THE PRAXIS OF BUILDING CAPACITY IN MATHEMATICS AND SCIENCE IN A RURAL, NON-GOVERNMENT SYSTEMS OF SCHOOLS: VOICES OF TEACHER LEADERS

Vince Connor, Billinda Auld, Patricia Eakin, Kerry Morris and Michael Tilston

Catholic Education Office, Diocese of Bathurst, NSW

ABSTRACT

Much is written about teacher leaders and the impact they have in promoting and influencing change. This is a reflection from four teacher leaders from four secondary high schools of a rural, non-government system of schools as they seek to build a capacity in the learning and teaching of mathematics and science within their schools. The original study began in 2008 identifying that participation rates and achievement rates in senior mathematics and science are below NSW state average rates in higher order courses, but above average rates in the general and lower end courses. This trend has been acknowledged anecdotally at school level for many years, and more recently in Brown's Review of Education in Mathematics, Data Science and Quantitative Disciplines Report to the Group of Eight Universities (2009). Yet, in contrast to the mathematics and science trends, a study of all subjects and courses in the senior years of this system since 2001 shows student achievement across the schools is slightly above state average. Whilst the national and state trend in higher order mathematics and science is worrying, the trend in this rural, non-government system of schools is more worrying as the downward trends are stronger than for state. The question is asked "What can be done to improve student participation and achievement in more rigorous senior Mathematics and Science?"

This presentation tells the story of the action research undertaken from the perspective of four teacher leaders who form a guiding Taskgroup. Their testimony identifies the praxis of forming learning teams that are isolated and autonomous. It engages the principles of change management identified by Michael Fullan and the professional development framework of Thomas Guskey.

INTRODUCTION

Location and Setting

The schools referred to in this study are part of a rural, non-government system of schools linked to the Catholic Diocese of Bathurst. The Diocese of Bathurst extends from the Blue Mountains to the Western Plains in the central area of New South Wales. The Catholic Education Office provides support and service for thirty-four schools, and approximately 9000 students from kinder to Year 12, with 3250 students in Years 7 – 12. This is approximately one quarter of the student population of the region. There are four secondary high schools in this system of schools ranging in size from 380 to 1040 students. Three high schools are co-educational and one school is an all-girls school with a boarding section attached. These schools are located in the four largest centres of the diocese that have populations between 10000 and 40000. Travel distance between these major centres varies from just under one hour to approximately two and a half hours. The schools are closely linked with their local community and are highly regarded for the high quality of education they provide. The vision and direction of the schools are based on their community's needs thus generating a strong sense of autonomy. However, professional communication links between the schools at the faculty level are described as weak. Relations between the high schools of the system and the local government and independent schools of their centres, whilst cordial, are limited in professional dialogue between the sectors.

Mathematics and Science are important for living in contemporary society

There is general acceptance that the acquisition of mathematical and scientific skills is important for citizens of contemporary society. In fact, The Allen Consulting Report (2006) to the Department of Education, Employment and Training identify four of the eight employability skills as concepts often considered inherent in the learning of mathematics and science: problem-solving; initiative and enterprise; planning and organising; and technological aptitude. It is not surprising the rationales from the draft Australian Curriculum identify the following concepts regarding the Mathematics and Science curricula (see Australian Curriculum Assessment and Reporting Authority (ACARA), 2009):

- The Australian mathematics curriculum focuses on developing increasingly sophisticated and refined mathematical understanding, fluency, logical reasoning, analytical thought processes and problem-solving skills to enable students to respond to familiar and unfamiliar situations by employing mathematical strategies to make informed decisions and solve problems efficiently.
- The Australian science curriculum provides opportunities for students to experience the joy of scientific discovery and to nurture students' natural curiosity about the world around them and is a dynamic, collaborative and creative human endeavour arising from our curiosity and interest in making sense of our world through exploring the unknown, investigating universal mysteries, making predictions and solving problems.

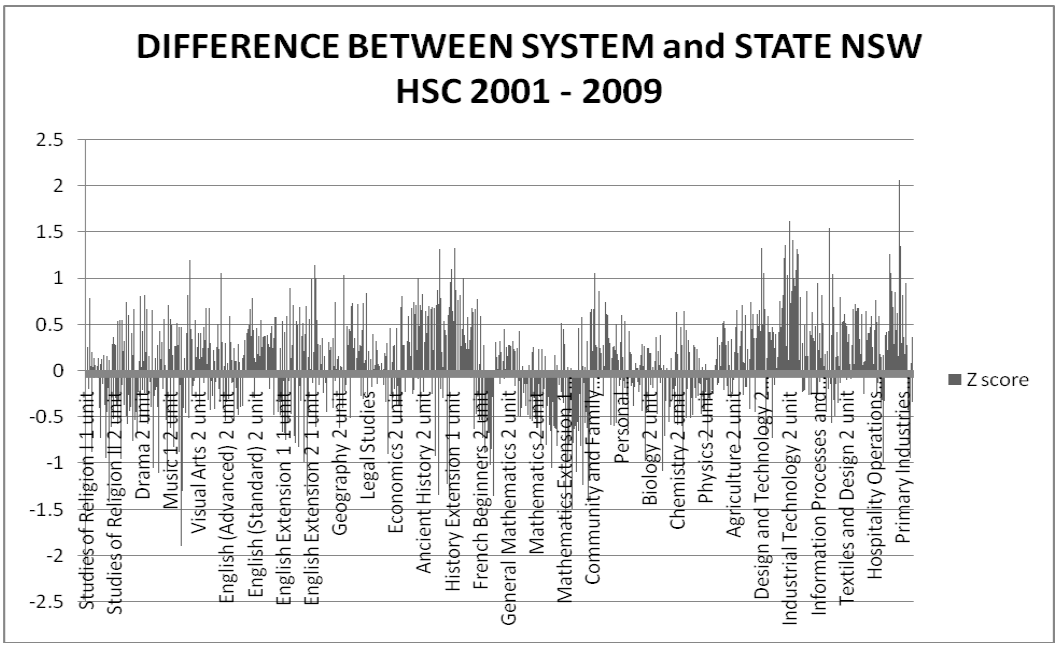
With mathematics and science identified as important in an ever technologically changing world one would think that the number of students studying and attaining at advanced levels in mathematics is increasing. This is not the case in Australia. In *A National Strategy for Mathematical Sciences in Australia,* Rubinstein (2009, pp. 2-3) notes:

- The Australian Council of Deans of Science observes that: "Intermediate, and especially, Advanced Mathematics students are essential for a strong science, research and innovation capacity. The statistics at hand indicate that numbers in these areas are shrinking and students are instead electing to take Elementary Mathematics."
- Between 1995 and 2007, the number of Year 12 students doing 'advanced' mathematics courses has declined by 20% (from 25,000 to 20,000), while the number of Year 12 students doing 'intermediate' mathematics courses has also declined (from 27.1% to 22.1% of Year 12).
- Between 1995 and 2007, the performance of Australian Year 8 students dropped from above average—for all tested nations—to below average in the Trends in Mathematics and Science Study (TIMSS). In this period Australian Year 8 students' performance went from statistically above that of the US and English students to statistically below that of their counter parts.
- In 2003 the percentage of students graduating with a major in mathematics or statistics from Australian universities was 0.4% compared with an OECD average of 1%.

This national trend is exacerbated in regional and rural areas with Pegg (2009), through an analysis of OECD data, noting that students in mathematics and science do not perform as well as students from metropolitan areas. A current study into mathematics and science in the system of schools the Diocese of Bathurst (referred to as the system) reflects this contention. In the New South Wales Higher School Certificate (HSC) schools of this system gain results less than the state mean in intermediate and advanced mathematics courses and the 'harder' science courses (Chemistry and Physics are anecdotally identified as being harder than the other three senior science courses of Earth and Environmental Science, Senior Science and Biology). But this system gains above state mean in the standard mathematics course and the three 'easier' science courses.

A broader study of all HSC courses in the system of schools (from 2001 to 2009) shows that system results are slightly better than state through a comparison of z-scores that places the school means in relation to the state distribution. Graph 1 depicts the z score of the mean for the different subjects and courses for each of the four high schools of the system. The subjects and courses are collated within key learning areas, so that the relative z-score in mathematics courses from 2001 to 2009 appear within a cluster. The graph shows that schools of the system gain results above state means in many subjects. However the system is clearly below state means in intermediate and advanced Mathematics, Chemistry and Physics yet above state mean in General Mathematics, Senior Science and Biology.

Graph 1: Difference between school means and state means recorded as a z-score for each subject and course from 2001 – 2009. Courses are gathered in subject groups (Key Learning Areas). Results above the horizontal axis indicate a school of the system gained a mean greater than the state mean and a result below the horizontal axis indicates a mean less than the state mean.



In order to deal with this concern, a taskgroup was formed from representatives of each of the four high schools of the system.

A Taskgroup to address the problem

The determination to use a specifically formed taskgroup reflects the perceived weight and complexity of the problem. The teachers who form the Taskgroup were chosen initially for their relationship with mathematics and science and for the respect they hold within their school and peers as teacher leaders. Crowther, Kaagan, Ferguson and Hahn (2002) identify six key traits of teacher leaders:

- Convey convictions of a better world
- Strive for authenticity in their teaching learning and assessment.
- Facilitate communities of learning
- Confront barriers in the school's culture and structures
- Translate ideas into sustainable systems of actions
- Nurture a culture of success.

Each of the teachers is a member of the school middle management and is highly regarded for their expertise in curriculum and understanding of whole school and broader community issues. Their reputations reflect the views of Crowther et al (2002, p.10) who define a teacher leader as one who "facilitate(s) principled action to achieve whole school success". This point became clear when the Taskgroup wanted to reframe their terms of reference at the conclusion of the first phase of the project seeking to expand the original brief from Year 11 and 12 (the two final senior years of schooling) into a whole secondary school project (Years 7 – 12). The initial terms

of reference were set by the system upon the formation of the Taskgroup and focussed strongly on the relativity of the problem in the senior years only, identification of needs and the determination of a series of strategies to address these needs. The new terms of reference reflect a set of goals and outcomes determined by the Taskgroup and encapsulate all secondary years. This reflective of the evaluation received in the early parts of the project and indicates the flexible and holistic view the group embraced. The simple act of resetting the goals for the group is an acknowledgement of the authority of the Taskgroup as leaders, both within their schools and as part of the system, authenticating them as transformational, strategic, educative and organisational leaders (Crowther et al, 2002). It also provides the group with an ownership of their moral purpose (Fullan, 2001).

Professional Development/Learning

Hattie (2003) determines teachers are integral (up to 30%) to the affect on student learning and contemporary thinking supports the use of professional development/learning as an essential process for informing and enriching teaching. Ramsey (2000) identifies 20 significant national and New South Wales reports on teacher education from 1980 - 1999 that support *professional development/learning* as a key to the development of a quality teacher. It is noted that many articles and reviews use the terms 'professional learning' and 'professional development' interchangeably. The terms here are used to refer to the learning gained from a planned professional activity. An initial scan of the schools shows teaching time meets or is above required allocations for the HSC and School Certificate credentials, resources are adequate, although availability of technology, such as interactive whiteboards, is variable and generally lacking.

The Taskgroup acknowledge their role is action based. Hence they are identifying and refining what they consider to be the issues that relate to students not choosing or gaining above state results in intermediate and advanced mathematics and physics and chemistry. Notably the group focusses on teacher support and professional development as key strategies. However, both Fullan (2001) and Guskey (1994) indicate there is no 'optimal mix' of strategies for professional development implying any solutions would need to be within the context of each individual school and the context of the system. An 'off the shelf' solution is not able to be imported from elsewhere.

Fullan notes that "to be effective in complex time, leaders (and members) must be guided by moral purpose" (2001, p.4) and the moral purpose must be closely linked with building relationships so that a transforming of the culture, not just structure, occurs. It is with this in mind that leadership of any change requires *Authorative Ideas, Democratic Empowerment, Affiliative Bonds and Coaching* (Fullan, 2001) in order to provide direction and support during in the change process. Commitment to the change initially and sustainably, requires engagement and ownership by the team members.

Fullan identifies five key components leaders need to attest to within a culture of change. These components are mutually reinforcing and occur within a spiralling rather than a linear progression. They reflect a philosophy of strategising rather than a distinct strategy.

1. Moral purpose
2. Understanding change
3. Relationship building
4. Knowledge creation and sharing
5. Coherence making

Whilst Fullan directs us to a leadership framework, Guskey (1994) provides advice on how to best implement strategies within *professional development/learning*.

Guskey (1994) argues there is no such thing as an 'optimal mix' of *professional development/learning* strategies to bring about effective change, but he suggests using six procedural guidelines (p.8). There are clear similarities with the paradigm suggested by Fullan.

1. Recognise that change is Both an Individual and Organisational Process
2. In planning and implementation: Think BIG, start small
3. Work in Teams to maintain support
4. Include procedures for feedback on results
5. Provide continued follow-up, support and pressure
6. Integrate programs

Previous to the establishment of the Taskgroup, schools of the system were considered strongly autonomous and communication between them was minimal. School based issues tended to be dealt with in-house through a sense of school-pride and the lack of an organisational process to allow common strategic views to be shared. Even with the formulation of the Taskgroup there was an initial fear that teachers and schools would be blamed for weaker performance. This fear quickly subsided through the actions of the Taskgroup with schools reporting they feel supported and challenged in addressing the issues by:

- identifying the issues are broader than their own school (i.e. systemic), but acknowledging there are local needs;
- creating a sense of collegiality between the Taskgroup members, faculty heads and teachers;
- actively seeking and reacting to staff feedback on professional development sessions;
- planning actions based on a broad strategy and staff feedback, and;
- providing opportunities and (some) resources for integration into their local context.

METHODOLOGY

Over the period of professional learning conducted by the Taskgroup, three elements of evaluation and feedback have been used. As the project was supported through the Australian Government Quality Teaching Projects (AGQTP) information is gathered through a dedicated template (see appendix 1) and published on the AGQTP website. These evaluations gather demographic data such as the: *Years since completion of initial teacher training; gender, primary/secondary; school location; teaching of identified groups (Indigenous, NESB, special needs, gifted and talented) and school role.* The evaluation also asked teachers to comment on three outcomes using a five point scale with 1 "low" and 5 "the greatest extent".

- Strengthened the currency and depth of your learning area knowledge
- Engaged productively in collegial networks that extend and support
- Met your professional needs

Participants were also asked to complete a system designed evaluation sheet that asks participants to answer.

- What did I learn today?
- What I would have liked to get from today, but did not.
- What will you do to incorporate your knowledge from today into your teaching?

While the system was responsible for the collating of the data from these evaluations, the Taskgroup members were responsible for analysing it. Taskgroup had representatives from each of the schools and gathered anecdotal comment from staff in their school. The evaluation data and anecdotal comments were synthesised by the Taskgroup in group discussions at a series of meetings held approximately 8-10 weeks apart. The minutes of these discussions are recorded and published to the Taskgroup members and Principals.

The Taskgroup members completed a structured open response survey to provide evaluative comments on local affects of the strategies used so far. Once collated the Taskgroup openly discussed the results of this survey, embellishing the comments when needed to ensure the intent was clearly understood. The survey is listed below:

- *Pick a nom de plume for your school so as to de-identify it. E.g. St Michael's High School*
- *Provide an outline of the maths department and science department: strengths and areas for development in your opinion (hence the need for de-identification)*
- *What were your major fears when the Taskgroup was formed (i.e. when you first joined)?*
- *What were your major hopes (goals) when the task group was formed (i.e. when you first joined)?*
- *Has there been any shift in teacher morale/views in maths and science in your school?*
- *Has there been any shift in student morale/views in maths and science in your school?*
- *Can success only be measured by the HSC? If so why? If not, why not and how can it be measured?*

- *What are the major successes of the projects to date?*
- *What are the major challenges still?*
- *If you could do any activity again, what would it be and how would you have changed it?*

The deliberations of the Taskgroup formed the ensuing short term and long term responses of the group and hence reflect a form of action/participatory research.

McNiff (2002) notes that *Action/Participatory Research* is a collective and self-reflective inquiry that seeks to improve or develop the participants in their work. This research seeks a "shared ownership of research projects, community-based analysis of (the) problem and an orientation toward community action" (Kemmis and McTaggart, 2005 p. 568). *Action/Participatory Research* gathers some criticism regarding the validity of the data and the potential for bias from participants because they care about the outcome. The Taskgroup were aware of this potential weakness in the analysis of the data and work hard at ensuring the deliberations are objective. This reflects Guba's criteria for validity of qualitative research, namely: credibility, transferability, dependability and confirmability (Mills, 2007 pp. 86-87). The data is validated by:

- credibility through structural corroboration and peer debriefing;
- transferability through reflections of the data within the context of the school;
- dependability through the overlap method between the evaluations and the audit by the Taskgroup through discussion, and;
- confirmability through the variety of collection methods, reflexivity (intentionally revealing underlying assumptions or biases) and ongoing research of literature.

DISCUSSION

Moral Purpose

While there are only four high schools in the system, they are strongly autonomous and their locations are geographically isolated from each other. As a result the members of the Taskgroup were not closely acquainted with one another prior to the forming of the Taskgroup and had not worked on a collaborative project with any other member of the group. An important first step was to establish the moral purpose of the group.

At the first meeting, the members of the Taskgroup were provided with an outline of the participation and achievement data from the previous year's HSC. This exposed the trend of diminishing and below state means in achievement as one experienced by all schools of the system, not just their school. Prior to the meeting they worried that the schools and teachers were being blamed for identified problem.

> *Being willing to accept our results were generally lower than state average and other subjects (was a fear) as it is only natural to assume as a teacher that it is your personal problem or you are the cause. However, the issues are very complex. (St Paul's)*

The Taskgroup also worried about an over-emphasis on HSC results. Whilst they acknowledged this was an important exit credential and provided a pathway for students into tertiary study or training the Taskgroup did not want the teaching of mathematics and science to turn into a factory for examinations. Rather they considered attitudes to learning, deeper understanding and individual improvement as more important than examination preparation. One school noted that their students liked chemistry and often performed better in this subject at university than their HSC results would suggest. They also cited concerns such as students' inability to cope with examinations, student stress and perceived examination inaccuracies.

> *A 3-hour snatch of 120 hours of learning is not always a good measure of the whole student, especially if that student doesn't cope well with examinations. Success can also be measured by retention rates from Year 10 into 11 and the number of students moving on to study Science based subjects at the tertiary level and succeeding. (St Paul's)*
>
> *The pursuit of high results in the HSC can have a negative effect on teachers, many of whom work tirelessly with students of varying ability. Having students achieve results which are good for them individually is important, not the number of students in the top band. (St Mark's)*
>
> *We have not yet explored student attitudes via a survey/questionnaire but need to do this to be able to quantify their views. (Santa Maria)*

As a result the Taskgroup nominated the following as the key issues. There is clear acknowledgement that the HSC is an important focus, but the end result needs to have more depth.

- Teacher training in HSC style responses
- Collegial links
- Student exposure to high quality work at HSC level (HSC standards)
- Use of engaging, interactive higher order questioning techniques and explicit feedback
- Assessment timing and process (rubrics, feedback)

UNDERSTANDING CHANGE

Fullan (2001) argues that change is complex and for the process to be successful leaders and members must understand a change process. Howard Gardner (2006) reflects Fullan's understanding of the complexity of changing people's minds by referring to the art and science of the process. Gardner suggests there are three main factors: entities (stories, theories, concepts and skills), arenas (ranging from large groups, such as a nation, to the individual) and levers (reason, research, resonance, representational redescriptions, resources and rewards, real world events and resistances). He is quick to add however that the choice of which entity, arena or lever "will always have contextual and fortuitous components" (2006, p.xi).

Research and reason were chosen as levers in this particular context as they provide an "intellectual argumentation" (Gardner, 2006). In review the Taskgroup commented on this action as a turning point as it allowed an objective analysis of the

problem that was metaphorically referred to as 'the elephant in the room'. The 'elephant in the room' is a term for an object or issue that is big and obvious to all but not referred to by anyone. The analysis was extended to provide longitudinal data for the system of schools from 2001 to 2009 and provided further assurance to the schools that the trend in participation and achievement was not just an individual school or an individual teacher. It is now accepted by the schools as an issue beyond isolated cohorts of students.

Guskey's advice in his first two procedural guidelines has also proved instrumental: *Recognise that change is Both an Individual and Organisational Process* and *In planning and implementation: Think BIG, start small*. The Taskgroup has set in place a number of strategies to engage both individual teachers and faculty heads. Initial involvement of whole staff groups was implemented as a way of engaging all staff, thus emphasising the broad nature of the issues. These sessions, however, generally proved less effective as not all teachers considered the concerns around the HSC were their problem. Rather, some participants were quick to blame the examination questions and marking process. As Guskey (1994, p.9) notes "professional development processes, regardless of their form, must not only be relevant to teachers, but must address their needs and concerns." In response the Taskgroup set in place an organisational system to engage the schools' faculty heads and, in conjunction with these groups, established specific professional development/learning activities, inviting only teachers with a direct link. These activities to date have two thrusts, HSC focus for individual teachers and broad educational issues for the clusters of faculty heads. In support of the broader discussions with faculty heads, the project has resourced schools with funds to upgraded technology to support the more engaging teaching. This year the faculty heads have so far met to provide a consultation for the draft national curriculum and discuss issues of lesson structure and pedagogy around classroom technology. A further discussion topic of how to engage junior students has been flagged and a school based survey for both staff and students is currently being established.

RELATIONSHIPS

Fullan (2001) argues that relationships are crucial in bringing about meaningful and sustainable change. This sentiment has been fully accepted by the taskgroup who believed in establishing a collegial network between the schools where previously there had been none.

> *By meeting with representatives from other schools, new ideas and directions could help bring about change and improvement in my school. The project could allow teachers to reflect on their teaching strategies and share with other teachers in developing new strategies. (St Mark's)*
>
> *That we would find a way to share good teaching strategies and resources amongst our schools. (Santa Maria)*

Building of network channels has been successful with much more sharing of ideas/resources between schools and a less competitive view of the other schools. There is a greater sense of we are in this together and are all aiming for the 1 goal – excellence in our student understanding and achievement (St Paul's)

This was supported by the participants of the activities. At the conclusion of the activity participants rated Outcome 2 (*Engaged productively in collegial networks that extend and support*) from 1 (low) to 5 (high). In Table 1 the values (as percentages) indicate clearly that the majority of participants rate the sessions at 3 or above. In 2009 across both Mathematics and Science, all activities received at least some ratings of three or less and hence no activities had all participants rate the activity at 4 or 5. However, in 2010 four of the six activities were rated at 4 or 5 by all participants. This matches the comments from both the AGQTP evaluations and the Taskgroup generated evaluations that identify the growth of a network amongst the faculty heads and teachers of like courses.

Table 1. Evaluation of AGQTP Mathematics and Science activities 2009 and 2010 for Outcome 2: *Engaged productively in collegial networks that extend and support* where 1 is low and 5 is high with values as percentages.

		2:01	2:02	2:03	2:04	2:05
Science	Activity 1 2009	0	9	0	64	27
	Activity 2 2009	0	0	13	88	0
	Activity 3 2009	5	10	24	62	0
	Activity 4 2009	0	0	33	50	17
	Activity 5 2009	1	5	18	65	10
	Activity 1 2010	0	0	0	0	100
	Activity 2 2010	0	0	0	57	43
	Activity 3 2010	0	0	0	0	100
Mathematics	Activity 1 2009	0	0	14	71	14
	Activity 2 2009	0	5	21	63	11
	Activity 3 2009	0	0	17	67	17
	Activity 1 2010	0	0	10	60	40
	Activity 2 2010	0	0	0	44	56
	Activity 3 2010	0	0	40	60	0

The use of digital communication was initially mooted as a method of contemporary communication to deal with geographical isolation. In the beginning a wiki was established to support a lesson study project. The use of the wiki was weak and it was soon realised that this form of relationship building was not successful. However since then a number of informal email forums have started amongst the faculty heads as a direct response to the cluster meetings. Teaching strategies and resources are regularly shared.

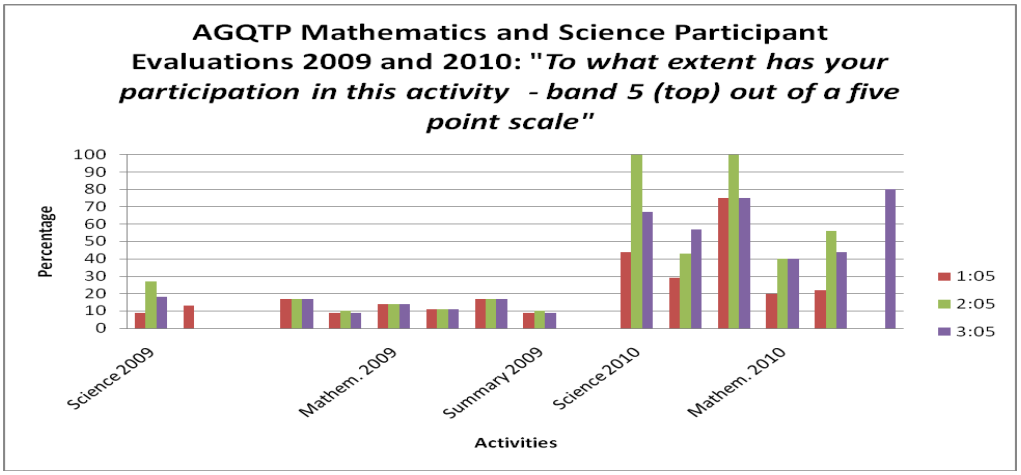
Guskey identifies the importance of *Work in teams to maintain support* and the *Inclusion of procedures for feedback on results* as guidelines for success in professional development/learning. The Taskgroup always gathers evaluations formally from activities and follows this up with informal discussion at the school level. This anecdotal data is melded with the formal evaluations and discussed as a specific agenda item at Taskgroup meetings. Activities are adjusted as a response to the evaluations so they reflect the impressions and desires of the network of teachers

involved. The instigation of subject coordinator (faculty head) meetings has meant that they also analyse evaluation data and are empowered to determine activities. This is considered a significant alliance in building the relationships within and between like faculties as identified below:

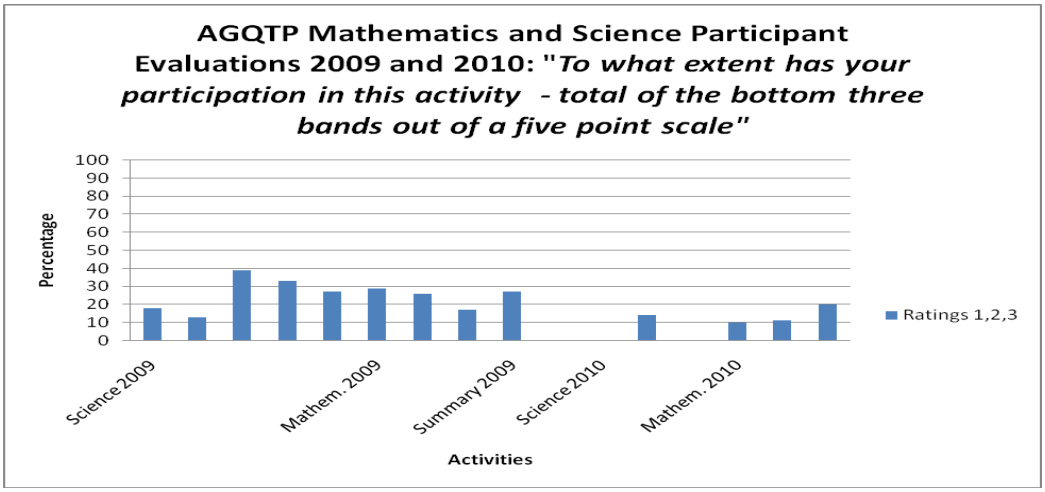
> *The inclusion of Subject Coordinator days was a major bonus – they helped determine the course of the initiative and ensured the needs of their staff were met.*
>
> *The inclusion of Subject Coordinator days was also the beginning of collegiality between the schools at this level – sharing of ideas, programs (Santa Maria)*

The effectiveness of this strategy is observable in considering the participants ratings of the activities on the AGQTP evaluation. Graphs 1 and 2 below plot how the percentage of participants rated the activity at the highest (5) and the lowest (1, 2 and 3) respectively. The trend in Graph 1 shows the percentage of participants rating at the highest in 2010 in many cases has doubled the rates of 2009. As would be expected the percentage of participants registering the lowest rate is lower in 2010 than 2009 and in some cases zero.

Graph 2: Evaluation of AGQTP Mathematics and Science activities 2009 and 2010 for Outcome 1: *Strengthened the currency and depth of your learning area* knowledge; Outcome 2: *Engaged productively in collegial networks that extend and support*; Outcome 3: *Met your professional needs* where 1 is low and 5 is high with values as percentages. (Key: Outcome 1 is 1:05, Outcome 2 is 2:05, Outcome 3 is 3:05)



Graph 3: Evaluation of AGQTP Mathematics and Science activities 2009 and 2010 for Outcomes 1, 2 and 3 where 1 is low and 5 is high with values as percentages.



KNOWLEDGE CREATION AND SHARING

Teachers report that the most effective activities have been those in 2010 that focussed specifically on improving teacher's knowledge of the markers feedback from the HSC. This activity allowed a representative group of teachers to attend the marker feedback days sponsored by the Mathematical Association of New South Wales (MANSW) and the Science teachers Association of New South Wales (STANSW). Teachers attending were expected to bring back and share the information from the markers on specific courses. The system based feedback was in the form of a workshop where participants were lead through a familiarisation and analytical process for the specific HSC exam. Some teachers lead these workshops, whilst others preferred to be a 'resident expert' of the markers comments. The workshops were discussion-based with teachings strategies shared. In responding to the evaluation question 'What did I learn?' participants overwhelmingly nominated:

- *Better ways to prepare General Maths students for the HSC exam.*
- *What questions were considered easy/hard on the paper*?
- *Some good ideas of constant things to do, homework sheets on whole topics, better use of formula sheets, reading and using the terminology.*
- *Some things that students should write when answering questions - what is expected to get full marks.*

Regular and ongoing revision practices as part of 'normal' lessons was a repeated theme in many evaluations. Anecdotal feedback from schools notes that these strategies have been introduced as part of regular practice.

Expertise from school personnel regarding the use of technology with podcasting and interactive whiteboards has been used within faculty head cluster meetings. Key questions such as 'What is an interactive classroom?' and 'What are some ways of making my classroom interactive?' have been put to the group as well as demonstrations of hardware (Data projector, IWB, WB with attachments, Wii,

graphics tablets and voting systems) and useful Websites (such as *mathsisfun.com*, *aaamaths.co*, *shodor.org*, *teachertube.com* and *youtube*). St Mark's Taskgroup representative noted there is:

> *Greater interest in looking at the mechanics behind the setting and marking of state exams, with items presented at faculty meetings and increased knowledge and use of technology in teaching.*

Guskey suggests the *provision of continued follow-up, support and pressure* within the creation and sharing of knowledge is a significant guideline for effective professional development/learning. The Taskgroup have made it a practice of recording and publishing evaluations and engaging faculty heads in determining direction and future activities. Minutes from meetings and evaluations of activities are presented to schools through the Taskgroup school representative, faculty heads, the Assistant Principal cluster and the Principal cluster that provide support and pressure. Guskey notes the importance of using local resource personnel in combination with "consultants, administrators, directors or professional colleagues" (Guskey, 1994, p.19) for a combination of direction and challenge.

While the Taskgroup, in conjunction with the faculty heads, initially focussed entirely on the HSC, they have since identified the importance of the junior years in preparing students for senior courses. The anecdotal evidence to support this direction reflects the findings of two substantial studies carried out by the Science, ICT, Mathematics Education in Rural and Regional Australia (SiMERR) *Maths? Why Not?* (McPhan et al, 2008) and *Choosing Science* (Lyons and Quinn, 2010). Both studies note the importance of junior secondary years in the development of content and student confidence. Taskgroup members, through discussion, have also specified questioning techniques and assessment processes as areas in need of development.

Agreed areas for further exploration include:

- *Discussion on what needs to be done in the junior schools to help prepare students for senior school.*
- *Use of engaging, interactive higher order questioning techniques and explicit feedback techniques*
- *Assessment timing and process: strategies, rubrics and feedback*

COHERENCE MAKING

Fullan notes that within the change process coherence making "is a perennial pursuit" (2001, p. 6) and "extracts valuable patterns worth retaining" (2001, p.7). In a later work, Fullan (2005) identifies eight elements of sustainability, some of which mirror his five elements already referred to. Of special note is his reference to *lateral capacity building through networks.* Fullan specifies vertical capacity building occurs through external trainers at a system level, but lateral capacity building occurs across peers. Teacher's informal and anecdotal comments with their peers are powerful drivers in building coherence and thus sustainability.

Informal processes are in place, but Guskey suggests purposeful intervention processes within *integrating programs.* He states:

> *If professional development efforts that focus on implementation of innovations are to succeed they must include precise descriptions on how the innovations can be integrated. That is, each new innovation must be presented as part of a coherent framework for improvement.* (Guskey, 1994, pp. 20,21)

One particular activity exemplifies this thinking. Science teachers regularly commented on the crowded nature of their syllabus with concern expressed about the need to teach every 'dot point'. In response to this concern the science coordinator (faculty head) of St Marks established a unit writing process that integrated key concepts. This approach has been shared with each of the schools with a unit writing day used to demonstrate and provide time to write a unit. Since then schools have modelled this approach in other units.

Gardner uses the terminology of resonance and re-descriptions in suggesting levers for bringing about change. It is the stories of the teachers themselves and the redefining the activity into the context of their school that leads to the ownership of the processes. It is clear that there is an acceptance by teachers that the solutions to the issues around mathematics and science are within the grasp of the local faculties.

> *Teachers are embracing a concept of using prepared practical manuals for each unit within their senior courses as introduced by their coordinator. Teachers from different schools shared ideas for the activities in these books. (St Marks')*

> *Teachers have adopted teaching strategies discussed at task group meetings. Teachers are more aware of 'quality' teaching. (Santa Maria)*

CONCLUSION

Like many rural schools, the four schools identified in this discussion are strongly linked to their communities. Each school considered themselves as an autonomous entity and as such issues and problems were dealt with in-house. Inter-school meeting opportunities for staff were weak. Some earlier attempts to generate professional learning communities of faculties between schools through a conference model were largely ineffective. However the issue of engaging students in senior intermediate and advanced mathematics, physics and chemistry was too big to ignore.

The establishment of a specific Taskgroup for mathematics and science was perceived initially with scepticism and fear. Even members of the group expressed concern that they would not be able to have a meaningful impact on what appeared a complex issue. However, through an objective discernment of the issues and use of authorative ideas, democratic empowerment, affiliative bonds and coaching (Fullan, 2001) a network of colleagues have been formed. The change process follows a close link to Fullan's framework, accepting that there is not an optimal mix (Guskey, 1994), but rather a process that is organic and in need of constant reflection and refinement. The solution lies in addressing the needs of the school within the context of the school. It is from this standing point that a number of points have emerged as significant in the progress made to date.

- The selection of the Taskgroup with members highly regarded by their peers.
- The identification of a common ideal (moral purpose).
- The articulation of the issue in a blame-free context (i.e. 'The elephant in the room').
- The constant evaluation and responsive behaviour of the Taskgroup to participant feedback.
- The establishment of an authorative meeting process for the faculty heads with scaffolded discussion.
- The empowerment of other senior faculty members to lead discussion across the four schools.

However, while much has been gained in the form of collegiality, confidence and the motivation to deal with this issue, the Taskgroup acknowledge that more is still to be done. Teacher leaders are emerging within the layers of schools and across the system. The following hopes for the Taskgroup listed below are complex issues, but the ground work and processes are in place to deal with them.

> *Breaking down barriers of complacency due to teachers entrenched in known systems. (St Paul's)*
>
> *Finding ways to keep the momentum of collegiality between schools and examining the link between how students perceive and perform in maths and science in lower stages of schooling, and how they perceive and perform in these subjects in senior schooling. (St Mark's)*
>
> *Working in the junior school to integrate new teaching strategies that meet the needs of students in 2010 – e.g. inclusion of good ICT strategies. (Santa Maria)*

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