Australian Journal of Teacher Education

Volume 38 | Issue 1 Article 6

2013

Working with Science Teachers to Transform the Opportunity Landscape for Regional and Rural Youth: A Qualitative Evaluation of the Science in Schools Program

Grania R. Sheehan
Monash University, grania.sheehan@unimelb.edu.au

Jennifer Mosse
Monash University, jennifer.mosse@monash.edu

Evaluation of a Program Designed to Build Science Teaching Capacity in Rural Australia

Grania Sheehan
Jennifer Mosse
Monash University
Gippsland

Abstract: This article reports on a qualitative evaluation of the Science in Schools program; a suite of science based activities delivered by staff of a regional university campus and designed to provide professional development for science teachers working in non-metropolitan schools in a socioeconomically disadvantaged region of Australia. The research identified a range of issues including: the influence of socioeconomic disadvantage and rurality on teachers' professional learning needs, and the importance of subject specific discourse communities and content knowledge for new and out-of-field teachers. Implications for the design and implementation of school-university partnerships are discussed.

Introduction

Students living outside metropolitan areas are under-represented in university student populations when compared with their metropolitan counterparts (Hu, 2003; James, Bexley, Anderson, Devlin, Garnett, Marginson & Maxwell, 2008). This inequity in higher education participation reflects endemic educational disadvantage experienced by these students and their teachers during children's years of schooling. Secondary school students in non-metropolitan Australia face significant barriers in accessing higher educational opportunities, which include difficulties in attracting and retaining suitably qualified teachers (Lock, Reid, Green, Hastings, Cooper & White, 2009), students' limited aspirations for further learning (Alloway, Gilbert, Gilbert, & Muspratt 2004), and substantial costs when undertaking tertiary studies (Polesel, 2009). The Gippsland Access and Participation (GAP) Project was established in 2009 to mitigate some of the educational challenges faced by students and teachers living in Gippsland. This paper examines the *Science in Schools* program of the GAP Project. This program comprises a range of activities that can be distinguished from the majority of Australian university led equity programs (Gale, Hattam, Parker, Comber, Bills & Tranter, 2010) by a focus on engaging professionally and geographically isolated science teachers to build science teaching capacity in non-metropolitan schools.

As a school-university partnership, the program is guided by what Gale, Seller, Parker, Hattam, Comber, Tranter and Bills (2010) have described as an equity policy logic, which reflects the Australian Government's current commitment to ensuring that university student populations reflect the composition of the wider national population (Australian Government, 2009). In Australia, "rurality and low SES together combine to produce the greatest educational disadvantage, prevailing against completion of schooling and entry into higher education" (Mills & Gale, 2011:244). Nationwide, young people living in non-metropolitan Australia are the focus of university led interventions directed at facilitating access to higher education of socioeconomically disadvantaged groups (Gale et al., 2010a). Participation and performance in mathematics and science is integral to expanding opportunities for socioeconomically disadvantaged students and reducing inequity in access to higher education. Analyses of performance in secondary science subjects and its association with individual and school level SES show considerable social inequity in relative achievement, yet school and individual based effects of SES on students' self-reported interest in science are marginal (McConney & Perry, 2010). The evidence from PISA (2011; see also OECD, 2011) indicates that, relative to their more advantaged peers, disadvantaged students spend less time learning science and have fewer opportunities to learn science at school. Among disadvantaged students in countries like France, Germany and the Netherlands, academically resilient students spend over one hour and 45 minutes more learning science at school than low achievers (OECD, 2011). This research suggests that school-university interventions to increase students' participation in science learning may be particularly important for socioeconomically disadvantaged students. The challenge for low SES non-metropolitan schools is to translate student interest in science into achievement and the development of science career linked aspirations. Evaluation of the *Science in Schools* program, while specific in context, has the potential to address questions of broader significance in teacher professional learning in socioeconomically disadvantaged non-metropolitan regions, and to inform the manner of implementation and content of school-university partnerships in science.

Literature and Background

The Gippsland Region

The *Science in Schools* program is based at the School of Applied Sciences and Engineering, Monash University, Gippsland Campus. The Gippsland region covers an area of 41,538 square kilometres (18.3% of the Australian state of Victoria). In 2009, the estimated resident population in Gippsland was 261,483 persons or 5% of Victoria's total population (ABS, 2011). Some areas of Gippsland are geographically isolated with schools located in remote communities. The region is predominantly a service economy where manufacturing, wholesale, recreation, mining (in the form of coal fired power generation) and agriculture based industries predominate (Baum, Mitchell & Hoon Han, 2008). Gippsland is further characterised by relative economic, education and occupation based disadvantage (Parliament of Australia, 2008: SEIFA indexes 2006). Success in the local economy increasingly requires aptitude in the Science, Technology, Engineering and Maths (STEM) disciplines (DEECD, 2009), yet it remains difficult to attract and retain skilled employees with this training background (DEECD, 2008; InnovationXchange Australia, 2009).

Increasing Gippsland secondary school students' participation in the STEM disciplines during secondary school and post-school training is a local policy imperative for the State Government of Victoria (DEECD, 2010a). The Australian Government has introduced a price on carbon emissions, which came into effect in July 2012. Concomitant with this environmental and economic reform, the Australian Government in collaboration with the State Government of Victoria is targeting Gippsland for a concentration of science driven industry development, workforce re-skilling and research activity in the area of greenhouse gas abatement technologies and renewable energy. This is because brown coal – a greenhouse gas intensive energy source – is extensively mined in Gippsland and used locally to produce the bulk of electricity for Victoria. A STEM skilled local workforce underpins the success of this impending technological and economic transition for the Gippsland community.

Secondary Student Participation and Performance in Mathematics and Science

Participation and performance in the senior secondary school subjects Mathematical Methods, Specialist Mathematics, Physics and Chemistry are "gatekeepers" for high stakes assessment and university entrance (Tytler, Mousley, Tobias, McMillan & Marks, 2006: 61), and considered prime measures of academic achievement (Lyons & Quinn, 2010). Lyons and Quinn identified the most "challenging and persistent issue in Australian science education over the last two decades" as declining secondary school student participation in Physics, Chemistry and Biology (Lyons & Quinn, 2010:1; see also Goodrum, Druham & Abbs, 2011). The downward trend in enrolments for these subjects in Australia has been well documented (Ainley, Kos & Nicholas, 2008), with similar patterns recorded for other developed countries including France, Germany, the United Kingdom (European Round Table, 2009), New Zealand (Hipkins & Bolstad, 2005) and Canada (Kennepohl, 2009). A corollary of this pattern of participation in the sciences at senior secondary school is the declining rate of participation in university science courses and related careers (Dobson, 2007).

These patterns of participation and achievement in secondary and tertiary science characterise the education landscape of Gippsland. During the period 1997 to 2010, Gippsland students enrolled in Victorian Certificate of Education (VCE) level mathematics (Specialist and Methods) and science (Chemistry and Physics) at lower rates compared to the state; and at comparatively higher rates for Further Mathematics and Biology (see Figure 1).

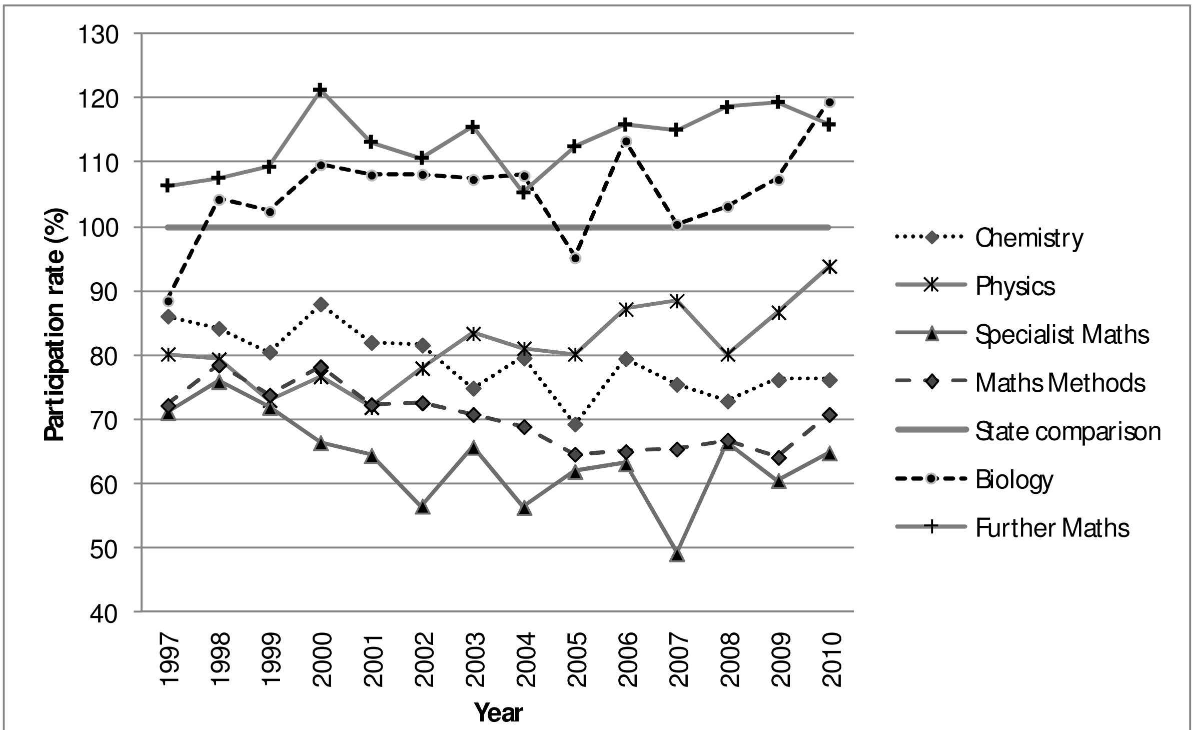

Figure 1. Participation rates of Gippsland students in VCE Chemistry, Physics, Biology, Specialist Mathematics, Mathematical Methods and Further Mathematics expressed as a percentage of the state participation rate for the period 1997 to 2010. Enrolment rates cited are sourced from the Victorian Curriculum Assessment Authority with the approval of the Department of Education and Early Childhood Development. Rates include government and non-government schools in Victoria and were calculated as a percentage of English enrolments.

This pattern of science subject choices by Gippsland students is not surprising given that Physics and Chemistry are perceived to be difficult by Year 10 students and their teachers (Lyons & Quinn, 2010). The broad array of subject options now available in Year 11, coupled with the absence of mathematics and science subject specific prerequisites for science based university courses, has enabled students to move away from those science subjects perceived to have low utility value relative to difficulty (Lyons & Quinn, 2010). Students' VCE performance is directly related to participation in higher education in Victoria through the calculation of the Australian Tertiary Admissions Rank (ATAR). The ATAR is a measure of a student's academic success in the Year 12 qualification. Reported as a number between 0 and 99.95, the ATAR represents a student's position in relation to that of other students. For example, students who receive an ATAR of 80 are positioned 20% from the top of the student group. In 2008 the mean VCE scores for Gippsland government school students in Physics and Chemistry were lower than the state mean, while Gippsland students' VCE level performance was on par with the state mean in Biology, and exceeded the state mean in Further Mathematics (DEECD, 2010b). Such findings suggest that Gippsland students who have an aptitude for mathematics and science are enrolling in the easier (or locally taught) VCE subjects, thereby elevating performance in these subject areas above what would normally be expected for non-metropolitan students. At the same time Gippsland students are narrowing the range of post-school options available to them to pursue careers in science, and to gain entrance to university more generally. VCE exam performance in Biology and Further Mathematics carries a lower weighting in the calculation of the ATAR than is the case for Physics, Chemistry and Specialist Maths.

Despite a gradual increase in the proportion of Gippsland students enrolling in university since 2007 (DEECD, 2011), the discrepancy between the proportion of Gippsland students and other Victorian students going on to higher education has increased over time. The ATAR is calculated for use by tertiary institutions to rank and select school leavers for admission to courses and, not surprisingly, Gippsland students have a different ATAR profile to the capital of Victoria (Melbourne) and the rest of the state. Gippsland tertiary applicants predominantly occupy the low to middle ATAR range (Skills Victoria, 2011), which precludes them from admission into many science based university courses.

A unique and complex interaction of education, socio-economic and cultural factors appear to be at play, generating tightly bounded opportunities for Gippsland students. The students' subject choices and academic performance limit their ability to pursue pathways to science based professional training in areas identified earlier as integral to the sustainability of local industries. Increasing the current level of student participation and performance in VCE maths and science subjects has the potential to transform the opportunity landscape for Gippsland students.

Teachers' Professional Learning Needs

Students' academic competencies, learning aspirations and imagined futures directly influence the pathways they take post schooling, including those leading to higher education (Mills & Gale, 2011). The role of teachers is important in supporting students to develop in these areas, particularly in communities that lack strong educational and professional histories. A central premise of the GAP project is that local teachers' ability to engage their students in mathematics and science learning is central to increasing Gippsland students' participation and performance in related subjects, and ultimately to increasing students' access to tertiary study. Enhancing student learning in mathematics and science, in turn, depends upon teachers' experience (Whitehurst, 2002), subject-matter-knowledge (Whitehurst, 2002) and an amalgamation or transformation of this subject matter knowledge into what has been termed pedagogical content knowledge (Lenhart, 2010; Loughran, Berry

& Mulhall, 2006; Shulman, 1986; van Driel, Verloop & de Voos, 1998). For science teachers, aspects of pedagogical content knowledge can include their orientations to teaching science, ideas about student thinking about science, instructional strategies in science, curriculum and assessment (Schneider & Plasman, 2011). Of particular relevance to the *Science in Schools* program is teachers' thorough and coherent understanding of scientific subject matter, which is a pre-requisite to the development of pedagogical content knowledge for secondary school science teachers (van Driel, Verloop & de Voos, 1998; see also Morine-Dershimer & Kent, 1999).

Despite the recognised importance of teachers' disciplinary knowledge in shaping student outcomes, rural and remote mathematics and science teachers have difficulties accessing professional development opportunities to redress gaps in this knowledge and support them in teaching new science subjects or curriculum areas (Tytler, Symington, Darby, Malcolm & Kirkwood, 2011). Analysis of national survey data regarding the professional development of secondary mathematics, science and ICT teachers in Australia (Lyons, Cooksey, Panizzon, Parnell & Pegg, 2006) revealed that these teachers in regional areas were twice as likely (in remote areas three times as likely) as their metropolitan counterparts to teach a subject for which they were not qualified. Such findings are not unique to Australia (Monk, 2007; Carlsen & Monk, 1992) and findings suggest the need for a carefully nuanced approach to professional learning for 'hard-to-staff' non-metropolitan schools characterised by low teacher qualifications, teaching out-of-field and vacancies in the staffing profile (Monk, 2007).

Lyons et al. (2006) reported that science teachers working in non-metropolitan schools expressed a considerably greater unmet need for professional development, material resources, support personnel and student learning opportunities, than did their counterparts in metropolitan centres. The further away from the metropolitan centres that schools were located, the greater the disadvantage reported by teachers (Lyons et al., 2006). A common theme across the STEM disciplines for teachers working in rural and remote areas is the experience of professional isolation in relation to their subject area (Lyons et al., 2006; Boylan, Sinclair, Smith, Squires, Edwards, Jacob, O'Malley & Nolan, 1993; Roberts, 2005). The establishment of professional learning communities (PLCs), which traditionally involve collaboration between teachers within schools with a view to improving teaching practice and student outcomes, is one way to address this sense of isolation (Vescio, Ross & Adams, 2008). Tytler et al. (2011) revealed, in their qualitative analysis of the professional learning experiences of rural mathematics and science teachers in Victoria, the difficulties faced by these teachers in maintaining links with a subject-based 'discourse community' in a context where there is a limited pool, or complete absence, of secondary school colleagues with the same specialisation. In the context of rural and remote schools, PLCs may need to operate broadly across school boundaries and specifically within subject disciplines (Tytler et al., 2011). The *Science in Schools* program aims to develop content knowledge and facilitate networking for senior science teachers in Gippsland as a vehicle for ultimately increasing students' engagement in science learning at the secondary and tertiary levels.

The *Science in Schools* Program

Typical of regional university campuses, the Gippsland campus of Monash University is engaged with its local community. Many of the activities that now form part of the program were introduced in response to direct requests from secondary science teachers seeking access to professional learning and student educational opportunities similar to those available to their metropolitan counterparts. Over time, the range and scope of these activities has grown. For example, the VCE Biology workshops, first offered to three schools (40 students) in 1998, accommodated 18 schools (350 students) in 2011. Program activities cover the senior secondary science curriculum where it best fits the academic expertise of the university staff charged with program delivery. The program provides activities designed to develop VCE science teachers' (and their students') understanding of curriculum based content and its assessment, and to establish a professional peer network for new science teachers and those teaching out-of-field. Thirty-one of the 33 schools in Gippsland offering VCE level science have had one or more of their senior science teachers involved in these program activities between February 2009 and March 2011. The core activities of the *Science in Schools* program, which aim to build teacher capacity, are described below. Table 1 presents the number of schools and teachers attending the three major program activities over time.

Activity	Participants	2009	2010	2011
Meet the Assessor Sessions				
Physics	Schools	12	17	15
	Teachers	13	17	15
Chemistry	Schools	14	14	8
	Teachers	18	14	9
Biology	Schools	25	23	27
	Teachers	31	29	31
Workshops				
Biology (DNA)	Schools	16	17	18
	Teachers	17	18	19
Chemistry (Instrumental)	Schools	15	22	21
	Teachers	15	24	23
Science Teachers Conference				
	Schools	-	14	11
	Teachers	-	31	25

Table 1: Attendance at *Science in Schools* program activities 2009 - 2011

VCE Science Examiners Meetings (also called 'Meet the Assessor Sessions')

During these two hour interactive sessions, held at the Gippsland campus and linked to remote and regional centres by telephone or video conference, teachers meet with Victorian Curriculum and Assessment Authority VCE Assessors for Year 12 Biology, Physics and Chemistry. The teachers are provided with a copy of past exams and assessment reports. The assessor expands on these reports, providing feedback on subject requirements and expectations of students' knowledge, exam technique and common problem areas on the exam. The teachers are able to ask questions of the assessor and to share their own experiences of teaching the subject. Similar sessions are run in metropolitan localities throughout Victoria each year with the support of the state government and subject specific professional associations.

VCE Science Student Workshops

A team of undergraduate and postgraduate students run curriculum based university laboratory activities for Year 12 Chemistry and Biology students and their teachers. Academics from the School of Applied Sciences and Engineering (SASE) prepare the workshop materials and supervise each workshop. The workshops cover DNA (Unit 4 Biology) and instrumental analysis (Unit 3 Chemistry), both of which are topics included in the Year 12 curriculum that are dependent on laboratory equipment and expertise not easily accessible to non-metropolitan schools.

In the Instrumental Analysis Workshop, a maximum of 30 students attend a two hour science laboratory session. Five analytical chemistry techniques are presented to the students, each by a different university student facilitator who demonstrates how an instrument is used to measure chemical phenomena, describes how the instrument works and briefly explains the chemical principles of each technique.

During the DNA workshop, a maximum of 24 students attend a 2.5 hour science laboratory session. Students participate in two linked activities, each demonstrating aspects of DNA technology under the guidance of a senior undergraduate or postgraduate student. The university student facilitators discuss the biology necessary to understanding these techniques. The data generated from these two experiments are later analysed and interpreted back in the classroom.

Science Teachers Conference

This is an annual full day conference for Gippsland secondary school science teachers, which includes a range of presentations and workshops provided by a mix of invited speakers, technical experts and experienced teachers. The conference also includes demonstrations of science, new technology, activities and external resources relevant to curriculum.

The Research Questions

This article presents the findings of a qualitative study of Gippsland secondary school senior science teachers' professional learning needs and perceived experiences of the *Science in Schools* program activities. Specifically, the study examined whether secondary science teachers in Gippsland: (a) report a need to develop their content knowledge and network with other teachers of senior science subjects; and (b) perceive their participation in the program activities to have assisted them in these two areas of professional learning. Whilst reflecting a particular educational and geographic setting, these research questions reveal themes about professional learning for geographically and professionally isolated science teachers that are relevant beyond Gippsland and, indeed, beyond Australia.

Data Generation and Analysis

The data were gathered by interviews with 19 teachers and principals from 9 schools throughout Gippsland. Principals were included in the sample because they provide information on the culture of the school and the resources available to support science teaching and professional learning. The interviews were semi-structured and based on a framework that allowed local issues to emerge and be explored. Each interview took between half and one hour and was conducted by one of the study team, in the work place of the interviewees. The interviews were recorded and transcribed, with the permission of the study participants. The study was approved by the Monash University Research Ethics Committee.

Interviews were conducted with secondary VCE science teachers who taught senior Biology, Chemistry and Physics, and who had been involved in the program activities. The interviews focussed on teachers' professional learning needs, and on how participating in the program activities related to their curriculum relevant content knowledge, ability to connect with professional peers and capacity to engage students in science learning. Principals' interviews included expectations of subject teachers and the resources and professional learning opportunities available to support science teachers.

Whilst the sample is small, it was purposively selected to focus attention on a range of school, classroom, teacher and community factors that characterise the documented challenges faced by senior science teachers in non-metropolitan schools. The schools involved in the study ranged in size and distance from provincial city areas. The SiMERR rurality index developed by Lyons et al., (2006) takes into account population density and accessibility and was used to identify schools and describe their location. Schools located in provincial cities, provincial and remote areas were selected. Table 2 provides a brief profile of each school and its community setting, and indicates the number of interviews conducted at each school.

School	Type of school	Brief description	Int
Blue-gum (BP-12)	Primary and secondary	This is a small school of 143 students and 14 teachers operating in a remote beachside town with a population of 972 residents. At Easter and Christmas the population increases by about 8,000. It is one of the most isolated towns in the state of Victoria.	2 teachers
Saltbush (SP-12)	Primary and secondary	This the smallest school in the sample with 47 students and 12 teachers operating in a remote location. The town has a population of 223 residents and is an important transit centre for trucking freight between state borders.	1 principal 2 teachers
Acacia (AP-12)	Primary and secondary	This is a small school of 124 students and 19 teachers operating in an outer provincial area. The school services a population of 281residents. The primary industries are forestry and livestock farming.	1 principal 3 teachers
Moonah (MSC)	Secondary	This college is located in an outer provincial area. It has 294 students and 27 teachers. The town is a service centre for the primary industries of beef and dairy cattle, and sawmilling. It is the largest secondary school in a remote region of Gippsland and a hub for networking and exchange of resources for science teachers across this region.	1 principal 2 teachers
Waratah (KSC)	Secondary	This is a medium sized secondary school located in an inner provincial area where dairy and timber industries predominate. The school has 328 students and 31 teachers, and services a population of 2106 people.	1 teacher
Cumbungi (CSC)	Secondary	This secondary college of 1,348 students and 96 teachers is part of education precinct that includes an Institute of TAFE and an apprenticeships training centre. It is co-located with a university campus. The town is in an inner provincial area in close proximity to the open cut mines and coal fired power stations.	2 teachers
Bloodwood (BSC)	Secondary	This secondary college is a privately funded school of 1,198 students and 85 teachers. It is located in a provincial city where the local economy is driven by brown coal mining and electricity production.	2 teachers
Paperbark (PSC)	Secondary	This school is a medium sized secondary school located in a provincial city area. It has 588 students and 46 teachers. The school offers a Select Entry Accelerated Learning Program for academically advanced students across the region and offers a broad VCE curriculum in mathematics and science every year.	1 teacher
Wirilda (WP-12)	Primary and secondary	This college is a private school of 1,427 students and 117 teachers, located in a provincial city area. Of the schools sampled it is the closest to the capital city. The town has a large education industry with three secondary schools and two tertiary institutions. The community is characterised by a high level of socio-economic and educational advantage.	1 teacher

Population figures taken from the 2006 Australian Census.

Table 2: Schools visited and interviews conducted.

The sample included two non-government and seven government schools that varied in academic culture, the aspirations of students and their parents with regard to higher education, and the resources available to attract specialist teachers in science. The Index of Community Socio-Educational Advantage (ICSEA: ACARA, 2012) values for the schools sampled ranged from 948 to 1130; the average ICSEA score for Victorian schools is 1000. The proportion of VCE students from each school who enrolled at university in 2010 ranged from 20% through to 54%; the 2010 average enrolment rate for the state is 49% and, for students from all non-metropolitan schools, 36.8%.

Teachers working in the small outer provincial and remote area schools sampled were constrained in their ability to provide a broad VCE curriculum in mathematics and science with Physics and Specialist Mathematics offered by correspondence, and Chemistry units taught every second year, or in composite Years 11 and 12 classes. The larger schools sampled were located in provincial cities within a two hour drive of a capital city. These schools offered a broad full senior science and mathematics curriculum on site every year.

Teachers' specialist knowledge and expertise in the science subjects taught varied across the sample. Applying Schneider and Plasman's (2011) categories of science teaching experience, the sample included new science teachers (0-3 years of experience); teachers with some experience (4-10 years) and much experienced teachers (11 or more years). Leader science teachers who acted as mentors for new science teachers or had leadership roles with peer teachers were also included in the sample. Teachers with a tertiary science specialisation who were teaching a VCE subject in this field were sampled, along with teachers teaching science subjects out-of-field. Some of these out-of-field teachers were new to teaching, whilst others were very experienced. All of the teachers interviewed had recently taught general science at the junior secondary level.

Despite the small sample size, the number of teachers interviewed is representative of the total number of teachers who participated in each of the three program activities. Saturation in the qualitative analysis was achieved despite considerable diversity in teaching experience, school and community characteristics (Atran, Medin & Ross, 2005; Glaser & Strauss, 1967). Teachers from outer provincial and remote area schools were more likely to participate in the study than those from provincial city based schools; no principals from the provincial city based schools sampled agreed to be interviewed. The larger provincial city based schools are arguably less dependent on the program activities as a source of professional learning than the small geographically isolated schools and consequently may have been less inclined to participate in an evaluation of the program.

We wish to understand how teachers' professional learning needs are framed by the context in which they engage with their students and to identify why they sought support for their professional learning through involvement with the *Science in Schools* program activities. We make no claim that our sample of schools is representative of non-metropolitan Australian schools in similar circumstances and do not seek to homogenise the experiences of science teachers working within other provincial city and outer provincial and remote area schools.

Analysing the Data

A sample of three interview transcripts was read by three people: the practitioner and science academic who led the design and implementation of the *Science in Schools* program; the academic who led the evaluation; and a social science researcher who was unfamiliar with the program and its evaluation. The coding structure and broad themes identified were discussed and a collective interpretation identified. Group coding and discussion continued until there was agreement between the three coders. These steps ensured the trustworthiness of the data analysis (Lincoln & Guba, 1985). The broad themes identified, around which the analysis was conducted, related to: the role teachers play in encouraging students to go on and study science at the VCE and tertiary levels; the professional learning needs of teachers and related opportunities available in their specific subject area; the influence that teachers' perceived their participation in the program activities had on their teaching and student learning. In reporting the data analysis, quotes are used to illustrate the main themes emerging from the data and variation within the theme. Quotes are variously labelled to indicate the individual teacher, the school and its location, the teachers' specialisation and experience. The generic category of outer provincial/remote area schools is used to designate the speaker for quotes in order to protect the identity of teachers working in small schools.

Findings and Discussion

The findings will be presented and discussed under three subsections, consistent with the main themes: the role of science teachers in facilitating participation in science at the VCE and tertiary levels, teachers' professional learning needs, and teachers' experiences of the program activities. The findings and quotes presented in this paper are predominantly those generated by teachers. The information provided by the principals helped to elucidate the context for this commentary but was not the focus of the evaluation.

The Role of Science Teachers

Teachers can serve as change agents to increase students' participation in science and broaden the opportunity landscape. Goode described the successful agency of individual teachers in the context of senior secondary information technology teaching as being able to "disrupt the organisation of schooling that limits opportunities for historically unrepresented students to access high-status knowledge" (Goode, 2007: 72). Central to identifying the presence and nature of this agency on the part of science teachers working in provincial and remote area schools is the perceived role that these teachers play in encouraging their students to go on to study science at the VCE and tertiary levels. This, in turn, informs the professional learning opportunities that teachers seek and influences the nature of their engagement with the program.

Facilitating Participation in VCE Level Science

The teachers generally described their role as that of science educators who facilitate participation in VCE level science by 'engaging' junior secondary students' interest in science learning. 'Engagement' relates to the intensity and emotional quality of a students' involvement in learning and has been variously described as having affective (e.g., interest), behavioural (e.g., persistence) and cognitive dimensions (e.g., deep level learning strategies) (Fredricks, Blumenfeld & Paris, 2004; Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey 2009). The affective dimension of students' engagement with science learning was a recurring theme in the teachers' commentary. Achieving 'engagement' was variously described by ten of the teachers interviewed as dependent upon their making science "fun", "interesting", "exciting" and "enjoyable" for their students.

> I think the biggest role for a junior science teacher is really to engage them and to interest them and probably not spend so much time on all the concepts and all the background ... I suppose it's more of a theatrical-performance-type role than actually imparting wisdom. (Much experienced General Science and VCE Biology teacher)

Student engagement in thinking about the connection between abstract ideas and the real world is integral to science learning (Gallagher, 2000). Demonstrating the application and relevance of science to everyday life was a recurring theme and considered by teachers to be central to fostering their students' interest in science.

None of the teachers who were interviewed identified their own knowledge of science as important for engaging junior secondary students in science learning, yet having breadth and depth of content knowledge in the subject was considered central to helping senior secondary students' pursue science at the tertiary level. Subject matter knowledge has been shown to influence instructional practice across the grade levels from middle to senior secondary schooling (Brophy, 1991; Lee, 1995). In this study, the qualitative findings suggest that its influence on teaching junior secondary students was downplayed by teachers, despite all but one of the interviewees having a specialisation in science. Perhaps these teachers' mastery of the general science curriculum was implicit in the way they taught and the importance of content knowledge became salient as the curriculum became more challenging for them professionally.

The heavy emphasis on 'engaging' junior secondary students in science, and the primarily affective nature of this engagement, was perceived by two teachers as setting them up to be science 'entertainers' at the expense of cognitively engaging students in science learning. These teachers suggested that this emphasis may distract students from the disciplined and difficult nature of scientific inquiry. They commented that such an approach could leave students ill prepared for learning the current Year 11 and 12 science curriculum where the academic rigour required contrasts starkly with the students' prior learning experience. Consistent with this perception, a recent national study of the quality of Year 11 and 12 science in Australian schools revealed the senior secondary science curriculum to be overcrowded, content- laden, and conceptually difficult with an emphasis on theoretical abstract ideas (Goodrum, Druhan & Abbs, 2011).

> Junior school [science] is exciting and it's more hands-on and the teacher is doing all sorts of exciting little things and kids get this idea of what science is, which doesn't match up with the reality in years 11 and 12. And part of it is inevitable. We can't make it as exciting, perhaps, as we can't always do finger painting. (Much experienced General Science and VCE Biology teacher)

Other perceived aspects of the science teachers' role in encouraging junior secondary students' future participation in science include building students' academic confidence in science and developing their foundational skills in scientific inquiry. Although the teachers who were interviewed rarely commented on skills development as facilitating junior secondary students' transition to VCE science, it was nevertheless implicit in the teachers' commentary about needing to build students' confidence or self belief in their ability to successfully study science at this higher level.

> Well, you've got to have them, they've got to be successful. They've got to do fairly well at it and enjoy it and then they'll be right then and you've got to get that in Year 7 and Year 8. (Much experienced General Science and VCE Biology teacher)

Students' skills and confidence in their academic ability during middle school influences their choice of subjects at the VCE level, yet only one teacher spoke directly about developing junior secondary students' foundational skills in scientific inquiry as being an important aspect of their role in encouraging students to enrol in senior secondary science. That teacher was the Head of Science in a private school, known in the region for its culture of academic achievement.

> They have the basic skills to enable them to do well for later on ... So we've put into that year seven and eight level, the understanding that really we are teaching them for the future. We're not just keeping them entertained for 75 minutes and then moving on. (Head of Science at a provincial city based school)

Australian research suggests that students' future participation in senior secondary science is influenced by a complex interplay of factors, many of which were identified by the interviewees. Students are most likely to achieve in science if they are interested and motivated, and if they have confidence in their abilities to learn science and to tackle new problems (Harris & Calma, 2009). Whilst secondary school students' attitudes toward science learning are correlated with achievement, 'self-belief' is a stronger predictor of success than 'general interest' (Ainley, Kos & Nicholas, 2008). Interest in science has been shown to explain no more than 9% of the overall variation in science achievement (Thompson & De Bortoli, 2008). These findings suggest that secondary science teachers' agency through focussing on their students' affective engagement with science may contribute little to increasing the rate of Gippsland students' participation in VCE level science.

Facilitating Participation in Science at the Tertiary Level

In contrast to the role science teachers adopted with their junior secondary students, these same teachers viewed their senior secondary students as dependent on them to broaden their educational and occupational horizons. This was especially important for teachers working in outer provincial and remote area schools, where students are considered by teachers to have tightly bounded aspirations that excluded going to university and have limited exposure to adults with diverse occupation histories.

> I think for us in a location like this, we face the challenge in that the students don't see a wide range of professionals and the parents aren't coming from a lot of professional backgrounds. So for us it's important to expose that to the students and to show them what is possible. I guess one of the challenges we face is that education is perhaps not as highly valued as it might be in other communities (Biology teacher with some experience working in an outer provincial/remote area school)

The lack of occupational models in rural communities in Australia provides students with few experiences and relationships from which to draw on in imagining what they might become (Mills & Gale, 2011; Alloway et al. 2004). This can also affect the value rural students place on schooling (Mills & Gale, 2011). James et al. (1999) found that rural students are significantly less likely than their urban counterparts to believe that a university course will offer them the chance of an interesting and rewarding career, and significantly more likely to believe that there is no point in going to university.

The teachers reported modelling a science based career for their students, and described relying on universities to assist them in this role by providing information about careers in science and opportunities to expose their students to campus life. Teachers also spoke of actively encouraging senior secondary students to pursue their interests and aptitudes in science, and exposing them to real world applications of science.

> Every time we start a topic in chemistry, of course I try to think of an application for it, or if something comes up in the course I say, "Oh this is what those sort of chemists do. This is what companies employ them to do". I guess at every opportunity trying to make it real for them. (Much experienced Chemistry teacher from an outer provincial/remote area school)

In contrast to this approach, science teachers from the two schools with a strong culture of academic achievement and high rates of student enrolment in tertiary education emphasised pragmatism and parental influence as drivers of student participation in VCE level science.

> I don't teach many kids that are doing physics for the pure love of physics. I teach kids that are doing physics because they like physics, they enjoy it and they can do it. But physics is a tool to get them to somewhere else. This is going to help their ATAR score. University is where they want to go. (Much experienced Physics teacher from a provincial city based school)
> Interviewer: Who's driving that?
> Teacher: Parents.

Teachers' commentary on facilitating their students' aspirations to go on to higher education was generally limited to their descriptions of how they engaged with senior secondary students. For junior secondary students, the emphasis is placed on facilitating students' interest in science, as opposed to identifying for students where science skills can ultimately lead them. This runs counter to research evidence for the effectiveness of aspiration based university-school partnerships that target socio-economically disadvantaged students (Gale et al., 2010b). Broadening these students' aspirations and assisting them to translate the aspiration into an expectation of academic success and self-confidence should take place much earlier in a student's schooling (Gale et al., 2010b).

Teachers' Professional Learning Needs

Many teachers had travelled to Melbourne in the past three years to avail themselves of professional learning opportunities, such as metropolitan based Meet the Assessor Sessions, the Science Teachers Association of Victoria Conference, and a workshop on genetics run by the Gene Technology Access Centre. The high degree of overlap between these metropolitan based activities and those offered by the program is not surprising, given the grass roots nature of its development; activities were introduced to meet the expressed professional learning needs of Gippsland teachers with whom the academic staff had come into contact.

Discipline Based Professional Learning Network

Teachers from across the Gippsland region reported wanting to network with local secondary science teachers, primarily for the purposes of sharing teaching resources and reducing professional isolation within subject specific VCE teaching areas. Access to professional peer networking opportunities was considered particularly important to those teachers working in outer provincial and remote area schools. These schools tended to have one senior secondary teacher per subject and the Chemistry and Physics teachers were often teaching out-of-field.

> One of the difficulties in a small school is you don't have a faculty... In biology, I am the faculty. So I think one of the key things for small schools is being able to develop that faculty approach across other campuses, or through associations ... The best PD for me was connecting with other teachers that were teaching biology... Just meeting people willing to share resources. (VCE Biology teacher with some experience from an outer provincial/remote area school)

National survey findings (Lyons et al., 2006) are consistent with this commentary. Secondary science teachers nationwide rated collaboration with teachers in other schools their fourth highest professional development need based on a list of 14 pre-identified areas of professional development. This need was greatest for those teachers working in remote and provincial area schools (Lyons et al., 2006). Interactions with a discipline based learning community and the exchange of subject specific resources was viewed as particularly important by Gippsland teachers new to the profession or teaching out-of-field. Specific to rural Victoria, Tytler et al's (2011) research highlights the importance of subject specific professional learning for mathematics and science teachers.

Development of Content Knowledge

Teachers who were teaching Biology, Chemistry or Physics out-of-field, or who were teaching a VCE subject for the first time, considered content knowledge to be their most important professional learning need. Whilst this particular area of professional development was not listed in the national survey (Lyons et al., 2006), it is consistent with the finding that teachers from provincial and remote area schools expressed a need for teachers qualified to teach the senior science courses. Teachers who taught in-field considered developing their content knowledge as key to engaging their senior students' interest in the curriculum content. Some of these teachers reported struggling with new curriculum content, which they hadn't covered in their tertiary training.

> The biology course now is so content rich and so different to any biology I did at uni, 15 years ago. And I spend a lot of time at home every night brushing up on content that I've never seen or heard before, just to be able to teach it the next day. I would jump at the chance to do some content biology PD. (New Biology teacher teaching in-field)

Access to laboratory based technical assistance and to the equipment used to conduct experiments and measure scientific phenomena was very limited in the outer provincial and remote area schools sampled and this generated a further area of ‘knowledge’ based professional learning for teachers working in these schools. A national review of technical support for science teaching (Hackling, 2009) highlights the additional pressure on teachers, and negative effects on curriculum, when technical support is inadequate.

The importance of teachers’ content knowledge is well recognised in the research literature on science and mathematics education. Secondary science teachers with a specialisation in their field of instruction have higher achieving students than those teachers who are teaching out of field, irrespective of the students’ socioeconomic background or prior achievement; and this effect is stronger in advanced science courses (Whitehurst, 2002). While science teachers require a deep understanding of the subject matter that they teach, knowledge alone is by no means sufficient (Ball, Thames & Phelps, 2008; Zeidler, 2002). Teachers also need to employ pedagogical content knowledge to ensure the content is comprehensible and to engage students in deeper learning (Shulman, 1986:9 as cited in Ball, Thames & Phelps, 2008). For Gippsland based teachers struggling with a new VCE science subject or challenging curriculum content in their area of specialisation, it was professional learning to deepen or broaden their content knowledge that they reported seeking.

Teachers’ Perspectives of the ‘Science in Schools Program’ Activities

This section presents the teachers’ reported experiences of the program activities, and examines whether these experiences accord with the aims of the program: the development of curriculum based content knowledge and professional peer support for senior secondary science teachers.

Content Knowledge

Biology, Chemistry and Physics are dynamic academic disciplines where knowledge and the equipment and processes employed to derive that knowledge change over time, as does the school curriculum. Secondary science teachers must continually up-date and acquire new content knowledge. This can be particularly difficult for teachers from non-metropolitan schools where access to discipline specific equipment and expertise is limited (Lyons et al., 2006). As one experienced Physics teacher teaching out-of-field in an outer provincial/remote area school, commented:

> I think most experienced teachers have got the pedagogy but maybe not the knowledge base to be able to expand and have really good dialogue with students.

Teachers reported attending the DNA and Instrumental Analysis Workshops with a view to developing their own content knowledge in the particular curriculum content area covered by the workshop.

> I’m taking my Year 12 Biology (students) down to the DNA Workshop. The School hasn’t done it before but I’m basically treating it as PD myself (New Biology teacher teaching in field at an outer provincial/remote area school).

For out of field and graduate teachers, the workshops were generally considered to have assisted them to develop their content knowledge.

> It was subject material I never knew about really. I just thought it was something they put in a machine and it was some sort of x-ray. I didn’t know and so, me having to teach it from not knowing anything about it, I’d spent quite a while combing through a couple of different textbooks, trying to teach myself a bit about it but being unaware of what the intention from the curriculum document study design was. The [Instrumental Analysis] Workshop just put it into focus. (Much experienced teacher teaching Chemistry out-of-field at an outer provincial/remote area school)

A very experienced Chemistry teacher at an outer provincial/remote area school who had completed a specialisation in Chemistry in the 1980s reported that the Instrumental Analysis Workshop has transformed her knowledge of the curriculum from "totally theoretical". She had never before seen the instruments she now covered in class as part of the curriculum.

Experienced science teachers, and those teaching Chemistry in-field spoke of the Instrumental Analysis Workshop as having delivered learning outcomes for their students by improving students' understanding of the curriculum.

> The whole point of doing instrumentation is - particularly for little schools like us - that we can't afford the instruments. So the students went down to the university and came back with a good visual understanding and a good understanding of how the things are applied - what they're used for ... We had a range of results mid-year ... We had an A+, A, B+ and two Cs. So they scored okay. But they had a good understanding of that section, I know that for sure. (Much experienced Chemistry teacher teaching in field at an outer provincial/remote area school)

Consistent with the teachers' views on the benefits to them and their students of attending the Instrumental Analysis Workshop, there has been a steady increase in the number of secondary school science students and their teachers attending this workshop since 2009. By 2011, 87% of all Gippsland students enrolled in Year 12 Unit 3 chemistry had attended the workshop. A leader teacher from a provincial city based school described the attraction of the Instrumental Analysis Workshop for Chemistry teachers as:

> Really efficient and really effective because it's really targeted in what you want to do [and] it provides exposure to infrastructure and measurement and stuff that you don't have access to here.

The intended benefits to teachers and students of attending the DNA workshops are linked more to equipment than theoretical concepts. All but one of the Biology teachers interviewed was teaching within field, making this group of teachers much less dependent on the workshop as an avenue for developing their own content knowledge than was the case for Chemistry teachers who attended the Instrumental Analysis workshop. Teachers rarely commented on student learning outcomes in relation to the DNA Workshop. As indicated in Figure 1, Gippsland secondary students enrol in VCE Biology Units at a comparatively high rate, and perform at a level equal to, or above, the state mean, hence Biology students may be better able to master the curriculum content.

A further theme to emerge from teachers' commentary on program development was the need to broaden the scope of the current workshops to cover other content areas of the Biology and Chemistry curriculum which teachers and students found difficult; and to introduce a workshop that covers the Year 12 VCE physics curriculum. This likely reflects the increasing rate of student participation in VCE Physics (see Figure 1) and the teachers' lack of specialist training in physics.

> We'd really love something in the area of physics. As a maths/chemistry teacher, that's my weakness. Because I can cover the kinematic stuff because of my maths background and some of the atomic theory, because I have a chemistry background, but electronics challenges myself and the other teacher here. (Much experienced teacher teaching Physics out-of-field at an outer provincial/remote area school)

The Meet the Assessor sessions were considered by the teachers interviewed to be directly relevant to the curriculum, and to have enhanced their knowledge of exam content and technique within the disciplinary areas of Biology, Chemistry and Physics.

> [The Biology session] certainly built knowledge, built knowledge of how to actually be successful on the exam. (Much experienced Biology teacher teaching out of field at an outer provincial/remote area school)

It was the subject specific nature of the activities, the small group context, the direct relevance of the sessions to the curriculum and the utility of the session with regard to enhancing students' performance in examinations, which made these sessions valued professional development opportunities.

> I found [the Chemistry session] good just for revision. ... Full of good information; subject-content specific; study techniques for students; teaching parts of the curriculum that have and have not been done well in the past that perhaps needed to be focused on a little more clearly... It has influenced how

> I use my revision time; structuring classes and having more classes after school to try and fit things in ... The results will be there because of a different approach to revision, more structured, perhaps more teacher-centred revision, pointing out things that they have to do or not have to do, and whether marks are gained or lost for very specific things. (Much experienced Chemistry teacher teaching out-of-field in an outer provincial/remote area school)

Connecting with Professional Peers

None of the teachers who were interviewed spoke of the program activities as having actively or effectively facilitated the development of professional learning networks that extended beyond their school or already established relationships. This was the area of greatest discordance between the teachers reported experience, the stated aim of the program, and the teachers' expressed need for professional learning. However, these qualitative findings may not be surprising, given that the program activities were not specifically designed to establish and facilitate a professional peer network for senior secondary science teachers.

One teacher described the generalist nature of the conference as making it difficult for him to connect with a community of professional peers in Physics – the desired object of professional networking for this particular graduate teacher:

> [I] guess there was a lot of different science teachers there, as opposed to the physics conference that I go to where everyone is a physics teacher and everyone you run into, you can say, "Oh what are you doing in your classroom?" and, "How have you done this topic?" **...** I mean the only person that I really got to speak to beyond our campus staff was a couple of teachers who are teaching different subjects. Didn't help with physics. (New Physics teacher teaching in field at an inner provincial area school)

Some teachers identified the Meet the Assessor Sessions as the activity which is best placed to help them engage in subject specific discourse with teachers from different schools throughout the region.

> I do know the Meet the Assessor Session when you're sitting around a table chatting and talking to the assessor, is an opportunity to talk to others and chat to others and sort of meet people from different areas ... Because you're there with the ability to share ideas and sit around a table there's opportunities there to really network and exchange ideas with people. (Much experienced Biology teacher teaching in-field at a provincial city based school)

Professional networks are important for teachers to continue to develop their practice (Fullan, 2010). The Meet the Assessor Sessions could be developed to provide subject specific collective professional learning for professionally and geographically isolated teachers. The assessors, who have been involved in the sessions for the duration of the program, are skilled facilitators of discussion amongst teachers. Most importantly, the sessions engage novice and experienced teachers in ways that tightly focus the discourse on student learning and performance. Tytler et al. (2011) examined the considerable difficulties faced by secondary maths and science teachers in rural schools in maintaining links with discipline based discourse communities. They concluded their analysis by stating that it is a matter of priority for the Australian and Victorian governments and teaching associations to develop "strategies to ensure adequate access by rural teachers to these critically important subject-based discourse communities" (2011:878).This could be an important role for a regional university campus; and Meet the Assessor Sessions could provide a potential mechanism for developing such communities.

Conclusions and Implications

While increasing the time allocated to science teaching may contribute to individual student and perhaps community resilience, this is impractical in outer provincial and remote area schools where specialist science teachers are in short supply. School-university partnerships are one way to influence student engagement and achievement in science by increasing the capacity of the existing teaching workforce.

The *Science in Schools* program, which combines academic disciplinary expertise, technical knowledge and university infrastructure, appears to constitute a unique contribution by a regional school-university partnership to building teaching capacity in a socioeconomically disadvantaged region.

Our evaluation indicates that the program is meeting the professional learning needs of VCE science teachers with regard to the development of subject specific content knowledge. The Meet the Assessor sessions explore difficult areas of the curriculum and clarify examiners' expectations, assisting the teachers to structure revision to optimise students' performance in the exam. The VCE workshops provide relevant activities in challenging curriculum areas that update the content knowledge of a broad range of teachers. The Workshops also expose teachers and their students to scientific equipment and processes that they would not otherwise be able to access, and which are considered by teachers to be essential to students achieving a deeper level of understanding of the curriculum.

Although professional networking was a stated aim of the program, it was hoped that it could arise organically, simply by bringing teachers together from across the region to participate in the program activities together. The present thematic analysis of teachers' experiences of the program activities and their professional learning needs suggests a need for direct and active intervention to facilitate peer support for senior secondary science teachers across schools in the form of discipline based (or subject specific) discourse communities. Teacher feedback further suggests that the Meet the Assessor Sessions provide an opportunity for subject specific professional peer engagement which is not fully utilised at present, and could be used in the future to develop subject specific discourse communities for Gippsland senior secondary science teachers.

Evaluation also indicates that the program is not currently meeting a need for support of, and engagement with, middle year science teachers required to teach a broad science curriculum, sometimes outside their areas of primary expertise. Teachers identified professional learning needs in this area are not clearly articulated and, for some, appear misaligned with students' academic achievement and skills development. Collaboration between GAP project staff and science specific pedagogical experts may be required to broaden the focus of the program to build teaching capacity in the middle years of schooling, as a way to broaden students' aspirations and develop their expectations of academic success. While performance at VCE is directly linked to ATAR and access to tertiary study, the middle years of schooling are critical to students' subject choices in the senior years and post-school destinations. The addition of targeted intervention in the middle years may be key to redressing the low participation rates of Gippsland youth in science at the senior secondary and tertiary levels.

This study highlights the need for evaluation of school-university partnership programs to ensure that such programs meet the needs of the teachers and students in the communities where they are based, and that programs remain relevant as they evolve.

References

Ainley, J, Kos, J. & Nicholas, M. (2008). *Participation in Science, Mathematics and Technology in Australian Education* (ACER Research Monograph 63). Camberwell: The Australian Council for Educational Research.

Alloway, N., Gilbert, P., Gilbert, R. & Muspratt, S. (2004). *Factors Impacting on Students Aspirations and Expectations in Regional Australia*, Canberra: Department of Education, Science and Training.

Atran, S., Medin, D. L., & Ross, N. O. (2005). The cultural mind: Environmental decision making and cultural modelling within and across populations. *Psychological Review*, *112*(4), 744-776.

Australian Curriculum Assessment and Reporting Authority (2012). *Guide to Understanding ICSEA*. ACARA: Sydney.

Australian Bureau of Statistics. (2011). *National Regional Profile 2006 to 2010* (No 1379.0.55.001).

Australian Government (2009). *Transforming Australia's Higher Education System*. Canberra: DEEWR.

Ball, D. L., Thames, M. H., & Phelps, G. (2008) Content knowledge for teaching: what makes it special? *Journal of Teacher Education, 59*(5), 389-407.

Baum, S., Mitchell, W., & Hoon Han, J. (2008) Socio-economic performance across Australia's non-metropolitan functional economic regions. *Australasian Journal of Regional Studies*, *14* (3), 215 – 249.

Boylan, C., Sinclair, R., Smith, I., Squires, D., Edwards, J., Jacob, A., O'Malley, D., & Nolan, B. (1993). Retaining teachers in rural schools: satisfaction, commitment and lifestyles. In C.Boylan & M. Alston (Eds.), *Rural Education Issues: An Australian Perspective*. Wagga Wagga, NSW: Society for the Provision of Education in Rural Australia (SPERA).

Brophy, J . (1991). *Advances in research on teaching. Vol. 2: Teacher's knowledge of subject matter as it relates to their teaching practice*. Greenwich, CT: JAI Press.

Carlsen, E. J., & Monk, D. H. (1992). Differences between rural and nonrural secondary science teachers: evidence from the Longitudinal Study of American Youth, *Journal of Research in Rural Education*, 8(2), 1-10.

Department of Education and Early Childhood Development (Gippsland Region). (2008). *Gippsland Region Getting it Right Together: Vocational Education and Training in Schools* (Unpublished).

Department of Education and Early Childhood Development.(2009). *Energising Science and Mathematics Education in Victoria*. Accessed May 2012 at: www.eduweb.vic.gov.au/edulibrary/public/govrel/Policy/energising-scimaths-ed.pdf

Department of Education and Early Childhood Development (Gippsland Region). (2010b). *Gippsland Youth Commitment: Terms of reference for the Maths and Science Focus Group*. (Unpublished).

Department of Education and Early Childhood Development (Gippsland region)(2010b). *Maths Science Participation* (unpublished)

Department of Education and Early Childhood Development.(2011). *Destination Data*. Retrieved from www.education.vic.gov.au/about/research/Pages/ontrackdata.aspx

Dobson, I. (2007). *Sustaining Science: University Science in the Twenty-First Century*. Centre for Population and Urban Research and the Educational Policy Institute (Monash University. Accessed May 2012 at: www.educationalpolicy.org/pdf/ACDS.pdf

European Roundtable of Industrialists. (2009). *Mathematics, Science & Technology Education Report: The Case for a European Coordinating Body*. Accessed May 2012 at: http://www.ert.eu/issue/science-technology-engineering-and-maths

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74, 59-109.

Fullan, M. (2010). The big ideas behind whole systems reform. *Education Canada, 50(3),* 24-30.

Gale, T., Hattam, R., Parker, S., Comber, B., Bills, D. & Tranter, D. (2010). *Interventions Early in School as a Means to Improve Higher Education Outcomes for Disadvantaged (particularly low SES) Students: A survey of the Nature and Extent of Outreach Activities Conducted by Australian Higher Education (Table A) Providers*. Canberra: Department of Education, Employment and Workplace Relations.

Gale, T, Seller, S., Parker, S., Hattam, R., Comber, B.,Tranter, D., & Bills, D. (2010). *Interventions Early in School as a Means to Improve Higher Education Outcomes for Disadvantaged (particularly*

low SES) Students: *A Design and Evaluation Matrix for University Outreach in Schools*. Canberra: Department of Education, Employment and Workplace Relations.
Gallagher, J. J. (2000). Teaching for understanding and application of science knowledge. *School Science and Mathematics*, 100(6), 310-318.
Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New York: Aldine Publishing Company.
Goode, J. (2007). If you build teachers, will students come? The role of teachers in broadening computer science learning for urban youth. *Journal of Educational Computing Research*, *36*(1), 65-88.
Goodrum, D., Druham, A., Abbs, J. (2011). *The Status and Quality of Year 11 and 12 Science in Australian Schools*. Canberra: Australian Academy of Science.
Hackling (2009). Laboratory technicians in Australian secondary schools. *Teaching Science*, 55(3), 34-39.
Harris, K., & Calma, A. (2009). *Evaluating University-to-School Peer Mentoring in Science: The Influence of the In2science Program in Victorian Schools*. Melbourne: Centre for the Study of Higher Education. The University of Melbourne.
Hiptkins, R. & Bolstad, R. (2005). *Staying in Science: Students' Participation in Secondary Education and on Transition to Tertiary Studies*. Wellington: New Zealand Council for Educational Research.
Hu, S. (2003). Educational aspirations and postsecondary access and choice: students in urban, suburban, and rural schools compared. *Education Policy Analysis Archives*, 11(14), 1-13.
InnovationXchange Australia (2009). Gippsland Regional Skills Forum: Skills Action Plan. (Final Report) (Unpublished).
James, R, Bexley, E., Anderson, A., Devlin, M, Garnett, R., Marginson, S., & Maxwell, L. (2008). *Participation and equity: a review of the participation in higher education of people from low socioeconomic backgrounds and Indigenous people.* Melbourne, Victoria: Centre for the Study of Higher Education, Melbourne.
James, R., Wyn, J., Baldwin, G., Hepworth, G., McInnis, C., & Stephanou, A. (1999). *Rural and Isolated School Students and their Higher Education Choices*: *A re-examination of student location, socioeconomic background, and educational advantage and disadvantage.* Canberra: National Board of Employment Education and Training, Higher Education Council.
Kennepohl, D. (2009). The science gap in Canada: A post-secondary perspective. *Canadian Journal of Educational Administration and Policy*, (93), 1-26.
Lee, O. (1995). Subject Matter Knowledge, Classroom Management, and Instructional Practices in Middle School Science Classrooms, *Journal of Research in Science Teaching*, 32(4), 423-440.
Lenhart, S. T. (September 17, 2010). The Effect of Teacher Pedagogical Content Knowledge and the Instruction of Middle School Geometry. Doctoral dissertation for the Faculty of Education, Liberty University.
Lincoln, Y. S., & Guba, E. G., (1985). *Naturalistic Inquiry*. Newbury Park, CA: Sage.
Lock, G., Reid, J., Green, B., Hastings, W., Cooper, M., & White, S. (2009). Researching rural-regional (teacher) education in Australia. *Education in Rural Australia* 31(2). Special 25th anniversary issue. 31-44.
Loughran, J., Berry, A., & Mulhall, P. (2006). *Understanding and Developing Science Teachers' Pedagogical Content Knowledge*. Rotterdam: Sense Publishers.
Lyons, T., & Quinn, F. (2010). *Choosing Science: Understanding the Declines in Senior High School Science Enrolments* (Research Report to the Australian Science Teachers Association). Armidale, NSW: SiMERR. Accessed May 2012 at: http://www.une.edu.au/simerr/pages/projects/131choosingscience.php
Lyons, T., Cooksey, R., Panizzon, D., Parnell, A., & Pegg, J. (2006). *Science, ICT and Mathematics Education in Rural and Regional Australia: The SiMERR National Survey*. Armidale, NSW: SiMERR. Accessed May 2012 at: http://www.une.edu.au/simerr/pages/projects/1nationalsurvey/
McConney, A., & Perry, L. B. (2010). Science and mathematics achievement in Australia: The role of school socioeconomic composition in educational equity and effectiveness. *International Journal of Science and Mathematics Education* (2010), 8, 429-452.
Mills, C., & Gale, T. (2011). Re-asserting the place of context in explaining student (under-) achievement. *British Journal of Sociology of Education*, 32(2), 239-256.

Monk, D. H. (2007). Recruiting and retaining high-quality teachers in rural areas. *The Future of Children*, 17(1), 155-174.
Morine-Dershimer, G., & Kent, T. (1999). The complex nature and sources of teachers' pedagogical content knowledge. In J. Gess-Newsome, & N. G, Lederman (Eds.), *Examining Pedagogical Content Knowledge: The Construct and its Implications for Science Education* (pp. 21 – 50). Dordrecht: Kluwer Academic Publishers.
OECD (2011), *Against the Odds: Disadvantaged Students Who Succeed in School*, PISA, OECD Publishing.
Parliament of Australia. (2008). Socio-economic Indexes for 2009 Electoral Divisions: 2006 Census (Research Paper 15 (2)). Canberra: Department of Parliamentary Services.
PISA. (2011). *Pisa in Focus 5*. OECD. Accessed May 2012 at: www.oecd.org/dataoecd/17/26/48165173.pdf.
Polesel, J. Deferral of a University Offer in Rural Australia. *Australian Journal of Education*, 2009: 87–103.
Pugh, K. J., Linnenbrink-Garcia, L., Koskey, K. L., Stewart, V. C., Manzey, C. (2009). Motivation, learning, and transformative experience: a study of deep engagement in science. *Science Education*, 94, 1- 28. Doi 10.1002/sce.20344.
Roberts, P. (2005). *Staffing an empty schoolhouse: Attracting and retaining teachers in rural, remote and isolated communities*. Sydney: NSW Teachers Federation (Unpublished).
Schneider, R. M., & Plasman, K. (2011). Science teacher learning progressions: A review of science teachers' pedagogical content knowledge development. *Review of Educational Research*, 81(4), 530-565.
Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.
Skills Victoria (2011). *A Tertiary Education Plan for Gippsland Victoria: Discussion Paper*. Melbourne: Department of Education and Early Childhood Development.
Thompson, S., & De Bortoli, L. (2008). *Exploring Scientific Literacy: How Australia Measures Up*. Camberwell: Australian Council for Educational Research.
Tytler, R., Mousley, J., Tobias, S., McMillan, A. & Marks, G. (2006) 'You don't have other teachers to bounce ideas off'. Report from SIMERR Victoria, in Lyons, T. (Ed.) Science, ICT and Mathematics Education in Rural and Regional Australia: State and Territory Case Studies, pp. 44-64. National Centre of Science, ICT and Mathematics Education, University of New England & Australian Government.
Tytler, R., Symington, D., Darby, L., Malcolm, C., Kirkwood, V. (2011). Discourse Communities: A framework from which to consider professional development for rural teachers of science and mathematics. *Teaching and Teacher Education*, 27, 871-879.
van Driel, J. H., Verloop, N., & de Voos, W. (1998). Developing science teachers' pedagogical content knowledge. Journal of Research in Science Teaching, 35(6), 673-695.
Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education*, 24, 80-91.
Whitehurst, G. J. (2002, March). *Scientifically Based Research on Teacher Quality: Research on Teacher Preparation and Professional Development*. Paper presented to the White House Conference on Preparing Tomorrow's Teachers, Washington.
Zeidler, D. (2002). Dancing with maggots and saints: Visions of subject matter knowledge, pedagogical knowledge and pedagogical content knowledge in science teacher education reform. *Journal of Science Teacher Education*, *13*(1), 27-42.

Acknowledgements

The research was funded by the Australian Government Department of Education, Employment and Workplace Relations. We acknowledge the support of the Department of Education and Early Childhood Development (DEECD), and the Catholic Education (Dicoese of Sale) in granting permissions for the involvement of government and Catholic schools in the Gippsland region. In particular we thank Vanda (Onno Van den Eynde)(Gippsland Youth Commitment Senior Project Officer, Department of Education and Early Childhood Development - Gippsland Region) and Dr Trish Corrie ('On Track' survey Manager, Department of Education and Early Childhood Development) for their support, insights and the provision of data for the background to the study. The VCE mean scores are sourced from the Victorian Curriculum Assessment Authority with the approval of the Department of Education and Early Childhood Development.

We are especially grateful to the science teachers working in Gippsland. The study would not have been possible if not for their willingness to describe their experiences and share their ideas.