reported having involvement in multiple outreach programs. Mostly, secondary science teachers reported experiences with outreach programs. This result could reflect the opportunity teachers have to access STEM outreach programs. When asked how the SMiS and ICTiS programs complement outreach, teachers provide a range of examples including:

- students undertaking competitions such as CREST, Spaghetti Machine competition, Science Talent search, and SPECTRA
- professional development opportunities with "networking potential with other teachers and science professionals"
- partnerships with universities.

This finding is of significance when considering the place of the SMiS program in the spectrum of such activities.

Many secondary science teachers are involved in other STEM outreach programs whilst most primary teachers and secondary mathematics teachers are not.

Survey responses from those in withdrawn partnerships

Survey responses for the withdrawn category were small, making it difficult to draw firm conclusions. However, even from the limited number of responses, it is evident that there were often extenuating circumstances such as illness, the moving of one of the partners, the STEM professional no longer working in the STEM area, and work load issues that contributed to the failure of the match. All the STEM professional respondents (N=10) had initiated the decision to be involved in the program. Four out of ten of the STEM professionals are involved in other partnerships in this program. For the teacher respondents (N=5), one teacher had been in four partnerships, one had been in two and for the others this was their first partnership experience.

The majority of the professionals were interested in the SiS program, wanting to inspire and engage with students. The reasons for not continuing with the program given on the survey by the STEM professionals (N=10) and teachers (N=5) was a lack of contact due to a lack of understanding as to who was responsible for making contact, workload and time constraints, and no plan of action or meeting. One teacher explained: 'We intended to meet but time slipped away'.

These responses were consistent with the written comments. They also highlight difficulties in arranging convenient meeting times and raise questions about the commitment of partners, and limitations in the role and resources of the SMiS team.

> ‘I had one correspondence from the teacher, a month after my initial email to them, just to tell me they haven’t responded because they were busy. I hope the other volunteers have had not experienced what I had.’

> ‘I made multiple attempts to contact the teacher, and offered to speak by phone to best understand their needs and how I could assist, but they only emailed at short notice for me to visit at one time/date, to speak to students about biology, which is not my field at all. They seemed not to understand, or want to understand what I could offer them, nor to be open about what their needs were.’

> ‘It was not really the program’s fault that this did not get off the ground. It depends on how proactive the program wants to be - they were aware that things had not happened and emailed a reminder, but did not actively follow up with the school following my response to the program officer.’

> ‘I think getting more inner city high schools would be great. The only high schools available were an hour drive away from Sydney CBD or rural. I couldn’t regularly get half a day of work to travel by public transport to a suburban school and the rural partnerships never panned out.’

5. NATURE OF THE SMiS PARTNERSHIPS

Part of the information sought from the survey related to the topics addressed within the partnerships. The options offered in the survey were shaped by several considerations, but particularly by the Australian Curriculum. The new Australian Curriculum, has an increased focus on students learning how to think, and work like scientists and mathematicians. Science as a Human Endeavour is the new strand of the Australian Science Curriculum, and Problem Solving and Reasoning are two of the four proficiencies in the Australian Mathematics Curriculum, and Mathematical Inquiry requires the activating of these proficiencies.

The Australian Curriculum also includes content-based learning areas. Science Understanding includes biological, chemical, earth and space, and physical sciences. Mathematics content is more explicitly identified in the discipline based learning areas: Number and Algebra, Measurement and Geometry, and Probability and Statistics.

In the survey 'Mathematics puzzles and games' was included as a possible topic on the survey since it is an approach that challenges students to think mathematically. Some resources that use this approach are featured on the MiS website e.g. NRICH enriching mathematics, Getset by the Australian Mathematics Trust. Depending on the games and puzzles under focus, such activity may include mathematical problem solving and reasoning.

The topics chosen for SMiS partnership activity often reflect new emphases within the Australian Curriculum in science and mathematics, such as Science as a Human Endeavour, or Problem-solving and Reasoning.

Choice of topics for partnership

The topics covered, and the year levels in which more partnerships occurred differed for science partnerships and mathematics partnerships. Topics associated with working like scientists (Science Inquiry Skills, Science as a Human Endeavour) and mathematicians (Mathematics Inquiry Skills, Mathematics as a Problem Solving Tool, Mathematical Reasoning) were included in the three most frequently identified topics in science and in mathematics partnerships.

In science, the majority of the partnerships with content-based topics (e.g., biology, chemistry, and physics) were spread across primary school levels with biology as the most frequently reported topic. In mathematics, the content-based topics (algebra, and geometry) occurred more than twice as frequently or almost twice as frequently at the Year 5 and 6 levels as they did at other levels.

In both science and mathematics partnerships, there were topics that were surprisingly infrequently reported as the focus: Engineering and Technology in both science and mathematics, and Probability and Statistics in mathematics. Lower frequency of partnerships focused on Engineering and ICT was a pattern evident in both data from teachers and from STEM professionals.

Due to the short amount of time ICT in Schools has been running, the topics addressed have been considered separately. The topics selected primarily focused on their relevance to the students but this was somewhat impacted by the hardware and software available.

Because ICT partnerships are relatively new to SMiS, it is not surprising that topics identified through the limited number of responses to the survey were mostly associated with learning how to use the available ICT confidently to support learning. That said, the following comments capture some of the potential associated with ICT now within SMiS:

> 'Students have access to a new set of knowledge and skills that allows us to consider projects that otherwise would not have been pursued. This has resulted in a $5000 grant being awarded by Intel for work we are planning for launch of a balloon into near space in early 2016.' (ICT Teacher)

> 'My work has largely been assisting my partner-teacher to navigate the strategic issues surrounding the implementation of front-edge IT in schools; e.g. BYOD policy, relevance/technical value of alternative platforms; privacy concerns using Google Apps for Education, etc.' (ICT professional)

The ICT professionals perceived the main benefit for students was an increased confidence in their ability to use available technology, and increased enjoyment in using that technology. Teachers similarly agreed that the value was in improved learning of ICT by the students, and the improvement of ICT teaching within the school. Teachers reported that topic selection was influenced by the expertise of the STEM professional.

The most frequently selected topics for science and mathematics partnerships point to the usefulness of SMiS in providing opportunities for teachers to raise student awareness of how STEM professionals work, and enable students to take part in such activity at a level appropriate to their present science or mathematics understandings. SMiS is thus contributing to student development in areas of the Australian Curriculum. It is too early to see whether there will be a curriculum focus in ICT partnerships.

If SMiS is looking to identify and promote partnerships on topics that are under-represented and are of current importance, a focus on Engineering and Technology to broaden STEM education, and a focus on probability and statistics as a significant amount of the mathematics curriculum could be productive.

For both science and senior secondary mathematics teacher partners, the main factors affecting the focus of the partnership, were the partner's field of expertise, and the relevance to students. The scientists' response was consistent with this except that they also rated 'the science curriculum' as influential/very influential, whereas in many cases, the teacher of mathematics was more likely to provide the curriculum documents for the mathematician as an understood part of what was expected. The following written responses provide some insight into how the choice works.

> 'I present different sessions based on what the students are focusing on. For example, this term the Level One students will be focusing on forces, so if I do something with them it will somehow integrate with the topic of forces. I've also done sessions with the art classes (for example design and drawing of meteorological icons), so these are obviously different than a session on (say) tropical cyclones.' (Scientist)

> 'The mathematician came to my school for a face-to-face meeting and then went away and planned 2 lessons on teaching proof by induction to the top Maths class in Year 12. He was very happy to do this because he was a pure mathematician working at a university.' (Mathematics Teacher)

> 'Once my partner teacher asked if I could talk about the search for MH370 - being as it was Bayesian statistics, & recently in the news. That was fun.' (Mathematician)

What mathematicians contributed to partnerships in general included: a) mathematical content within the curriculum [senior secondary]; b) showcasing mathematics to add interest and excitement, sometimes with attention to what is within the curriculum (and sometimes more broadly, or linking with the mathematicians' own research to aspects of the curriculum); c) supporting teachers with mathematics with which they are not sufficiently familiar; and d) providing activities to stimulate interest in mathematics which was sometimes linked to the curriculum and sometimes of interest more generally.

As with the senior secondary mathematics partnerships, there was diversity in the ways the partners participated in topic selection, and the autonomy the mathematician had in working. There was a minority of mathematics teachers who handed the curriculum documents to the mathematician and allowed them to determine the focus of the activity. The size of this minority is uncertain. The following quotes capture some of the diversity across and within science and mathematics partnerships.

> 'The Scientist started by introducing his work and initially had a discussion with the students. Many questions were asked and these were a guide as to where we would go next.' (Science Teacher)

> 'The mathematician [called by first name] has asked for ideas on what we have been covering in class and then he will come up with some ideas, we will discuss those and then he will come with the lesson ready to go.' (Mathematics Teacher)

> 'My scientist partner and I are always looking at new ways that he can conduct science in my classroom. We try to integrate these into my science unit of work where possible.' (Science Teacher)

> '[My] Initial contributions to MiS partnership tend to be not quite in line with the present curriculum, or what is useful to the teacher and his or her program. Listening to the teacher presentation to the class can assist in design of more pertinent maths content.' (Mathematician)

These differences in participation by mathematics and science partners in topic selection, the implementation process, and the degree to which the teacher considers the curriculum to be an important area of focus raise questions about whether this is due to the level of schooling at which the partnerships exist, or whether there is a difference in culture in the ways science and mathematics are taught in schools or in the ways science and mathematics teachers perceive STEM professionals could be useful to their students.

The topic focus of partnerships is negotiated, depending on the curriculum, the views and imagination of the teacher, and the expertise and imagination of the STEM professional.

Expertise brought by the STEM professional

One of the factors affecting the topic chosen was the knowledge and expertise of the STEM professional. The topics and focus often changed over time as the partners gained experience and confidence. Table 5.1 indicates the knowledge that STEM professionals brought to the partnership as perceived by scientists, teachers of science, mathematicians, and teachers of mathematics.

The stand out choice for teachers of science and mathematics, scientists, and mathematicians was STEM professional 'passion for science/ mathematics'. Teachers valued 'knowledge of contemporary practices' more so than 'knowledge of concepts', whereas the STEM professionals valued 'knowledge of concepts' more. Teachers of science reported 'the stories the scientists told', and 'contemporary science including the way science builds evidence' as equally frequent second and third choice, and teachers of mathematics second most frequently valued: 'knowledge of contemporary mathematics and the mathematicians think and act'. 'Capacity to tell stories about scientists/ mathematicians' was frequently reported as 'very important' by teachers of both science and mathematics, although slightly less so for the latter. The category was frequently selected as very important by scientists but not by mathematicians. These differences echo research indicating a more prominent place for stories in science teaching and learning compared to mathematics (Hobbs, 2012).

Table 5.1: Percentage choosing 'very important' for the question— What particular knowledge and experience did the (STEM professional) bring that was important in this partnership?

Knowledge/ experience item	% Scientist N=263	% Teacher of Science N=144	% Mathema-tician N=43	% Teacher of Maths N=22
Passion for science/ mathematics, and curiosity	64	88	63	77
Knowledge of key science/ mathematics concepts	48	55	49	55
Capacity to tell stories about science/ mathematics and scientists/mathematicians	41	56	16	50
Knowledge of contemporary science/ mathematics and the way science builds evidence/ mathematicians think and work	36	56	33	68
Knowledge of what it's like to work as a scientist/ mathematician, as part of a team.	33	61	21	50
How I use science/ mathematics in my profession	32	N/A	33	N/A
Knowledge of science/ mathematics careers or how science/ mathematics can be used in many careers	24	40	21	50

Written comments about what was very important echoed this:

> 'In the specific area of our Scientist's expertise, the students and teachers involved in the program had access to current thinking and research which enhanced their learning. In addition, the students were very engaged in that area through research and investigation.' (Science Teacher)

> 'Interacting with a real life, practicing scientist is an amazing opportunity for the students. My partner is inspiring and down-to-earth which makes her both accessible and relatable. The partnership continues to inspire my teaching practice; it has increased my experience, knowledge and understanding. I LOVE being involved in the SiS program.' (Science Teacher)

The STEM professionals told a similar story, with 'passion and curiosity' the stand out choice, followed by 'knowledge of key concepts', 'capacity to tell stories' (for scientists only), and 'how science is used and practiced'. From the patterns of response and oversight of comments, the expectation from both sides of the science partnerships focuses strongly around the scientist as an identity figure who represents particular attitudes and ways of working, rather than as a deliverer of knowledge per se. In research into students' attitudes and aspirations there is increasing interest in the construct of identity, representing questions such as 'Is this scientist the sort of person I want to become?' or 'Am I the sort of person who is interested in this problem?' (Tytler, 2014). Developing a STEM-friendly identity is an important component of decisions to continue in STEM pathways.

Comments from teachers of mathematics and mathematicians have what they consider very important implicit within them.

> 'The students love the challenge and excitement generated by the interesting problems.' (Mathematics Teacher)

> 'A competent mathematician who is comfortable in front of a class and can communicate easily to students … Age appropriate material and activities … A mixture of activities to keep students interested and engaged.' (Mathematics Teacher)

> 'It … basically revolves around problem solving structures and engaging students through interesting problems and stories around mathematics as well as the nature of mathematics and proof.' (Mathematics Teacher)

> 'Knowledge of how maths is used in Science and Engineering.' (Mathematician)

> 'Have student participate in team efforts to solve real math problems.' (Mathematician)

> 'The creative application of geometry to problem solving.' (Mathematician)

The focus on the scientist as an identity figure, revealed in science, is not evidenced in the mathematics partnerships, which focus more directly on the ways mathematicians work and think (inquiry, problem solving and reasoning), and a passion for the mathematics rather than a focus on the humanity of the mathematicians. It is possible that the curriculum focus Science as a Human Endeavour might contribute to this but it could also be a cultural difference between what is valued in the two subject domains more generally.

The valued characteristics brought by the STEM professionals includes passion, knowledge of how scientists and mathematicians think and work, more than conceptual knowledge. In science there is a greater identity focus compared to mathematics. Often the STEM professional brings knowledge and experience that enables them to move beyond standard activities to focus on STEM thinking and practice.

Case 2: Kelly working with Alice and Phillip

Kelly is passionate about attitudes and values about science … (She) speaks of the personal benefits she has experienced as a result of participating in this program in terms of the students, particularly "the excitement of the kids when they are doing science". She now has students approaching her in the playground eager to tell her about their aspirations to become a scientist, or to speak to her about their love of anything from insects to rocks.

'I could really see at that point that it is not about having someone teaching science, it's about having a role model which is what I was expecting at primary school - To have someone who you can see in the playground and say 'I want to do that one day'. So I've gotten out of it what I was expecting'.

(Kelly, Scientist.)

The nature of the partnership arrangements

Table 5.2 shows the collaborative patterns between scientists and teachers for each level of schooling. The one teacher-one STEM partner model that is the basis of SMiS was found the most common in both primary and secondary schools.

Table 5.2 Number of teachers the scientist collaborates with, as a percentage for each level of schooling

Number of teachers collaborating with STEM professional	% Primary N=74	% Junior Secondary N= 23	% Senior Secondary N=24
1	38	48	54
2	12	22	13
3	11	17	21
4	8	4	8
5	1	0	4
>5	30	9	0

There were cases where this model was extended over time to include more teachers and students in the school. It is unclear whether partnerships with multiple teacher partners usually developed out of successful one-to-one partnerships, nor whether the multiple partnerships were generally in the same school. There was a difference between primary and secondary schools, in the number of teachers the STEM professionals collaborated with. For primary schools it is much more likely that the scientists interacted with teachers in the school more widely, with 30% collaborating with more than 5 teachers. Senior secondary partnerships can be mainly characterised as individual in nature. The following themes emerged for partnership collaborations in science and mathematics.

Collaboration in One-on-One Partnerships

'My scientist partner and I are always looking at new ways that he can conduct science in my classroom. We try to integrate these into my science unit of work where possible.' (Science Teacher)

'We're a bit more opportunistic. My partner [teacher] came up with a new suggestion, we are trying it out'. (Mathematician)

Development of partnerships to whole school involvement

> 'Our Scientist is becoming more involved in the actual planning of the Science Program at school. He in turn has shown increased interest in our school philosophy and culture and has made the effort to participate in some community events and Professional Development sessions. More and more our teachers are tapping into the wide knowledge and experience the Scientist brings to our school.' (Science Teacher)

> 'We also decided to work with a group of parents coordinating 'Plastic free July' and World Water Day etc. … [so] students would have opportunities to participate at home or in science class and it would go toward a special event or assembly where the Scientist would make a short presentation to the school community to introduce what and why students were involved in activities.' (Science Teacher)

The communication skills and motivation of the partner to commit to the partnership make a difference to what occurs. Where rapport is developed between partners, other teachers' are aware of student and / or teacher engagement with the STEM Professional, and the STEM professional has the ability and inclination to collaborate with other teachers in the school partnerships are more likely to expand to include more students and multiple teachers. This evidence suggests that where a STEM professional is passionate, motivated, has good communication skills, and is inclined to include more of the school in the partnership, there is potential for the partnerships to develop with minimal managing by the SMiS team.

STEM partnerships can also grow from the existing partnerships and this is demonstrated through the STEM professionals who are actively ready to seek additional partnerships either because of the enjoyment they have experienced through their partnership, the skills they find they can practise during the process, or their desire to work at the secondary level as well. SMiS tracks this process and it would be useful to explore further ways SMiS could develop further resources or processes from this.

STEM professionals mainly work with one teacher but for primary science in particular partnerships can grow to involve multiple teachers, with wider benefits to the school. Many of these established partnerships are strongly collaborative. There are potentially useful lessons in this for the SMiS model.

Given primary schools are more likely to have multiple teachers in a partnership than secondary schools, identifying STEM partners able to communicate and engage may help to increase these multiple partnership links.

Table 5.3. Scientists and mathematicians nominating activities that occurred often.

Activity	% Often (Science: N=258)	% Often (Maths: N=42)
Visit classroom to interact with students	51.9	57.1
Assist teacher(s) with science/ mathematics content	17.8	4.8
Presentation to students about careers in science / utilising mathematics	11.6	9.5
Supervise students(s) in a project	11.2	2.4
Support a science/mathematics club	7.0	2.4
Participate in excursion with students	6.2	0.0
Judge a science/ mathematics competition	5.0	2.4
Presentation to parents or teachers about science/ mathematics	2.3	4.8
Answer students' email questions	1.9	4.8
Other activity – please describe:	3.5	9.5

Partnership activities

Table 5.3 shows the percentage of scientists and mathematicians describing various activities as having occurred 'often'.

The balance of activity for mathematics and science was different. The activity for mathematicians was more concentrated on classroom-based activity and presentations. Individual student attention such as answering email questions or helping advanced or struggling students with homework (in 'other') also featured. There was less focus on a variety of activities such as, for science, clubs or excursions, reflecting the more constrained and sequential nature of the subject area. For mathematics there was less assistance of the teacher with content, perhaps reflecting the fact that in primary schools particularly, teachers are more experienced and confident with teaching of mathematics than science. Differences in focus are illustrated by the following quotes.

> 'Being able to communicate with the kids at their level and help them gain their love for the subject as they get better at it'. (Mathematician)

> 'Our Scientist is becoming more involved in the actual planning of the Science Program at school. He … has shown increased interest in our school philosophy and culture and … participated in some community events and Professional Development sessions. More and more our teachers are tapping into the wide knowledge and experience the Scientist brings to our school.' (Science Teacher)

'SiS allows us to have a "real-world" scientist participate in our mentoring program to support student inquiry skills development and also to help students understand the importance of science in their everyday lives.' (Science Teacher)

For ICT, while the survey response numbers are too small to present quantitative patterns, comments indicate that activities focus on supporting students in coding or using digital devices, supporting teacher skill development, and improving school ICT systems:

'My first term I ran an after school ipad club, second term I ran an after school computer club, third term I performed research across the school community and this term we are planning to provide a fortnightly meet-up for teachers to gain coaching on use of technology in the classroom.' (ICT professional)

'The teachers I am worked with so far are provided with a lot of tools and technology. While they may not be on the bleeding edge of technology, they are definitely not far behind. I think the key benefit to the teacher is the ability to access an ICT professional and I do cover some of the in depth technologies'. (ICT professional)

There was some suggestion that because this is a new area, structured advice from the SMiS team on activities would be beneficial:

'I wonder if some more structure/definition could be given to how one might make contributions (as a professional); e.g. strategic/policy advice, project/implementation planning/assistance, specific education activities, etc. Such a structure can more readily set and manage expectations across all participants.' (ICT professional)

Nature and extent of interactions in the partnerships

Table 5.4: The total number of interactions with school community members, estimated by scientists*, per annum.

Question	0	1-2	3 -4	5-10	11-20	>20	Total inter-actions	Student inter-actions Per Scientist (N=265)	Student inter-actions Per Mathema-tician (N=42)
Individual students	127	38	21	11	10	29	1243.5	4.7	2.6
Your partner teacher	4	70	96	47	26	22	1891.5	7.1	5.5
Groups of students	80	60	44	24	15	20	1271	14.4	15.3
Whole class	39	99	64	25	7	13	1087	94.3	79
Groups of teachers at the school	76	112	36	12	2	4	552	6.2	6.6
Several classes or whole school	97	89	25	8	2	3	413.5	78.0	23.2
The principal or school leader	92	101	32	13	2	2	467	1.8	1.0
Other:	7	2	0	2	0	2	78		

*To estimate the total interactions the mean of each category was used (e.g. 11-20 becomes 15, >20 becomes 30). To estimate the number of student interactions with the scientist it is assumed that a class interaction involves a multiplier of 25 students (OECD, 2013), a multi-class or whole school interaction involves 50 students, and a group interaction involves a multiplier of 3 students, or 3 teachers. The results of the equivalent calculations for mathematicians is also shown.

The number of interactions per SiS partnership per year with students is, according to this calculation, almost 200. There are also 13.4 teacher interactions, presumably many of these day-long, and 1.8 interactions with the school leadership. For mathematicians the number of student interactions is less, at 120, and 12.1 teacher interactions.

There were different patterns in mathematics compared to science. The mathematics numbers are small (N=42) compared to scientists (N=265). There were fewer interactions with individual students, somewhat less whole class, and considerably less interactions with the whole school.

Hours spent by STEM professional (scientists)

The survey asked both teachers and STEM professionals to estimate the number of hours they spent in each of a number of categories of activity. The results are shown in Table 5.5 below. For 135 teacher responses to this question the results show the balance of hours spent interacting with students in whole class, small group or individual students.

The estimate of scientists is slightly less, at 24.7 hours, but broadly comparable to the teacher estimate, including in details of the breakdown. In addition the scientists estimated they spent on average 12.5 hours planning for visits, per year. These figures show a commitment by each scientist per year amounting to 4 full days plus planning time. There is wide variation in this figure, with some partnerships describing efficient processes with one annual interaction, and clearly a number of scientists spending considerable time supporting schools. Case 2 provides an example of this, with the scientist Kelly involved in many activities, linked to her role as a parent at the school. It can be seen that all categories of activity were represented to a reasonable extent, with planning time with teachers accounted for differently by scientists and teachers in terms of the balance of individual and group planning.

Table 5.6 separates these estimates out for different school levels, where this was unambiguously identifiable, and includes also the estimates by teachers of mathematics for the mathematicians' time. What is intriguing about these figures is the greater time spent by scientists partnered with primary schools when compared with time spent in secondary settings. Anecdotally there seem to be more cases of scientists becoming involved significantly in supporting the whole school at primary level, and perhaps this may entice them to spend more time at the school. In comparison with scientists mathematicians seem to spend marginally less time in schools but the differences is unlikely to reflect a significant difference in mode of engagement.

Overall, from these estimates, the commitment of STEM professionals to working with their partner schools is clearly shown. The partnerships are characterised by many interactions with students, and teachers. Considerable hours are spent across a range of activities, but this varies depending on school level, and discipline area. The practical and economic implications of these profiles will be further explored in the analysis of return on investment (Section 8).

Table 5.5: Estimate by teachers of science of the total hours spent by the scientist over a year* in various activities. The scientists' equivalent estimate is also shown.

Activity	0	1-2	3-4	5-10	11-20	21-50	>50	Total hours	Hours per partner-ship
Whole class presentation/discussion	16	49	33	25	5	2	5	821.5	5.91
Working with individual students	77	29	4	10	5	5	4	622.5	4.48
Working with a small group of students independent of a class	75	23	8	13	8	3	4	625	4.50
Working with small groups within a whole class	61	22	15	22	4	4	3	630.5	4.54
Working with several classes or whole school	48	34	23	14	6	2	2	516.5	3.72
Planning with me	15	62	36	21	3	1	1	516.5	3.72
Planning with groups of teachers	80	36	8	6	0	2	1	257	1.85
Other:	2	3	1	0	0	1	0	43	0.31
						Total hours per partnership:			29.01

*The total hours are calculated by multiplying the number of responses by the mid point of the number of hours in the column, namely 1.5, 3.5 … up to 60 hours as the 'midpoint' of >50. Thus the mean number of hours spent by the scientist per year, estimated by the teacher, is 29 hours.

Table 5.6: The hours spent by the scientist per activity for each of primary, junior secondary and senior secondary cohorts, and overall cohort, based on teacher estimates. The equivalent estimate of mathematicians' time by the overall cohort of teachers of mathematics is also shown.

Average hours spent:	Senior Secondary N=26	Junior Secondary N=22	Primary N=75	Scientist Overall N=135	Mathema-tician Overall N=21
Planning with me	3.9	4.1	4.2	3.7	3.0
Planning with groups of teachers	2.2	0.8	2.2	1.8	2.2
Working with individual students	3.3	0.3	6.0	4.5	2.4
Working with a small group of students independent of a class	4.4	1.4	5.5	4.5	1.8
Working with small groups within a whole class	5.3	2.3	5.6	4.5	4.7
Whole class presentation/discussion	4.9	1.6	8.1	5.9	6.6
Working with several classes or whole school	2.2	2.2	5.2	3.7	2.4
Other	0	0.3	0.5	0.3	1.7
Total hours per year spent in school by scientist	26.3	13.0	37.4	29.0	24.9

6. OUTCOMES OF THE SMiS PROGRAM

The SMiS program aims to focus on students, teachers, and STEM professionals; the core stakeholders in the partnership. In this section we will draw on evidence from the survey, and case studies and SMiS team interviews to examine the nature and extent of outcomes particularly for these three groups of stakeholders. Where evidence is available we will also examine outcomes for the wider school community involved in the partnerships. Section 5 on the nature of the partnerships and their operation could be construed as dealing with 'outputs' in the impact model. The current section is dealing with outcomes as the value added aspect of partnership practices and changes that result, either in individuals or processes.

Balance of outcomes

A number of questions in the survey asked for teachers' and STEM professionals' judgment about the balance of outcomes they perceived arising from the partnerships. In the question "How valuable has the SMiS partnership been" to various participants they clearly identified value for both their students and themselves. Teachers of science choosing the top category 'very valuable' on a four-point scale to the question "How valuable has the SMiS partnership been to ..." responded:

You as a teacher	62% very valuable
Your students	69% very valuable

Teachers of mathematics similarly rated value of the partnership to themselves and to their students but at a lower frequency (40% and 50%) than teachers of science. The lower percentage of mathematics teachers overall who experienced this benefit may reflect differences in culture associated with teaching mathematics and science that results in lack of recognition by some teachers of mathematics, of what the mathematician can offer about pedagogies appropriate to mathematics. Some seemed not to involve themselves significantly with the activities of the mathematician as the following quote shows:

> 'I am not much in contact with the teacher, I don't think she is having any benefit at all (unless she is reading my reports and replicating our experiments).' (Mathematician)

Teachers and STEM professionals identified substantial benefits from the SMiS partnerships for students, and themselves. There were differences in emphasis between the different partners, and between science and mathematics. The benefits often extended to other teachers and the school community.

However, this should be read against the fact that 71% of mathematics teachers found the partnership to be valuable or very valuable.

About 30% of teachers of both science and mathematics considered it also very valuable for 'other teachers at your school', 'the school community', and 'your partner scientist'. There is thus a hierarchy in teachers' minds: students, then teachers, with STEM professionals and wider school coming equal third.

For STEM professionals, a notable difference from the teachers' judgment however, was the strength of their statement concerning the value of the program for themselves. They considered they gained more value than even students (Table 6.1). For the STEM professionals the value to the school community was less significant than for teachers, and for mathematics professionals the value overall was generally held to be lower.

Nature of student outcomes

Having established strong perceptions of benefits to students, a question asked of teachers explored the nature of these benefits. Table 6.2 shows the categories of major benefit.

Table 6.1: STEM professionals' response to 'How valuable has the SMiS partnership been to ... ?:'

	% Very valuable (Science: N=261)	% Very valuable (Maths: N=41)
Students at school	41	27
Yourself personally	48	34
Your partner teacher	34	22

Table 6.2: Teachers' response to: Based on your observations, what do you think have been the perceived benefits of the partnership for the students?

Relevant benefit	**Science: % very significant benefit (N=134)**	**Maths: % very significant benefit (N=21)**
Increased awareness of how scientists/ mathematicians think and work	63.4	66.7
Increased appreciation of scientists/ mathematicians as people	66.4	57.1
Increased interest in science/ mathematics	61.9	57.1
Increased enjoyment of doing science/ mathematics	59.0	52.4
Increased ability to recognise and ask questions about science/ mathematics -related issues in the world around them	52.2	38.1
Increased knowledge of contemporary science/ mathematics	51.5	52.4
Increased awareness of the relevance of science/ mathematics to society	46.3	57.1
Increased awareness of the nature of scientific/ mathematical investigations and Science/ mathematics Inquiry skills	45.5	47.6
Increased self-confidence in their ability to do science/ mathematics	41.0	33.3
Increased awareness of science/ mathematics-related careers	40.3	47.6
Increased understanding about how they can use scientific evidence to make decisions about health and the environment/ use mathematics as evidence for decision making.	32.1	42.9
Willingness to look to science to make decisions about their own lives/ how mathematics can be used to interpret the world	26.9	47.6

For students of science the major benefits, listed in order of significance in the table, were increased appreciation of scientists as people, interest and enjoyment, and increased awareness of how scientists think and work. A further set of benefits was associated with knowledge of contemporary science, recognition and interest in science related issues around them, awareness of the relevance of science, and increased confidence. These benefits are related to engagement, and identity issues around recognition and appreciation of science and scientists, hence, in a curriculum sense, of the strands 'Science as a Human Endeavour' and 'Inquiry Skills'.

The benefits for students from mathematics partnerships showed a substantially similar pattern. Like science, how mathematicians think and work was the most frequently rated benefit. The next cluster of benefits, appreciation of mathematicians as people, increased interest in mathematics, increased awareness of mathematics in society were strongly represented. The benefits more strongly represented for mathematics related to relevance, and use of knowledge in making decisions.

Likelihood of choosing a STEM career path was further down the list for teachers of both mathematics (33%) and science (34%). However this outcome revealed a difference between secondary and primary teachers, with 52% of secondary science teachers indicating knowledge of careers as a very significant benefit, much higher than for primary teachers.

The overwhelming sense from this ordered list for science is of a focus on engaging students with identity models around scientists as people, as representative of distinctive ways of working and thinking, and as illustrating possible commitments to using STEM knowledge in students' present and future lives. It is not about topping up specialist knowledge, or skills, so much as introducing students to science as a ways of being in the world. For STEM professionals the list was very similar. A very high correlation coefficient between the means for the response from teachers of science and scientists to the various alternatives (r=0.94) indicates an extraordinary level of agreement between the partners.

Comments from teachers of science emphasised access to 'real' science experiences, and a changed view of what it is to be a scientist. Authenticity associated with access to the scientist is a major theme.

> 'Access to a real scientist and seeing them as a person was also really important. The perception that a scientist wore a white coat and was"nerdy" disappeared.' (Science Teacher)

> 'Some of the students have realised that science is not a stagnant job. Rather it is changing and adapting to different problems that arise and the focus can be across a number of areas as opposed to just one set area of science.' (Science Teacher)

> 'The profile of Science has lifted through the range of co-curricular activities offered and facilitated by the SIS. The SIS is adding to changing the culture and perception of who and what scientists do and this is really important from a gender perspective too.' (Science Teacher)

> 'So students can see that a scientist can be a young female and see a real lab in a workspace.' (Science Teacher)

Case studies 2 and 3 (Section 9) are good examples of the variety of activities and role modelling that can occur through the SMiS program.

For mathematics, the sense from the ordered list (increased awareness of how the mathematics activities. Students who do not always experience success in formal written mathematical work feel success with hands on activities and can express

Case 4: Patrick and Heather

About two weeks after Heather's visit students began requesting her return visit as they had questions they wanted to ask her about mathematics, some wanted to discuss things they'd seen on television. Although the partnership is in its infancy, Patrick feels that the students are beginning to develop a greater appreciation for the role of mathematics in their lives.

mathematicians work, increased interest in mathematics, increased awareness of the relevance of mathematics to society, and increased interest in mathematicians as people) is about bringing mathematics to life, and about recognising the work of mathematicians. The benefits for students from both science and mathematics partnerships is consistent with the thrust of the SMiS aims.

Comments from teachers of mathematics sometimes reflect these anticipated outcomes and sometimes identify different outcomes. The sense of identifying with the individual mathematician is not as strong as for scientists.

> 'The partnership is working for the benefit of the students. They are enjoying sessions and being challenged in their mathematical thinking.' (Mathematics Teacher)

> 'Students really look forward to the visits of our partnered Mathematician and enjoy their understandings verbally.' (Mathematics Teacher)

> '[The mathematician] opened up the need for applied mathematics, real-life modelling with mathematics, and the interest of students in computer coding - and how it relates to mathematics.' (Mathematics Teacher)

These comments show how MiS partnerships have engaged students with mathematics, including students who have not previously considered themselves to be good at mathematics. In addition, in some instances challenge has been linked with mathematical reasoning, and learning.

While there are too few ICT professional responses to the survey to draw robust conclusions, comments from teachers in ICT partnerships support the proposition that this new partnership area will also introduce

The perceptions of benefits for students, for both teachers and STEM professionals, emphasised identity issues relating to engagement with 'real' science and appreciation of scientists. Students appreciated mathematics as a tool, and developed raised awareness of ways of working scientifically and mathematically knowledge accumulation.

students to authentic contemporary practices, and ways of working and thinking with ICT:

> 'We have many students into gaming. The coding offers them the opportunity to experience how games can be created and begin that process themselves. That our partner works in defence adds an extra significance to the students.' (Teacher in ICT partnership)

> 'Students have access to a new set of knowledge and skills that allows us to consider projects that otherwise would not have been pursued..' (Teacher in ICT partnership)

Evaluation of outcomes

There is a history in the literature on partnerships of concern about the lack of clear evaluation of outcomes for students. While there is no requirement within the SMiS program that individual evaluation of partnerships by the partners involved take place, it was felt important to explore what evidence exists for the student outcomes claimed. While the perception of student engagement and learning outcomes is very strong across the partnerships, the data indicate that the evidence is overwhelmingly informal and anecdotal. 79% of teachers nominated this as the basis for judgment. There were a substantial minority, however, who claimed judgment of student work (29%), surveys (15%), and formal assessment of knowledge (13%) as the basis of claims. In a few cases there were claims of evidence for increased enrolment in STEM subjects, but scrutiny of the nature of this evidence in comments did not uncover any cases where the evidence was robust.

Statements about students being aware of or now considering careers in STEM may provide evidence over time of SMiS increasing

Evaluation of student outcomes is mainly informal and anecdotal, although a solid minority of teachers claimed evidence based on judgments of student work.The SMiS team could usefully explore ways that evaluation of ways of working mathematically and scientifically might proceed to help teachers and STEM professionals conceptualise appropriate outcomes.

the likelihood for students to continue with STEM subjects.

> 'The mathematician is currently working with a year 10 class and a number of students are now considering careers in STEM which was not previously the case. This includes one of the top girls in the class.' (Mathematics Teacher)

> 'The profile of science in the school has been raised substantially, along with the numbers of students looking to sciences as future career options. Enthusiasm is contagious.' (Science Teacher)

> 'Several students have been given the option to do work experience with our partner scientist and as a result a couple have even gone on to study his field at …'. (Science Teacher)

> 'The class have access to a "real" scientist and are aware that it may be a legitimate career.' (Science Teacher)

Teacher outcomes

Learning and engagement of teachers is one of the goals of the SMiS program. Table 6.3 shows responses to two questions of teachers asking specifically about types of benefits for them. 'Enjoyment of working with the scientist', 'opportunity to communicate with scientists', and 'increased engagement of my students' were the top items. This is consistent with teacher expectations of the partnership. A second rung of items related to updating of knowledge of science and scientific /mathematical practices and there were a number of other significant benefits related to teaching and learning of science and mathematics. In general, mathematics teachers were less likely to claim very significant benefits, although for almost every item 70% of mathematics teachers perceived significant or very significant benefits.

The list in Table 6.3 includes items for which at least 30% of teachers of science or mathematics nominated this to be a very significant benefit. Only two items did not reach this level of benefit – 'support for science understanding' and 'mathematical fluency' strands of the curriculum, and 'opportunity to communicate with other teachers'. The list provides an impressive array of very significant benefits claimed by teachers.

Table 6.3: Teachers' response to—Are any of the following of perceived benefit to you?

Relevant benefit	Science: % very significant benefit (N=132)	Maths: % very significant benefit (N=23)
Enjoyment in working with the scientist/ mathematician	67	39
Increased engagement of my students with science	64	39
Opportunity to communicate with scientist/ mathematician/ mathematicians	59	52
Updating current science/mathematics knowledge	47	35
Updating knowledge of scientific practices/methods	45	30
Increased motivation to teach science/mathematics	40	22
Support for my teaching of the science as a human endeavour strand of the Australian curriculum	36	N/A
Establishes me as a dedicated teacher of science/ mathematics	36	22
Improvements in my teaching practice in science/ mathematics	34	26
Support for my teaching of the science/mathematics inquiry skills/ mathematics reasoning strand of the Australian Curriculum	29	30
Increased awareness of science/mathematics-related careers	19	35
Increased understanding of ways students can learn mathematics	N/A	30

Comments from teachers illustrate the nature of their learning through interaction with scientist partners.

> 'Teachers also benefit from observing science being taught effectively, conducting experiments they can then replicate later on for other classes.' (Science Teacher)

> 'I have increased in confidence and in my understanding of the Science curriculum. It has in turn given me the confidence to run special activities for our students to highlight the fun and learning that Science can provide students. This has had a whole school impact.' (Science Teacher)

> 'My science teaching involves what I dream about for my students and how others help me achieve my goals through creative problem solving. Our students were exposed by our SIS to hover board building and slowly we became proficient enough to developed improvements. We have invested significantly in bringing back animals into classrooms. Our SIS has advised us on materials for innovative stick insect enclosures. We will promote a renaissance in keeping animals in the classroom in 2016 throughout WA once our exquisite animals start breeding. All thanks to the enclosures. Our SIS has advised me on equipment to revolutionise heat activities with students in primary school. We have built the world's first 3D Printed Harmonograph thanks to inspiration from our SIS organisation. Look that one up on Google, the video went viral thanks to 3D Print.com.' (Science Teacher)

Outcomes are also illustrated through the following comments from mathematicians about the benefits of the program for their partner teacher/s.

> '(The partnership) gave the teacher a chance to see students working on different topics and engaging with creative ideas in approaching mathematical tasks. It also gives the teacher a chance to ask questions of a mathematician, if fellow teachers cannot help.' (Mathematician)

> 'I have found most primary teachers have a limited view of mathematics and perhaps feel a little isolated in dealing with maths. It is good for them to see how students can have fun with maths outside the standard curriculum. One teacher commented to me that she now understood it was more about the thinking process and not the particular numbers.' (Mathematician)

While there were a range of perceived very significant benefits from SMiS to do with improved teaching and awareness, the compelling benefits related to the relationship with the STEM professional, and the engagement of students.

Improved confidence is reported as a benefit by 26% of primary teacher partners, but is less significant for secondary teachers.

The outcomes included teachers changing their perspective on what it meant to learn mathematics, and developing understandings of how this could be achieved by observing their students in sessions with the mathematician. Outcomes also flowed from having an expert available to ask questions, to further their mathematical understandings.

Confidence

In previous reports, increase in teacher confidence to teach science was highlighted as a major outcome of the program. This was not so evident from the survey data, with many teachers beginning the partnership already confident with their teaching.

This also showed in comments from teachers of mathematics. Just over 50% of the teachers who commented stated that they were already confident mathematically. Amongst the small number of comments from mathematics teachers though, there were several that recounted how working with the mathematician had raised their awareness of how to engage students in mathematics, and pay attention to students' mathematical thinking. This shows the potential of SMiS in this regard.

> 'A focus away from isolated maths practices to enquiry learning based on mathematical models.' (Mathematics Teacher)

Changes in confidence reported in teachers of mathematics related to specific aspects of the mathematician's expertise in mathematics, or pedagogy associated with increased student autonomy in thinking mathematically.

The question of confidence with science is tied to school level, with primary teachers starting off markedly less confident than their secondary science counterparts, particularly senior secondary teachers. There is a correspondingly greater gain in confidence, with 26% of primary teachers experiencing a gain in confidence, compared to an 8-9% shift for secondary teachers.

> 'I have increased in confidence and in my understanding of the Science curriculum. It has in turn given me the confidence to run special activities for our students to highlight the fun and learning that Science can provide students. This has had a whole school impact.' (Primary Teacher of Science)

Case 4: Patrick and Heather

Patrick reports benefits to himself: '… by sitting with someone outside of teaching' he has observed the difference in how his students ask questions of an outsider … Subsequently he has tried to be 'a bit more open about how I structure my classes'.

Table 6.4: Changes in confidence for teachers of science, by school level

Level of confidence	% Primary N=74		% Junior Secondary N= 23		% Senior Secondary N=24	
	Before	After	Before	After	Before	After
Not confident	9	1	5	5	0	0
Somewhat confident	33	16	5	0	4	0
Confident	40	47	32	29	13	8
Very confident	17	36	59	67	83	92

Benefits for STEM professionals

Perceived 'very significant benefits' were similar for scientists and mathematicians, and focused on enjoyment of the relationships with students, and the chance to promote public understandings and understand public perceptions. Enjoyment of working with teachers was significant but lower than the equivalent benefit claimed by teachers, of enjoyment of working with the STEM professionals. There were many anecdotal stories of strong relations between the partners that grew over time.

Table 6.5: STEM professionals' response to —Are any of the following of perceived benefit to you?

Relevant benefit	Science: % A very significant benefit N=246	Maths: % A very significant benefit N=40
Enjoyment of interacting with students	69.1	72.5
Opportunity to promote public understanding of science/mathematics	57.3	45
Enjoyment of working with the next generation of scientists/mathematicians	55.3	50
Enjoyment of contributing to school of family and/or friends	41.5	30
Increased understanding of the general community's understanding of science/ mathematics	37.4	32.5
Opportunity to promote science/ mathematics-related careers	37.0	42.5
Enjoyment of interacting with teachers	32.5	32.5
Caused me to reflect on my knowledge and skills	30.1	17.5
Improved skills in communicating	28.9	25

Benefits that were not subscribed to were 'providing a fresh perspective on my own work' and 'helping with career development'. 25-30% of STEM professionals claimed a significant benefit in improved communication skills. The following quotes capture some of the diversity of what STEM professionals wrote in relation to benefits:

> 'Stimulation of different ways to present maths for young students of maths. Satisfaction of some achievement in students.' (Mathematician)

> 'After discovering how the lay public misunderstands what the scientist does and that I can help to clarify this, my confidence has increased about the importance of what I do.' (Scientist)

> 'I understand now how to communicate enthusiasm with kids, and appreciate their own enthusiasm in a friend/mentor relationship. I'm trusted and warmly greeted, and I spend time to listen to the kids and share their passion and excitement.' (Scientist)

STEM professionals identify a range of very significant benefits for themselves, arising from the partnerships, particularly in relation to working with students, and promoting public understanding. There are also significant benefits associated with working with partner teachers, and improved understanding and skills.

Claims of very significant benefits for the school community constitute a strong minority theme associated with primary school teachers of science. These relate to raised profile of the subject, and improvements in teaching and learning.

Benefits for the school community

As well as the mainstream benefits for teachers and students or STEM professionals, there were often benefits to the school community. Most partnerships involve one or up to three teachers: but in primary schools we can often see significant numbers of teachers involved. For the primary teacher respondents, the percentages claiming significant benefits for the school community are generally 5-10% higher.

Here again however we see the generally lower values for mathematics. These findings are consistent with the belief that, in primary schools in particular, the science curriculum is less central and assured than the mathematics curriculum, so that issues of profile, attention from leadership, improvement in curriculum and teaching practice are more central for science.

Amongst the comments made were those from partnerships that were including the whole school community in the partnership.

> 'We (STEM partners) also decided to work with … groups of parents coordinating 'Plastic free July' and World Water Day etc. … students would have opportunities to participate at home or in science class and it would go toward a special event or assembly where the Scientist would make a short presentation to the school community to introduce what and why students were involved in activities … We will try to get every opportunity to develop our Science program with the support of both our Scientist and School Principal.' (Science Teacher)

> 'It is rare that a student in Primary school would have access to a Geology program which included the correct identification of rocks, creating a labelled collection and going on fieldtrips to view the different structure of rocks and soil. This program concluded in the students presenting a powerpoint to their parents on their learning.' (Science Teacher)

Mathematics partnerships did not identify the same types of whole community benefits although there were instances where a benefit to the whole school community was identified.

Table 6.6: Teachers;' response to — Are any of the following of perceived benefit to the school community (i.e. staff, students and parents)?

Relevant benefit	Science: % A very significant benefit N=129	Primary Science: % A very significant benefit N=72	Maths: % A very significant benefit N=21
A raised profile of science / mathematics in the school community	49	54	33
Greater attention to science/ mathematics from the school leadership and parents	35	29	24
Ongoing improvements in the school science/mathematics curriculum	33	40	24
Ongoing improvements in science/ mathematics teaching practices in the school.	27	35	19
Greater awareness of contemporary science/ mathematics amongst teachers generally	29	40	29

For a number of ICT partnerships there is a major focus on supporting schools to refine their ICT systems, and/or supporting teacher skills in ICT (see Section 5), beyond working with students on ICT related projects.

Changes resulting from the SMiS partnerships

Teachers were asked to nominate 'the two most significant changes that would not have occurred had you not participated'. Overwhelmingly the teachers of science chose:

- Increase in my students' engagement with science (79% chose this in the top two), and
- Improved learning of science by students (60% chose this in the top two)

Changes identified by teachers of mathematics, using quotes from mathematics teachers (see Student Outcomes Section), focused on student engagement most frequently (74%) but improvement to learning in mathematics was implicit in some comments through a focus on mathematical thinking. Improvements in teacher learning, and teaching, and confidence, featured as one of the two most significant changes for less than 20% for teachers of science, and similarly low for teachers of mathematics. Thus, for teachers the focus of the partnership, and the outcomes, is student engagement in learning, with mathematics teachers identifying more sharply a focus on mathematical thinking.

In responding to a question concerning whether the partnership had changed over time, about 60% of teachers described either 'no change', or 'modification rather than a change in nature'. A sizeable minority however described changes in the nature of the partnership based on changes in either of the STEM professionals' knowledge and skills, and understanding of the school curriculum, or changes in teachers' confidence, in their knowledge and teaching skills, or in the school program. The cases described in section 9 show that, over time, partnerships develop as teachers and STEM professionals learn how to best utilise their respective knowledge and experience to craft meaningful activities for students. Comments from teachers and STEM professionals provide some insight into the nature of these changes. While a number of STEM professionals were critical of the non-generative nature of the partnership, many talked about negotiated change over time that illustrates deepening partnership activities.

> 'The program became more ambitious as a long term monitoring of what started as visits to wetlands.' (Scientist)

> 'The activities have become more focused on student's understanding of mathematics and has become more appropriate to their needs. The sessions are more relaxed as we have all become more comfortable with each other.' (Mathematics Teacher)

> 'Initially we did a range of activities on chance and probability--now we have much more diverse problem solving activities.' (Mathematics Teacher)

> 'As I have developed a better understanding of what "turns on the light" in a primary school child's head, we have modified the content and the way we present.' (Scientist)

> 'Utilisation of my skills has increased, I am now invited and attend planning sessions with teachers, frequently receive emails and advise teachers.' (Scientist)

There are significant changes for many partnerships over time in the nature and quality of activities and collaboration between partners.

7. THE SMiS MODEL AND OPERATION

The key features of the operation of the program

In this section of the report comment will be made on the formation of, the supporting of, and the oversight of partnerships. The evidence upon which the commentary is based has come primarily through interviews with the SMiS team, but also draws on the case study interviews, and the survey data.

Documentation from the SMiS team, and the website, makes it clear that there are a range of well thought through support structures in place, including workshops and networking sessions, regional tours, and school visits. Particularly since the last evaluation in 2011 which called for a 'Stakeholder Engagement Strategy' and associated media plan a number of initiatives have been launched including the conduct of webinars for newly assigned partnerships, engagement through Twitter, creating a presence on LinkedIn, and piloting an online collaborative space. The program has had a presence at teacher conferences and in teacher journals, on the CSIRO blog space, and has been, through its partner network, a major participant in a high profile 2015 National Science Week launch involving 26 members of parliament. The SMiS team in 2014 was awarded the CSIRO Medal of Support Excellence for the delivery of outstanding services to support the delivery of science.

Further, SMiS has established strong links with teacher associations, and has collaborated with the Australian Institute for Teaching and School Leadership (AITSL) to produce illustrations of practice videos featuring partnership teachers, and has negotiated to establish SMiS partnerships as a recognised route to professional learning standards. SMiS has developed strong links with the Australian Curriculum, Assessment and Reporting Authority (ACARA) including participating in the Digital Technologies Curriculum Implementation Group.

When a sample of the SMiS team, key participants in the governance of the program, was interviewed all of those interviewed expressed great enthusiasm for the program and their role in it. They clearly believe that what is happening is most worthwhile for education and they appreciate the opportunity to contribute to the program's success. Further they expressed confidence in the leadership of the program and the opportunity given to them to contribute ideas to the planning and management processes.

> 'I think that our model of operation is actually something that a lot of other people can learn from.' SMiS Team Member PO130)

There is clear support amongst those most directly involved in the operation of the SMiS model for continuation of the model. They also expressed ideas that could contribute to its refinement.

The formation of partnerships

The formation of partnerships is a crucial activity since the model for the program is for the development of an ongoing, productive partnership between a STEM professional and a teacher, with the understanding that the nature of the joint activity will be determined by the partners themselves.

Currently this matching is done primarily by the Regional Project Officers, and would appear to be one of their major activities. They are assisted in the areas of Mathematics and ICT by the National Co-ordinators for these areas. The information on which the SMiS team operates for this activity, in most cases, is the data supplied by the teacher on the area of the discipline in which they would like the STEM professional to operate, e.g. physics, the level of schooling at which the teacher is operating, and the location of the school. Matching data is obtained from the STEM professional. Location is significant as funds for travel are limited and travel time can add significantly to the commitment required from the STEM professional. On this last point modern communication technology has been used in some instances to overcome the issue of distance.

'We just happened to have this Scientist who had registered … want(ing) a long distance

Case 7: Just what we were looking for

'Flynn Primary School is a small rural primary school about 2 hours (200km) drive from a large city. The school has thirty-one students and two full-time staff who work in multi-age grades (F-2, 3-6). One of the teachers is also the principal, but has a significant teaching load. In addition, they have a specialist staff member who teaches all children science on one day each week. As part of her role, the science specialist wanted the children in grades 3-6 to see science in a broader context, so she registered with the SMiS program, requesting to be matched with someone with a biology background. A partnership was made with a molecular biologist from a capital city around 1200kms away.

The partnership occurred in term 1, 2014 and consisted of preliminary email interchanges between the scientist and the science specialist to set up the times and other logistical arrangements. There were four sessions, conducted through an online video system, where the children were introduced to the scientist and he explained his work and showed them around his laboratory. At each session, he would explain something and have the children undertake experiments in-between his online visits.'

partnership. So this (scientist) has gone over to Africa and she's over there for 6 or 9 months studying giraffes. Prior to leaving and the school gave her a little toy giraffe which she takes photos of and sends to their Dropbox of all their adventures and then … they did activities around World Giraffe Day and she Skypes in and does all sorts of stuff. So that's been a really successful partnership and they are both super enthusiastic. The Teacher just loves everything that the Scientist does and the Scientist just loves doing everything.' (SMiS Team Member PO130)

The data gathering revealed that the Regional Project Officers did use both local knowledge and additional information supplied by either party to supplement the standard information. For example, there are STEM professionals working, as a result of their request, in the schools of friends or family members.

The views of the SMiS participants on all aspects the matching process were sought through the survey of participants. Generally these data indicate satisfaction with all aspects of this process.

'The Getting Started support primarily by e-mail- it was prompt, appropriate and easily followed.' (Survey Comment from STEM Professional)

However, in the light of the complexity of what is being asked of the participants, as argued above, there were some who were critical in the face of challenges. The quote below from a scientist suggests that the partnering teacher did not appreciate the importance of negotiating the arrangements.

'I felt I had inadequate knowledge of exactly what was required of me.' (Survey Comment from Scientist)

Case 2: An outward facing school

'She (a teacher, Alice) had previous experience working in the SMiS program.

Serendipitously, a parent approached Alice and informed her that she had "just" registered as a scientist in the SMiS program. The parent, named Kelly, works in nuclear medicine. Kelly contacted the SMiS team and a match was made.

Alice was delighted to have a female scientist to dispel the students' stereotypical notion of scientists being male. Alice found Kelly personable, enthusiastic and willing to contribute to the planning of the partnership program. Kelly's role as an interested parent and partner scientist created a unique opportunity for the partnership.'

The challenge facing the SMiS team in facilitating such an arrangement should not be underestimated. Researchers (Cripps Clark et al, 2014) have drawn attention to the fact that this process brings together two people from very different work environments, each with its own distinctive practices, who then need to discover ways of working collaboratively. The interviews with the SMiS team members pointed to the fact that the initial phase of successful partnerships depended upon the two parties becoming aware of one another's expectations, availability and so on.

> 'I also think another aspect of a successful partnership is just building an appreciation of the requirements that each other has in their careers.' (SMiS Team Member PO230)

> 'I think, for both pieces of that partnership it's about the openness and willingness to communicate first and foremost. Even the teachers that I've spoken to that weren't really sure what they were going to be doing, or what the STEM Professional was going to be able to do, through the conversation they've obviously both learnt about each other, and they find the spot that suits both, and whether that's taking a session with a few students or just talking to the staff in their staffroom it's really about how they communicate with others and how they can then come up with something together, so that's the really – once again I'll use the word powerful, I think that's the powerful part.' (SMiS Team Member PO103)

There is strong support for these statements from the survey data. Table 7.1 presents the response of the science teachers and the participating scientists to the question: "In your view, how important are the following factors in determining a successful partnership in the SMiS program?". 'Effective communication and negotiation between the partners' are seen as much more important than other alternatives offered such as 'Flexibility of timetabling arrangements', 'The demands of the curriculum', and 'Support from CSIRO SMiS Project Officers'.

The key factors leading to successful and sustainable partnerships are the strength of the relationship built between the STEM professional and teacher, and a commitment to working collaboratively that lends flexibility to partnership arrangements.

Table 7.1: Alternatives most frequently chosen in response to the question in the survey: In your view, how important are the following factors in determining a successful partnership in the SMiS program?"

Alternatives offered:	% Very important (Science teacher)	% Very important (Scientist)
Communication between the scientist and partner teacher	88	82
Ability of the scientist to translate his or her knowledge to engage students	83	78
Alignment of goals between the scientist and teacher	77	71
Matching the scientist and school/teacher appropriately	76	54
Rapport between teachers and the scientist	65	64
Opportunity and willingness of teachers and scientist to jointly plan activities	64	65

The oversight and support of partnerships

The primary means of oversight is that the Regional Project Officers contact the partners six weeks after the primary introductions have been made and continue to follow up until partnerships are active. Additionally there is a check after 12 months on the state of health of the partnership. There are, however, processes and activities designed to support the partnerships. For example the Regional Project Officers run networking sessions to which participants, both STEM professionals and teachers, can participate and share experiences and expertise.

> 'I do … run networking events and it's, you know I get a good core of people who come along to those, mine are really well attended and they're great fun.' (SMiS Team Member PO130)

However, the number of 'not applicable' responses to the question in the survey (see Table 7.2) asking respondents to rate the significance of SMiS components to keeping the partnership active suggest that for various reasons these resources are not used by many of the participants.

There are many reasons for this failure to utilise support mechanisms for example a full work schedule can mean that SMiS partners, while aware of the opportunities, are not able to take advantage of these support measures. Access to support mechanisms is difficult for dispersed and rural partnerships.

> 'She had not attended an induction program and had not been able to participate in any of the program networking events due to other commitments.' (Case 1)

The governance of the SMiS program is well designed with many support structures in place that are appreciated by both teachers and STEM professionals. In particular the work of the SMiS project team is appreciated by partners. The evidence suggests that the role of the SMiS Project Officers as a local point of contact with the program is quite significant.

Table 7.2: Responses to: Please rate the SMiS components: staying active

SMiS support mechanism	Teachers of science responses: % Not applicable	Scientists' responses: % Not Applicable
Networking sessions or workshops	43	39
EMPHASiS Newsletter	46	36
Showcases	56	60
Recognition events (e.g. End of Year Celebration)	54	55
SMiS Partnership specific social media	62	64
Online resources	48	36
Webinars	71	69
Visit by local SMiS Project Officer	59	62
Congratulatory emails or letters	43	35
Ongoing partnership support by SMiS Project Officers	26	22

While the initial support structures around setting up partnerships are generally well regarded, many aspects of the SMiS components are not accessed by participants. Consideration should be given to finding ways to make these more visible and appropriate for each of the partners.

The strengths of the model

As has been reported earlier, the SMiS model is a unique means of engaging STEM professionals in school programs. The flexibility it allows teachers and their partners to develop arrangements which maximise the contribution that can be made to the educational program means that the formation and support of partnerships is critical to the program's success. The data point to some great successes in this regard and to some of the challenges faced.

It could be expected that a simple guide to the success of the matching process would be to consider the ratio of matches that are terminated at an early stage to those that proceed successfully. However, the data gathered in this study show that in such a large scale operation matches are terminated for a great variety of reasons, such as changes in either partner's employment, so that it was not possible to gather any reliable quantitative data on the success of the matching process.

There are numerous instances where the SMiS model, involving a negotiated partnership between a teacher and STEM professional, has been highly generative in supporting a variety of high quality experiences for students, teachers, and STEM professionals.

One indirect indicator of success is the number of partnerships that continue over time, sometimes over some years. For teachers responding to the survey, there was a spread in terms of how long the partnership had been operating, with a mode of 3-4 years and 56% between 1 and 4 years. The STEM professionals' partnership length was slightly less but broadly commensurate. These statistics speak well of the processes employed to form and support partnerships.

The opportunity to continue on over a number of years is a very significant, if not unique in Australia, strength of the SMiS program. The survey data provided insight into ways in which programs have developed over time as the partners grow in their grasp of the understandings and experience upon which the partnership could draw and the needs of the school program.

Although there is no data available to test the model within a quantitative framework, there is ample qualitative evidence that in many cases the potential of the model is being realised; where the two professionals together plan a program which will assist in the realisation of its goals. The Regional Project Officers were able to cite instances where the program is fulfilling its promise.

> 'I'm just thinking of one school where the scientist was in partnership with a number of teachers at the school, it was a small school. And this school has turned around what they do every week to include a science day every week and those students are just so engaged in science, this is a school in a very, very rural area where you know it's generations of farmers that have not gone on to tertiary education. I am willing to bet that in a few years' time when those, the students who first started in that partnership are making

Case 4: A mathematical approach

The partner-mathematician, Heather, has visited the school twice since the partnership began less than 12 months ago. She has addressed the year 12 students speaking about, among other things, how mathematics works in her area of employment (astrophysics), and how it is such a big part of getting any job. When Patrick spoke with these students afterwards he noted that this latter point resonated most with them. Patrick hopes that this message might be communicated to all students in the future.

Heather has also spent time with the students in year 8 and 9 speaking about how mathematics relates to astrophysics. Patrick was 'blown away' by the impact Heather has had on the students so far and has begun planning with Heather to facilitate a project for the year 8 and 9 accelerated students with a focus on the mathematics involved in astrophysics. Some students have also requested that they have one-on-one time with Heather to discuss her area of expertise.

Other teachers in the school have been inspired and requested that Patrick 'share' Heather with them. He anticipates that this will also happen as the partnership continues.

their career choices, those students are going to go on and study science at uni. And I'm certain it's because of that particular partnership and because of the … that that professional has given that school.

And you know I've often … that I wish I could get an honours student to actually go and do like a social science study of that school and the area in which it is, to see what those students have as their career choices as they go on through school, because I honestly believe that scientists are going to come from that community where they've not ever come from before.' (SMiS Team Member PO230)

Similar positive testimony can be found in the survey responses for teachers and STEM professionals.

The challenges of the model

Attention has already been made to one significant challenge to the program, the requirement that two people from different work communities with their distinctive practices work together in the school environment. There are however a number of other challenges to the effective use of the model. One of these has been the introduction of the additional disciplines of mathematics and ICT. The survey data included reports of very successful partnerships in these fields.

> 'Our partnership has had wonderful outcomes for students and teachers alike. Our partnered mathematician has published a paper about the unit of work on chance we completed on chance in Prime Number. Our students also benefited from visiting La Trobe University to see our partner and experience what a maths lecture is like. We toured the campus and discussed pathways for attending university and career pathways as well as having an authentic science experience. The profile of our school was raised in the local press though articles published about our work and school staff were really enthused to follow up work that we worked on as a part of the ongoing collaboration.' (Survey Comment from Mathematics Teacher)

> 'Patrick feels that he has benefitted in that "it is wonderful to work with someone like Heather", by sitting with someone outside of teaching he has observed the difference in how his students ask questions of an outsider, compared to when they ask questions of him, their teacher. Subsequently he has tried to be "a bit more open about how I structure my classes.' (Case 4)

However, some of the data brought to light the fact that the application of the model to these areas is not without its problems. For example, there were indications that initially many teachers were not sure, partly due to their own lack of knowledge of the roles that mathematicians and ICT Professionals play in industry, in what ways a mathematician or ICT professional could contribute to the program they were offering at their school.

> 'I do find that once Mathematicians in Schools partnerships establish themselves, they're generally ongoing and very productive and successful. But it can be really difficult to convince a teacher especially as to why (a MiS partnership) is a good idea and how it might work.' (SMiS Team Member PO230)

A challenge which runs across all of the different areas is that posed by a change in the circumstances of either of the parties, for example if one of the parties moved to a different place of employment. One example of this challenge can be found in Case 1. However in this instance the situation was redeemed by the STEM Professional who took the initiative and maintained the link with the school.

> 'At the end of 2014 the partner teacher left the school but she (the scientist) was not informed. However she took the initiative and contacted the school who put her in touch with the new teacher, a younger person. That teacher was responsive to the idea and has been supportive, as has the Deputy Principal of the school. The new partner/teacher was described by Thelma (the scientist) as more hands on and has done a lot of organising for the science week program.' (Case 1)

The existence of a substantial minority of partnerships that terminate indicate a need to look closely at ways of supporting partnerships in the early stages through a combination of management of role expectations, and targeted support.

A further challenge to the success of the model arises if the information provided by the potential partners is not sufficient to allow an appropriate match to be made. In one of the case studies the teacher interviewed, while delighted by the success of the partnership in which he was currently involved, pointed to an initial proposed matching which would not have provided the person with the expertise to be able to fill the role he had in mind in the school.

Critical factors determining the success of partnerships

What emerged most clearly from the interviews with the SMiS team was the importance of the teachers and the STEM Professionals being enthusiastic, having a clear idea of what the possibilities of the partnership might be, respecting each other, understanding each other's expectations and limitations, and planning together in determining the success or otherwise of partnership. Overall what is striking in all of the data collected is the enthusiasm and openness of most people volunteering for the program. There were of course a few exceptions. There were those who clearly were unsuited or lacked enthusiasm or suitable understandings for a genuine partnership.

> 'My Mathematician was very boring and had few ideas, … we all slowly lost interest, … He just volunteered to look good on his resume.' (Survey Comment from Mathematics Teacher)

> 'The partner school expected me to come up with the entire format … that we were going to work on together, that there would be no input from them. So, while I didn't mind putting my time in, I wasn't prepared to do so with no input from them.' (Survey Comment from STEM Professional)

However, they contrasted this with examples where there was joint planning, a situation which they reported was normally much more successful.

> 'I also think another aspect of a successful partnership is just building an appreciation of the requirements that each other has in their careers.' (SMiS Team Member PO230)

> 'George notes the need for the partners (teacher and scientist) to be sensitive to each other's skills, have sensitive communication skills, and the need for flexibility. Each school manages their partnerships with him in a different way; he acknowledges that an awareness of this is helpful for a successful partnership.' (Case 6)

> 'This active partnership began in term 1 2014. The scientist, called Kelly works part time and was flexible with timing. She was willing to volunteer for 2 hours per week.

Initially, Kelly and Alice met every fortnight, for quite a few weeks to discuss how Kelly could be best utilised in the school. These conversations were important in establishing the scientist's interest and skills, orientating the scientist into the school and gaining an understanding of each partner's objectives.' (Case 2)

The field in which the STEM Professional works can in some instances have a bearing on the success of the partnership. The SMiS team members were able to recount stories of instances where the work in which the scientist was engaged was a topic which could be readily understood and appreciated by the students.

'An expert in honey possums this scientist, and she wanted to … develop a unit of work in biology. And so … we partnered her with a primary school teacher and the two of them work together now to develop this lovely unit of work all about honey possums and actually about the web of life, the interconnectedness of everything, so now there's this unit of work that this scientist can actually take to any primary school class and she now has several partnerships where she goes in and she runs this unit of work with the students and they go out and have a look at what happens in, what's out in their environment in their local environment and then they bring it back, they bring samples back into the classroom and then they build these diorama type things where they've got and then they interconnect everything with string….. So it's a fabulous unit of work that they developed and that then is now transportable to other schools and other schools can use it and those teachers get trained up in it and it's really cool, yeah.' (SMiS Team Member PO125)

Possible changes to operational processes

There were several suggestions proposed for changes which some of the SMiS team believe could have a positive impact on the program. These are raised here for consideration.

One of these arose from discussion of the workload involved in matching which was described as a 'labour intensive task'. A proposal made by some was that the matching could be done by the people themselves. The analogy used was to a dating website where the relevant information about the STEM professionals offering their services and the teacher and school could be detailed and the potential partners propose a partnership based on the available information. This, it was argued, could reduce the time the Regional Project Officers spend on this task, freeing them to spend more time on the other aspects of their work: recruiting professionals and assisting with existing partnerships.

'I thought of ways in which why don't we just get everybody to register on-line, have their bio's on-line and they self match. Why are we involved in the matching?' (SMiS Team Member PO125)

Further, attention was drawn to the requirement that the Project Officers should follow up partnerships after 6 weeks then again after 12 months.

'A big thing I see as an improvement is to free up the project officers to be more face-to-face communicators, rather than doing those, for one example, and this is a known situation that the follow-up aspect of their jobs, either by email or phone they're told to do it at certain times of the year or when

> a partnership is of a certain age, and I think they are amazing people, and sitting behind a computer or a phone is not utilising their talents as well as they could be.' (SMiS Team Member PO103)

A further suggestion was that partnerships should be made between the STEM professionals and the school, rather than with the individual teacher. This, it was argued, would enable programs to continue when teachers moved schools. The present arrangements mean that the momentum for the program in the school is lost unless another teacher at the school applies to enter into the scheme, an alternative that involves further work for the Project Officers.

> 'it's very labour intensive and I think it needs to be streamlined a bit or we need to think of some new models to, to make it like I say, in one professional perhaps joined with multiple people at the school to ensure that if one leaves it, it doesn't automatically collapse because that's a lot of work involved then if, the, if the partnership breaks up then SMiS … have got to come in and, and work to recreate partnerships for both people. Whereas if there was a structure in place to, to let it automatically keep going that would be a big labour saving which means the SMiS … could be working on establishing new partnerships and ...' (SMiS Team Member PO203)

We have seen that this extension of partnerships beyond the individual teacher is more common with primary than with secondary schools.

A suggestion made with regard to supporting recruitment of STEM professionals was that the Project Officers should report back to the organisations from which the volunteer professionals come.

> 'I think there is going to have to be a bit of a change in ... who recruits those people and ... how we respond to the needs of those organisations about what they want to know about..., what their reporting requirements are from us and for themselves.' (SMiS Team Member PO230)

It should be noted that this is currently done on a coordinated national basis. Finally, it has been suggested that there should be consideration of a shift in the focus of Regional Project Officers away from recruiting ever increasing numbers of partnerships to free up time for greater consideration being given to assisting the existing partnerships.

> 'Are we better to have a smaller number of really good partnerships that are really doing the job well rather than having a Scientist in every school….. So perhaps we need to look at how we're measuring success as well because in the past it certainly has come down to numbers. How many partnerships do we have and while we're doing a much better job at making sure that they're good partnerships ...' (SMiS Team Member PO130)

Of course, the two activities need not be in competition providing sufficient funding is available to support both activities.

These suggestions are based in considerable experience of the operation of the program but not necessarily on experience of the alternatives being suggested. A major theme coming through is that there would be benefits in streamlining processes to allow more time for partnership support. This is echoed in a number of survey comments from teachers and STEM professionals that they would have appreciated more support from the team. These suggestions point to a need for the SMiS team to think carefully about optimising processes to ensure targeted support for partnerships in the early stages to form, and to prosper.

Reflections on the model

The data gathered in this evaluation, in earlier evaluations and in other research point to some outstanding partnerships arising from application of the SMiS model in which a STEM professional and teacher are brought together to form a partnership to enhance the students' science, mathematics, or ICT experience. One critical factor in a productive SMiS partnership will obviously be the expertise that the STEM professional can bring to the partnership and the relevance that it has to the school curriculum. An analysis of the case studies presented on the SMiS website indicates an awareness within the team of this issue. The case studies show how various sets of partners have developed programs which draw on the expertise the STEM professional brings to the school. Perhaps however, there is still a need for more assistance in this regard in some partnerships.

> 'Perhaps some local contacts from successful partnerships to gain ideas of what to do to assist the school, what activities I could potentially do etc.' (Survey Comment from STEM Professional)

A second factor is the matching of the potential partners. The data gathered in this study shows that a great deal of the human resources of the project is directed to this task. The information upon which those making the match draw is primarily the curriculum area which the teacher has identified, the matching information from the STEM Professional, and the location of both parties. These are important steps toward a successful match but in no way guarantee that a productive relationship will ensue. It would be useful to ask what other information and activity would increase the success rate of the matching exercise.

The findings of this evaluation support the findings of previous research that it is important to recognise that a successful partnership depends upon the partners bridging barriers arising from the different operating practices in schools and the scientific world. It is important that the SMiS team recognise this aspect of partnership formation and provide appropriate support to newly established partnerships.

There is however a third factor to which attention needs to be given. That is the background which the potential partners bring to the challenge of understanding one another's expertise and work practices. It is clear that in some partnerships this issue is not addressed.

> 'This is very difficult to generalise; each teacher-scientist partnership will be different. I have had partnerships which were extremely successful; others where the teacher assumed they were getting a "free teacher", or once, a "free research assistant", rather than a "science mentor.' (Survey Comment from STEM Professional)

'I think it could be useful to ensure that new participants (scientists and mathematicians) have an understanding of how schools operate with regards to the focus on teaching within the curriculum and that there may be a need for the activities to fit in with the curriculum at least initially.' (Survey Comment from Teacher)

'More advice/assistance is the very early stage of the partnership. Maybe an assisted discussion with teacher and scientist to encourage ideas of what things they might do with the students etc.' (Survey Comment from STEM Professional)

That some of the SMiS participants are aware of this issue as can be seen in the comment made by one scientist in the survey:

'I think the key function of SMiS is to match scientists to schools, and then to gently encourage these relationships. This is already great, but to go to the next level SMiS would need to (i) provide some in-depth online material for scientists on effective teaching strategies for different age-groups (after which we might prefer to let the teachers handle that!) and (ii) to actively collect detailed, curriculum-linked activity ideas from us and provide them in a

The matching of partners is a very labour intensive operation that takes a lot of the time of the SMiS team, away from support of partnerships and recruiting. This raises issues, in the absence of increased funding, about the balance between quantity and quality of partnerships.The SMiS team needs to consider how to make this matching aspect of the program more effective through ideas such as:

a. Generating targeted advice to potential and assigned partners as to expectations of their respective roles and the benefits that flow from effective collaboration

b. Identifying information from potential partners, both teachers and STEM professionals, which would enhance the prospect of matching for a successful partnership?

c. Conducting a trial, initially on a small scale, where such information is used to support teachers and STEM professional to suggest, or even arrange, their own partnership.

d. Investing resources in developing support materials and processes that would effectively and efficiently support partnerships in the beginning phase.

convenient searchable web format. I haven't seen the teacher side of the SMiS interaction, but SMiS might like to link in to the teacher professional development stream and develop one-day "working with SMiS" training courses, or at least contribute to a unit in the science professional development stream.' (Survey Comment from Teacher)

To provide every possible support in the early phases of a partnership is very important since, as was stated earlier, one of the great strengths of the SMiS model is the potential it provides for lengthy partnerships where the partners learn from their experiences and over time build a highly productive program.

8. PERFORMANCE EVALUATION

Introduction

In evaluating the SMiS program an important question is whether its outcomes represent a good return on the government funds invested.

A conventional cost-benefit approach is not appropriate in evaluating a program like SMiS as the outcomes and flow-on impacts are not easily quantified in monetary terms. The approach we have adopted is an analysis of the program in terms of its components, identification, and to the extent possible, quantification of the outcomes. A combined quantitative and qualitative approach to the return on investment is used, with reference to the efficiency and effectiveness of the program. (Refer Performance Evaluation Framework Figure 2.2). The cost efficiency of the program in delivering its outputs and its effectiveness in achieving its intended outcomes are analysed.

We also address the broader, longer-term impacts and the impact pathway distinctive to the SMiS program. The counterfactual situation – the situation which might exist in the absence of the SMiS program – is also canvassed.

Analytical Framework

In considering the return on investment we adopt the terminology of the Kellogg Evaluation Logic Model (Figure 2.1) namely inputs, activities, outputs, outcomes and impacts. In Table 8.1 the relevant aspects of the SMiS program for each of these component categories are summarised.

Table 8.1 Inputs, activities, outputs, outcomes and impacts of the SMiS program

	SMiS program
Inputs	Australian Government Department of Education and Training funding CSIRO funding Volunteered services of STEM professionals Collaborating schools and teachers
Activities	SMiS program team, including • national coordination and relationship management • working with Vulnerable People Check support • finding suitable matches between teachers and volunteer STEM professionals and establishing partnerships • supporting and maintaining established partnerships • network meetings and support
Outputs	Partnerships between teachers and STEM professionals
Outcomes	Engagement among STEM professionals, students and teachers across Australia which leads to: • For students: changes in attitude towards STEM; identification of STEM professionals as role models; increased awareness of STEM careers • For teachers : increased enthusiasm for STEM teaching and learning; strengthened teaching of STEM subjects; increased knowledge of current STEM practices; increased awareness of STEM career paths • For STEM professionals: increased commitment to communication of STEM to teachers, students and more broadly; increased understanding of community perceptions of science; sharing ideas and practices across community of teachers and STEM professionals • For schools and the community: sharing of ideas and practices across community of teachers and STEM professionals; curriculum benefits for participating schools and education system
Impacts	Longer term, indirect changes attributable to the program, e.g. • Innovation and human capital (an improved capacity to contribute to invention and creativity and productive wealth embodied in higher skilled and more knowledgeable workforce) • Access to resources, services and opportunities (access to new or improved knowledge and participation in economic and social life) • Quality of life (degree of wealth and material comfort available)

Inputs

Funding for the SMiS program in 2014/2015, annualised across the 2012-2016 funding quadrennium, was $2.125 million, which accounts for the costs of program administration by CSIRO.

The $8.5 million funding for the 2012-2016 quadrennium was derived from the Australian Government Department of Education and Training (86%) and CSIRO (14%). Cumulative funding of the program since 2007 is approximately $13million in total.

Other important inputs to the program are not costed in this analysis. CSIRO brings other valuable but non-costed inputs to the program, notably its strong national brand as Australia's largest research institution and access to a well-developed science education and communication network reaching into primary and secondary schools across Australia. In addition the program draws on the time and efforts volunteered by highly qualified and experienced STEM professionals, drawn from public sector organisations, universities and industry. For this evaluation, the participation in the SMiS program by schools, teachers and students is not separately costed; this is taken to be part of the education program within the schools.

Activities

The SMiS program is administered by a team in the CSIRO Education Unit headquartered in Canberra with additional locations at CSIRO offices in the different states. This team provides national coordination, finds suitable matches between teachers and volunteer STEM professionals and establishes and supports partnerships through a variety of processes.

Outputs

The outputs of the program are the 1:1 partnerships between teachers and STEM professionals, which take a take a variety of forms across the three delivery areas – science, mathematics and ICT.

In June 2015 there were 1799 current active and assigned partnerships in 1263 schools across Australia, involving 1515 teachers and 1424 STEM professionals. The cumulative total of partnerships created by the program since its inception in 2007 exceeds 4500.

The net output of the program is a complex portfolio of partnerships across Australia covering science, mathematics and ICT. The portfolio is balanced in respect of the different states and territories, between primary and secondary level schooling, between government, independent and catholic schools, and between schools in rural and urban areas.

Outcomes

The outcomes are the changes in behaviour or performance resulting from the program for students, and participating teachers and STEM professionals. In addition there are potential benefits for the schools and community arising from the program.

It is useful to frame the observed changes within the outcomes intended for the program as set out in its aims. The aims of the SMiS program are set out in Table 8.2. The corresponding intended outcomes for students, teachers, STEM professionals and Schools and the community are provided in Table 8.3.

Table 8.2 SMiS program aims

1. Bring the practice of real world science, mathematics, and ICT professions to students and teachers
2. Inspire and motivate teachers and students in the teaching and learning of science, mathematics, and ICT;
3. Provide teachers with the opportunity to strengthen their knowledge of current scientific practice, mathematical and ICT applications;
4. Enable scientists, mathematicians and ICT professionals to act as mentors or role models for students;
5. Broaden awareness of the types and variety of careers available within the science, mathematics, and ICT fields;
6. Enable teachers, scientists, mathematicians, and ICT professionals to share ideas and practices with other teachers, scientists, mathematicians and ICT professionals;
7. Increase scientists', mathematicians' and ICT professionals' engagement with the broader community, thus raising public awareness of their work and its social and economic importance.

Impacts

The impacts are the longer term flow-on outcomes of the SMiS program, attributable to the success of the program in broadening the participation of Australian students in STEM subjects and lifting their performance. While undoubtedly important the indirect benefits of education initiatives such as the SMiS program are often difficult to attribute, and potentially include economic, environmental, and social changes.

We draw on the CSIRO Impact Categories Refinement Project (CSIRO, 2015) to identify several categories of impacts most applicable to the SMiS program namely innovation and human capital, access to resources, services and opportunities, and quality of life. SMiS, and other STEM outreach programs, exercise a positive influence on the future technology and innovation capabilities of the country, and in the use and management of knowledge to contribute to national development and the improvement of daily life.

On one hand there is the challenge of attributing the contribution of STEM outreach programs to these wider impacts, beyond what would have been achieved in their absence. The other challenge, which is more tractable, is identifying the particular role of the SMiS program within the range of current STEM outreach activities, and its distinctive contribution to Australian STEM education.

Table 8.3 Intended outcomes of SMiS program, by target groups

SMiS aim	Students	Teachers	STEM Prof-essionals	Schools & community
1	Exposure to STEM professionals and real world STEM practices	Exposure to STEM professionals and real world STEM practices		
2	Increased enthusiasm for STEM learning	Increased enthusiasm for STEM teaching		
3		Strengthened STEM knowledge and practice		
4	Identification of STEM professionals as role models		Opportunity to act as mentor/role models	
5	Improved STEM career awareness	Improved STEM career awareness		
6		Sharing of ideas and practices across community of teachers and STEM professionals	Sharing of ideas and practices across community of teachers and STEM professionals	Sharing of ideas and practices across community of teachers and STEM professionals
7			Increased STEM professional engagement with schools and broader community	Increased STEM professional engagement with schools and broader community

Evaluation of outcomes

In evaluating the outcomes several questions are relevant:

- What is the extent of the activities generated by the SMiS program?
- What are the observed outcomes of the program in terms of changes for students, teachers and STEM professionals and how significant have these been?
- Can the value of the program be quantified?

These are considered in turn below.

STEM Interactions generated by the program

Table 8.4 shows that in 2014/15 an estimated 55 000 to 65 000 students were involved in the SMiS program, with an estimated total of 326 000 student-STEM professional interactions in the 1700 partnerships estimated to be active in June 2015. This included an estimated 23 000 hours of STEM professional time with students as individuals and in small groups. On average it is estimated that in each of these 1700 partnerships the STEM professional dedicates about 29 hours per year. This includes interaction with students but also meetings with partner teachers and with other teaching staff in the participating schools. A further 12.5 hours is spent in planning. An equivalent amount of time – 29 hours – can be taken as the time dedicated to the partnership by the partner teacher, an estimate that does not include time spent by other teachers in small group planning with the STEM professional.

For example, the program leverages a considerable resource in the time contributed by STEM professionals, which is revealed by Table 5.5 to be approximately 25 hours per year in the school, and 12 hours planning time. This figure is likely to underestimate rather than over-estimate the time commitments as it does not include travel time or ancillary related activities. This equates, at a program-wide level, to a total number of hours volunteered in excess of 60 000 hours each year. This represents over 40 years input from an expert highly qualified group of professionals. Having regard to STEM professional salaries and overheads this is equivalent to an input to teaching in excess of $6m per year.

Observed outcomes

The 2015 survey of teachers and STEM professionals provides a measure of the outcomes of the SMiS program. Table 8.5 lists the intended outcomes and their ranking by importance by survey respondents.

Students

Table 8.5 shows that the program, as judged by participating teachers and STEM professionals, has secured impressive changes in all of its areas of intended outcomes for students. These include increased awareness of STEM and an increased appreciation of STEM professionals as people with particular ways of thinking and working. Other changes, such as students' increased enjoyment and interest in science and mathematics, increased knowledge of contemporary STEM ideas, and awareness of how these relate to themselves, their world and their potential careers. Another important outcome observed is increased student self-

Table 8.4 Interactions generated by the SMiS program, per year

Number of students in the SMiS program	The 2012 review of the SMiS program review calculated that between 42 000 and 50 000 students were involved in the program in 2011. The broad pattern of partnerships and level of interactions has prevailed since that time and a corresponding estimate based on an increase of partnerships from 1310 in 2011 to 1700 today an updated estimate of the number of students involved would be 55 000 to 65 000.
Number of student -STEM professional interactions	Data from the survey (Table 5.4) which shows the number of interactions per partnership is 192; scaling for the number of partnerships yields a total of 326 000 interactions per year.
Interactions of STEM professionals with subgroups of students and individual students.	In addition to classroom teaching the SMiS program enables STEM professionals to be involved in projects or special activities within the class. The survey of STEM professionals (Table 5.5) showed that they spent an average of 20.5 hours per year interacting with students. On average (teacher estimates) STEM professionals spent about 4.5 hours working with individual students, 4.5 hours working with small groups independent of a class and 4.5 hours working with small groups within a class – 13.5 hours in all or just under half the time spent in the partnership, consistent with scientist estimates. Taken across the full set of partnerships this represents about 23 000 hours of individual attention afforded through the SMiS program to aspiring scientists, mathematicians and ICT professionals.
Teacher interactions with STEM professionals	Teacher involvement in partnerships, on average 29 hours per year, was spent in planning meetings sometimes jointly with other teachers, and as a participant in the teaching activities delivered by the STEM professional. These meetings, working together and observing student interactions with STEM professionals can be regarded as good professional development for the teacher.
Time contributed by STEM professionals	As reported by STEM professionals (Table 5.5) about 37 hours per year is contributed to the SMiS program – 24.7 hours in direct interaction and 12.5 hours planning. This does not include travel time or ancillary related activities. In addition to interactions with student and partner teachers. STEM professionals also engaged with the school through meetings with principals and with other teachers. On average these occurred about 8 times (Table 5.4) and totalled about 3.2 hours per year (Table 5.5)

confidence and ability to inquire and problem solve.

The value of these outcomes is bolstered by reference to the policy directions in Australia around STEM occasioned by widely expressed concern about engagement and learning of students; new curriculum directions in science and mathematics in Australia, and the research literature around learning and engagement, and student aspirations with regard to STEM.

For example an increased awareness of STEM work and appreciation of STEM professionals as people with particular ways of thinking and working is consistent with considerable literature around identity as a key driver for eventual student choice of STEM careers and appreciation of the basis of science (see Tytler & Osborne, 2013; Tytler, 2014 for reviews), and supports policy direction of making school science and mathematics more relevant and contemporary. It also supports the Australian Science Curriculum 'Science as a Human Endeavour' strand.

In addition the observed improvements in student self-confidence and ability to inquire and problem solve, is supported by the scientific literacy and 21st century skills aims in contemporary curriculum writing, by the policy direction of producing a population with enhanced problem solving and higher order thinking skills, and by the Inquiry Skills and Reasoning strands in the Australian Science and Mathematics Curricula and the Processes and Production Skills digital technologies strand.

Teachers

The SMiS partnerships were judged to be very valuable by a high percentage of teachers surveyed in terms of working and communicating with STEM professionals, leading to increased inspiration and motivation for STEM teaching and engagement of their students, and the updating of current science knowledge and knowledge of science practices and methods. For teachers of science this is a significant and valuable outcome given the concern expressed over many years about the need to update teachers' knowledge of contemporary science ideas and practices, and represent these in their classroom approaches (Osborne & Dillon, 2008; Tytler, 2007).

A finding of the survey was a distinct increase in teaching and communicating science notably for primary level teachers with a growth in numbers who were 'confident' or 'very confident' from 57% to 83%. This is a significant and valuable outcome given longstanding policy concerns with primary teachers' competence and confidence with teaching science (Tytler & Darby, 2009).

STEM professionals

The survey shows the program to have been very successful in its aim of increasing STEM professional engagement within the broader community. This is reflected in survey data on benefits relating to working with students, promoting public understanding of science and working with the next generation of scientists. These benefits underline the altruistic component in the contribution by the STEM professionals, wider social dimension of their volunteering efforts.

School and community

In addition to these outcomes directly canvassed and expressed by survey respondents, there is a valuable system-level outcome attaching to the fact that these individual partner outcomes are occurring for 1700 partnerships scattered across Australia. At this level of effect, it could be argued that the SMiS program must inevitably produce feedback effects on curriculum and policy simply by the weight of numbers expressing a significant curriculum innovation. The fact that there are at least 1400 teachers and that number of STEM professionals across the country with between one-third and two-thirds describing each substantial outcome as 'a very significant benefit' indicates a very significant educational and public outcome flowing from SMiS. These partnership programs generally provide a model through which contemporary science and mathematical and ICT thinking can be practiced in classrooms, and the SMiS program is a major exemplar of these.

Outcomes for students, teachers and STEM professionals which were rated highly by participants are all significant in being consistent with national STEM policy directions, curriculum innovation, and the research literature on student and teacher engagement with STEM.

Table 8.5: Observed outcomes (by surveyed teachers and STEM professionals) in areas of intended outcomes

Target group	Intended outcome of SMiS program	Observed outcome	Ranking*	Data Source
Students	Exposure to STEM professionals and real world STEM practices	Estimated 55 000-65 000 students with 340 000 interactions per year	H	Table 5.4
	Increased enthusiasm for STEM learning	Increased interest in science/ mathematics	H	Teacher Survey Table 6.2
		Increased enjoyment of doing science/ mathematics	H	Teacher Survey Table 6.2
		Increased ability to recognise and ask questions about science/ mathematics -related issues in the world around them	H	Teacher Survey Table 6.2
		Increased knowledge of contemporary science/ mathematics	H	Teacher Survey Table 6.2
		Increased engagement of (my) students with science	H	Teacher Survey Table 6.3
		Increased self-confidence in their ability to do science/ mathematics	M	Teacher Survey Table 6.2
		Increased awareness of the nature of scientific/ mathematical investigations and science/ mathematics Inquiry skills	M	Teacher Survey Table 6.2
		Increased awareness of the relevance of science/mathematics to society	H	Teacher Survey Table 6.2
		Increased understanding about how they can use scientific evidence to make decisions about health and the environment/use mathematics as evidence for decision making	M	Teacher Survey Table 6.2

		Willingness to look to mathematics to make decisions and interpret the world	M	Teacher Survey Table 6.2
	Identification of STEM professionals as role models	Increased awareness of how scientists/ mathematicians think and work	H	Teacher Survey Table 6.2
		Increased appreciation of scientists/ mathematicians as people	H	Teacher Survey Table 6.2
	Improved STEM career awareness	Increased awareness of science/ mathematics-related careers	M	Teacher Survey Table 6.2
Teachers	Exposure to STEM professionals and real world STEM practices	Enjoyment in working with the scientist/ mathematician	H	Teacher Survey Table 6.3
		Opportunity to communicate with scientist/ mathematician(s)	H	Teacher Survey Table 6.3
	Increased enthusiasm for STEM teaching	Increased motivation to teach science/ mathematics	M	Teacher Survey Table 6.3
		Support for my teaching of the science as a human endeavour strand of the Australian curriculum	M	Teacher Survey Table 6.3
		Improvements in my teaching practice in science/mathematics	M	Teacher Survey Table 6.3
		Increased confidence in teaching of science and mathematics in primary schools particularly	H	Table 6.4
		Establishes me as a dedicated teacher of science/mathematics	M	Teacher Survey Table 6.3
	Strengthened STEM knowledge and practice	Updating current science/mathematics knowledge	M	STEM pro survey Table 6.5

Target group	Intended outcome of SMiS program	Observed outcome	Ranking*	Data Source
		Updating knowledge of scientific practices/ methods	M	STEM pro survey Table 6.5
	Improved STEM career awareness	Increased awareness of science/ mathematics-related careers	M	STEM pro survey Table 6.5
STEM pro-fessionals	Increased STEM professional engagement with schools and broader community	Enjoyment of interacting with students	H	STEM pro survey Table 6.5
		Opportunity to promote public understanding of science/ mathematics	H	STEM pro survey Table 6.5
		Enjoyment of working with the next generation of scientists/ mathematicians	H	STEM pro survey Table 6.5
		Enjoyment of contributing to school of family and/ or friends	M	STEM pro survey Table 6.5
		Increased understanding of the general community's understanding of science/ mathematics	M	STEM pro survey Table 6.5
		Opportunity to promote science/ mathematics-related careers	M	STEM pro survey Table 6.5
		A raised profile of science/ mathematics in the school community	H	STEM pro survey Table 6.6
		Greater attention to science/ mathematics from the school leadership and parents	M	STEM pro survey Table 6.6

School and community	Sharing of ideas and practices across community of teachers and STEM professionals	Ongoing improvements in the school science/ mathematics curriculum	M	STEM pro survey Table 6.6
		Ongoing improvements in science/ mathematics teaching practices in the school.	M	STEM pro survey Table 6.6
		Greater awareness of contemporary science/ mathematics amongst teachers generally	M	STEM pro survey Table 6.6

* H: received highest rating in survey from over 50% of respondents (either science or maths); M: highest rating from 35-50% of respondents

Quantifying the value of the program

One measure of the value of the program is the change in student longer term behaviours, notably in relation to the secondary or tertiary education pathways pursued by students involved in the SMiS Program studies in STEM subjects, as well as their subsequent career choices. While the literature points to the importance of early and ongoing positive experiences with science and mathematics in determining subsequent STEM pathways (Tytler, Osborne, Williams et al., 2008) the data are not available to address this outcome in this case. A strong argument exists for future longitudinal economic and macroeconomic studies to examine the impact of SMiS and other STEM outreach programs on student behaviour and educational achievements.

Putting a monetary value on the outcomes of the SMiS program is also difficult. Unlike other program activities the products or services that are generated in this case are not marketed and cannot be simply priced. In the absence of market based data a non-market revealed preference approach can offer some insights into the value of outcomes achieved. These employ proxy measures, effectively costing the provision of an equivalent outcome by different means. Three proposed proxy measures and the derived estimates of the value of outcomes are shown in Table 8.6.

- A proxy measure for achieving the outcome of increased enthusiasm for STEM learning could be a set of one day visits to all participating schools. The daily rate for a professional STEM presenter able to inspire student learning is estimated to be $1000. Taken across all schools involved, and providing an equivalent amount of STEM professional exposure (29 hours as estimated by teachers) the derived value would total some $6.3M.
- Another proxy measure for stimulating increased enthusiasm for STEM learning achieved, in this case via direct contacts with STEM professionals as individuals or as members of small groups, might be engagement of a professional STEM tutor. At an hourly rate of $80 per hour, the derived value of this outcome would be $1.84M per year. This would complement the above-mentioned case.
- A proxy for the teacher outcome of strengthened STEM knowledge and practice could be professional development training for the individual partner teachers. At a rate of $800 per day (covering the cost of the course itself and a replacement teacher) for a period equivalent to the number of hours engaged in the partnership and for the teachers involved in the 1700 active SMiS partnerships would generate an equivalent value of $6.8million.

Table 8.6 Estimating the value of selected SMiS outcomes – revealed preference worked examples

	Time per year	Proxy measure	Equivalent value per year
Increased enthusiasm for STEM learning (students)	30 hours per school	Cost of one day visit by science presenter-$1000*	1000 x 5 x 1263 = $ 6.3M
Increased STEM knowledge (students)	23 000 hours individual and group tuition	Hourly STEM tutor fee - $80*	23 000 x 80 = $1.84M
Strengthened STEM knowledge and practice (teachers)	29 hours per teacher	Cost to school of one day professional development training - $800*	800 x 5 x 1700 = $ 6.8M

* Survey-based estimates. Replacement teaching costs included for PD training,

These measures are underestimates in that a substantial number of schools are involved in two SMiS partnerships. While such measures overlap and involve some double counting, they have value in providing some context for the value of SMiS outcomes, expressed on an annual basis.

We do not develop this proxy value approach further in this report. The nature of the outcomes requires a high degree of artificiality in generating potential proxy measures, each of which covers a small part of the program. Moreover, in trying to reduce a complex set of experiences to component parts that are in fact ultimately connected, these comparisons fail to capture the distinctive feature of the ongoing, negotiated and flexible relationships frequently generated by the SMiS program and hence run the danger of being quite arbitrary.

Discussion of impacts

The impacts can be regarded as the long term and indirect outcomes of the SMiS program. The outcomes from the SMiS program – such as enthusiasm for STEM teaching and learning, greater STEM career awareness and increased STEM knowledge – may be expected to have a positive effect on STEM education in Australian schools and future national STEM capabilities.

The national benefits of increased capabilities in STEM disciplines are pervasive and extend across the environmental and economic spectrum. Three notable areas are innovation and human capital, access to resources, services and opportunities, and quality of life. A workforce more highly skilled and knowledgeable in STEM areas would be better able to contribute to invention and creativity. The growth in national welfare depends on improved national productivity, which in turn increasingly hinges on dynamic change and innovation. Similarly access to new and improved knowledge in the STEM areas expands the potential for increased participation in economic and social public activity and increasing the quality of life for Australian citizens.

The prospective impacts of the SMiS program overlap, and are convergent with the impacts of other STEM outreach programs currently operating in Australia (Appendix). What is notable about the SMiS program is its distinctive impact pathway.

The SMiS impact pathway

Within the portfolio of STEM outreach activities in Australia the SMiS program has a number of distinctive features, namely the ongoing, negotiated and flexible nature of the partnerships that provide opportunities for close encounters of students and teachers with contemporary practices and ways of thinking of the STEM professional and research community, through engagement with practitioners as personal models of these STEM commitments.

The longer-term impact of the program can be framed through a number of policy and practice lenses. These can be viewed as sitting in causal relation to each other, and are:

1. creation of a STEM literate population (Office of the Chief Scientist, 2013, 2014)
2. increase in the number of students choosing STEM pathways (Office of the Chief Scientist, 2013, 2014)
3. increased engagement of students with quality learning in STEM subjects
4. increased knowledge and capability of teachers of STEM subjects
5. increased engagement of STEM professionals in contributing to public understandings of STEM
6. support for the Australian Curriculum in representing and promoting new practices.

The chain of causality represented in this list can be found within the STEM education literature, involving evidence that student attitudes and aspirations towards STEM are established earlier than previously thought and that in order for students to engage with STEM pathways they need to identify science and mathematics ways of thinking and working and valuing as consonant with their own persona and intentions at least through the upper primary and lower secondary school years, and be exposed to STEM curricula throughout their schooling that they see as contextually relevant, and challenging (Tytler, 2007, 2014; Tytler, Osborne, Williams et al., 2008). STEM outreach programs in which teachers and students interact with scientists are potentially powerful in providing role models for students.

The SMiS model is potentially particularly powerful because of the close engagement with the STEM professional over a period of time and the negotiation that occurs around representing their work and aligning with the curriculum. Further, in partnerships where the scientist supports students in inquiry projects for instance around local environments, or support for science fair work, where the mathematician supports students in problem solving and reasoning, or where the ICT professional works with ICT in authentic situations, the teaching and learning approach is likely to be much more inquiry based (Tytler, Symington & Smith, 2011) and provides significant professional development for the participating teacher. Evidence for this was found in the data generated in this study also, with inquiry and problem solving a strong feature of partnership activities. We can thus presume a potential ongoing impact across a significant number of these partnerships on, not only student engagement with STEM learning and possible STEM pathways, but on classroom practice for the partner teacher and in many cases for the school more generally, particularly for primary schools.

Further, at the system curriculum level there is evidence that the partnerships focus significantly on inquiry skills and processes in both science and mathematics, and on the Science as a Human Endeavour (SHE) strand of the science curriculum. These are relatively new and important strands of the curriculum that teachers have limited experience with, so that the SMiS program in common with, but more so than other STEM outreach programs, offers a potential model for classroom practices to support these areas. The SHE strand in particular has limited models for implementation, being new, so that the experience within these partnerships potentially provides a valuable model for its wider representation in the curriculum. It could be expected that the ICT partnerships will over time provide similar support for the digital technologies curriculum, and the fact that the SMiS team is involved with the ACARA Digital Technologies Curriculum Implementation Group is an illustration of the potentially powerful impact that this managed and high profile program of partnership between teachers and the STEM professional community can have on curriculum and classroom innovation in Australia.

The further aspect of SMiS that is relevant to the wider impact of the program in terms of STEM policy agendas is the engagement of STEM professionals in communicating and representing their work. SMiS is creating a cohort of STEM professionals committed to an agenda of supporting the next generation of STEM literate individuals and to developing insight into public understandings of STEM and STEM careers and commitments. Further, this impact extends upwards, supported by exemplars of classroom practice, to potentially influence policy at the highest levels, as illustrated by the National Science Week event involving hundreds of STEM professionals and their partner teachers, and 26 Federal parliamentarians.

Judgments concerning the significance of the potential wider, longer-term impact of the SMiS program are thus premised on the quality and the relevance of these outcomes, through a causal chain, established through literature analysis, to significant policy agendas in Australia. It is argued that the particular strengths of the SMiS model position the program to lead directly and effectively to supporting the need in Australia for an increased STEM-literate population and increased number of students choosing STEM career pathways.

Return on investment – efficiency and effectiveness

The return on investment on the SMiS program is considered in two respects – firstly the cost efficiency of the program in delivering its outputs and secondly the effectiveness of the program in achieving its intended outcomes.

Efficiency

Funding for the program in 2014/15 was about $2.125 million. The outputs sustained by this program are a total of at least 1700 active partnerships, in some 1263 schools. The portfolio of partnerships is balanced in terms of representation between different states and territories, between primary and secondary level schooling, between government, independent and catholic schools, and between schools in rural and urban areas. The level of interactions between STEM professionals, students and teachers are set out in Table 8.4.

The breadth and diversity of the program are part of its inherent strengths, but they do entail a cost premium. A more narrowly focused partnership program, say restricted to one discipline and one urban area, would likely allow lower administrative costs per partnership.

Nonetheless the evidence points strongly to cost efficiency in delivering the SMiS program. One indicator is the value of time contributed to the program by STEM professionals. The program is a conduit for highly qualified and experienced professionals to channel their efforts, and the value of time contributed by this group is estimated at more than $6m per year. Other indicators can be obtained by costing proxy approaches to achieve equivalent selected outcomes. This approach is prone to problems and neglects the systemic value of the partnership program. Nonetheless, a first order consideration of measures (Table 8.6) that would achieve comparable outcomes of firstly increased student enthusiasm for STEM learning (and STEM knowledge) and secondly strengthened STEM knowledge and practices for teachers yielded value estimates of about $8.1 million and $6.8 million per year respectively. Collectively this set of estimates points to a good return on annual funding of the SMiS program.

Effectiveness

Table 8.5 provides a systematic response to the question of how effective the program has been in achieving its intended outcomes. It ranks the observed outcomes reported by teacher and STEM professional respondents to the survey questionnaire and groups them under the respective intended aims of the SMiS program by target group (Table 8.3). The results displayed in Table 8.5, and discussed above, point to a high level of success in achieving the intended outcomes for students, teachers, STEM professionals, schools and the community.

It is argued that SMiS is high in terms of effectiveness due to the alignment of the model, and the benefits to students, teachers and schools, and STEM professionals, with significant national policy agendas.

This finding is moreover supported by consideration of the impact pathway for SMiS and the distinctive longer term contribution that the partnership model can make in Australia for an increased STEM-literate population and increased number of students choosing STEM career pathways.

Counterfactual assessment

The value of considering a counterfactual situation in impact analysis rests on the need to avoid overestimating the beneficial impact attributable to an activity – for example a successful research project. The appropriate baseline is an estimate of what would have happened in the absence of this activity. For example, some of the impact may be achieved through "secular" changes or trends, or it could be that the activity displaces another which would have achieved some or most of the observed impact.

The questions therefore are:

- What scale of changes in the impact area might have taken place without SMiS?
- Are there any substitutes that could have led to similar outcomes/impacts available to society in the absence of this work?

In relation to the first question it is possible that some of the benefits delivered by SMiS would have been generated in its absence. There is evidence of STEM professionals engaging with schools on their own and of other, for example, university-based programs involving STEM professional-student/teacher interactions. The extent that these would have increased, though, in the absence of SMiS - and in the absence of the government funding of approximately $11 million from 2007 to mid 2015 – is far from clear. Moreover, the nature and breadth of the program enabled by the combination of CSIRO's geographical dispersion, disciplinary range and extensive national contacts with schools and STEM professionals would require the successful co-evolution of a number of programs across Australia, in a number of subject areas. In this there appear to be clear economies of scale and scope for an organisation such as CSIRO.

The counterfactual for removal of an efficient program delivering significant benefits in an area of national need would be significant loss of national benefits.

In relation to the second question, as discussed above, the SMiS program occupies a distinctive niche within the spectrum of STEM outreach programs that would be difficult to emulate by other programs. It can be argued that the existence of SMiS creates the frame for STEM professionals to think about engagement in schools. Indeed, there are a number of findings from the survey which point to the unique value added by the SMiS program. One is the fact that 32% of teachers were in other STEM outreach partnerships and many of these commented on the specific advantages of SMiS, distinct from their other partnerships. The second is that teachers were clear about improvements in outcomes that were uniquely attributable to SMiS. The third is that comments from many teachers related to the particular value offered by the ongoing, flexible, and personally focused model, which would not be duplicated by other outreach programs. Therefore it can be argued that the outcomes attributable to SMiS are distinctly associated with the particularities of the model; hence the counterfactual would be a significant decrease in numbers directly and through removing the model as an iconic program.

In short the counterfactual for removal of what is perceived to be an efficient program delivering significant benefits in an area of national need, namely outreach programs to improve STEM education, would be significant loss of national benefits.

Summary

In this chapter we have considered the outputs, outcomes and impacts attributable to the SMiS program. Despite the difficulties inherent in evaluation, because of the qualitative nature of the outcomes and impacts the evidence points to a strong return on annual investment in SMiS.

Analysis of the outputs points to efficiency in delivery of the program which spans several disciplines, many subject areas, a variety of schools and schooling levels and participation across all the states and territories of Australia. For example it leverages near to three times its annual funding of about $2.125 million in terms of volunteered time by experienced and highly qualified STEM professionals. In addition the application of proxy measures for delivery of equivalent outputs in areas such as such as STEM teaching, student tuition, and teacher professional development – despite some double counting – point to the overall cost efficiency of the program.

Analysis of survey data from participating teachers and STEM professionals shows a high level of achievement for the program in all of its intended outcome areas. The value of these outcomes is underlined by reference to significant directions in STEM curriculum, and evidence from contemporary literature on student engagement and aspirations, and teacher learning. The economic value of these outcomes derives from their positive impacts on STEM in schools, and their potential effect on educational attainments and academic career choices. At present there is a lack of data in these areas and there is a strong case for economic analysis of the longer-term impacts of SMiS and other STEM outreach programs.

Finally we consider the economic importance of SMiS. Its impact lies in it firstly being an efficient and effective element in patterns of national STEM outreach programs, widely acknowledged to be addressing the national problem of an undersupply of STEM professionals and the need to develop a STEM literate population. Secondly its impact lies in its distinctive role within Australia's portfolio of STEM outreach programs and the alignment of the model to national STEM policy agendas.

While impacts of the SMiS program are difficult to quantify, the evidence points to the program having high impact through the alignment of the model and its benefits to significant national policy agendas. Its economic importance lies in its being an efficient and effective element of highly regarded national STEM outreach programs and its distinctive role as an exemplar of partnership programs that bring contemporary STEM practices into Australian classrooms.

9. PARTNERSHIP CASE-STUDIES

Purpose and selection of the case-study interviews

A different perspective on the SMiS program from that gathered through the survey was gained by interviewing some teachers, STEM Professionals, and students in selected partnerships. Respondents to the survey were asked to indicate willingness to participate in the data collection for a set of case-studies. This meant that ethics permission could not be sought until the survey was completed. The case studies were selected to represent a number of explicit partnership experiences and conditions: different patterns of outcomes for teachers and for students; the varied nature of the changes that were perceived to occur; different patterns of interactions and time commitment; characteristic differences between primary and secondary, rural and metropolitan schools. The cases enable us to explore in greater depth some of the themes that were identified through the survey and project team interviews.

Having selected cases which it appeared, from the available evidence, would be valuable to explore, the pattern of interviews was determined by factors such as availability. In some cases only the STEM professional was interviewed, in other cases only the teacher, and in some all three groups: the teacher, the STEM professional, and students. In two of the case studies the partnership was around mathematics, and around science in the remaining six. None of the small number of teachers in ICT partnerships who completed the survey volunteered for follow up interviews.

Case descriptions

Case 1: Passion and persistence

Drawing from an interview with a STEM Professional

Partnership type: Scientists in Schools

Thelma is motivated by her desire to support children to be interested in science early in their lives. When she graduated from university in Europe she did a year as a school teacher (unqualified in teaching). The CSIRO SMiS program offers her an opportunity to respond to this motivation in a meaningful way, to 'give them an idea of the possibilities', 'a sense of what science could be outside of the classroom'.

When Thelma registered with SMiS in 2014 she was delighted to be partnered with a primary school teacher. Thelma and the teacher planned a week-long program that aimed to reach 'as many children as possible' in the school, during which she prepared a talk based on Australian research, discoveries and inventions which she adjusted to each group depending on the age of the students. 'Being the link between my science organisation and an education organisation is great.'

The students she addressed ranged from grade 4 to grade 7. Thelma marvelled at the 'really positive reaction' she got from the students and teachers. Students appeared to relish the opportunity they had to talk to a scientist, ask questions, and hear about the range of industries and careers that are influenced by science.

Thelma contacted the school in preparation for her visit in 2015, and was surprised to learn that her partner-teacher was no longer at the school. A new partner-teacher was arranged for her by the school, and Thelma 'took the initiative' to contact the new teacher. Thelma has the opinion that if she had not persisted the school may have let the partnership go. 'if I had not taken action to meet the new teacher nothing would have happened'. Together she and the teacher prepared an event to take place during Science Week. One of the activities was a quiz in which Thelma included questions based on her presentation from the year before. Thelma was impressed with how teachers alter activities to suit varying ability levels of students. The quiz 'involved pictures, cut out pictures, that they had to work out, it was excellent it was actually quite diverse and the kids loved it and they did fairly well too, very well, generally speaking, it was great.' She was delighted when some of the students could recall details from a year prior. While Thelma now works closely with one teacher on an annual basis, it seems that more teachers will be involved each year as the partnership continues, demonstrating the evolving nature of the partnership. However, she feels that the continuation of the program depends on her to a great extent. Thelma reiterates that her experience highlights the need for principals to be involved in the partnership. 'I think there is room for more structure. School principals should get involved and support this actively.' She proposed that to have some of her fellow scientists accompany her to the school during the SMiS activities could demystify the experience a little. Thelma thinks that the program is 'great' and that other scientists should join the program because 'everyone would benefit from interacting with kids and explaining their science to children and supporting education broadly.' She recognises that the program relies a lot on 'personality and time commitment' of the partners; that is the flexible nature of the program relies on partners taking initiative. 'I was left to my own devices but it didn't bother me too much because there's nothing wrong with having that freedom.' She wonders if having example modules for scientists to use would support and encourage other scientists to join the program for those who like more 'structure', having room for both formal and flexible ties to schools. Thelma had not engaged with any of the SMiS induction materials and had not been able to participate in any of the program networking events due to other commitments.

In terms of benefits, Thelma reflects on this partnership as an opportunity to pass on knowledge, expertise and to get a different angle or component of her own work. She considers the need to 'translate' ideas to common words that students can relate to, as a chance to open doors for students to explore further.

While Thelma has to negotiate her time at work to make time for visiting the school, she feels that it is worth it in terms of student outcomes and personal benefits for herself. 'Enjoyment first, I really enjoy doing this, it gives me a kick, it is good. I love contributing to anything that improves education.' She also indicated that she personally had benefitted from her participation in the program in that she improved in her ability to communicate with different audiences and that she loved the enthusiasm of the children.

> 'In a way a bit of a change from the usual work I do, it helps put things into perspective as well, put things in context.'

Case 2: An 'Outward Facing' School

Drawing from interviews conducted with the scientist, two teachers, and two students.

Partnership type: Scientists in Schools

Alice and Philip are specialist science teachers at Mountain Primary School and share the objectives to run an 'interesting, rigorous and broad' program at the school. Built into that is Alice's goal of making Mountain Primary School an 'outward facing school with regards to science.' To meet these goals they utilise various strategies and resources, including participating with the CSIRO Scientists and Mathematicians in Schools program.

Early in 2014, and as part of her role as a specialist science teacher, Alice made a presentation at assembly about the school's science program. After the assembly she was approached by a parent, Kelly (a scientist working in nuclear medicine) who had recently moved from interstate and had 'just' transferred her registration with SMiS to her new state. Although Kelly was hoping to be matched with a primary school she had recently been offered some secondary school teachers and she was in the process of deciding which she would choose. So when this serendipitous opportunity to work with her son's school arose, Kelly contacted the CSIRO SMiS team and the match was made.

Alice felt that Kelly's role as an interested parent and partner scientist created a unique opportunity for the partnership. Both Alice and Philip were thrilled with the many ways that Kelly could meet the needs of the students and the school; as a woman working in nuclear medicine, Kelly dispelled the belief held by many of the students at Mountain Primary School that 'scientists are white-haired wearing glasses and lab coats; the "crazy" scientist.' Alice found Kelly personable, enthusiastic and willing to contribute to the planning of the partnership program.

Since Term 1 2014, Kelly has supported Alice, Philip and their students with two major projects, and has worked with other teachers in the school in other ways. The projects are across subject areas, e.g. art, sustainability, science, mathematics and include many school members. In the first project Kelly worked with teachers and the Grade 1 students during science lessons on the topic of materials with a focus on recycling, to build an igloo out of plastic milk bottles. It was a mammoth undertaking and impacted on all students in the school - they could even sit inside the completed structure.

In 2015 World Ocean Day was acknowledged with a project involving students, other parents and teachers in this collaborative effort with a colouring competition, and the making of murals from recycled materials – litter collected from the beach. The students worked after school and at lunchtime on this project making murals, which were displayed at a Marine conference that focused on Healthy Oceans, Healthy Planet. Kelly spoke to the school community at assembly with regards to the litter the students drop in the schoolyard – she invited them to think about the things they are dropping, they do go into the creeks and oceans. As a result, not only did a number of students (grade 3-6) commit to devoting some lunchtimes to the World Ocean Day mural project, two other parents with expertise in this area volunteered some time to the project. Philip considers this to be an optimal use of a partner-scientist when, within the constraints of a curriculum and timetable with 'not a lot of flexibility', more students can be involved this way (a lunch time science club).

In addition, Kelly has run other occasional science clubs at lunchtimes, and has spoken to different classes and teachers about their current science topic. As a result of Kelly's suggestion the school is participating in Terracycle – an initiative that recycles certain materials that would traditionally be considered non-recyclable - e.g. coffee pods, toothbrushes.

Kelly works part time and was somewhat flexible with timing. She was willing to volunteer for 2 hours per week. Initially, for quite a few weeks, Kelly and Alice met every fortnight to discuss how Kelly could be best utilised in the school. These conversations were important in establishing the scientist's interest and skills, orientating the scientist into the school and gaining an understanding of each partner's objectives. Alice and Philip then planned the projects with Kelly and prepared for Kelly's visit (school timetabling, supporting classroom teachers etc.).

It is clear that Kelly has brought more to the partnership than expected; Philip spoke of the opportunities there are to link to the curriculum given Kelly's range of experience in science. Kelly acknowledges that 'lots of things relate to science', and that a partnership such as this allows an opportunity to 'think about science in other ways', and give ideas about 'how to adapt the resources they have' to enhance their science curriculum.

According to Alice, being comfortable with the uncertainty of what will grow out of this partnership and being willing to take risks has proved a key factor to the success of this partnership. Alice explains:

> 'It's messy, and so as the person guiding it you have to be comfortable in that space, of not knowing necessarily what is going to come up next. So right now, we have done the stage and a big thing around that and it's all finished, so now we are looking for a new thing, and when I say looking, we are all actively thinking where to go next and so it's an evolving thing and requires a high degree of creativity, flexibility and some time.'

Alice explained that the scientist gets 'intrinsic satisfaction, from the work she does' and 'she loves to see the love of science in children.' Kelly is passionate about attitudes and values about science. Her children attend the school so she sees her involvement as added value to herself. Kelly considers the greatest outcome is to see a bigger commitment to science in the school and to see students supported before they go high school. Kelly speaks of the personal benefits she has experienced as a result of participating in this program in terms of the student outcomes, particularly 'the excitement of the kids when they are doing science'. She now has students approaching her in the playground eager to tell her about their aspirations to become a scientist, or to speak to her about their love of anything from insects to rocks.

> 'I could really see at that point that it is not about having someone teaching science, it's about having a role model which is what I was expecting at primary school - To have someone who you can see in the playground and say 'I want to do that one day'. So I've gotten out of it what I was expecting.' (Kelly, Partner-Scientist)

Alice would concur - she is very satisfied that the partnership program is providing huge benefits to students and school and teachers, beyond her expectations.

'It's an evolving thing', says Alice, 'and it involves a high degree of creativity, flexibility and some time.' Alice also considered the success of this partnership to be dependent on the consultation between the partners that is necessary to build the working relationship. Philip agrees, 'We've always sat and had an honest conversation with her about what would she be willing to do, what are her interests, and what is her knowledge? We sat down with her, made a list of those things and then we've deliberately then, we being Alice and myself, sat and thought how can we fit this into the program?' The partners invest time and energy in the partnership and work as a team. Kelly is clearly committed 'I am willing to contribute a lot, and I want to feel that I am able to contribute.' With agreed objectives in mind, meeting times are arranged, other teachers are invited to be involved, and opportunities sought for the scientist to add value to the school. Kelly remarks on the open communication she has with her partner-teachers allowing 'active flow of ideas going back and forth'. Alice acknowledges that 'Kelly is very passionate about attitudes and values about science, and sustainability and energy', 'It's that aspect of her (Kelly's) personality and those layers to her as a scientist that have made this successful'.

In discussion with two upper primary school students from Mountain PS they agreed that they now have 'another layer of learning, we want as much science as we can because we are going to high school next year'. The students describe Kelly as very 'knowledgeable'. She can 'educate us in something new that our teachers aren't as confident with.' She 'explains things really well', and 'she likes to learn things as much as we like to learn things'.

Based on her experience, Alice suggested a need to be really specific about the sorts of expertise and qualities in the request for a scientist. She recommended providing scientists with the professional learning about the landscape they will be working in e.g. primary or secondary. Her wish is for additional resourcing in time or money to be available for the coordinating person to liaise and to initiate ideas and opportunities. She also suggested that the profile of the program could be promoted to a wider audience with greater acknowledgement of the value the partner scientist can bring to the school.

Kelly acknowledges that the support from CSIRO has been 'really good.' She was supported to find partnerships when previous matching did not 'get off the ground.' Kelly finds attending the networking events interesting as she can see other scientists doing 'real science' as opposed to the 'fun stuff related to science.'

> 'Although every child is not interested in science I think that if it is done, it is pitched at such a level that they can get excited, and, again to encompass different areas like art or literacy or maths or whatever that might spark that child's imagination.' (Kelly, Partner-Scientist

The students echo this in their own way 'She (Kelly) would explain what they (scientists) do in the lab. We just thought scientists were doing explosions and stuff. She explained they are doing more than that. It is more than we thought.' Thanks to Kelly, the students have come to realise that there is 'always has a reason behind the projects. There is always a meaning.'

Case 3: An Authentic Experience

Drawing from an interview with one teacher and a student focus group

Partnership type: Scientists in Schools

Anna loves science and is always looking for ways to engage her students in science. When she first heard about the CSIRO Scientist in Schools program six years ago, Anna thought it was a 'fabulous opportunity to work with someone authentically and for the kids to meet someone and work with someone really authentically.' She 'couldn't wait to say yes.'

When Anna and her partner-scientist, Susan, were first matched, Anna was working at a school close to Susan's workplace, a university. Susan's area of expertise, astrophysics, happened to fit perfectly with the topic Anna was teaching her grade 5 students at the time – the phases of the moon. Anna recalls the hands-on activities Susan facilitated; making observations of the moon and creating representations of the moon's craters.

Anna sees that Susan has brought an 'authentic experience' of science to all the students she has engaged with, especially when the year 5s were making observations of the moon. Anna considers year 5 students a 'bit more difficult to impress' so they got a lot 'more out of the inquiry process by actually participating in authentic inquiry'; 'They had to go and make the observations themselves and report back to her (Susan). They were accountable to her. It just made it more meaningful and because of that they were more engaged.'

The biggest benefit for the students according to Anna is 'meeting a real life, and really cool, scientist.' Anna likes that Susan 'debunks' the image of a stereotypical scientist, 'she is young and she's funky, not, you know, a grey-haired Einstein type in a white coat, she's just this really fun enthusiastic, young, knowledgeable, incredibly generous person.' Anna is in awe of how Susan talks to the students 'at quite a high level, but a level they still understand.' Anna considers that the curriculum is much richer having a partner-scientist, that Susan enhances what is already taught.

When Anna moved to her current school, she offered the partnership with Susan to her former colleagues. Anna is not sure whether anyone at her previous school has taken that opportunity or not, however Anna has maintained contact with Susan. Anna, now a teacher of students in Foundation level, is working in a school at a much greater distance from her previous school. Changes in nature to the partnership have had to occur to accommodate that distance. Anna has taken Foundation students to Susan's university for the last three years, in contrast to Susan visiting students as was the case in Anna's previous school. 'For me it's for the kids to meet Susan,' says Anna, 'and for the kids to go out (to the university); that in itself is a fabulous opportunity for the kids especially (Foundation) kids to go to a university and meet a real scientist.'

At the university the Foundation students were shown 3D models of stars and planets and interactive 3D videos of the solar system to complement the teaching and learning of a unit of inquiry that had occurred at school. Students' accounts of the learning they did while on the excursion, included topic vocabulary used mostly correctly and with ease.

> 'We looked for "model planets"'
>
> 'I know what stars are made of, they are made of gas'
>
> 'She might be looking for shooting stars'

'We know now what some moons are made out of, ice and super freezing'

'There's a little robot that goes around Jupiter that sends back information'

'The robot sends information that they didn't know'

'On Jupiter there is a big, big storm'

'She told us where the asteroids live'

'Asteroids are the shooting stars'

'I know now that "The sun is a star"'

'The Earth goes around the sun'

When asked what scientists do for a job the students describe scientists as asking 'good questions' like 'Does Pluto have a ring?' Students said scientists use telescopes and cameras. They said that scientists do science to 'learn about stuff.' They are aware that 'Professor Susan' 'searches around the world looking for "baby stars"', that 'she looks at all the planets', and that 'she is wondering about what it's like in outer space.' Anna's students also claimed that scientists could learn about bones and animals, demonstrating some understanding of the scope of science learning. Their experience with Susan made an impact beyond the classroom – a small number of the students interviewed discussed their excursion to Susan's university with their parents explaining to them how the moon is 'made out of a big rock.' Anna said that parents of the school are impressed that their children have had this opportunity to meet an astrophysicist and go to a university to enrich their learning.

Anna thinks that the longevity of this type of partnership depends on the teacher and the scientist because the program is 'opt-in', and it is 'so individualised'. Anna asserts 'each school has to figure out what is going to work best for them.' She recommends that the scientists bring some ideas regarding what to do because for example she 'didn't even know what an astrophysicist did and didn't know what to ask'; because Susan was able to suggest a project on the moon, it just 'went from there'.

Professionally, Anna feels she has benefitted enormously especially 'when I've been looking for activities or trying to get kids to understand things she can come up with suggestions and things like that. That's really helpful'. Anna is grateful for the opportunities she has been afforded by being in this program - 'to be authentically engaged with a scientist who is working in the field and have opportunities to discuss things that are happing' – not only because of her successful partnership, but also because of the CSIRO SMiS networking events. Anna attended such an event at a university (not Susan's university) that was 'a fantastic opportunity to do something I would have not been able to do so that was really positive. I think those sort of experiences are really good.' 'It has enhanced my experience.'

When discussing the matching process offered by CSIRO, Anna says 'to be honest I would have been happy to work with any scientist in any field because that authentic learning you can't beat that; that authentic experience'. She would like to hear quick examples of how other schools implement the program, and hopes that CSIRO communicates to others 'how easy and fun it is', because 'the costs (to Anna) are only a couple of emails.'

Anna has 'loved it so much' having access to a real life astrophysicist, and having the opportunity to discuss ideas to teach science with a real scientist.

Case 4: A mathematical approach

Drawing from an interview with a secondary school mathematics teacher

Partnership type: Mathematicians in Schools

Patrick is a passionate mathematics teacher who was inspired through reading an article by his state-based mathematical association about the CSIRO Mathematicians in Schools Program. He decided to act ASAP applying to have a mathematician-partner. He 'really wanted someone with experience in the real world.'

When the first suggested partnership did not eventuate, Patrick was partnered with an alternative mathematician, Heather, an astrophysicist. A successful partnership ensued, in fact he 'was just blown away by it' … 'It was fantastic to have someone with that experience to be able to come to our school and spend some time with our students.'

Patrick did not know what to expect when first partnered with Heather. He wondered 'Would she come in and purely be the mathematician who would just speak to the students and walk out, or would she be someone who wanted to get involved.' As it turns out, Heather really wants to be involved with the students, and offers to help out in many classes during her visits, beyond those she was scheduled to visit. Heather comes across as someone who 'really wants to put the time and effort in to it'. Patrick 'couldn't ask for anything better.'

Patrick has noticed that student engagement in mathematics increased significantly as a result of Heather's visits. She has visited the school twice since the partnership began less than 12 months ago. Heather addressed Patrick's year 12 students speaking about, among other things, how she uses mathematics in her area of specialty, and how it is such a big part of getting any job. When Patrick spoke with these students afterwards he noted that this latter point resonated most with them. Patrick hopes that this message might be communicated to all students in the future.

Heather has also spent time with the students in year 8 and 9 speaking about how mathematics relates to astrophysics. Patrick is impressed with the impact Heather has had on the students so far and has begun planning with Heather to facilitate a project for the year 8 and 9 accelerated students with a focus on the mathematics involved in astrophysics. Some students have also requested that they have one-on-one time with Heather to discuss her area of expertise.

Other teachers in the school have been inspired and requested that Patrick 'share' Heather with them. He anticipates that this will also happen as the partnership continues. He hopes to utilise Heather for many students in the school, not just 'accelerated' students, but also those disengaged with learning mathematics.

Patrick envisaged that having a partner-mathematician was an opportunity to provide his students with a fresh face to answer their questions

> 'When you are teaching mathematics, especially in the year 8 and 9 area, you get these students constantly wanting to know "why?"; "Why do we have to do this?"; "When will we ever use this?" type of questions, we get a lot of that, maths teachers across the board do I guess. And this seemed like an opportunity, well I can answer the questions but that's a teacher answer, the same fellow who comes in every day and whatnot. But this was somebody from outside to answer those questions, and those questions were posed to her.'

About two weeks after Heather's visit students began requesting her return visit; 'When is she coming back?' Students had clearly continued to think about what Heather had discussed with them as they had questions they wanted to ask her about mathematics, some wanted to discuss things they'd seen on television. Although the partnership is in its infancy, Patrick feels that the students are beginning to develop a greater appreciation of the role of mathematics in their lives, as a result of being able to 'speak to someone other than a teacher to tell them this (maths) is needed.'

Patrick observed changes in approaches taken by the students. He noted that by sitting with someone outside of teaching he has observed the difference in how his students ask questions of an outsider, compared to when they ask questions of him, their teacher 'questions were asked of her that I doubt will ever be asked of me.' Subsequently he has tried 'to structure my classes to be a bit more open with how I see things or how things can be done.'

Patrick feels that 'it is wonderful to work with someone like Heather.' He comments on how 'professional' Heather is when addressing the year 12 students, consequently Heather 'got a lot out of them.' Heather's desire to work with the students is obvious to Patrick and he feels that the 'students pick up on that right away.'

Members of the school leadership team are supportive of Patrick's partnership with Heather. Patrick monitors how the partnership has been tracking and communicates this to the principal. Parents of some the students commented on the fact that they like the fact that the school has taken the initiative to pursue such a partnership, 'they like the idea of that happening.'

Patrick used the online support materials provided by SMiS to prepare himself for the partnership. He acknowledges that quality communication is a key factor in maintaining this partnership. Patrick thinks that encouraging people from industry to participate in the program would be most relevant. Patrick feels this type of person – someone working in 'real world maths' – would be the most beneficial type of partner. Patrick can highly recommend this program to other teachers, if the teacher is willing to use it to its full potential, then 'you've really got an asset you can use for the benefit of the students.'

> 'She brings with her the ability of the wonderment of mathematics which is great, and we can build on that. I think that's important. It's one thing to have someone out here who is a good presenter or an entertainer – we don't want that. We want someone who can give us a mathematical approach that students can pick up and use later in life.'

Case 5: Share your skills

Drawing from an interview with a STEM Professional

Partnership type: Mathematicians in Schools.

Louis takes 'pleasure' in 'the idea that children at an early age can learn, can acquire skills that most people do not acquire even at university.' With a background in economics and a PhD in physics, Louis now works as an ICT professional, and volunteered for the CSIRO Mathematicians in Schools Program several years ago. He was partnered with a curriculum coordinator who was looking for support with 8 students the teacher identified as 'brilliant in mathematics.'

When Louis met with the teacher, he understood that the teacher's expectation was to 'make them curious' and 'show them something that is independent from what they do at school' and 'beyond the scope of what they do at school.' When Louis began working with the 8 students, he started with 'experiments in probability.' He thinks 'the students liked it' and so 'very quickly we moved to calculus and building animations.' Louis designed a 'little course' for the 8 students in programming, beginning with a 'statistical package.'

The curriculum coordinator of the school encouraged Louis to take control of the direction of this course empowering him to 'do whatever you like'. Louis subsequently feels that he has the freedom to, be very 'bold' with the students and has introduced them to computer programming languages and trigonometry. He works with them once per week for 1 hour, and has so far done 12 sessions. He poses problems to the students for example 'how do you draw a star without lifting your pen?' and supports them to 'talk to the computer' to solve the problem.

Louis sees benefits for the students in that the students are learning to 'deal with the frustrations' that occur when they make an error. Louis hopes the students will eventually 'feel inspired to study more mathematics' as they progress in their schooling. As he continues this course what Louis would like to do is show the students how to 'use the new skills in more creative ways and use them for the normal school activities that they do every day.' If that can be achieved he thinks that would be 'a success for the teacher.' 'My hope is that students become independent and be able to solve their own problems using the code.'

Although he is feeling bold and acknowledges that he is likely extending the students beyond the curriculum, Louis indicates his respect for the teachers. He would like to work with the students on their 'classroom work' but is wary of possibly entering the teachers' 'space.' He recognises that he needs support in the teaching aspect of his interaction with students, e.g.: 'getting the students' attention' and how to cater for varying abilities as some students 'learn very quickly' compared to others. He feels that greater communication and interaction with the teacher would assist with this problem. While the teacher has placed a great deal of trust in Louis, he is hoping to receive a lot of feedback from the coordinator to inform the future direction of his course.

Louis would recommend that other professionals also consider partnering with a teacher. He thinks that the learning and skills received in university are valuable, and that 'it's a pity not to share with others.' He believes that sharing these ideas with younger children allows those children to put these skills 'in their toolkit' so they can do the work themselves in their future career.

Louis believes that an organisation like CSIRO is necessary to facilitate partnerships of this type because he believes that such partnerships do not 'happen organically.' He finds it 'very beautiful' that students at a very early stage can be involved and have a wide range of options where they can feel inspired. He thinks it is positive, and worth the commitment of 'only' one or two hours per week.

Case 6: Kids Ask Better Questions

Drawing from an interview with a STEM Professional

Partnership type: Scientist in Schools

George loves the way kids ask questions, in fact, he thinks, in a tongue-in-cheek way, that 'kids ask better questions, scientists are boring!'. This opinion, coupled with his drive to communicate the 'depth' of what science is to the wider community, has resulted in George supporting schools in various ways since the 1990s (e.g. sponsoring prizes, visiting schools). In 2007 when he heard that the CSIRO was setting up the Scientists in Schools program, he felt it would 'fit in to directly what he was doing.'

His involvement has since increased to 8 partnerships. Each partnership varies; some are sporadic, some involve frequent contact. One partnership involves having year 10 students work with him on research projects about 2-3 times per year, another invites him to school during science week to demonstrate clinical activities, another has him give career guidance to aspiring scientists. George notes the positive effect on student engagement when he brings in equipment from his laboratory for them to use.

George, having a wealth of experience (he trained in neuroscience, did post-doctoral studies in psychiatry, and then set up a private organisation), believes that it is his obligation, and the obligation of all scientists, to maintain partnerships with teachers and schools. Additionally 'the enjoyment you get out of approaching younger minds who you might influence in a positive way. It is a very rewarding experience.'

In his experience, primary students are looking at 'fun' science, and he has had to come to terms over the years with the way primary schools teach science, whereas in secondary schools he believes schools start to involve the 'more serious end of it'. George notes the teachers' commitment to curriculum and attempts to fit in with that by conducting activities related to students' topics of learning. He does however express concerns about the 'lack of sincerity' the current curriculum has in representing science. George believes that he offers some 'real' examples providing opportunities for students to develop are more 'in-depth' understanding of a 'superficial' curriculum which further motivates him to support teachers; 'the main contribution is giving them hands on experience … hands on experience of what's done.'

Depending on the school, teacher input varies, and the number of students involved varies. George notes the need to modify his explanations and approaches depending on whether he is visiting a primary school or a secondary school. George's contribution has evolved over the years to the point where he knows how to better 'adapt to the audience.' He thinks that the CSIRO SMiS Program could teach people how to speak in public and present to kids.

He believes that there is a need to change the attitudes towards science by 'being careful how you portray the right message about what we (scientists) do every day' to the point where he now 'trains scientists to speak publicly.' When he began his partnership, George did not participate in any of the induction processes offered by CSIRO. However, he recommends a briefing be held for STEM professionals to support them to be aware of how to speak to young students, how to run activities for them etc. He is aware that different people, teachers and scientists, have different needs, and there is opportunity to offer support in order to develop the 'sensitivity of the scientist on how to appeal to kids and on what the school wants to achieve.' Each school manages their partnerships with him in a different way; he acknowledges that an awareness of this is helpful for a successful partnership. George thinks that a successful partnership depends on the scientist's 'drive.'

George believes that scientists could best be used in schools by having a 'greater definition of what science does, what technology does, and the many areas that it covers', and that teachers could better 'understand the difference between science and technology'. He suggests a bigger campaign by CSIRO to let teachers know the 'depth and breadth' of what science does.

George believes that the benefit for students in the SMiS program is 'increasing the breadth of knowledge of what we in fact do.' 'We are giving them a real breadth of exposure of the subject areas that science covers.' For George it's about 'the accomplishment of letting kids experience and see things that we do first hand.'

Case 7: Just What We Were Looking For

Drawing from interviews with a science specialist teacher, classroom teacher/principal, and a focus group of children

Partnership type: Scientists in Schools

Flynn Primary School is a small rural primary school about 2 hours (200km) from a large city. The school has thirty-one students and two full-time staff who work in multi-age grades (Prep-2, 3-6). Penny is one of the teachers and is also the principal, but has a significant teaching load. In addition, the school employs Caroline, a specialist science teacher, who teaches all the children science one day each week. In 2014, as part of Caroline's science teaching role she registered with the SMiS program, requesting to be matched with someone with a biology background. The SMiS Project Officers facilitated the match and a partnership was made with a molecular biologist, Peter, from a capital city around 1200kms away.

The partnership occurred in term 1, 2014 and consisted of preliminary email interchanges between Peter and Caroline to set up the times and other logistical arrangements. There were four sessions, conducted through an online video system, where the grade 3-6 children were introduced to Peter and he explained his work and showed them around his laboratory. The children were enthralled with the idea of working with a real scientist and undertaking real science.

Across the four sessions, with 2-week intervals, the children grew bacteria and fungi on agar plates. In the session with the children, the scientist explained how to do the sampling and inoculation of the agar medium. He provided the agar plates for the children, sent by courier from his institution, which were then used in their science lesson. They swabbed various classroom surfaces and body locations. After a growth period, they were able to show Peter the infected plates and he identified various microorganisms. The children were stimulated to ask a range of questions and were able to accurately describe what they were doing.

The Project Officers contacted both Caroline and Peter at the beginning and then at approximately three months into the partnership to see if everything was all right. At that stage it was. However, once the four sessions had finished the email interchange between Peter and Caroline also finished. Despite feeling that the partnership was valuable, Caroline did not really understand why it stopped. 'It started off well, and then seemed to fizzle out.' 'We were ready to do more', she said. Caroline thought that Peter had to undertake research overseas. 'We didn't really have a formal closure - and that would have been good, even if we said ... oh that's not going to work out.' Caroline expressed the view that it would have been good to have further contact with the Project Officer to assist with the sustainability of the project.

Caroline commented on the value of the program indicating that Peter was '… just what we were looking for.' She commented that he was particularly good at building a rapport with the children and that he related well with the students. 'He was so good with the students, he was relaxed and easy-going.' This was demonstrated in the way the children felt comfortable asking a wide range of questions and in his ability to be able to respond at a level that they could understand, without oversimplifying the science. Penny (the teaching principal) however, did not have the opportunity to be strongly involved and has indicated that this was an opportunity missed as she felt she could have more readily built the science into a more integrated teaching approach within her classroom.

The children displayed enthusiasm about the program and readily commented on what they had learnt, '… different sorts of bacteria and what makes them grow … what type of fungus was what ... there was one that looked like a spider web, but I can't remember what it's called.' They learnt that there are different bacteria everywhere. In terms of children's learning, Caroline commented that with greater insight into the program, she would have aligned the content of the SMiS partnership with the school science goals. She felt that the sessions finished before they could make best use of the learning. She indicated that it would have been useful to have had a mixed mode of delivery, with face-to-face interaction with the scientist at some point, 'the polycom was good, but we were ready for visits.' Penny raised the point that the relationship aspect of any teaching is important, so having someone more accessible or available to visit the school is preferable.

The online video link allowed the school to reach out and to interact at the broader level. The children commented that before their interaction with the scientist, they thought that scientists were just involved with 'mixing one type of chemical with another type,' acknowledging that they had a limited understanding of the role of a scientist. However, after the sessions with Peter, they all commented that they understood better that scientists had different ways to do things. As one student said, 'I got a better sense of what that type of scientist does ...' Caroline commented that she wanted the children to realise that science was more than just people in white coats and the interaction with the scientist enabled them to see 'science as a human endeavour.' '…exposing the children to science as an occupation, science as a vocation and being exposed to the workplace as such … and widening children's perspectives on science in real life.'

The school involved the broader community in the SMiS Program by advertising it in its weekly newsletter. Caroline indicated that it sparked some interest with a few comments coming to her from parents, but that there wasn't as much interest as she had expected.

The school has not undertaken the SMiS partnership again this year, with both Caroline and Penny not being fully aware that they could 'try again'. Once they realised that they could be involved again, both expressed a strong interest in contacting the SMiS website to register.

Case 8: The World Depends on Scientists

Drawing from an interview with a teacher

Partnership type: Scientists in Schools

While searching for an idea to 'enhance' her science teaching, Grace came across the CSIRO Scientists in Schools program. Always willing to 'give things a go', and having just moved back into full time work after having worked part time for a numbers of years, Grace saw this as an opportunity to 'improve her own skills as well as making it more interesting for the kids.'

Now into the third year of their partnership, Grace and her partner-scientist, Matthew, have negotiated a routine. At the beginning of each year they 'sit down and map out what areas we are doing in which term.' Matthew, an agricultural scientist, 'took it upon himself' to download the curriculum and decides 'what he thinks he can offer or what he can help me (Grace) with.' He then comes in about twice a term with a fully prepared lesson. While he delivers the lesson Grace supports him. Each lesson is followed with a conversation where Matthew explains to Grace 'how he did things or why he did things.' Grace feels that not only is she learning the vocabulary and the concepts, she is also 'learning how he is doing the teaching of the topic' - 'I think I am very lucky'.

Grace was clear about what she needed with regards to her own professional development and has benefited immensely by communicating this with Matthew. 'Each year we have built on my knowledge because I feel that the idea of having him in here is not to be like a show-and-tell or an incursion - I want him to be teaching me.' As the partnership evolves, so do her professional development goals. 'Last year he did a lesson on trees, well this year, I'm doing the lesson on trees. We're building - I am trying to up-skill myself with terminology and facts.'

While the main target is to 'up-skill' herself, she also aims to 'promote more interest and more love of science' within the students. This showed through last year at graduation when the students were invited to say what their favourite subject was and 'never before has anyone said science and last year we had about five that said that science was one of their favourite subjects.'

Matthew disclosed his realisation to Grace that 'you can't do the same thing twice,' recognising the need to modify the program each year to suit the students' needs and interests. Grace's advice is for scientists to be flexible and be willing to teach across all areas, and outside their area of expertise. She recalls that Matthew was at first 'very reluctant to get involved with the chemical and physical sciences', so they started in his area of biology. As he got to know the students, 'he realised that he would be able to do anything in other areas.' In fact, last year Matthew 'took it to the next level' by extending Grace's students in chemistry because they were 'very interested in the elements.'

The benefits are far-reaching. Grace recognises that bringing scientists into schools is an opportunity to demonstrate the 'really valid process of science' and 'the role that scientists have'. This is realised by listening to her students make 'educated predictions rather than something off the top of their head.' Overall, during the past 3 years, Grace continues to notice that students increasingly use science terminology correctly, that they want to discuss things they hear in the news, and that 'they put it into their general discussions and language.’ Not only that, Grace has observed ‘the principal can see there’s more interest in science than there used to be.’ Furthermore, Grace notes ‘there is discussion in the parent community about the program,’which includes wondering how all students, not just those in Grace’s class, can be involved in the program.

‘If you haven’t got a good working relationship or a good understanding and good communication it’s not going to work’. Grace goes on to say ‘Communication is the big thing, but that doesn’t mean you’re in contact all the time.’ Furthermore Grace believes that a partner scientist ‘needs to be interested in children, they have to be interested in hands-on, they have to have an understanding of how schools operate.’

Would Grace encourage other teachers to participate in the SMiS program? ‘Absolutely.’ When asked to elaborate Grace says:

> The change in my attitude towards science, I used to hate teaching science, but now that I have a partner. And the effect it’s had on the kids they are now more knowledgeable about what science is, that it can be fun. And that the world depends on scientists.’

Findings from the case study interviews

In this section the data from the case interviews are analysed to generate themes that add to the findings from the survey and other interview data.

Unique contribution of the STEM professional

One of the findings from the case studies was that in most of the partnerships the STEM professional brought into the school program something that the teacher could not. Table 9.1 presents extracts from the reports of the case studies selected to illustrate the unique contribution the partnerships made possible. The diversity revealed illustrates how the SMiS model allows the schools to tap into the unique contribution that the STEM professional can make.

Table 9.1: The unique contribution of the STEM Professional through the SMiS partnership

Case	Unique contribution of the STEM Professional
1	The STEM Professional ….prepared a talk based on Australian research, discoveries and inventions, mostly related to the organisation where she works.
2	Alice, the teacher, was delighted to have a female scientist to dispel the students' stereotypical notion of scientists being male.
3	The teacher took …students to Susan's place of work, a university, where the students were exposed to 3D models and interactive videos of the solar system … something that otherwise would not have happened.
4	Heather has addressed the year 12 students speaking about, among other things, how mathematics works in her area of employment (astrophysics), and how it is such a big part of getting any job.
5	Louis demonstrates how to 'talk to the computer' by teaching students logic and trigonometry for example.
6	In one school George has year 10 students work with him on research projects …, another invites him to school during science week to demonstrate clinical activities, another has him give career guidance to aspiring scientists.
7	The children grew bacteria and fungi on agar plates… Peter, the scientist, explained how to do the sampling and inoculation of the agar medium…. Such hands-on activity and the resulting insights would not have been possible with the school's existing equipment and without the expertise of the scientist.
8	Each lesson is followed with a conversation where Matthew (scientist) explains to Grace (teacher) "how he did things or why he did things". Grace feels that not only is she learning the vocabulary and the concepts, she is also 'learning how he is doing the teaching of the topic.'

The flexibility of the SMiS model enables partnerships to build on the expertise of the STEM professional while addressing specific needs identified by the teacher. For example, Heather, the astrophysicist was able to provide first-hand information of how mathematics is used in her work, something that the teacher Patrick was not able to do. However, the case study interviews pointed to the fact that these valuable outcomes were frequently not apparent immediately but evolved as the partners explored the needs of the school and the capabilities of the STEM Professional.

These cases highlight that the SMiS model does enable schools to take full advantage of the expertise that the STEM Professionals bring to the school and the importance of ensuring that all parties understand that it may take some time and discussion before the full potential of the partnership can be realised.

The flexibility of the model

The survey data showed that partnerships involved quite diverse arrangements. The case studies provide further evidence of this and

Many if not most STEM professionals bring to school programs activities and experiences that partner teachers could not. The SMiS program thus affords a valuable and innovative contribution to school STEM education.

additional insights into patterns of variation. Table 9.2 shows that in most of the case study partnerships the program involved different sized groups at various year levels.

Again the evidence is that, although the partnership may be formally between a single teacher and a STEM professional, over time the contribution of the STEM Professional is not always confined to a single class of students.

Indicators of success

One of the issues for programs such as the SMiS program is the difficulty of obtaining data that can establish the outcomes of the program. However, although the design of the case study interviews did not cover this issue, in a number of the interviews the interviewees pointed to some evidence of success of the partnership.

- In Case 1 the scientist 'reported a very positive response from the children indicating that they asked lots of questions, so many that she couldn't deal with them all. Further, she pointed out that some of the children were able to recall 12 months later the ideas to which she had introduced them'.

Table 9.2: The groups of students involved in the partnerships covered by the case studies

Case	Nature of participating groups of students
1	Many grades across a primary school
2	The grade 2 classes in a school plus multi-age groups at lunchtime club
3	Two classes of Foundation students plus all the year 8 students
4	Classes of advanced mathematics students in years 8, 9 and 12
5	8 Year 5/6 students with advanced skills in mathematics
6	Students across a range of grade levels in 8 different schools
7	Grade 3-6 students in a small rural school (school population 31)
8	One primary school class

- In Case 2 two upper primary school students from the school said they now have 'another layer of learning, we want as much science as we can because we are going to high school next year.' The students describe Kelly as very'knowledgeable.' She can 'educate us in something new that our teachers aren't as confident with.' She 'explains things really well', and 'she likes to learn things as much as we like to learn things.'
- In Case 3 'students recounted the learning they did with Professor Susan, included topic vocabulary used correctly and with ease. …the students describe scientists as asking "good questions", using telescopes, and what scientists think about.'
- In Case 4 the teacher reported that 'some students have also requested that they have one-on-one time with Heather to discuss her area of expertise'.
- In Case 7 'the children displayed enthusiasm about the program and readily commented on what they had learnt'.
- Case 8 points clearly to teacher learning: 'Grace was clear about what she needed with regards to her own professional development and has benefited immensely by communicating this with Matthew … We're building - I am trying to up-skill myself with terminology and facts.'

Again, while there is rarely any formal evidence of the outcomes of such partnerships, the participants themselves were able to point to indicators of success.

Matching is no simple matter

The cases provided further evidence and more detail to support the conclusion from the other data sources, that matching is no easy task. There are teachers who are not really clear on what it is that they want from the partnership. Again, there are occasions when the project officer does not fully know what it is that the teacher is looking for. In Case 4 the teacher rejected the first mathematician proposed as not having the appropriate background to meet his needs.

Participants change their employment. In Case 1 the teacher left the school at the end of the year without informing the appropriate people. In this case the situation was redeemed as the scientist checked back with the school and a new relationship was formed.

The matching process can be simplified when there are factors outside the formal processes which bring the potential partners together. For example, in Case 2 one of the parents at a school advised the teacher that she had offered to join the SMiS program. When this was communicated to the project team a successful match was made.

The evidence from this part of the assessment suggests that this issue must continue to be under review by the SMiS project team to increase the likelihood of successful matches. Having potential participants spend more time and effort on clarifying what the partnership could provide may pay dividends for the matching process.

Relative responsibilities within the partnership

As shown in Table 9.3 there was great diversity within the partnerships in the roles played by the partners.

Table 9.3 Spread of responsibilities in the partnership

Case	Spread of responsibilities
1	The scientist took the major role in determining the nature of the partnership.
2	Initially, Kelly and Alice met every fortnight, for quite a few weeks to discuss how Kelly could be best utilised in the school. These conversations were important is establishing the scientist's interest and skills, orientating the scientist into the school and gaining an understanding of each partner's objectives.
3	The focus was determined jointly by the expertise of the scientist and the teacher's curriculum knowledge.
4	'Patrick (teacher) did not know what to expect when first partnered with Heather. As it turns out Heather really wants to be involved with the students, and offers to help out in many classes during her visits.
5	In this partnership the teacher determined the format – working with a small group of talented students – and the content of the program was left to the mathematician.
6	The scientist reported on 8 partnerships in which he has the major responsibility for deciding what will be done.
7	There were four sessions, conducted through an online video system, where the children were introduced to the scientist and he explained his work and showed them around his laboratory…. The classroom teacher was not really involved in the arrangement except to support the children's experimental work.
8	Now into the third year of their partnership, Grace and her partner-scientist, Matthew, have negotiated a routine. At the beginning of each year they "sit down and map out what areas we are doing in what term".

This enormous diversity clearly points to the strength of the SMiS model which allows partnerships to address identified needs and utilise the capabilities that the STEM professional brings. But the cases also point to the value of time spent, such as in Case 2, in exploring how the resources being offered to the school can best be used.

There is considerable diversity in the respective roles of the STEM professional and partner teacher, reflecting differing approaches to effectively utilising the strengths of each partner to meet the needs of students and the school.

Curriculum

The data suggest that there is variability in the centrality of curriculum to the thinking of the people interviewed for the cases. The curriculum was mentioned by three teachers and a scientist.

- 'Alice and Philip planned the projects with Kelly and prepared for Kelly's visit (school timetabling, supporting classroom teachers etc.). Philip spoke of the opportunities there are to link to the curriculum given Kelly's range of experience in science.' (Case 2)
- 'Anna considers that the curriculum is much richer having a partner-scientist, that Susan enhances what is already taught.' (Case 3)
- 'George notes the teachers' commitment to curriculum and attempts to fit in with that by conducting activities related to students' topics of learning. He does however express concerns about the 'lack of sincerity' the current curriculum has in representing science. George believes that he offers some real-life examples providing opportunities for students to develop a more 'in-depth' understanding of a 'superficial' curriculum. 'The accomplishment of letting kids experience and see things that we do first hand'. (Case 6)

While SMiS activities relate to the curriculum in different ways, the school curriculum is an important consideration in planning within the partnership.

- Matthew, an agricultural scientist, 'took it upon himself' to download the curriculum and decides 'what he thinks he can offer or what he can help me (Grace) with'. (Case 8)

With a focus on Science as a Human Endeavour within the Australian Curriculum, the SMiS Program provides an opportunity for students at both primary and secondary schools to interact positively with scientists. Although they did not mention curriculum specifically, for some of the teachers this was the main focus of the partnership and the activities were designed to allow the scientists' background and career to be the basis of discussions and investigations.

Impact on the school community

The CSIRO SMiS Program pairs a teacher with a STEM professional but some of the cases show that the impact often spreads beyond this pairing to others in the school community. This may be planned or a flow on effect whereby the details of the activities are shared at school assemblies, through the school newsletters, staff meetings or reportedly parents discussing the benefits with teachers or each other. From the case data there were clear examples where the impact of the program was being felt throughout the wider school community. This was evident through the interest of principals, other teachers wanting to interact with STEM professional or the activities, and parents commenting at parent teacher nights.

Suggestions

The teachers and STEM professional interviewed provided some suggestions for improving the program. Some of these are set out in Table 9.4.

Table 9.4: Suggestions for the future operation of the SMiS program

Case	Suggestions for the operation of the SMiS program
1	She suggested that more formal contacts with the program staff would be helpful, believing that a more structured arrangement might encourage and support more scientists to participate in the program.
2	From her experience, Alice suggested a need to be specific about the sorts of expertise and qualities in the request for a scientist. She recommended providing scientists with professional learning about the landscape they will be working in e.g.: primary or secondary. She also suggested that the profile of the program could be promoted to a wider audience with greater acknowledgement of the value the partner scientist can bring to the school.
3	She (Anna) recommends that the scientists could have some ideas of what to do because for example she 'didn't even know what an astrophysicist did and didn't know what to ask'; because Susan was able to suggest a project, it just 'went from there.' She would like to hear quick examples of how other schools implement the program, and hopes that CSIRO communicate to others 'how easy and fun it is,' because 'the costs are only a couple of emails.'
4	Patrick feels this type of person – someone working in 'real world maths' – would be more beneficial than someone from a university.
5	Louis believes that an organisation like CSIRO is necessary to facilitate partnerships of this type because he believes that such partnerships do not 'happen organically.'
6	George suggests a bigger campaign by CSIRO to let teachers know the depth and breadth of what science does.
7	Caroline commented that she thought the role of the project officers should be extended to include more contact or more specific contact, such as a school visit.
8	Grace has observed 'the principal can see there's more interest across the board, in science, than there used to be.' Furthermore, Grace notes, 'there is discussion in the parent community about the program,' which includes wondering how all students, not just those in Grace's class, can be involved in the program.

The data show that all of those involved in these cases have respect for the SMiS model and what it is able to achieve. However all have suggestions about ways in which the program could be enhanced. Most of the suggestions, matching those made in the survey, involve greater support, in various forms, from the SMiS team. Naturally, it is recognised, this depends on the availability of resources.

In summary

The case studies demonstrate that while the SMiS model allows a great deal of flexibility and results in quite unique arrangements in each school there are some common issues which emerge across the partnerships portrayed. For instance, unsurprisingly the curriculum is a major factor in the thinking of the teachers when deciding on the focus of the partnership. Again, attention must be given to the unique contribution that the STEM professional can make and to the relative responsibilities of the partners in planning the collaborative activity.

Further, these case studies have shown that, although each of the partnerships represents a unique interpretation of the SMiS model, those being interviewed pointed to impacts that went beyond the classroom of the partnering teacher. In some cases the interaction involved other teachers and impacted on the school community as a whole.

Such considerations provide a base from which to consider how to generate and maintain effective partnerships using the SMiS model.

10. CONCLUSION

The Scientists and Mathematicians in Schools (SMiS) and ICT in Schools: a partnership program (ICTiS) is a major national program involving many teachers, students and scientists, mathematicians and ICT professionals. As such it not only has presence in a large number of schools but is significant as an exemplar for a national agenda in bringing schools and STEM professionals together in collaborative arrangements. The program has implications for student engagement in STEM and career choice, for teacher professional development, for national STEM curricula, and for national policy directions around public understanding of science, mathematics and ICT.

The SMiS program has grown from a pilot with teachers and scientists in 2007 to being a major STEM partnership program involving teachers, scientists, mathematicians and ICT professionals. There have been changes in operation, mainly expansion following three successive evaluations that found significant benefits from the program. This evaluation has attempted to examine more closely than hitherto the nature of the partnerships, the partnership activities, and the patterns of outcomes, with a view to provide advice on the status of the SMiS model and how it might be refined to maximise the returns on the considerable investment represented by these STEM professionals working with teachers in schools.

The SMiS model is unique in Australia, if not in the world, in being based on a one-to-one partnership between a STEM professional and a teacher, in being flexible in the nature of the activities and particular focus of the partnership, and in the longer term nature of the partnerships. These features were distinct in the findings both from the survey and the case studies. While many partnerships, especially at primary schools, involved more than the partner teacher and were significant at the school level, overwhelmingly the partnership arrangements were driven by the partner teacher and STEM professional. The flexibility is apparent in all the data sources, showing up in the varied nature of activity profiles, reported on in Section 5, and in the case descriptions. The ongoing nature of the partnerships is evidenced by the longevity of many of the partnerships that were reported on, with a mode of 3-4 years and quite a few still active after 7 years.

This assessment has attempted, through chiefly three data sources – the online survey, interviews with the SMiS team, and case studies of selected partnerships or partners – to unpack in some detail the nature of the partnerships in terms of the activities undertaken and the evolving nature of the partnership arrangements. It has also attempted to examine the variety of intentions the partners bring and the benefits that are seen for the three sets of participant groups – students, teachers, STEM professionals – and the way these relate to aspects of the SMiS model. It has generated an analysis of the return on investment, which looks at the outputs, outcomes, and longer-term impact flowing from the SMiS program. Findings have been canvassed throughout the sections. In this concluding section we will draw on this data to respond to the evaluation questions guiding this evaluation of impact and value. These questions are:

1. What are the outcomes for students, teachers and STEM professionals as a result of the Scientists and Mathematicians in Schools program?
2. How is the Scientists and Mathematicians in Schools Program changing students' and teachers' engagement with, and knowledge and understanding of, STEM practices?
3. What are the similarities and differences among the partnerships developed by teachers and scientists, teachers and mathematicians, and teachers and ICT professionals?
4. What are the strengths of the Scientists and Mathematicians in Schools model? What significant attributes of the SMiS model are highlighted when considering an overview of a range of initiatives involving STEM professionals, including university and industry working with schools?
5. In what ways could the Scientists and Mathematicians in Schools model be implemented which would result in it being ahead of leading practice and which would enhance program outcomes and impact?

The structure of this closing chapter has been shaped by these questions but also by the data which has emerged from the study and which has been analysed in earlier chapters

Outcomes of the SMiS program

The data generated in this assessment point clearly to a range of significant outcomes for students, teachers, STEM professionals, and, in some cases, whole schools. Taking the high benchmark measure of 'very significant' benefits for each of these stakeholders, a range of positive outcomes were identified for each participant group that are consistent with the aims of the SMiS program and with wider policy frameworks for STEM in Australia, for science, mathematics and technology curriculum priorities, for teacher professional learning, and for the engagement of STEM professionals in education and in public understandings of STEM more generally. It needs to be noted that there are different relative emphases amongst the partnerships, some with a greater impact on student outcomes, others on teacher outcomes, others on outcomes for the STEM professionals, reflecting the flexibility of the SMiS model.

The key outcomes for students were engagement with science, mathematics and ICT learning and reasoning, engagement with models of thinking and working in science and mathematics and ICT that would not have been possible without the STEM professional's presence, and knowledge of, and enhanced attitudes towards, STEM pathways and careers. For teachers the outcomes were improved motivation and engagement in science and mathematics teaching, the enjoyment of working with STEM professionals, and of increased engagement of their students, improved teaching processes and, for primary teachers especially, increased confidence with teaching. For STEM professionals the outcomes included enjoyment of promoting their commitments and knowledge to a new generation of students, increased understanding of, and confidence in, promoting public understandings of STEM, gaining an alternative perspective on their own work, and enjoyment of working with teachers.

The analysis of the return on investment showed that the cost of managing the program was returned 1) almost three-fold in terms of the time commitments of STEM professionals, and 2) three-four fold in terms of the cost of equivalent outputs by other means first for student learning through proxy interactions with professional educators, and second for teacher access to equivalent PD, and school access to professional change management in STEM. Further, it is argued that the nature of the program yields returns in effectiveness and appropriateness of outcomes, given that the modelling of contemporary STEM practices, that is the focus of these partnerships, is central to contemporary policy and curriculum thinking. Wider potential longer-term impacts of the program are identified in school and teacher change, Australian STEM curriculum development, and STEM policy input, which position the SMiS program as an exemplar of STEM partnership models.

Changes to students' and teachers' engagement with and knowledge of STEM practices

One of the key findings of this assessment is that the focus of the partnerships was clearly and jointly understood by most teachers and STEM professionals, and centred not on transmission of concepts in science and mathematics but rather on students engaging with the values, commitments and practices of scientists and mathematicians. The key knowledge / experience that scientists and mathematicians bring to the partnerships was acknowledged by all partners as their passion and curiosity. High on the list also was the ability to tell stories about STEM and STEM practitioners, knowledge of how evidence is built and scientists and mathematicians think and act, and what it's like to work as a scientist or mathematician. The case interviews provided illustrations of the unique contributions of the STEM professionals, many of them built around their own inquiry practices. Similarly, outcomes for students centred on increased awareness of the nature of STEM work, scientists as people, the way science and mathematics are used in the world, and in the world of work. These are all outcomes strongly linked to identity development aligned with STEM, providing students with models of what it is to practice science, mathematics and ICT in real situations. These outcomes are strongly linked to student interest in and enjoyment of science, mathematics and ICT, which are also high on the list of perceived benefits.

For teachers the key outcomes were related to enjoyment of working in the partnership and of enhanced engagement of students. We could read this enjoyment of working with their partner scientists and mathematicians as related to the exposure this brought to knowledge and valuing of contemporary practice and how to represent it in classroom teaching. Evidence of this comes from the further outcomes expressed by teachers, of updating knowledge of STEM practices and knowledge, and increased motivation and improvement in teaching practices in STEM. Again, the focus is on practices and methods rather than textbook knowledge, and how to translate this into teaching approaches.

Again, the analysis of the return on investment highlights the value of the professional learning teachers gained through the partnerships, through considering the cost of replacement professional development activities, and the effectiveness of the outcomes in supporting key policy and practice dimensions for teacher learning.

Variation in the partnerships

The SMiS program partners teachers with STEM professionals and provides support for the beginning and ongoing relations between partners. However beyond that there are no constraints on the partnerships and the data shows an enormous variation in the activities, and time committed, for the teachers and STEM professionals. Some partnerships involve yearly events where the scientist or mathematician visits to present to a class, while others involve ongoing visits around special projects with the STEM professional spending considerably more time with the school and in some cases being significantly involved with the school science curriculum.

This flexibility in arrangements allows the model to be adapted to the needs of different levels of schooling, the different discipline areas, and contexts. There were significant differences between primary and secondary schools on a number of dimensions to an extent that gives the program a different focus. The basis of this is, of course, the different circumstance of primary and secondary teachers of science, with primary teachers generally non-specialist and not familiar with disciplinary practices of science, or often with problem solving and reasoning practices in mathematics. Thus, secondary teachers and particular senior secondary teachers of science went into the program already quite confident, such that growth of confidence was not such an issue. On the other hand primary teachers showed a lower beginning confidence level and a much more significant growth of confidence through the partnership. STEM professionals tended to spend more time working with primary schools (37 hours compared to 20 hours for secondary), and were more likely to work with larger groups of teachers on whole of school activities. Some scientists have become quite involved with primary school programs and take some responsibility for organising curriculum. For secondary schools, and particularly at senior secondary levels, the partnerships seemed more targeted and framed by the science teachers who were specific about their curriculum needs related to particular topics. For secondary schools there was a significant focus on career identification that was not present for primary schools where the focus was more on

The survey data show significant differences between science partnerships in primary and secondary schools, that imply that support for and framing of the program by the SMiS team should take account of these very different contexts for the partnerships.
The SMiS team could undertake more detailed exploration of these differences, to develop processes and resources to optimally assist the formation of successful partnerships at both levels of schooling.

recognition of the ways in which scientists and mathematicians think and work. Through the analysis of data generated from a number of survey questions this evaluation, distinct from previous evaluations, has explored differences between science partnerships in primary and secondary schools. The data do show significant differences that imply that support for and framing of the program by the SMiS team should take account of these very different contexts for the partnerships. The SMiS team could undertake more detailed exploration of these differences, to develop processes and resources to optimally assist the formation of successful partnerships at each of these levels of schooling. Thus, information sought from primary teachers about needs and contextual factors may be different than for secondary teachers. Illustrations and recommendations for activities, and advice concerning teachers' roles in relation to their schools, may also be different.

Mathematicians in Schools (MiS) and particularly ICT in Schools (ICTiS) are more recent inclusions in SMiS and are smaller in terms of number of partnerships. This made it difficult to generate secure findings about the ICTiS program in particular. There were a number of differences however between the MiS and SiS partnerships for which there is robust evidence that relate to the different nature of the disciplines, and the different circumstances of the curriculum areas. One difference was the greater variety of activities scientists were involved in including excursions, science competitions, supervising projects, science clubs, and assisting teachers with content knowledge. Mathematicians spent a greater fraction of their time in classes or giving talks, or helping individual students. In terms of the knowledge/experience mathematicians brought to bear, this was similar to scientists except the capacity to tell stories featured less for mathematicians. These differences are consistent with the more sequential and structured nature of the mathematics curriculum compared to the variety of science curriculum activities.

There was, however, a similar focus on thinking and working in science and mathematics, on inquiry and reasoning. In mathematics, compared to science, this was not cast as an outcome involving recognition of mathematicians as people. In terms of outcomes, there was more focus on career knowledge for mathematics, perhaps reflecting a desire to broaden students' notion of the variety of professions for which mathematics is a key capability. There is a different connection between scientists' work and the science curriculum, compared to mathematics, in that scientists are more recognisable, and named as such in professional work, than mathematicians. A mining geologist is more recognisably a scientist, than an actuary is a mathematician. These differences, again, imply a need for the CSIRO SMiS team to diversify the way they characterise the program for the different disciplines, the different knowledge and experience the STEM professionals can bring to the table, and how these relate to curriculum innovation.

The strengths of the SMiS model

The SMiS model is characterised by its focus on a one-on-one partnership between a STEM professional and a teacher, and by the flexibility that is allowed in this. The model also includes support by the SMiS team for matching partners, for getting started, and ongoing support from the SMiS team. There are a number of very readily apparent strengths of the model. First is the individual and collaborative nature of the partnership. Many comments in the survey and data from the case interviews attest to the strong collaborative nature of successful partnerships, where over time the arrangements have developed as both partners come to recognise strengths that can be tapped into to create activities that draw on the STEM professional's expertise, and the teachers' professional insights into students' learning needs. SMiS is one of few programs that can facilitate a focus on a range of capabilities such as teamwork, inquiry and problem solving skills, productive dispositions, as well as knowledge of concepts and practices in contemporary STEM settings.

The second strength is the flexibility and adaptability of the model to local context, leading to great variety in ways of running the partnership. Thus, the partnerships have been able to develop differently for primary and secondary schools, and for science and mathematics, as well as for different contexts of the partners. This includes, for primary schools mainly, the possibility of the STEM professional working across the school. The nature of activities is negotiated according to the particular strengths and knowledge and availability of the STEM professional, and the curriculum needs of the students as perceived by the partner teacher.

A third strength is the longitudinal nature of the partnership. Many most frequent partnership length reported on by teachers was 3-4 years, and some of the science respondents were reporting on partnerships that had been active for 5-7 years, attesting to the value ascribed to these by both partners. In many cases these partnerships had altered in character as the partners grew in their understandings or changed in their work contexts, indicating a commitment to this way of working together.

The SMiS model would benefit from a sharper framing of the nature and purpose of the involvement of STEM professionals in schools in terms of curriculum innovation, and in terms of the knowledge and experience that STEM professionals can bring to enliven students' experience of science, mathematics and ICT.

There is an opportunity for more explicit recognition of the challenges of the boundary crossing between the STEM professional and school community and ways of productively negotiating this, in framing SMiS processes and resources.

This evaluation has made the point that the SMiS model sits alongside many STEM partnership and outreach initiatives in Australia, all of which contribute to encouraging engagement with STEM learning and practice in some sense. What is distinctive about the SMiS model however are the strengths described above — its one-to-one collaborative nature, and the longitudinal nature of the collaboration. Both these features make it unique in encouraging and supporting partnerships that are sensitive to the context of the teacher and school and the

STEM professional. This allows for genuine negotiation and refinement in the partnership to occur based on the partners' strengths and developing understandings. It also encourages the projection of the STEM professional's ways of thinking and working, leading to higher level STEM skill development and also positive identity work for students, in ways not afforded by more managed, and shorter term programs. It is distinctive in conferring significant benefits for all three players.

The wider curriculum significance of the model lies in the fact that the partnerships involve a negotiation between two distinct communities of practice – that of the STEM professional field, and that of the teacher in school. In order to plan and implement productive activities partners need to recognise the boundary between these communities and work to establish ways of 'boundary crossing' (Akkerman & Bakker, 2011; Tytler, Symington & Cripps Clark, in press) between them. A number of comments on reasons for reframing partnerships, revealed in the survey and the case studies, illustrate the process of teachers helping the STEM professional to interpret their expertise in a form that engages students, and STEM professionals planning with teachers to introduce new ideas into the curriculum, and ways of supporting inquiry skill development. In the strongest cases, the partnerships yielded a classroom practice that represented a coming together of professional and classroom practices, supporting the significant curriculum agenda of bringing STEM curricula more into line with STEM professional practices in order to better engage and challenge students. In this sense, the SMiS model offers the possibility of advancing curriculum thinking in the STEM fields of science, mathematics and ICT. More explicit recognition of these challenges and ways of resolving them, within the framing of the model and its support structures, would be a helpful step forward.

Challenges for the SMiS model

It has been argued at various places in this assessment report that the SMiS model is unique in Australia and possibly in the world for its flexibility through local partnership negotiations. The SMiS program is thus significant in promoting such a model in a field of STEM outreach that has wide international currency. As with any model that allows and encourages flexibility and local autonomy there are risks also associated with this freedom. Thus, the data shows a number of instances the partnerships fail to take hold, or continue with misgivings held by one or more of the partners. There is also a significant incidence of assigned partnerships that do not become active (i.e. 23% of partnerships are withdrawn). The data do not identify a common factor in these less than satisfactory partnerships but relevant insights can be gained from the many teachers and STEM professionals in the longer term partnerships who describe the strength of their relationship, and mutual benefit, and point to a coincidence of interests and strong personal characteristics as the key to productive and sustainable partnerships. Teachers and STEM professionals alike were agreed on the major factors determining successful partnerships, being the nature of the relationship, communication, alignment of goals, ability of the scientist to translate their knowledge to engage students, matching of the partners, rapport, and opportunity and willingness to jointly plan.

The SMiS team should give serious consideration to the partner matching and early partnership support processes with a view to improving efficiencies through reduction in numbers of withdrawn or less productive partnerships.

The process of setting up partnerships

From the evidence gathered in the study, as noted above, it is clear that a successful partnership hinges on the nature of the relationship, the capacity for negotiation and mutual support, and a coincidence of interests. Thus, the matching process is critically important for ensuring ongoing success, and also ongoing support to help when these are minimally present. In terms of matching of partners, currently this is done by the CSIRO SMiS team primarily on the basis of identification of topic by the school, matching expertise of the scientist, and location of both individuals. Yet it seems that in successful cases the expertise is not as crucial as expectations and willingness to negotiate. There are a number of cases where the STEM professional felt the partner teacher did not understand their role and expected the scientist or mathematician to offer 'free lessons', rather than expect to play an active part in framing the partnership activities. Negotiation between the teacher and STEM professional involves 'boundary crossing' as described above, and matching processes should be cognizant of this challenge both in ensuring the partners understand the nature of the role each must play, and that they are clear in their expectations of what the partnership might offer. Here, support devices might involve a requirement of teachers and STEM professionals to articulate what their respective contexts and expectations are, beyond a list of substantive topics. More important in terms of the partnership was the capacity of the STEM professional to represent the nature of thinking and working in their discipline. The production of a resource with suggestions for possible activities and roles, supported by case narratives, would open up possibilities for both parties as to what their expectations might be. Further, a requirement that applications articulate clearly a felt need and a set of possible intentions for the partnership that go beyond requests for topics, may sharpen potential participants' thinking about and expectations of the program.

One issue that was raised by a number of the SMiS team, and evident in the data, was a tension between the quality and quantity of partnerships as SMiS expanded. The needs of recruiting and matching partners as against offering ongoing support is a balancing act given the finite resources of the SMiS team. There were a number of comments in the survey, and also the case interviews, that indicated a need for support that was not met, when partnerships were stagnating. If means could be found of streamlining the matching and setting up process, through some degree of automation, supported by appropriate informational resources, this would free time for the team to support ongoing partnerships.

Ongoing partnership support processes

It has been pointed out that the SMiS model supports contemporary curriculum thinking in allowing a focus on science inquiry skills, science as a human endeavour and mathematics inquiry and reasoning.

Facilitating this in the partnerships involves an interesting mix of STEM professional partners' knowledge, including passion and curiosity, part of the mind-set that scientists and mathematicians bring to tasks, knowledge of STEM practices, including the way evidence is built to support knowledge, and stories of how STEM professionals think and work. It is this form of knowledge – of how ideas are built and justified in science and mathematics, and of ways scientists and mathematicians think and work – that support these directions. There thus exists the possibility that the SMiS program can offer significant support for these curriculum directions by utilising the partnerships as exemplars of how to incorporate contemporary thinking and practice into the school STEM curriculum. In order to do this effectively however, the particular expertise that STEM professionals can bring to the partnerships, and how this can be expressed in the classroom, need to be more sharply identified and articulated. This report offers a start in that direction.

In summary: key findings

The data in this evaluation show clearly that SMiS is a highly effective program in terms of the scale of its operation as a significant part of the Australian STEM education scene, the multiple significant benefits for students, teachers and STEM professionals, and the clear return on investment of resources. It is a well-managed program that is becoming increasingly mainstream in terms of curriculum links and directions. It has built up a solid cadre of teachers and STEM professionals who are enthusiastic about its benefits.

The challenges the program faces relate to operational issues concerning partnerships that withdraw or wilt through lack of inspiration or understanding of possibilities. Constructing evidence based resources through which partners can understand possibilities, their roles, and how to conceptualise outcomes, could help in better harnessing the good will of participants to a worthwhile end.

The program has distinctive features that set it apart from other STEM partnership programs in supporting significant links between the Australian STEM community, teachers and school communities, and curriculum. With attention to more sharply articulating the nature of the knowledge that STEM professionals can uniquely bring to schools, the nature of student and teacher learning outcomes, and the relationship of these to STEM curricula, the program would be well placed to position itself to be ahead of leading international practice.

Below is summarised the key findings that have implications for continuation and further refinement of SMiS resources and processes.

1. This evaluation has clearly established that the program is both effective in achieving its outcomes and that the model makes a unique and significant contribution to Australian STEM Education. The implication that flows from this is that the program is worthy of ongoing funding at least at its current level. Given the opportunity it offers to substantially support new directions in Australian STEM education, consideration should be given to further expanding the program.
2. In order to further support the creation of productive partnerships through matching potential partners' needs and expectations, the CSIRO SMiS team should give consideration to the development of specific

resources and/or processes that provide teachers, schools and STEM professionals with clear understandings of the benefits of the partnerships, possible partnership activities, and the respective roles of the partners. This would include explicitly identifying:

- the types of expertise that STEM professionals can uniquely contribute to the partnerships,
- the roles and responsibilities of teachers and STEM professionals and the challenges they can expect to face,
- the student learning in each subject that can flow from partnerships, and
- the benefits for STEM professionals flowing from participation in the program, and by implication the benefits that flow to their organisations.

3. The CSIRO SMiS team in its further development of resources to support partnerships, should give consideration to creating resources that explicitly recognise and develop advice around:
   - challenges due to the different cultures that operate in schools and STEM workplaces, and the challenges of developing mutual understandings of educational purposes and possibilities.
   - significant differences in school culture and possibilities which impact on the way the SMiS model can be applied differently in primary compared to secondary classrooms and schools.
   - significant differences in current practice and in possibilities when the SMiS model is applied in ICT, mathematics and science classes.
4. To increase the efficiency and effectiveness of matching of partner needs and expectations the SMiS team should give consideration to:
   - refining the nature of information provided by teachers and STEM professionals when enrolling for the program.
   - initiating a trial on-line process that could be used by teachers and STEM professionals to identify potential partners.
5. The CSIRO SMiS team should continue to engage with all relevant groups concerned with STEM education to more sharply position the SMiS program in relation to Australian STEM Education
6. In order to position the SMiS program to lead international practice, the SMiS team should consider initiating a project aiming to more sharply articulate the nature of the expertise that STEM professionals can uniquely bring to schools, the nature of student and teacher learning outcomes, and the relationship of these to STEM curricula. These understandings would inform policy directions and partnership support processes.

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Model mapping table

Program Delivery Method	External Partner/ Mentor				Program Discipline Focus					Program Flexibility*		
	Ongoing involvement	Online	One-off interaction or one-off project based	None	Science	Maths	ICT	Engineering	Combination	None	Limited	Complete
In School Programs												
Scientists in School Australia	X				X	X	X	X	X			X
PENCIL (USA)	X				All Disciplines							X
STEMNET (UK)	X								X			X
Scientists in School Canada	X		X		X	X	X	X	X		X	
Science in the Schools (France)		X	X	X	X						X	
ABCN Building Critical Skills 1:2:1	X					X						X
SCITECH - In School programs			X		X					X		
Royal Botanic Gardens Melbourne School Partnership, Mentor or Gardening Programs	X				X						X	
In2science	X				X	X	X	X	X			X
Concept2Creation	X	X	X		X	X	X	X	X	X		
SciWorld			X		X					X		
Science on the Go			X		X					X		

* Flexibility provides potential but requires the support.

Timeline				Year Level			Co-ordinator affiliation			Initiator			Cover-age			Program incorporates						
Annual	Ongoing	Module based	One off	Primary	Secondary	Primary & Secondary	Government	Private Organisation	University	School	Teacher or Professional	University	State or Terittory based	Australia wide	International	Australian Curriculum link	Increasing Teacher understanding	Increasing Student engagement	Problem Solving	Inquiry Skills	Teamwork	Career development
	X					X	X				X			X		X	X	X	X	X	X	X
	X					X	X	X	X	X					X		X	X	X	X	X	X
	X					X	X	X	X		X				X		X	X	X	X	X	X
	X			X			X	X		X					X		X	X				
X	X	X	X		X		X			X					X		X	X	X	X	X	X
	X			X			X	X		X				X				X				
			X			X	X			X			X			X	X	X		X		
X	X					X		X		X			X				X	X				
			X		X				X	X			X				X	X			X	X
		X				X		X		X			X			X	X	X	X	X	X	X
			X			X		X		X			X					X				
			X			X			X	X	X		X			X	X	X				

Program Delivery Method	External Partner/ Mentor				Program Discipline Focus					Program Flexibility		
	Ongoing involvement	Online	One-off interaction or one-off project based	None	Science	Maths	ICT	Engineering	Combination	None	Limited	Complete
Competitions and Awards												
BHP Billiton Science Awards				X	X			X	X		X	
CSIRO CREST		X			X	X	X	X	X		X	
Australian Science Innovation Programs - Big Science				X	X					X		
NATA Young Scientists Award				X	X					X		
Australian STEM Video Game Challenge				X					X	X		
STAQ (Science Teachers' Association of Queensland) Science Contest				X	X							X
NSW Young Scientists Award				X	X							X
Woodside Scitech Science Awards				X	X							X
Oliphant Science Awards				X	X						X	
Australian Informatics Olympiad Program (including Australian Informatics Competition)				X			X			X		
'FIRST (For Inspiration and Recognition of Science and Technology). Lego League Jnr Lego League Robotics Competition Tech Challenge'	X	X	X		X	X	X	X	X		X	

Timeline				Year Level			Co-ordinator affiliation			Initiator			Cover-age			Program incorporates						
Annual	Ongoing	Module based	One off	Primary	Secondary	Primary & Secondary	Government	Private Organisation	University	School	Teacher or Professional	University	State or Teritory based	Australia wide	International	Australian Curriculum link	Increasing Teacher understanding	Increasing Student engagement	Problem Solving	Inquiry Skills	Teamwork	Career development
X					X		X			X	X			X	X			X	X	X		X
X		X				X	X			X				X		X	X	X	X	X	X	X
X					X			X		X				X						X		
X						X	X			X				X								
X						X	X			X				X				X	X	X	X	
X						X	X			X	X		X									
X						X			X	X	X		X			X		X	X	X	X	
X				X					X	X			X					X				
X						X		X		X			X					X	X	X	X	
X					X			X		X				X	X	X		X	X			X
X						X		X	X	X				X				X	X	X	X	X

Program Delivery Method	External Partner/ Mentor				Program Discipline Focus					Program Flexibility		
	Ongoing involvement	Online	One-off interaction or one-off project based	None	Science	Maths	ICT	Engineering	Combination	None	Limited	Complete
Competitions and Awards [continued]												
The FI in Schools™ Technology Challenge	X				X	X	X	X	X			X
Launchbox L IFTOFF! Competition		X							X		X	
Gold Coast Science Competition				X	X					X		
Regional Science and Technology Fairs (NZ)				X	X					X		
New Zealand's Next Top Engineering Scientist				X					X	X		
American Mathematics Competiton				X		X				X		

Timeline				Year Level			Co-ordinator affiliation			Initiator			Cover-age			Program incorporates						
Annual	Ongoing	Module based	One off	Primary	Secondary	Primary & Secondary	Government	Private Organisation	University	School	Teacher or Professional	University	State or Teritory based	Australia wide	International	Australian Curriculum link	Increasing Teacher understanding	Increasing Student engagement	Problem Solving	Inquiry Skills	Teamwork	Career development
X					X			X		X				x	X		X	X	X	X	X	X
X						X		X		X	X			X	X			X	X	X	X	
X						X			X	X	X		X					X		X		
X					X		X			X					X			X	X	X	X	X
X					X				X	**					X				X		X	
X							X			X	X				X			X				

** Students nominate

Program Delivery Method	External Partner/ Mentor				Program Discipline Focus					Program Flexibility		
	Ongoing involvement	Online	One-off interaction or one-off project based	None	Science	Maths	ICT	Engineering	Combination	None	Limited	Complete
Online Resources (with and without in school options)												
EngQuest 2015		X			X		X	X	X		X	
Science Assist (Australian Science Teachers Association)				X	X					X		
Primary Connections				X	X					X		
Regional Universities Network (RUN) Maths and Science Digital Classroom Project		X		X	X	X	X	X	X	X		
SCITECH - DIY Science kits				X	X					X		
ABC Splash (including Sleek Geeks)				X	X	X	X	X	X	X		
CAASTRO in the Classroom		X			X					X		
Make it Count				X		X				X		
STELR				X	X	X	X	X	X	X		
Wonder of Science		X			X					X	X	
Cosmos for Schools				X	X				X	X		
PULSE@Parkes		X			X				X		X	
QMEA (Queensland Minerals and Energy Academy)				X	X				X	X		
Science by Doing				X	X					X		
Hands on Science			X		X					X		
Science Alive (School Programs)			X	X	X					X		
Launchbox (pilot pject) - Victorian Space Science Education Centre (VSSEC)			X	X					X	X		
All you need is {C<3DE} (The European Coding Initiative)		X	X				X				X	
Future Classroom Lab (European)		X							X		X	

Timeline				Year Level			Co-ordinator affiliation			Initiator			Cover-age			Program incorporates						
Annual	Ongoing	Module based	One off	Primary	Secondary	Primary & Secondary	Government	Private Organisation	University	School	Teacher or Professional	University	State or Terittory based	Australia wide	International	Australian Curriculum link	Increasing Teacher understanding	Increasing Student engagement	Problem Solving	Inquiry Skills	Teamwork	Career development
X		X				X		X			X			X		X	X	X	X	X		X
		X				X	X			X	X			X		X				X		
		X		X				X		X	X			X		X	X	X		X		
		X			X		X			X	X			X		X	X	X	X	X		
		X				X	X			X			X			X		X		X		
	X					X	X			X	X			X		X	X	X		X		
		X			X		X			X			X					X				
						X	X			X			X			X	X	X				
		X			X			X		X				X		X	X	X		X		
		X		X				X		X	X		X			X	X	X		X		
		X			X			X		X	X			X	X	X	X	X				
			X		X		X			X	X			X		X	X	X		X		
		X				X		X		X	X		X			X	X	X		X		
		X			X		X			X	X			X		X	X	X	X	X		
		X		X				X		X			X			X	X					
			X	X				X		X			X			X	X	X		X		
		X				X	X			X			X									
	X	X				X	X	X			X				X		X	X	X	X	X	
		X				X	X	X		X	X				X		X	X	X	X	X	

Program Delivery Method	External Partner/ Mentor				Program Discipline Focus					Program Flexibility		
	Ongoing involvement	Online	One-off interaction or one-off project based	None	Science	Maths	ICT	Engineering	Combination	None	Limited	Complete
Other including Pilot programs												
Australian Maths and Science Partnerships Programme (AMSPP) projects:				X	X	X				X		
University of Tasmania - STEM Education and Outreach Programs			X		X	X					X	
Growing Tall Poppies Program	X				X	X	X	X	X			X
The Smart Science Initiative				X	X					X		
Adelaide Bite STEMball Program			X		X	X	X	X	X	X		
Western Australian School Pathways Program - Defence Industries	*				X	X	X	X	X			X
Mobile Science Education			X		X	X				X		
TechLauncher	X						X					X
CRADLΣ (Singapore)				X	X					X		
CHAOS (Singapore)				X	X					X		
Science Membership Program (Singapore)	X				X						X	

* A range of options are available including work experience and traineeships

Timeline				Year Level			Co-ordinator affiliation			Initiator			Coverage			Program incorporates						
Annual	Ongoing	Module based	One off	Primary	Secondary	Primary & Secondary	Government	Private Organisation	University	School	Teacher or Professional	University	State or Terittory based	Australia wide	International	Australian Curriculum link	Increasing Teacher understanding	Increasing Student engagement	Problem Solving	Inquiry Skills	Teamwork	Career development
X							X		X			X	X	X		X	X	X				X
			X			X			X	X			X			X	X	X		X		X
X					X		X	X	X	X				X		X	X	X	X	X	X	X
		X			X		X		X	X				X		X		X		X		X
			X	X				X		X			X					X			X	
	X				X		X			X			X									X
			X			X		X		X			X			X		X	X	X		
X					X			X	X	**			X					X	X	X	X	X
		X	X		X		X	X		X	X				X		X	X	X	X	X	X
X					X		X	X	X	**					X			X	X	X	X	X
X					X		X	X	X	**					X			X	X	X	X	X

** Students nominate

Program Delivery Method	Website
In School Programs	
Scientists in School Australia	http://www.scientistsinschools.edu.au/
PENCIL (USA)	http://www.pencil.org/
STEMNET (UK)	http://www.stemnet.org.uk/
Scientists in School Canada	http://www.scientistsinschool.ca/
Science in the Schools (France)	http://www.sciencesalecole.org/
ABCN Building Critical Skills 1:2:1	
SCITECH - In School programs	http://scitech.org.au/education/at-your-school
Royal Botanic Gardens Melbourne School Partnership, Mentor or Gardening Programs	http://www.rbg.vic.gov.au/learn/programs/other
In2science	http://www.latrobe.edu.au/in2science
Concept2Creation	http://www.concept2creation.com.au/
SciWorld	http://sciworld.org.au/
Science on the Go	http://www.griffith.edu.au/griffith-sciences/science-on-the-go
Competitions and Awards	
BHP Billiton Science Awards	http://www.scienceawards.org.au/
CSIRO CREST	http://www.csiro.au/en/Education/Programs/CREST
Australian Science Innovation Programs - Big Science	https://www.asi.edu.au/site/programs_bigscience.php
NATA Young Scientists Award	http://www.nata.com.au/nata/news/nata-young-scientist-award
Australian STEM Video Game Challenge	www.stemgames.org.au
STAQ (Science Teachers' Association of Queensland) Science Contest	http://www.staq.qld.edu.au/queensland-science-contest
NSW Young Scientists Award	http://www.stansw.asn.au/
Woodside Scitech Science Awards	http://scitech.org.au/events/all/959-woodside-scitech-science-awards
Oliphant Science Awards	http://www.oliphantscienceawards.com.au/
Australian Informatics Olympiad Program (including Australian Informatics Competition)	http://orac.amt.edu.au/

Program Delivery Method	Website
Competitions and Awards [continued]	
FIRST (For Inspiration and Recognition of Science and Technology): Lego League Jnr Lego League Robotics Competition Tech Challenge	https://firstaustralia.org/competitions/
The F1 in Schools™ Technology Challenge	http://rea.org.au/f1-in-schools/
Launchbox L IFTOFF! Competition	http://www.launchboxspace.com/
Gold Coast Science Competition	http://www.griffith.edu.au/griffith-sciences/science-on-the-go/events/gold-coast-science-competition
Regional Science and Technology Fairs (NZ)	https://www.niwa.co.nz/education-and-training/science-and-technology-fairs
New Zealand's Next Top Engineering Scientist	http://www.des.auckland.ac.nz/en/for/secondarystudentsandschools/nzntescompetition.html
American Mathematics Competiton	http://www.maa.org/math-competitions
Online Resources (with and without in school options)	
EngQuest 2015	http://www.engquest.org.au/
Science Assist (Australian Science Teachers Association)	http://assist.asta.edu.au/
Primary Connections	https://primaryconnections.org.au/
Regional Universities Network (RUN) Maths and Science Digital Classroom Project	http://www.usq.edu.au/research/research-at-usq/institutes-centres/adfi/digital-classroom
SCITECH - DIY Science kits	http://www.scitech.org.au/education/at-your-school/diy-science
ABC Splash (including Sleek Geeks)	http://splash.abc.net.au/
CAASTRO in the Classroom	http://www.caastro.org/education-and-outreach/school-engagement/caastro-in-the-classroom
Make it Count	http://mic.aamt.edu.au/
STELR	http://www.stelr.org.au/
Wonder of Science	http://wonderofscience.com.au/

Program Delivery Method	Website
Online Resources (with and without in school options) [continued]	
Cosmos for Schools	https://cosmosmagazine.com/schools
PULSE@Parkes	http://pulseatparkes.atnf.csiro.au/
QMEA (Queensland Minerals and Energy Academy)	http://www.qmea.org.au/
Science by Doing	https://www.science.org.au/science-by-doing
Hands on Science	http://www.handsonscience.com.au/
Science Alive (School Programs)	http://sciencealive.com.au/
Launchbox (pilot pject) - Victorian Space Science Education Centre (VSSEC)	https://www.vssec.vic.edu.au/programs/launch-box/
All you need is {C<3DE} (The European Coding Initiative)	http://www.allyouneediscode.eu/
Future Classroom Lab (European)	http://fcl.eun.org/
Other including Pilot programs	
Australian Maths and Science Partnerships Programme (AMSPP) projects:	https://www.education.gov.au/australian-maths-and-science-partnerships-programme-amspp
University of Tasmania - STEM Education and Outreach Programs	http://www.utas.edu.au/stem
Growing Tall Poppies Program	http://www.growingtallpoppies.com/
The Smart Science Initiative	http://www.smartscience.com.au/
Adelaide Bite STEMball Program	http://www.d2dcrc.com.au/news/adelaide-bite-stemball-program/
Western Australian School Pathways Program - Defence Industries	http://det.wa.edu.au/curriculumsupport/schoolpathways/detcms/portal/
Mobile Science Education	http://www.mobilescienceeducation.com.au/
TechLauncher	http://cs.anu.edu.au/courses/COMP3500/
CRADLΣ (Singapore)	http://www.science.edu.sg/
CHAOS (Singapore)	http://www.science.nus.edu.sg/
Science Membership Program (Singapore)	http://www.science.nus.edu.sg/

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