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John Daniel Kenny

University of Tasmania, John.Kenny@utas.edu.au

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University-School Partnerships: Pre-Service and In-Service Teachers Working Together to Teach Primary Science.

John Kenny
University of Tasmania

Abstract: This paper reports on a partnership approach preparing pre-service primary teachers to teach science. Partnerships involving pre-service teachers and volunteer in-service colleagues were formed to teach science in the classroom of the colleague, with support from the science education lecturer. Each pre-service teacher collaboratively planned and delivered a sequence of at least six science lessons over six weeks.

An earlier paper reported on how the program affected the confidence of the pre-service teachers. Over three iterations, 61 in-service teachers from 23 local schools participated.

In this paper the data from the colleague teachers and principals who participated is explored. The evidence indicates that the principals valued the program as an opportunity to improve science in their schools and as science professional development for their staff. The in-service teachers were positive and results show that the triadic partnerships offered professional development that addresses common barriers to teaching science in primary schools.

Background

In Australia, “scientific literacy” has been widely described as the key outcome for school science education across all levels of schooling. It is usually linked to the longer term national interests and developing scientifically capable citizens (Goodrum, Hackling & Rennie, 2001; National Curriculum Board, 2008; Osborne 2006; Tytler, 2007). Achieving these outcomes is likely to be restricted, however, by the widely recognised lack of confidence of many primary teachers with science, which leads many to either avoid teaching science or to teaching it minimally (Appleton, 2005; Appleton, 1992; Goodrum, Hackling & Rennie, 2001; Henderson, 1992; Hand & Peterson, 1995; Tytler, 2007).

A further impediment to effective teaching of science in primary schools arises from the “crowded curriculum” arising from increased accountability demands and an emphasis on raising literacy and numeracy standards in Australian schools. This leads to a reduction of time teachers devote to subjects such as science (Goodrum et al. 2001, p.158) and combined with perceived difficulties in managing science classes, obtaining and organising equipment and concerns about adequate curriculum resources for science, the barriers to teaching science in primary schools are considerable (Appleton, 1999; Kenny & Colvill, 2008).

Mulholland & Wallace (2003) discussed a specific range of difficulties by teachers as they made a series of transitions, or “border crossings” in their development from novices to experienced teachers. These included a transition firstly from a pre-service to an in-

service teacher, intent on “survival”; followed by their development from a non-science learner to a science teacher. Although only based two case studies, they claimed the transition to teaching science was “more difficult than teaching other subjects” because it required specialised knowledge and skills and presented significant challenges for managing classrooms due to hands-on activities to the extent that “(m)any teachers find the crossing impossible and do not attempt science teaching” (p. 893).

Shulman (1987, p. 8) described “pedagogical content knowledge” (PCK) as a “special amalgam of content and pedagogy...that category most likely to distinguish the understanding of the content specialist from that of the pedagogue”. While the notion of PCK and its relation to science education is still widely debated (Abell, 2008), it is useful as a concept that identifies two key aspects that may affect the attitudes of primary teachers to science: their knowledge about science content; and their knowledge of how to teach the science.

As generalists with typically little science learning in their educational background, primary teachers have different needs to secondary teachers (Appleton, 2005, p. 32; Tytler, 2007). Due to their responsibilities to teach across a number of curriculum areas, primary teachers may have a good range of pedagogical skills, but may lack specific science content knowledge and the confidence to apply their pedagogical skills in a science context (Hudson, 2005). Proposals suggested to address this general lack of science PCK have included calls for more science content to be included in initial primary teacher education programs. Tytler (2007, p. 58) suggested that “primary teachers need to have included, as part of their initial training, a mixture of science content knowledge and pedagogical content knowledge (PCK) in order to confidently teach science in primary school.” An Australian Government Committee for the *Review of Teaching and Teacher Education*, concluded that persistent problem of improving science in primary schools points to “the need to find other means of engaging primary pre-service teachers with science” (DEST, 2003, p. 133).

Appleton (2003, 2005, p. 43), on the other hand, argued that the “confidence level” of primary teachers is “a major influence on their development of science PCK” and pointed to evidence that doing “more science [content] per se does not necessarily lead to increased confidence, more science teaching, or better science teaching” unless it is part of a holistic approach addressing the other aspects of science PCK, including their attitudes and the barriers to primary science mentioned above. Similarly, Howitt (2007, p. 43) argued that the research reveals “conflicting results” on the effectiveness of approaches based on providing primary teachers with science content. She suggested that science methods courses concerned with how to teach science effectively are more likely to build the “attitudes, confidence and efficacy” of primary teachers.

Appleton (2005, p. 46) further suggested that when provided with “activities that work”, experienced primary teachers can draw on their general pedagogical skills and use their knowledge of students and their store of pedagogical knowledge “to fill in gaps in their science PCK”. His concern however, is that in doing so, they learn to cope and do not necessarily adopt effective science related pedagogies such as inquiry approaches to learning. It stands to reason that in-experienced primary teachers will be less able to draw on their general pedagogical expertise to interpret descriptions of science activities in a classroom situation and will need support to overcome the substantial barriers to teaching science

Approach suggested to support in-experienced primary teachers to develop their science PCK include the provision of authentic science teaching experiences for pre-service

teachers within their teacher education program (Howitt, 2007; Palmer, 2006). Indeed, Howitt (2007, p. 44) argued that pre-service teachers *must* teach science during the school experience component of their teacher education if their confidence to teach science is to improve. In reality, however, universities have little control over the placement of teachers or the qualities of the teachers assigned to them as supervisors (Top of the Class, 2007, p. 72). In a survey of 331 final year pre-service primary teachers from nine Australian universities, Hudson (2005) found that only 49% were required to teach science during their practicum and that the number of science lessons actually taught by the pre-service teachers varied considerably from one to six lessons, and in addition he had concerns that most primary teachers would not have the necessary science background or confidence to provide effective science mentoring.

Timperley (2001, p.111) articulated the professional learning complexities that exist in these supervisory situations and how there is a tendency for the parties to become pre-occupied with “immediate issues of practical performance, rather than inquiry” to gain a deeper understanding of the theories underlying practice. She outlined an extended program designed to specifically train mentors to develop their “understanding of the theory of effective teaching” so that they could assist the pre-service teachers to translate their own theories into practice.

DEST (2003, p. 153) also argued that a “beginning science teacher may need a mentor to assist with classroom management as well as a science mentor to assist with subject-specific challenges”, however, Hudson (2005) noted that mentoring beginning teachers in science presented specific problems, due to the lack of science background and confidence of most primary teachers who may otherwise be suitable as mentors:

Modelling and articulating effective practices are key aspects of mentoring; however, ‘non-expert’ mentors of primary science may not be able to model or discuss effective science teaching practices (Hudson, 2005, p. 1724)

It follows that the identification and training of suitable experienced primary teachers to a point where they are able to act as science mentors for in-experienced teachers would involve considerable time, cost and effort for any educational system (DEST, 2003).

The formation of mentoring partnerships has been suggested specifically for pre-service teachers to teach science as an effective approach to overcoming some of the difficulties associated with preparing primary teachers to teach science (DEST, 2003; Top of the Class, 2007). The term ‘partnership’ implies that each person brings something distinctive to a situation (Smedley & Van Rooy, 1996) and it also implies a more equal arrangement between the parties compared to the supervisory situation in a normal practicum. A number of researchers have proposed approaches that have as their essence authentic experiential learning, involving in-service and pre-service primary teachers working in a collaborative endeavour to teach science (Howitt, 2007; Jones, 2008; Murphy, Beggs, Carlisle & Greenwood, 2008, Palmer, 2004).

Murphy et al. (2004) studied the effects of “co-teaching” of science in which pre-service teachers worked with practising teachers to plan, teach and evaluate “investigative science and technology lesson. While co-teaching the pre-service teachers “were given the opportunity to work side by side with classroom teachers” as “equal partners” (p. 1026). While their article did not expand on any preparation for the collaborative aspect of the program, it explained that the classroom teachers were to act as co-learning professionals rather than as a mentors or assessors of the pre-service teachers’ performance. They reported that the co-teaching aspect was a key element in the project in that the pre-service

teachers acted as “catalysts” (p. 1033) in the classroom, encouraging a more investigative approach to teaching science than in other programs, which led to a more engaged and attitude from the students taught.

Hudson (2005) identified five key factors associated with good mentors: 1. their personal qualities; 2. their pedagogical knowledge; 3. their knowledge of the system requirements; 4. their ability to model good practice; and 5. their ability to give meaningful feedback.

His study found that 75% of pre-service teachers perceived that they had not received sound mentoring regarding key factor 3, specifically concerning the teaching primary of science and minimal experience or advice on “planning for their science teaching experiences” (p. 1729). With respect to key factor 4, he reported that “as many as 75% (of pre-service teachers)... appeared not to have received comprehensive mentoring in aspects associated with science PCK such as preparation, classroom management, questioning techniques, assessment, etc., and only 42% of pre-service teachers felt they had seen “effective science teaching” modelled during their practicum (p. 1731). On key factor 5, Hudson’s data revealed that most pre-service teachers “perceived that their mentors did not articulate expectations, provide written feedback or assist... with (the evaluation of) primary science teaching practices” (p. 1732).

Consistent with the observation by Hudson (2005), the author of this paper noted anecdotal reports from many pre-service teachers that they had little or no experience of teaching science or seeing science teaching modelled during their teacher practicum. It seemed that the lack of confidence with science made many supervising teachers reluctant to provide science experiences to pre-service teachers under their supervision, so the majority of pre-service teachers were graduating having had little if any opportunities to teach science and develop their confidence during their teacher education course, so the problem of an under teaching of science would most likely be transferred to the next generation of primary teachers.

This complex array of inter-related issues led to the development of the program reported in this paper. Its primary purpose was to provide pre-service primary teachers with an authentic teaching experience explicitly targeting science and the success of the approach in building the science PCK of the pre-service teachers has been reported elsewhere (Kenny, 2010, 2009).

The Key Elements of the Triadic Partnership Approach

Each triadic partnership included the science education lecturer (who was also the researcher), a volunteer primary teacher and a pre-service teacher. Each member of the triad had a distinct role to play and as the project evolved, these roles were clarified. The structure of the triadic partnership was specifically designed to ensure that Hudson’s five key factors were present and in doing so, address the complex problem of supporting pre-service teachers as they undertook a genuine science teaching experience (Kenny, 2010). With the support of the teacher educator and volunteer in-service teachers the pre-service teachers were to collaboratively plan and deliver a science based learning sequence of at least one 90 minute lesson per week over a six week period. The sequence of lessons was to address a conceptual learning area in science and to be delivered in classroom of the volunteer teacher.

The in-service teacher were to take a supportive rather than a supervisory role, so they were not required to assess the performance of the pre-service teacher, or necessarily provide science related expertise and advice. As qualified teachers, operating in their normal classroom environment, their key task was to support the pre-service teacher with general pedagogical advice, help them to quickly become familiar with the diverse needs of the class group, the school environment, knowledge of the learning context and the established classroom student management practices and protocols.

Howitt (2007) and Murphy et al. (2008) suggested the role of the teacher-educator is critical in these situations. In this case the role science teacher-educator was to provide specialist science PCK advice and guidance to each pre-service teacher in the form of appropriate resources and pedagogical advice as they planned and then delivered their learning sequence in the schools. He also liaised with the school to set-up the program, dealt with queries and facilitated initial meetings between the pre-service teachers and their colleague teachers. He provided regular feedback to the pre-service teachers during the teaching phase through their reflective journals, which were completed on a weekly basis throughout the unit and submitted periodically online.

At the beginning of each year, school principals were contacted to ascertain interest in the program and there was a strong response each time the program was offered. Over the three iterations of the project, a total of 61 in-service teachers from 23 schools participated with many more expressing interest. Typically 18-24 pre-service teachers chose the elective which was offered as part of the final (fourth) year of their Bachelor of Education (B.Ed.). This limited the number of in-service teachers which could be selected. A list of the teachers interested was presented to the pre-service teachers at the start of the semester and each chose a teacher to work with, usually based on the preferred grade level in which they wanted to teach.

For the first four weeks of the semester, the pre-service teachers were based at the university as they planned their sequence of science lessons. During this planning phase, the pre-service teacher and the in-service teachers were expected to make contact and negotiate a suitable science related topic area to be taught. During this phase, the science teacher-educator concentrated on supporting the pre-service teachers as they planned and developed their unit of work which was to consist of at least one 90 minute lesson per week for the six weeks they were to be in the classroom.

During this phase, the science educator provided science pedagogical advice, resources and regular feedback. The pre-service teachers were expected to discuss their plans regularly with their colleague teacher and arrange to visit the class to meet the students prior to the teaching phase. The value of the triadic partnerships is that it offered the possibility of providing effective support without the need for specially trained primary science mentors which would have clear cost benefits for educational systems aiming to improve skills and confidence of pre-service teachers with primary science. The underlying structure of the triadic partnerships made it possible to satisfy the five key factors for good mentoring (Hudson 2005) because, within each triad, there was a science teacher-educator as well as the in-service teacher colleague to support the pre-service teacher. Jointly, they could play complementary roles in supporting the pre-service teachers. Assuming both had suitable personal qualities to be mentors (factor 1), the science educator could take major responsibility for providing advice on associated science related PCK (thus meeting the key factors 2, 3, 4, and 5) while the in-service teachers would play a role in addressing the

general pedagogical practices associated with the specific systemic, school and class context in which the pre-service teacher was working (factors 2, 3, 4 and 5).

The design of this program is also consistent with sound principles of effective teacher PD in several key ways: the participation of the in-service teachers in the program was voluntary; the program occurred over an extended period of time (about ten weeks); it provided opportunities for the participants to discuss and share ideas; it occurred close to where the teachers worked; and it met their needs (Garet, Porter, Desimone, Birman & Yoon, 2001; Henderson, 2006; Webb, Robertson & Fluck, 2005; Westling, Herzog, Cooper-Duffy, Prohn & Ray, 2006).

While the initial intent of the program was to support pre-service teachers, during the first iteration, indications were that there were benefits for the in-service teachers who participated (Kenny, 2010). This is consistent with other research on partnership based programs which reported professional development for in-service teachers who participate in them (Jones, 2008; Murphy et al., 2008). A range of data was collected from principals and teachers who participated in the project and this data has been analysed in relation to the following research question:

What perceived benefits did the participating colleague primary teachers and principals associated with their participation in the triadic partnership approach to teaching science in their classrooms?

Methodology

This paper reports on an on-going action research project exploring a triadic partnership approach to teaching science. It was framed as a participatory action research study in which the researcher was also the university based science educator (Kemmis & McTaggart, 2000; Zuber-Skerritt, 2001). Three full cycles of action research occurred, in 2007, 2008 and 2010, during which the program was established and progressively developed over this period. In each iteration data were collected from participating pre-service teachers, principals and in-service teachers. There is a gap in 2009 where no data was collected because the science elective, with which the project was linked, did not run in that year due to administrative complications at the university.

An interpretive methodology was adopted due the emergent nature of the project and the fact that there were many situational variables that could not be controlled such as the inherent variations between the schools and classrooms in which the teaching was to occur. These variations included variables such as: the grade level, size, and gender balance of the classes; the science background of colleague teachers; socio-economic and geographic variations between schools; and the number of special needs students; choice of topic. A mixed methods approach to data collection was employed in that both qualitative and quantitative data were collected, using pre- and post-teaching questionnaires, interviews, emails, phone communications and reflective journals kept by the pre-service teachers. This range of data sources enabled “triangulation” of findings to validate the data (Zeichner & Noffke, 2001). This paper focuses on the data set collected from the participating in-service teachers and principals.

An initial questionnaire was sent to all teacher participants and their principals immediately after the formation of the partnerships and before the pre-service teachers began the teaching phase. It aimed to collect demographic data and to ascertain background

information, their attitudes towards science, and to clarify their expectations of and reasons for being involved in the project. The questionnaire largely consisted of Likert type questions with some open text responses.

Further data was collected after the teaching phase. In 2007 and 2010 a second questionnaire was sent to the colleague teachers immediately after the pre-service teachers had completed the six week teaching phase to collect feedback on and reactions to the program. In 2008 only, due to a small amount of funding being available to employ a research assistant, the second questionnaire was replaced with a semi-structured interview of the in-service teachers.

In 2007 only a third questionnaire was sent to the teachers six months after the teaching phase had ended which aimed to determine if there were any lingering impressions or effects of the project. Although some data were obtained, the response rate was to this questionnaire was so low that it was abandoned in the later iterations.

Analysis and Discussion of the Data

A total of 23 schools participated in the program, 19 principals provided feedback in the 2007 and 2008 iterations. Table 1 gives a summary of the responses for all questionnaires and interviews, from both the principals and teachers, for each of the three iterations of the project.

The overall response the rates were good. Fourteen principals provided feedback in the pre-teaching phase and 7 provided post-teaching data. The principal cohort consisted of 6 females and 13 males. Of the 61 individual teachers who participated in the project, 50 responded to at least one request for feedback data, with 26 providing two responses. Over the three iterations 37 teachers responded to the pre-teaching (initial) questionnaire and 40 provided post-teaching data, including 12 who participated in the interviews in 2008. The post-teaching data were solely qualitative in the form of open text responses, conversations with individual teachers and/or interviews.

The average number of years experience reported by the 37 teachers was 15.9 years. The sample was bi-modal with four teachers reporting 8 years and four reporting 20 years experience, with the range from 3 years to 41 years. The teachers who responded consisted of 39 females and 9 males (note this only totals 48 because two teachers participated in two separate iterations).

Year	Pre-teaching phase		Post-teaching phase		
	Population (by year)	Initial questionnaire	Second questionnaire	Third questionnaire (2007 only)	Interview (2008 only)
Principals					
2007	9	9	7	NA	NA
2008	10	5	NA	NA	NA
Total	N=19	14	7	NA	NA
Teachers					
2007	21	15	11	5	NA
2008	15	11	NA	NA	12
2010	14	11	12	NA	NA
Total	N=50*	37	23	5	12

Table 1: Number of responses to the questionnaires and interviews conducted in 2007, 2008 & 2010.

***Note: Two teachers participated in two iterations.**

“NA” means that no data were requested, e.g. there was no second or third questionnaires for teachers in 2008.

Pre-teaching phase (Principals): Initial Questionnaire (2007 and 2008 only)

The strong support by the schools in each year indicated there was an unmet need for science related support in these schools. At the time of the first iteration of the project, recent changes to the state science curriculum involving a shift from an integrated learning approach, to one more based on traditional disciplines, in line with the proposed development of a new Australian Science Curriculum (ACARA, 2009). With the implementation of the new curriculum planned for 2011, it was likely that there was a systemic imperative to prioritise science behind the willingness of schools to participate in the project.

In the initial stages, the principal were surveyed in the pre-teaching phase in 2007 and 2008, and in the post-teaching phase in 2007, but as the focus of the research was on the partnership aspects of the program this data was not collected in later iterations. A total of 14 principals responded to the initial questionnaire, nine in 2007 and five in 2008. Table 2 shows their responses to the four statements using a Likert scaling, where SD (Strongly disagree) =1, D (Disagree) =2, U (Unsure) =3, A (Agree) =4 and SA (Strongly agree) =5. With the Likert responses constituting ordinal data, the use of parametric statistics is not warranted, but descriptive statistics, based on the numerical values above will be used to determine the mode, median and inter-quartile range for each response.

Statement	SD	D	U	A	SA	Mode	Median	I-Q Range
1. My school values science in the curriculum.	0	2	2	8	2	4	4	3-4
2. My school is well resourced to do science.	0	3	6	5	0	4	3	3-4
3. I see the value of science in the curriculum	1	0	0	6	7	5	5	4-5
4. I feel that more time needs to be devoted to science at our school.	0	1	2	3	8	5	5	4-5

Table 2: Principals: Initial questionnaire responses to Likert statements 2007-2008.

With n=14, the results for statement one reveal that 71% of the principals agreed or strongly agreed that their school values science in the curriculum, with the modal response A= 4. Statement 2 provided much less agreement (36%) when the question of resourcing to do science was raised. These two statements pointed to some ambivalence amongst the principals, probably driven by the curriculum imperative to develop science in their schools and a wish to raise the profile of science, but uncertainty about their readiness. This is borne out in their responses to statement 3 in which 92% of the principals gave their personal position on the value of science in the curriculum as opposed to their opinion of how their school valued science. In response to statement 4, 79% of the principals agreed more time needs to be devoted to science in their schools.

The open text responses from the principals in the pre-teaching phase provided some insight into the motivations behind these responses. By way of explanation of their reasons for being involved in the project three key themes emerged: 12 expressed a need to build the profile of science in their schools; 5 mentioned a desire to support the pre-service teachers and build relationships with the university; and 3 said they saw it as a professional development (PD) opportunity for some of their teachers:

Science is a priority in 2007. Science enables us to teach inquiry thinking. Science is a way to lead boys into literacy. (Principal-Charles)

Teacher interest(ed) to extend her knowledge and skills; demonstrated interest in science (Principal-Henry)

Clearly the principals saw benefits for their schools from participating in the project but their focus was largely on meeting strategic curriculum demands associated with developing the profile of science in their schools.

Post-teaching phase (Principals)

At the completion of the teaching episodes in 2007 the second questionnaire was circulated to the principals. Seven of the 9 principals responded and all were positive about the concept behind the program:

The feedback from participating uni students was positive and the increased enthusiasm for science across all stakeholder groups was obvious. Great concept (Principal- Jack)
Jemma put a lot of effort into the project – she was super organised – always arriving early to set up or locate resources – it was a real pleasure being involved with the project – thank you (Principal- Debbie)

In terms of the actual benefits flowing for their teachers and students from involvement in the program one principal, Francesca, was critical of the way project had operated in her school because she thought 2 of the 4 pre-service teachers who had taught there needed to be “better prepared”. During the teaching phase, when the science-educator was informed that there was a problem, he immediately met with the in-service teachers concerned and Francesca to discuss the issues. It turned out that the preparation done by the two pre-service teachers had been inadequate and they had not sought assistance from the science educator, nor made prior contact with their colleague teachers, or visited the classrooms prior to beginning the teaching phase as required. This meant they had little knowledge of the context in they were to teach and knew little about the student’s ability range. This placed the pre-service teachers at a serious disadvantage when they began the teaching phase and undermined the credibility of the program in the eyes of the teachers involved.

The teacher-educator acknowledged that the expectations for the pre-service teachers needed to be made clearer and the accountability processes were improved for the 2008 iteration of the project by: strengthening the communication with the schools in order to set-up the partnerships more effectively; moving to establish the partnerships more quickly; better communication to identify and support pre-service teachers at risk earlier; improving the documentation to make the expectation more explicit that the pre-service teachers were to make contact with the in-service teacher colleague as soon as possible; improving the collaborative planning process at the university in the pre-teaching phase; and refining the reflective feedback process.

Notwithstanding these problems, the program ran smoothly in the other schools during the first iteration and the principals were very positive about the program:
The lessons have been organised in a very purposeful manner. This has been of real benefit to the class teacher involved as she has declared herself to be somewhat ‘science phobic’. (Principal George)

I think there can only be benefits for all by participating in such programs. (Principal- Charles)

Even in the case where the 2 pre-service teachers had not performed well, the principal Francesca could see value in the program:

Yes, if students came better prepared and had a real commitment to developing their practice and taking on board suggestions for improvement of lessons and better understanding of student management. The model is an excellent idea...(Principal- Francesca)

Pre-Teaching phase (Teachers) - Initial questionnaire

All the teachers were sent an initial questionnaire prior to the teaching phase. As in the case of the principals, it collected some demographic data and background information on their attitudes to science, using Likert type scaled responses and qualitative open text questions. The teachers’ responses to the Likert questions are summarised in Table 3. Note the first four statements in the questionnaire were common to both the principals and the teachers. Statements 5 and 6 were given to the teachers only.

Statement	SD	D	U	A	SA	Mode	Median	I-Q range
1. My school values science in the curriculum.	1	0	4	26	6	4	4	4
2. My school is well resourced to do science.	3	9	13	10	0	3	3	3-4
3. I see the value of science in the curriculum	1	0	0	16	20	5	5	4-5
4. I feel that more time needs to be devoted to science at our school.	0	4	10	18	4	4	4	3-4
5. My own school experiences with learning science were positive.	3	6	7	20	1	4	4	3-4
6. I feel I have to know a lot about a science topic before I feel confident to teach it.	0	11	7	17	0	4	3	2-4

Table 3: Teachers: Initial questionnaire responses to Likert statements 2007, 2008 & 2010.

Thirty seven teachers responded to the initial questionnaire and their responses to the first statement are consistent with the responses from the principals (Table 2) in terms of the value placed on science in the curriculum by their schools. For statement 2, however, with the lower modal value of 3 indicates that the teachers were less certain about the level of resourcing for science in their schools than the principals, with the majority either unsure or disagreeing with the statement. This point also comes through very strongly in the open text responses (see below).

Both the teachers and principals provided consistently high ratings in response to statement 3 about the value of science in the curriculum from a personal perspective, with the teachers’ mode, median and inter-quartile range at (5, 5, 4-5) respectively. In response to statement 4, however, about the need for more time to be devoted to science, although still high, their responses were consistently lower with a mode, median and inter-quartile range (4,4, 3-4) compared to (5,5, 4-5) for the principals. This could be explained by the teachers being more likely to focus on the immediate problems of implementing science in their classrooms when responding to this statement, whereas the principles may have been more concerned with the broader strategic aspects of implementing science in their schools as mentioned earlier. This view is supported by the number of teachers referring to a lack of “time”, resources and the “crowded curriculum” in the open text responses discussed below and is consistent with the findings of other research (Appleton, 1999; Goodrum et al., 2001; Kenny & Colvill, 2008).

Statements 5 and 6 went only to the teachers. Again with a high values of (4, 4, 3-4) a majority of this group of teachers (57%) (n=21) felt their own school experiences of science were positive (statement 5). In responding to statement 6, with the statistics being (4, 3, 2-4), there was more uncertainty about the statement that they would need “to know a lot about a science topic” before they would feel confident to teach. Of the 35 who responded to this question, only 11 (30%) disagreed with the statement, with 17 (48.6%) indicating their lack of specific science content knowledge would affect their confidence to teach a topic. A further 7 (20%) were unsure.

Qualitative data: Pre-teaching phase

The open response questions the teachers revealed three main themes: their awareness of the value of science in the curriculum; the barriers they perceived to teaching science; and their expectations that their involvement in the program would lead to some professional learning for themselves.

Value of science (2007, 2008, 2010)

While it may reflect that fact that this group of teachers volunteered to participate in the program, the teachers were quite articulate when describing the specific value of science in the curriculum. The data over the three years provided was consistency. Of the 37 respondents, 31 (84%) referred to the chance science offered their students to understand the real world and to foster their curiosity and thinking skills through inquiry. Twenty-five (68%) also referred specifically to the value of “hands-on” learning experiences:

Science can offer an insight and understanding of the world around us, stimulate and interest all students and provide a starting place and an avenue for those who have a strong leaning towards a scientific future (Teacher- Brenda)

Lots of hands on tasks where children can learn from inquiry based learning experiences and observation. It allows children to draw on the knowledge and understandings needed to know and understand how things work in the world around them. (Teacher- Liza)

Others noted that natural links to other areas of the curriculum, specifically literacy and numeracy, arose from teaching science.

Hands on experiences and links to literacy. Access to literacy by providing something that all students can write about because they did it. (Teacher- Claire)

A broad integration of curriculum outcomes that are exercised and practised in hands on and engaging tasks. (Teacher- Lyall)

These results help to explain the strong agreement with the statement 3 above about the value of science in the curriculum.

Barriers to teaching science

While the teachers were clearly aware of the value of teaching science in their classrooms, when asked what were the barriers, a number of issues emerged that were consistent with other research and are neatly summarised by Liza:

Not having enough supervision when undertaking experiments. Having enough equipment and resources for all students to take part at the same time. The time that it takes to prepare for lessons and having enough time to complete experiments in a short time frame. The curriculum is so crowded that sometimes Science does not have a huge focus. Teacher-Liza)

Thirty six teachers gave an estimate of the time they devoted to science each week. The open response made this data difficult to interpret in some cases, but the range of times given varied from a low described as “Not Much!” or “incidental” happenings of about 15-30 minutes per week, with five teachers reporting 2 to 2.5 hours per week. The mode was in the range 1 to 1.5 hours per week. About one hour per week devoted to science is a figure consistent with other estimates reported in the literature (Angus, Olney, Ainley, Caldwell, Burke, & Selleck, 2004; Exley & Luke, 2009; Goodrum et al., 2001, p.157; Kenny & Colvill, 2008).

Using time devoted to science as reported by the teachers as a classifier, they were

sub-divided into two groups. Group A contained those who indicated that they dedicate more than an hour or less per week to science. Group B consisted of those who dedicated more than an hour per week to science. Group A contained 19 teachers (51%) and Group B contained 17 teachers (46%), so there was an approximately equal proportion in each sub-group. Table 4 gives a summary of the barriers to teaching science mentioned by each of these two sub-groups for each iteration.

There were a similar number of total obstacles to teaching science mentioned by teachers in each subgroup. In their comments, 61 barriers to teaching science were mentioned with Group A reporting a total of 33 barriers and Group B reporting a total of 28. The individual comments fell into four major categories. Resources to teach science was the biggest concern for both groups with the Group A mentioning it 14 times as compared to the Group B who mentioned it 11 times. This indicates this is may be powerful barrier to doing science, even for those who spend a significant amount of time teaching it. This barrier was also often linked to time in terms of the extra effort needed to source and organise resources, manage hands-on activities and equipment in science classes.

Sub -Group	Barriers mentioned	2007	2008	2010	Total
Group A An hour or less per week	Resources	3	3	8	14
	Time	3	1	3	7
	Confidence	4	0	3	7
	Crowded curriculum	2	2	1	5
		Sub total			33
Group B More than an hour per week	Resources	1	4	6	11
	Time	2	1	5	8
	Confidence	0	0	1	1
	Crowded curriculum	1	4	3	8
		Sub total			28
		Total			61

Table 4: Summary of barriers to doing science mentioned by teachers sorted by confidence.

“Time” (or the lack of it) was the next most common obstacle, mentioned 7 times by Group A compared to 8 times by Group B and it was also specifically linked to the “crowded curriculum” on 5 and 8 occasions respectively:

Unfortunately time needed to teach literacy and numeracy skills has become much greater. Parents value these skills far more than scientific skills and therefore would begin to question too much time spent away from these skills. I also need to do quite a deal of research as well. Teacher-Maree)
There are just too many subject areas to cram into a week, and with a main focus being placed on mathematics and literacy I find that I often run out of time to include areas like science etc. Teacher-Kristi-Lee)

TIME – crowded curriculum. Lack of curriculum/ guidelines for grade level. Difficulty in locating necessary equipment and resources. (Teacher-Kim)

Time, PD (lack of it) availability of ready prepared activities that are cheap to do (we have a constrained budget !!!) general lack of confidence. (Teacher-Bonnie)

Confidence to teach science was clearly a bigger issue for Group A with 7specifically mentions in the comments compared to Group B who mentioned it only once.

This indicates that time devoted to science may be a good indicator of confidence to teach it. Confidence also was often linked to the other barriers through the time needed to research content knowledge and gather resources as exemplified by Nellie and Olivia below:

So much else to do. Unless Inquiry Units have a specific science focus, (I) may not undertake any science for a whole term. Often requires increased amount of time for planning and preparation so when feeling under pressure, (I) find it easier to not do science. (Teacher- Nellie)

Lack of knowledge of the background of science concepts. Managing 28 children with science activities – using equipment etc. Gathering equipment. (Teacher-Olivia)

Nellie was classified as lacking in confidence, however, Olivia, who was classified as confident because she reportedly was doing science 2-3 hours a week, was also feeling a range of pressures associated with teaching science.

These results indicate that these barriers to teaching science come from a range of pressures on teachers, are persistent and often interrelated and may be independent of the confidence reported by the teachers. For example, the collection of resources is directly associated with teaching science, implementing hands-on science lessons and researching topics requires effort by teachers, whether or not they feel confident with science. The external accountability pressures arising from systemic curriculum reforms would be felt by many teachers, so this probably explains the relative reticence of the teachers to devote more time to science evident in the response to statement 4 above and it seems to leave the teachers feeling conflicted. This data indicates that the problems associated with implementing science in the primary curriculum is not about convincing teachers of its value, but may be more a question of how to support them to implement science.

Professional development

When asked about what they hoped to gain from their participation in the program, before the teaching phase began, of the 37 responses, 31 (84%) mentioned a range of specific benefits they expected to flow from their participation for themselves, their students and the pre-service teachers. Nineteen (51%) mentioned they hoped to gain ideas for teaching science. For some such as Shirley and Geraldine, both of whom lacked confidence with science, this amounted to some ideas they could use in their teaching with their students:

Ideas for teaching science, that science isn't hard to teach, an interest from my students for science. (Teacher-Shirley)

More ideas from student, learn about different ways of doing things. (Teacher-Geraldine)

Others, such as Lyall, Prue and Joe, who self-reported as quite confident with science, appeared to have moved beyond this stage and were thinking in ways that indicated they had stronger levels of science PCK. They were more focussed on ideas to help their students develop conceptual learning in science, integrating science, assessment and implementing the science curriculum:

Alternative thinking to how science is taught and assessed, working from different angles on introducing a science topic and keeping a student's interest in the tasks. (Teacher Lyall)

I am looking forward to working with (pre-service teacher) in developing an integrated unit of work around electricity, and closely matching the work with the demands of the new Tas(manian) Science Curriculum. (Teacher- Joe)

I hope to engage my students and stimulate their natural curiosity, promote and develop literacy and numeracy skills through science, accurately assess student progress so that I can fulfil reporting requirements mandated by the school. (Teacher Prue)

As indicated by Joe's comments, the collaborative aspect of working on a science task with a pre-service teacher was appealing to many of the teachers. Eleven of them (30%) specifically mentioned this aspect and the benefits that would flow for themselves and/or the pre-service teachers from a joint effort in teaching science:

Student and teacher satisfaction and stimulation; added knowledge on all sides; being able to provide an opportunity for a university student to add to his/her experiences; a heightening of awareness of science and the inclusion of the subject in our Australian curriculum. (Teacher Brenda)
I am looking forward to working collaboratively with the UTAS student to provide an exciting, curriculum based, educational 'scientific experience' for my students. I am happy to support pre-service teachers and I believe by allowing them to work with the students in my classroom it gives them a wonderful opportunity to gain valuable teaching experience and to develop their teaching strategies and skills. (Teacher Janine)

Consistent with Murphy et al. (2004), ten teachers (27%) commented that their participation would motivate them to do more science and devote more time to teaching it, affirming the presence of the pre-service teachers in their classroom as 'catalysts' in overcoming some of the barriers to teaching science and providing a buffer from the encroachment of other competing curriculum areas:

Ensure the children get to develop some scientific concepts this term, and motivate me to get a bit more science back into the curriculum! (Teacher- Olivia)
I like to support pre-service teachers and I think collaboration can be a powerful experience for both pre and in-service teachers. It also helps me dedicate a period of time to science teaching that isn't swallowed up with competing curriculum areas and school demands. It should hopefully give me a chance to focus on science with another capable adult present to help assist in their learning. (Teacher Nathan)

Only five of the 37 (14%) teachers specifically mentioned that they hoped to build their own confidence to teach science as a goal, but many of these comments could be linked to building confidence. The structure of the project seemed to be able to accommodate the needs of teachers who lacked confidence and those who felt confident with science.

The teachers clearly had a range of professional learning goals, motivations and expectations they hoped would flow from their involvement. Nathan's comments imply that, because the teachers were not to be supervisors, as they would in a normal practicum situation, they could work collaboratively with the pre-service teachers and it would be a mutual learning situation. This may also have assisted those teachers lacking in confidence to see it as a learning experience their role was to not provide the science related expertise.

Consistent with findings by Murphy et al. (2004), for these teachers, their participation in the partnership project offered an opportunity to engage in science and the structure of the program offered a way of overcoming some of the barriers to teaching science. The structure of the project also provided the teachers with an opportunity to have science taught in their classrooms with their own students, but with someone else (the pre-service teacher, supported by the teacher educator) taking on the bulk of the responsibility to develop the teaching ideas and collect the resources. It remained to be seen what effect their experience had on their confidence or attitudes towards science. This information could only be gleaned from the post teaching data.

Teachers - Post Teaching Data

In each of the three iterations of the project data were also collected after the teaching phase had been completed. This feedback led to improvements in the program over time and forms the basis of the following discussion. The summary in Table 1 shows that of the 61 teachers who participated, a total of 40 provided post teaching data in the form of 23 responses to the second questionnaires (2007 and 2010), five responses to the third questionnaire (2007 only) and 12 records of interview (2008 only). These data were qualitative in nature allowing the teachers to express their opinions and thoughts about the program.

Overall, the teachers expressed very strong support for the program and when the data were analysed three key themes again emerged. There was some overlap with the themes from the pre-teaching phase, with the teachers focussing on their reactions to the organisation of the program, articulation of specific professional development aspects and their thoughts on how the partnerships with the pre-service teachers had functioned.

Reactions to the program

Many of the colleague teachers who had lacked confidence expressed a change in their *own* attitudes to science reporting an increase in their own motivation and confidence to teach science after the experience:

I realise that science isn't scary and that it can be easy and uncomplicated. I am inspired to teach more of it! (Teacher-Shirley)

Definitely a change in attitude. I found a fantastic book in our school library full of science activities and sheets ready to go for the children to fill in when they completed the experiment. ... I feel confident to take science now because of this book, but it was watching James take science with my class that encouraged me to seek out a book such as this. (Teacher-Sally)

When asked about how they think the program benefited their *students*, the in-service teachers reported a number of positive outcomes:

They loved it and learnt Heaps!!!! We did lots of other science related things on growth on the other days when the uni student was not present. (Teacher-Clara)

Different voice. New ideas. Different approach. Two teachers instead of one. (Teacher-Jerry)

Some, however, still perceived barriers to teaching science and the persistent issues mentioned were again a lack of time, resources, over-crowded curriculum and lack of confidence:

Perhaps it is a matter of lacking confidence, insufficient resources and PD or simply a matter of cramming more into an already full program. Science is still often (seen) as an area of study which is separate from the primary classroom teachers. (Teacher-Renee)

Time, resources and a strong focus on reading literacy/numeracy benchmarks = more time dedicated to these areas (Teacher-Paula)

Five teachers responded to a third questionnaire in 2007, six months after the teaching episodes had ended. Three of these had not responded to the second questionnaire. In response to the question "What are the three key things you recall from your participation in the program?" three teachers specifically remembered the enthusiasm of their children's response to the science activities and one other commented that her children remembered the activities. Two teachers mentioned that they remembered that science was easier to implement than they had thought and the third said she knows she does not "do enough science". More significantly, 2 reported that they had changed their attitudes and or practice:

I now look for a scientific component to all units taken. e.g. during our last unit, "Which Animal is that?" we used our knowledge of the 5 senses covered by Jemma at beginning of year to assess our excursion to the Yolla School Farm. It reminded children of previous lessons and gave a different approach to an excursion and gave a heightened awareness of their surroundings. (Teacher-Renee)

The teachers clearly reported a change in their attitudes to teaching science, expressing greater awareness of how it might be incorporated into what they were doing. Further research would be needed to determine if this program has led to any subsequent change in teaching practice for these teachers or if it has helped overcome some of the barriers to teaching science or at least those barriers within the control of the individual classroom teachers.

I feel it is a valuable ... the Uni should look at using this program as part of the process university students need to qualify as time spent in schools. I personally won't be on class next year so therefore am unable to take students. I believe if this continues uni students need to submit their planning to the class teacher ahead of lessons and spend some time in the classroom building relationships with students before they are expected to start teaching. (Teacher-Cassie)

Cassie hinted at a weakness with program, with the students having so short a time to establish a relationship with their class. The importance of this aspect was exacerbated in the case of the 2 students who were under-prepared for their teaching, in phase 1, and this clearly affected the experience of the in-service teachers concerned:

I was really hoping to have learnt something more valuable from this experience. I was hoping that the pre-service teacher would have some great ideas and strategies. I'm quite disappointed that this wasn't the case and hope that the course it tweaked in the future so as both pre-service and practising teachers find it a worthwhile process. (Teacher-Elisha)

Science students to provide a detailed lesson plan to colleague teachers before they commence which outlines guiding questions and learning objectives. I think a simple form of assessment addressing each student against the intended outcomes would also benefit all parties. (Teacher-Ursula)

In contrast to these comments, mainly focussed on planning and preparation, nine teachers mentioned the positive aspects of the program

The importance of including science in the teaching program. The engagement of children. That science need not involve complicated preparation, it can be easy to implement (Teacher Renee)

I thought it was very well organised. My student in particular ... was very well prepared (Teacher-Sally)

Clearly the preparation of the pre-service teacher was a significant element in the way the partnerships functioned and the benefits that the in-service teacher would associate with the program.

Professional Development

Twenty-eight (76%) of the 37 who responded after the teaching phase articulated how the program had benefitted them. In 2007, seven of the eleven respondents pointed to specific professional and/or pedagogical benefits from their involvement:

Observing another person teach enables me the opportunity to reflect on my own teaching practice and allows me to observe classroom dynamics as well as student engagement and progress. (Teacher-Ursula)

She introduced me to the 5E's, I had seen those before but not in a science context ...and she did mention to me about the Primary Connections, which I knew about but I hadn't really got into them because I was doing maths and literacy and doing other things...I've picked up (Primary Connections) now and I've done more science this year than I ever have before...I can see where it fits now, so take a literacy idea ...and bring all your science activities into it, so...I've really enjoyed

it. (Teacher-Maree)

Several colleague teachers, initially lacking in confidence with science, expressed an increase in their own confidence to teach science after the experience:

My practice has not changed as yet but I am now more aware of the value of science in the classroom and am on the lookout for experiments that I feel I could take with confidence.

(Teacher-Sally)

Some of those teachers already confident with science were motivated further and were keen to see how others do it:

Having a science prac teacher has been an excellent opportunity to sharpen my own teaching skills in order to demonstrate to a prac teacher. ... it was great for the 6/7's to experience science in the lab but with the continuity of the classroom teacher. The quality of beginning teachers is, in this case excellent. (Teacher-Hennie)

It has motivated me to try and keep teaching science in my classroom. (Teacher Liza)

After the problems referred to in 2007, the collaborative planning aspects were strengthened for the 2008 iteration. The comments from all the 12 colleague teachers in the interviews after the teaching episodes revealed they found it to be a positive professional learning experience. The teachers were explicitly asked if they saw any benefits in the partnership approach for them as practising teachers. The responses were clearly influenced by the perceived performance of the pre-service teacher they had worked with. Many reported that modelling of good practice and the response of their own students to science was a motivational experience:

Made me stop and think about the importance of science in the early childhood section: inquiry and thinking skills and a better understanding of science activities in the classroom...My science was previously ad-hoc but now I am more aware of what is possible. (Teacher Rhonda)

It has probably affirmed it's a really beneficial thing (for students) to have a series of lessons that are scaffolding the kids understanding and knowledge, rather than just doing bits and pieces of exciting science things, actually having a whole series of lessons that can be building on ideas and building up to a main understanding. (Teacher- Kristie-Lee)

A number of teachers also again commented on how being able to observe the pre-service teacher in their class provided them with insights about their class group they had not noticed before:

It was good to see how the students reacted to having a new teacher in the room. It was good to be able to watch the student's responses and to see who reacted well and who did not. We don't often have the chance to watch our children and how they respond. Much easier to see those who rarely communicate. (Teacher -Ina)

In 2010, the 12 teachers who participated universally commented that the program was a valuable professional experience for them. When asked what they had gained professionally from the program some saw it as a source of ideas and a stimulus for their own teaching of science:

It was good to see how the students reacted to having a new teacher in the room. It was good to be able to watch the student's responses and to see who reacted well and who did not. We don't often have the chance to watch our children and how they respond.(Teacher- Ina)

The teachers also reported becoming aware of new ideas and resources and appreciated having space to reflect on their own teaching due to someone else being in the room:

It allows me to reflect on my teaching, to see what works for me and what doesn't, as well as seeing that my techniques may not always be suitable for others. I have gained new ideas for teaching science as well as gaining access to University resources that I have not used before ie digital microscope. (Teacher- Marcus)

Where the program worked well, the data indicated that there seemed to be something very powerful for the teachers in watching how enthusiastically *their own students* responded to the science activities. This may be strength of the program in that it

occurs in the teachers' own classrooms and what they observed caused some of them to reflect on their own practice:

Yes this was a great way to get science in the classrooms and give practicing teachers some ideas and confidence. Seeing how well the students responded to science - how engaged they were - has made me realise how much more I need to be doing science in my room. (Teacher- Sally)

I have always enjoyed teaching science – the students in my class loved all the hands-on fun activities – it highlighted for me just how powerful science can be to teach all sorts of skills. (Teacher-Prue)

A number of teachers commented that seeing new ideas and curriculum materials demonstrated had actually added to their understanding and willingness to give science a try:

The learning sequence that Steph has run is certainly something I will use in the future. Just seeing someone else run (the 5E's) was really interesting because when I went to the PD I thought that was good, but, watching from the outside I was able to make links... (Teacher-Noelene)

It really engages the pupils. I learnt concepts about pulleys and levers that I didn't know about before.- so I will probably use these again if I ever work on this topic again. (Teacher-Roslyn)

We did lots of other science related things on growth on the other days when the uni student was not present. (Teacher-Clara)

Always great to work collaboratively when planning and implementing learning sequences. Good to see uni students getting more practical experience. (Teacher- Ceri)

A different point of view, new ideas, enthusiasm. It gave me an opportunity to share planning and ideas and to observe my students working with the pre-service teacher. (Teacher-Geraldine)

Yes heaps! It enables us to have support/help while setting up and conducting science activities. It's also wonderful having someone else to plan and organise the lessons. (Teacher- Ginger)

My pre-service teacher assessed the students at the conclusion of the unit of work. This was most helpful to me as I needed this feedback for my mid-year reporting. It was also a very valuable thing for the pre-service teacher to do as part of her own self-assessment. (Teacher- Prue)

The majority of the in-service teachers who took part in the program reported that they had benefitted professionally from working with the pre-service teachers, which is consistent with findings of other collaborative partnership approaches (Jones, 2008; Murphy et al., 2008).

Partnership Related Issues

The effective functioning of the partnerships became more of a focus for the project as the program developed. It also naturally became a focus for the teachers as they reflected on their experiences after the teaching phase was over. The instances alluded to in 2007 during the first iteration, when two pre-service teachers went to the teaching episodes under-prepared had caused a degree of dissatisfaction which 4 teachers from that school expressed in their feedback:

Get students to thoroughly plan BEFORE commencing. Students could still attend science curriculum at uni – as well as conduct the lessons in schools – therefore they could constantly reflect/refine their teaching with help from their peers/lecturer/colleague teacher. (Teacher-Paula)
Pre-service teachers need to be more organised with planning, assessment, etc. In class visit by science teacher (educator?). Compulsory visits prior to the commencement of the placement by the pre-service teacher. (Teacher- Elisha)

In response to these criticisms, for the 2008 and 2010 iterations the program was improved to more explicitly articulate and facilitate the partnership aspects. The need for the pre-service teachers to meet with their colleague teachers early and to engage in a collaborative planning process with them were emphasised more clearly as an expectation.

Data from the in-service teachers indicated that in the subsequent iterations the partnerships actually were more effective. The twelve respondents in 2008 were all positive

about their working relationship with the pre-service teachers, but expressed the importance of good communication and the need to feel confident that the pre-service teacher was organised and well planned:

The pre-service teacher is hardworking and organized and this makes the project worthwhile... (she) values the experience and it is taking up a great deal of her time consequently I want to be as supportive as possible. It is a partnership. (Teacher- Brenda)

Very good, she is a good communicator (and has) kept in contact. She has taken suggestions that I made and worked on those... (we) established the working relationship fairly quickly the opportunity to work with a student teacher ... causes me to reflect on my practice. We had a look at the curriculum together, we talked about pedagogy... I would have concerns if the pre-service teacher didn't communicate well with me and explain his/her ideas or follow advice. Fundamentally it is about being able to establish a working relation and I didn't have any problems with that. (Teacher- Joe)

There were still problems, however, as other teachers commented that time was needed for the pre-service teachers to get to know their students before the teaching began and that it was not always easy to debrief and discuss the issues during the teaching phase: (feedback)

In terms of my working relationship with the pre-service teacher it has been quite difficult (there has been no chance to debrief) because when he finishes I have to take the class over. We need a bit of extra time there for talking about how he is going and what he is doing... to try to develop a bit of feedback between the two of us. (Teacher- Lyall)

Didn't have a great deal of time to de-brief with the pre-service teacher. (Teacher Rhonda)

Related to the comments above, communication between the in-service teacher and the pre-service teacher was a key issue specifically mentioned by five of the 12 teachers in 2008. It is clearly as an important part of how they work together and to overcome the problems, some made use of technology to facilitate their communication:

Good working relationship. It was really good, (Steph, pre-service teacher) is a very open person, she's a really good reflective thinker on her own practice. When she finished her sessions, she would go home and think about it, then send me an email with how she had reflected on it and I would respond and add anything else. Really open two-way communication. Very enthusiastic, really well planned very organised... made things very easy. (Teacher- Noelene)

The pre-service teacher and I are in constant weekly communication, mostly via email, wherein we peruse, discuss and remodel lessons. I support her in her preparation by helping prepare aides, and engaging the students to bring materials from home, and following up activities in the classroom at other times. (Teacher- Brenda)

There was some evidence of persistent communication difficulties between the university and the schools as some in-service teachers commented that they found it hard to get information about the program.

I found that I had to really hunt for information as to how the program was going to run. My pre-service teacher thought the Uni was going to tell me.... Did I need to assess this person... trying to find out what my responsibility in this partnership... and that wasn't clear for me ... the outline of her course ... didn't tell me what I had to do...(The) Program needs to spell out all aspects of how it was expect to run. (Teacher- Genevieve)

In the 2010 iteration, to make information about the program even clearer, and to address the other problems mentioned immediately above, a half-day briefing session was organised at the university by the science educator in the early part of the semester. The purposes of the session were: to outline the program; to clarify the expectations of each member of the triad; to formally introduce the participants to each other so they could begin planning; and to collect the initial questionnaire data. The in-service teachers were released from class to attend, with the support of the Department of Education.

This seemed to improve the operation and understanding, but despite the half-day briefing session, of the twelve respondents in 2010, four teachers said they were still not

completely sure about the expectations of their role in supporting the pre-service teacher; two expressed some uncertainty about the role to be played by the pre-service teachers; and three also expressed a lack of clarity about the role of the university lecturer: There needs to be more communication between the student, the university and the colleague teacher. (Teacher-Gaye)

On the whole though, the stronger emphasis on collaboration and building the partnerships seemed to have paid dividends. Ten (83%) of the 12 in-service teachers who responded were very enthusiastic about their working relationship with the pre-service teacher and specifically commented on the mutual learning from their partnership with the pre-service teacher.

It is a partnership.... Yes, it has added to my knowledge of science and its place in the classroom. (Teacher-Brenda)

Very positive and reciprocal: I have got ideas from her and she has learned from me. (Teacher-Genevieve)

It worked well – I was able to discuss all aspects of the unit of work and make suggestions where appropriate. My intern was most accepting of any advice and help I could give eg. resources, activity ideas etc. We did work cooperatively and it was great to share our ideas and strategies, not only for lesson content but also for behaviour management, safety etc...(Teacher-Prue)

An interesting twist on this theme was that one in-service teacher was concerned that his pre-service teacher was over-prepared and did not include him:

I think it was often a one sided partnership with the pre service teacher feeling they had to run the whole program. (Teacher-Tony)

This latter comment highlights the point that the partnerships work best when the colleague teacher was engaged in the process as a co-learner and there was genuine collaboration:

I am very interested in continuing this program as I believe 1. it is important to have strong links between the university and schools. 2. it gives learning teachers further classroom experience 3. students appreciate another voice and another perspective 4. supervisor teacher learns from student teacher and vice versa 5. it's a win-win situation for all. (Teacher-Jerry)

Further improvements are planned to better integrate the communication in the partnerships: for example, the pre-service teachers were required to keep a reflective journal, but while the reflective process suggested the pre-service teachers should discuss their science teaching experiences with their in-service colleague this was not required. In future iterations it will be made more explicit by requiring the pre-service teacher to raise specific issues arising from their teaching experience and scaffolding the process for their discussion based on that suggested by Timperley (2001).

Further research is planned to explore whether involvement in the triadic partnership approach has led to any sustained, longer term changes in science teaching practice for both the pre-service and in-service teachers. Future iterations of the program will also fine tune the communication processes and the emphasise the key factors that contribute to successful triadic partnerships which include: holding an initial briefing session to quickly establish the partnerships; clarifying further the expectations of the roles in the triadic partnerships; improving scaffolding for the collaborative planning process to assist the pre-service teachers to plan their sequence prior to the teaching phase; ensure the pre-service teacher regularly collaborate with the in-service teacher in the planning phase and adjusts their plans to suits the specifics of the class situation; ensuring the pre-service teacher meets the class and surveys the learning environment prior to beginning the teaching phase; and implementing strategies to encourage regular feedback and discussion between the partners in the program.

Conclusions

The triadic partnership program was set-up as a response to the lack of opportunity reported by pre-service teachers to have genuine experience of teaching science during their teacher education and associated practicum periods. This was linked to the general lack of confidence of primary teachers with science so the partnership project was to set-up to provide final year pre-service teachers with an authentic science teaching experience in the class of an in-service primary teacher. As it happened, the program also met a need for teachers in the schools to which the program was offered for PD in science. Principals were keen to be involved and the Department of Education in Tasmania supported the program by releasing staff to attend the briefing session.

The feedback from the principals indicated they saw it as a means of addressing a strategic curriculum priority for their school (i.e. science) and as a professional development (PD) opportunity for their staff. These two themes were probably linked to the imminent implementation of the National Science Curriculum.

Feedback from the in-service teachers clearly indicated they were aware of the value of science as relevant and interesting to their students, however, they expressed concerns about numerous barriers to teaching science including lack of knowledge, time, resources and the “crowded curriculum.”

The in-service teachers responded well to the emphasis on a partnership approach where the relationship with the pre-service teacher was more collaborative than the supervisory role they would have in a normal practicum situation. They were keen to work closely with pre-service teachers in the class, seeing it as an opportunity to get some PD in science. Many expected it would expose them to new ideas, resources and new approaches to teaching science. As the program was in their class with their students, the in-service teachers have a clear stake in the success of the program.

As an extended professional development program occurring in their own classrooms it had the potential to be a powerful learning experience for them. When the partnerships worked well, the teachers gained from the working with the students to deliver a sequence of science lessons. Seeing science modelled in their *own* classrooms, with their *own* students, was a powerful motivator and prompted them to want to do more, and in some cases, also assuaged concerns that science is hard to organise and manage. Others took the opportunity to reflect on their own practice, and even those in-service teachers who felt confident with science commented that it re-affirmed their enthusiasm for teaching it.

The establishment of effective triadic partnerships was crucial to the success of this approach as the roles of the teacher educator and in-service teacher complemented each other. This was evident when the in-service teacher and the pre-service teachers collaborated in the planning and teaching process and the pre-service teachers were well prepared and open to feedback. The structure of the triadic partnerships therefore addressed some of the key problems associated with supporting pre-service primary teachers to gain experience and confidence with teaching science and the data also indications that the in-service teachers who participated also gained professionally from their involvement.

Communication was a key element in the functioning of the triads. The communication between the in-service teacher and the pre-service teacher in the lead up to and during the teaching phase was crucial. The communication between the science-educator and pre-service teachers occurred in their university classes and through email and reflective journals. Communication between the science-educator and the in-service

teachers was more problematic. Expectations of each party needs to be made more explicit, particularly as the in-service teachers seem to not have ready access to the information provided by the university or may hear of the program through a colleague. Technology will play a key role in facilitating better communications in future iterations.

Particular effort is needed in the program to clarify the role of the science-educator. Despite the briefing session conducted in 2010, while his role in organising the program and facilitating the establishment of the partnerships maybe have been relatively obvious, some in-service teachers were not fully aware of how he also provided science pedagogical support prior to and during the planning and teaching phase. Again, technology may assist in this regard by enabling improved on-going contact with pre-service teachers while they are scattered in different schools

Teachers came to the program with an expectation of it being a significant professional learning activity for them. They were looking for ideas and approaches that worked with their students. After the teaching phase they identified a range of specific benefits, often connected to the positive response of their own students to the science activities, and this seemed to be a powerful motivator to do science. Teachers reported greater awareness of the value of hands-on science; changes in their attitudes towards the perceived difficulties associated with teaching science; new ideas and a deeper understanding of approaches to teaching science; a chance to see science teaching modelled in their classroom; and increased motivation to implement science with their own students. In some cases the gains were less specific to science, particularly for those teachers who already felt confident with science, but they still reported benefits because the program gave them a chance to reflect on their own practice; to re-affirm their commitment to science; and a chance to work collaboratively with a pre-service teacher. Many of these changes are elements of science PCK, so in this sense the findings support the approach suggested by Appleton (2003, 2005) that good science pedagogy and supporting teachers with activities that work can build the confidence, and therefore the PCK of primary teachers.

In conclusion, the triadic partnership approach can promote increased motivation, confidence and awareness of science pedagogies and lead to professional benefits for the in-service teacher participants and these findings are consistent with earlier research (Jones, 2008; Kenny, 2009; Murphy et al., 2008).

Further research is planned to determine how the triadic partnerships might be more effectively facilitated and supported as a sustainable strategy of pre-service teacher preparation and in-service teacher PD and to explore if the approach leads to long term change in science teaching practice for both the colleague teachers and pre-service teachers.

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