Journal of Science and Mathematics
Education in Southeast Asia
2009, Vol. 32 No. 2, 105-130

Teaching Primary Science in Rural and Regional Australia: Some Challenges Facing Practicing and Pre-service Teachers

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The teaching of science has long been viewed as problematic within primary classrooms across Australia. This study explores the teaching of primary science in an area of rural and regional Australia (the New England Region of New South Wales) where small populations, remote settings and isolation can make the teaching of science and other Key Learning Areas (KLA) very challenging. The study employed a mixed methods approach involving a survey of pre and in-service primary teachers (n=41), and semi structured interviews (n=11) with individuals from both of these groups. The findings indicated that many primary teachers and pre-service primary teachers in the New England Region feel challenged by science for a number of reasons including low levels of confidence in relation to scientific content and pedagogical knowledge (specifically in relation to the physical sciences), insufficient resources and equipment, time constraints and limited professional development opportunities. Furthermore, the research indicated that the in-service teachers involved in this study rated science as their second least preferred subject of the six Key Learning Areas within the New South Wales primary curriculum. However, a recent innovation entitled Primary Connections, currently being developed and trialed cross Australia, was favorably received by interviewees in this study and once fully operational, may help to address some of the challenges faced by primary teachers in the area of science.

Key words: Regional; Rural; Science; Resources; Pedagogical content knowledge

Background and Literature Review

The literature on science education is replete with the problems associated with the teaching and learning of science at the primary level (K-6). This article presents research on primary science teaching in regional Australia to determine the extent to which these "generic" problems exist in this particular context. A description of a new initiative that may help improve the delivery of primary science throughout Australia is provided and maybe of interest to those involved in primary science outside Australia.

To be scientifically literate, is an increasing requirement in today's technological world. Yet in Australia, as in many other countries, science is one of the least taught subjects within primary classrooms (Angus, Olney & Ainley, 2007). Australian students spend seven years of their education within the context of a primary classroom, a critical time in which they begin establishing the values and perceptions that they may carry with them through their lives (Australian Science Technology & Engineering Council [ASTEC], 1997), so effective science teaching at this stage is extremely important. Within Australia, as in other countries, research suggests that primary science is not being taught as effectively as it might be. This appears to be the result of a number of issues, including low levels of teacher confidence and competence in relation to scientific pedagogical content knowledge, insufficient resources, time constraints, and lack of support in the form of professional development. Furthermore, these issues appear to have remained unchanged over a long period (see e.g. Appleton, 2002; Carr & Symington, 1991; Corrigan & Taylor, 2004; Goodrum, Hackling & Rennie, 2001; Yates & Goodrum, 1990). In these circumstances and given these factors there is evidence that primary teachers often adopt very didactic approaches or even avoid teaching science altogether (see e.g. Summers 1992). Thus science is often attributed a low status in primary schools and this issue is compounded by the increasing emphasis on numeracy and literacy.

Thus in Kindergarten to Year 6 (K-6) Australian classrooms in 2002, the average reported exposure of students to science was only 36 minutes per week (MCEETYA, 2003). In 2006, over the full range of primary school experience, science occupied 45 minutes per week (3% of an average teaching week of 1486 minutes) while mathematics occupied 263 minutes (18% of an average week) (Angus, Olney, & Ainley, 2007).

This research reports in-service and pre-service teacher perceptions of teaching primary science in an area of regional Australia, the New England Region of the state of New South Wales (NSW). In particular it explores the challenges facing teachers in rural areas where isolation and remoteness from major centres can lead to specific problems such as lack of professional development opportunities and limited interaction with other colleagues (Herrington & Herrington, 2001; Lyons 2008; Lyons, Cooksey, Panizzon, Parnell & Pegg, 2006; Squires, 2003).

The Australia Context and Recent Developments in Primary Science

In Australia there are six states and two territories each with their own governmental structure (all of which include a ministry or department of education) and at the time of writing each state and territory was responsible for its own education system including the development of the majority of curriculum materials and associated assessment regimes. Thus at present there are eight different primary science or primary science and technology curricula and syllabi in Australia. The current New South Wales Primary Science and Technology syllabus had been due for a major revision, however, this revision has been put on hold, as recently, the Federal (Central) Government has embarked upon a program to create a new national curriculum for certain Key Learning Areas (KLAs), of which science (including primary science) is one. In 2003, the Australian Academy of Science initiated a proposal for the development of an Australia wide program to improve learning outcomes in both literacy and science across K-6. The model proposed a professional learning program supported by a comprehensive curriculum resource, designed to meet the needs of primary school teachers and students across Australia. This first stage was funded by the Australian Academy of Science through its Australian Foundation for Science. This proposal gained wide support across all state and territory jurisdictions and in August 2004, the Australian Government Department of Education, Employment and Workplace Relations, announced support for this project under the Australian Government Quality Teacher Programme. This initiated the second stage and the development of a series of resource materials entitled Primary Connections. The Primary Connections resources cover four content strands (Earth and Beyond; Energy and Change; Life and Living; Natural and processed Materials) from K-6. Each strand consists of seven units and for each unit a teachers' guide has been produced. The units provide teachers with a set of suggested lesson plans. These are comprehensive, providing teachers with a sequence of activities mapped into a constructivist framework modeled on the 5Es teaching and learning model (Bybee et al. 1989), a list of required resources, background information on the science concepts involved in each unit and assessment strategies. Furthermore, strong links are made between science and literacy, one of the key underlying philosophies of the project, with science-based activities that help primary teachers to develop their students' literacy skills.

The 5Es teaching and learning model links learning, teaching and assessment. Edwards (2007) summarizes the five phases integral to the model.

- Engage — activities to stimulate student curiosity, and assess students' prior knowledge, interests and learning needs (diagnostic assessment).
- Explore — practical opportunities for students to explore a concept in ways that challenge pre-conceived ideas, encourage collaborative learning, and assist with the formulation of new questions. Teachers have the opportunity to explore alongside their students.
- Explain — teachers work with students to develop an appropriate science understanding of the concept being explored (formative assessment).
- Elaborate — opportunities for students to consolidate and/or extend their understanding by investigating their own questions and ideas prompted by Explore and Explain (summative assessment of the investigating outcome).
- Evaluate — activities designed to assist both teachers and students to share and evaluate the learning in the classroom.

To date 19 units have been published and a proposed total of 28 will be written, effectively providing a comprehensive framework to support a primary science curriculum (for more details on this initiative go to www.science.org.au/primaryconnections).

Research Questions and Methodology

The overall aim of this research was to determine how in-service teachers and pre-service teachers in the New England Region perceived the teaching of science in the primary classroom. This involved three research questions:

1. What features influence how teachers implement the science curriculum in primary classrooms across a rural and regional area of Australia?
2. What mechanisms do rural teachers perceive as necessary for improving the enactment of primary science programs in rural schools?
3. To what extent do teachers feel the new Primary Connections initiative might assist in improving the delivery of primary science in rural schools?

The research design developed to address these questions involved a mixed-methods approach comprising the administration of a survey with subsequent semi-structured interviews conducted with a sample of subjects who had completed the survey. Cresswell (2003), amongst others, asserts that mixed method designs are effective in capturing the best of both quantitative and qualitative approaches. The collection of both quantitative and open-ended qualitative data can often provide the best insight into a research problem. Furthermore, Tashakkori and Teddlie (2003) believe that there could be as many as six different typologies in mixed methods research, all of which sit somewhere on a continuum between pure quantitative research and pure qualitative research. They encourage researchers to select the combination that is best suited to their individual project. A mixed method approach is also thought to increase the validity of the findings as the data is triangulated (Cohen, Manion & Morrison, 2000).

Research Design, Methods and Participants

The research was conducted in two phases. The first phase involved the administration of the survey that was largely quantitative. The survey for this study (see Appendix A) was informed by the Science Curriculum Implementation Questionnaire (SCIQ) (Lewthwaite, 2001a, 2001b) developed to assist schools in improving the quality of science program delivery.

The second phase involved a series of semi-structured interviews undertaken with a number of the participants who had completed the survey. The protocol for the semi-structured interviews was informed by the analysed responses to the surveys. The participants included in-service and third year pre-service teachers on practicum from six government primary schools in the New England region of New South Wales (NSW). This is a rural and agricultural region of Australia where many schools are quite small and isolated and as a result there are a large number of multiclass/ composite classroom schools. At present all government primary schools in NSW follow the NSW Board of Studies Primary Science and Technology syllabus (Board of Studies NSW, 1993). This is an outcomes based syllabus comprising six content strands: Physical Phenomena, Products and Services, Information and Communication, Earth and its Surroundings, Built Environments and Living Things. A series of assessment indicators is provided to assist teachers in determining if students have met the outcome statements associated with each content strand. Teachers are also free to write their own indicators for any of the outcome statements (Board of Studies NSW, 2006). The NSW Science and Technology syllabus covers years K-6 and comprises four different stage levels.

The pre-service teachers who took part in the study where in their third year of a four year Bachelor of Education (B.Ed.) primary degree at a regional university in New South Wales, and undertaking the third year teaching practicum. In the second year of their degree programme, all of these pre-service teachers had successfully completed a one-semester unit on Primary Science and Technology Education based upon the NSW Primary Science and Technology syllabus.

Participants in Phase 1

Two hundred surveys were distributed across the six primary schools with 41 in-service teacher participants responding (a return rate of 20.5%). These teachers held positions from K-6 and the responding participants included 36 female and 5 male teachers. The employment status of the in-service teachers comprised 32 full-time, 3 part-time and 6 casual. These teachers ranged in experience from new graduates to some with over 35 years of service. Table 1 provides a summary of the experience of the in-service cohort that took part in the survey.

Table 1
Experience of In-service Teachers Involved in the Survey

Years of teaching	0-5	6-10	11-15	16-20	20+
Number of teachers	6	5	1	5	24

One hundred third-year pre-service teachers were also sent the survey and of the 48 who responded 37 were female and 11 were male. Participation in the survey was voluntary.

Phase 1- The Survey

The first phase involved the administration of a survey that was largely of quantitative nature comprising 19 items with a 1 to 5 Likert scale ("1 Strongly Disagree", "2 Disagree", "3 Uncertain", "4 Agree", "5 Strongly Agree"). However, the survey also included a number of free response items that allowed participants to elaborate on some of their responses. Two slightly different versions of the survey were developed; one for in-service teachers and one for pre-service teachers (see Appendix A). While most items in the two versions of the survey were the same, the wording for items 13, 15, 16 and 17 were varied to take account of the difference in experience between the two groups. The survey instrument was developed by the first author but drew on items by adapting questions from SETAKIST, a survey developed by Roberts and Henson (2000), and from previous research in this area including work by Goodrum, Hackling and Rennie (2001).

In order to ensure face validity (Nardi, 2006), both versions of the instrument were piloted prior to administration. Five participants from each group of in-service and pre-service teachers were involved in this process. Based upon this pilot in consultation with the participants some items were modified to improve their clarity in order to elicit information to address the intent of each survey item.

The survey data were transferred to an Excel spreadsheet. The responses to each Likert scale item were then collated with the mean and standard deviation of each calculated. The data were tabulated and are presented in Table 2.

Phase 2 – The Interviews

Semi structured interviews were conducted with six in-service and five pre-service teachers (approximately 13% of participants from in-service and pre-service teacher survey respondents). The interview participants were part of a convenience sample based largely on their availability and willingness to be interviewed. The interview protocol commenced with an individual pre-interview discussion which outlined the aims of the project allowing the interviewees time to reflect and prepare. The interviews were conducted within the schools at which the participants where teaching and all interviewees were provided adequate time to answer the questions. A set of initial seed points derived from the survey analysis covering the areas of: confidence, strategies and types of resources and support needed were presented and formed the basis of the open-ended interview questions which were mediated by the researcher. A spiral approach was adopted where the researcher would encourage the interviewee to further elaborate upon earlier questions as the interview progressed. Interviews ran an average 26 minutes and ranged from 18 minutes to 37 minutes. All interviews were recorded and transcribed. Each transcript was analysed to identify teachers' views and comments and a series of categories were then identified (Ridge, 1995). The researcher chose a phenomenological philosophical approach to the study of phenomena and human experiences contained within the data. Several practitioners (Giorgi, et al 1971; Colaizzi, 1978; van Manen, 1984) have developed analytic strategies that allow phenomenology to be applied at a practical level in research. For this analysis, Colaizzi's (1978) seven steps of phenomenological analysis were adopted to reduce the data. An outline of these seven steps follows:

1. The researchers reviewed the collected data to become familiar with it and to gain a feeling for the subject's inherent meanings.
2. The researcher returned to the data and focused on those aspects that were seen as most important to the phenomena being studied. From the data significant statements were extracted.
3. The researcher took each significant statement and formulated meaning in the context of the subject's own terms.
4. The meanings from a number of interviews were grouped and organised into a cluster of themes. This step revealed common patterns and trends in the data.

5. A detailed, analytic description was compiled of the subject's feelings and ideas on each theme forming a set of exhaustive descriptions.
6. The researcher attempted to identify the fundamental structure for each exhaustive description.
7. A member check was performed where the data analysis was taken back to the subjects to check to see if the researcher had omitted or misrepresented any aspects.

Findings and Discussion

In this section the data from the survey and interviews are presented and discussed. Examples from the qualitative data drawn from interview responses are used throughout to provide greater insight into the findings from the quantitative survey data.

As mentioned previously, items 1 to 19 of the survey involved a Likert scale ("1 Strongly Disagree", "2 Disagree", "3 Uncertain", "4 Agree", "5 Strongly Agree"). Table 2 presents the means and standard deviations for each of the items for both groups: in-service and pre-service teachers. Where items differ for each participant group, an "a" has been assigned for items used with in-service teacher participants and a "b" for those used with pre-service teacher participants.

Table 2

The Means and Standard Deviations of the Responses to Items 1-19 Provided by the In-service Teachers (N=41) and Pre-service Teachers (N=48)

Items (bracketed words were only in the pre-service version of the survey).		In-service M	In-service SD	Pre-service M	Pre-service SD
1.	I feel comfortable with my own understanding of most scientific concepts in primary science.	4.00	0.96	2.96	0.94
2.	I (would) feel comfortable teaching most scientific concepts in primary science.	3.95	0.96	3.28	0.89
3.	Most of my experiences in teaching science have been positive.	3.88	0.94	3.52	0.96
4.	Science lessons should be mostly investigative and hands on.	4.43	0.68	4.52	0.66
5.	Science lessons should be student centred.	4.20	0.79	4.46	0.55
6.	I (would) integrate science with other KLA's.	3.85	0.92	4.07	0.68
7.	I (would) teach scientific concepts within a sequential unit to build students' knowledge.	3.98	0.86	4.30	0.63
8.	I teach science as a one off lesson to go with the theme of another subject.	2.38	1.13	3.72	0.86
9.	I feel I have access to effective teaching strategies for science lessons.	3.40	1.00	3.15	0.79
10.	I feel I have access to effective classroom management strategies for science lessons.	4.25	0.67	3.57	0.65
11.	I feel classroom management is harder during science lessons.	3.08	1.29	3.22	0.84
12.	I think science is an important KLA.	4.50	0.51	4.13	0.78
13a.	I feel that I am supported in teaching science at school.	3.50	1.01		

Items (bracketed words were only in the pre-service version of the survey).		In-service M	In-service SD	Pre-service M	Pre-service SD
13b.	On practicum experiences I have felt supported and encouraged to teach science lessons.			2.98	1.11
14.	I find the K-6 Science and Technology Syllabus and Documents to be helpful when planning for and implementing science.	3.15	0.89	3.46	1.07
15a.	I have access to the equipment and resources I need to teach science effectively.	2.93	0.97		
15b.	Schools I have been to are generally well resourced with equipment to teach science.			2.91	0.94
16a.	My school takes a whole school approach to the teaching of science.	3.20	1.07		
16b.	Schools I have been to on practicum generally take a whole school approach to the teaching of science.			2.59	0.83
17a.	I am happy with the way I teach science in the primary classroom.	3.45	0.88		
17b.	Schools I have been to on practicum generally teach science for at least 1 hour per week.			3.00	1.12
18.	I feel I would benefit from more professional training in teaching science.	3.93	0.94	4.13	0.62
19.	I (would) plan and implement for an equal amount of teaching time for each strand in the K-6 Science and Technology Syllabus.	2.75	0.93	3.54	0.75

It was interesting to note that for many of the items in the survey there was little difference between the responses of the pre-service and in-service teachers. Item 12 indicated that most in-service and pre-service teachers believe that science is an important KLA with an average rating of 4.5 and 4.13 for in-service and pre-service teachers respectively. Both participant groups also indicated that their past experiences concerning science have been fairly positive. These findings were encouraging and formed an important basis to build upon if science is to be taught effectively in primary classrooms. Furthermore, both groups appeared to hold similar views on integrating science (item 6) with other KLAs and were in favour of this approach. Such an approach can maximise the time available to teach science if integration is implemented successfully and efficiently.

The perspective that science lessons should be investigative, hands on and student centred was also supported by both groups of teachers (items 4 & 7). In addition a common view was that the majority of lessons should be from within a sequential unit in order to build upon student knowledge.

The data indicate that there was a difference in perception of how confident in-service and pre-service teachers were with their conceptual knowledge and understanding of primary science (item 1), with in-service teachers showing higher levels of confidence in this area. While this may reflect their greater experience, the relatively high level of confidence exhibited by the in-service teachers' response to this item, with an average rating of 4, runs counter to other research reported in the literature (see e.g. Appleton, 2002, ASTEC, 1997; Yates & Goodrum, 1990).

In this study, the qualitative data for in-service teachers indicated that confidence may be restricted to teaching certain sections or strands of the current science curriculum, those they had previously taught or had a personal interest in.

> *When I know the topic myself I'm much more confident in it, if you've got an interest in it, it helps as well. You are more likely to be able to come up with an answer more immediately rather than not know. Also if you have an interest in it (particular science concept/topic) it is easier to get the kids interested in it.*

One encouraging finding for pre-service teachers was that despite seeming to lack confidence in their science content knowledge (item 1), they were more confident in their ability to teach primary science (item 2). Although this may seem contradictory some of the interview findings helped to explain this. For example:

I think the teaching side of it, I guess I'm usually pretty confident, if you are not confident in the content knowledge you can always just go and look it up, do some research. Find it out before the lesson or involve the kids in the learning experience.

I think that if you are confident in your teaching, well those (concepts) that you don't know about, you can just look up and learn about them.

Yeah, as a teacher, you can't know everything, no-one does. You are always going to have to teach topics that you don't know much about so you just need to know where to go to for information, resources and help. As long as you know about it before you actually teach it I think it is a fairly normal thing. That's the importance of lifelong learning.

These comments were encouraging because during their training in science, pre-service primary teachers undertake a component of self-regulated learning in which they have to thoroughly research the science behind a topic for which they have to prepare a lesson sequence and present their conceptual understanding of this (see Taylor & Corrigan, 2005; Corrigan & Taylor, 2004). The data above suggest, at least tentatively, that this approach of using self-regulated learning, provides the pre-service teachers with a sense of self-reliance in relation to developing their own conceptual knowledge in science.

However, survey responses for pre-service teachers indicated that most participants were unsure if they were encouraged or supported to teach science whilst on practicum experiences (Item 13b). In some cases this was a direct result of limited opportunities to actually teach science lessons whilst on practicum. As one pre service teacher commented:

We didn't do any science so there was nothing to go on. I haven't felt supported on practicum experiences as it just wasn't taught. I was never given the option on any of my pracs (practicum experiences) to plan or teach science. I can't say the teachers didn't teach any science but none was taught while I was there.

This was a common response throughout interviews and suggested that many pre-service teachers were receiving very limited experience in the teaching of science lessons whilst on practicum. Furthermore, this finding was supported by the response of pre-service teachers to item 17 which indicated uncertainty as to how much science was taught each week in practicum schools.

The survey findings indicated that many pre- and in-service teachers did not plan for nor implement each of the content strands within the Science and Technology K-6 Syllabus equally. Thus all strands within the syllabus may not be covered adequately. This may well be a reflection of how confident pre- and in-service teachers felt about their knowledge of some of the content stands.

Table 3 presents data from the survey showing content strands in which both participant groups felt least confident in teaching.

Table 3
Content Strands in Which In-service and Pre-service Teachers Indicated Feeling Least Confident in Teaching

Content Strands	Percentage of participants who indicated that they were least confident in each strand	
	In-service teachers (n=41)	Pre-service teachers (n=48)
Physical Phenomena	37.8	51.3
Products and Services	27.0	11.7
Information and Communication	21.6	23.3
Earth and its Surroundings	13.5	16.3
Built Environments	10.8	4.7
Living Things	0	7.0
None	10.8	2.3
Most content strands – All content strands	5.4	2.3

The teachers were least confident teaching the physical sciences and most confident teaching the biological sciences. Two pre-service teachers commented:

I'm uncomfortable because of lack of knowledge and experience in this area, haven't really done much study in this area. I feel like I need more knowledge and experience.

When we doing our unit (core unit in B.Ed. degree), I was uncomfortable with the theory behind some of the concepts, for example electricity…basically the understanding behind the concepts are not particularly that clear to me.

Thus despite some pre-service teachers stating that they were confident in their ability to research content knowledge, some still appeared to lack confidence specifically in the area of physical science.

In the survey, KLA's were ranked by in-service teachers in the following order: (1) English; (2) Mathematics; (3) Creative Arts; (4) History, Social Science and the Environment; (5) Science and Technology, and; (6) Personal Development, Health and Physical Education. Thus overall, in-service teachers ranked science as their fifth preferred KLA of the six in the NSW primary curriculum.

Both participant groups were asked in the free response section of the survey instrument about any perceived "obstacles" to good science teaching that they encountered. The responses from the groups to this item are summarised in Tables 4 and 5.

Table 4
Perceptions of In-service Teachers about Obstacles When Implementing Science Lessons (n=41)

Perceived obstacles to effective science teaching	Percentage response
1. Lack of resources and equipment	91.8
2. Insufficient pedagogical content knowledge regarding science	27.0
3. Limited amount of time	18.9
4. Lack of appropriate space/area to conduct experiments and investigations	8.1
5. Lack of interest from students and fellow staff	5.4
6. Inadequate Syllabus	2.7

Table 5
Perceptions of Pre-service Teachers about Obstacles When Implementing Science Lessons (n=48)

Perceived obstacles to effective science teaching	Percentage response
1. Lack of access to resources and equipment to teach science	53.6
2. Teaching and classroom management strategies	30.3
3. Insufficient content and pedagogical knowledge regarding science	28.0
4. Behaviour management strategies	25.6
5. Adequate time allocated to the teaching of science	23.3
6. Conducting engaging and age appropriate science lessons	16.3
7. Lack of school support network	2.3
8. Lack of personal interest in subject	2.3

Lack of resources and equipment was identified by 92% of in-service teachers and by 54% of the pre-service teachers as a significant obstacle to the teaching of science in primary classrooms. The interviews revealed these "resources" to be lesson and sequential unit plans, background information on scientific concepts, equipment needed to undertake experiments and investigations, and sufficient work-spaces to carry out activities when needed. However some of the teachers interviewed indicated that even when there was suitable equipment available in their schools, they were unsure how to use it effectively.

The majority of the teachers interviewed believed that the current syllabus documents needed to be improved. For example, one in-service teacher commented:

> *Well I think that the syllabus and its support documents should include a list of core equipment that every school should have, and then base their sample units around that. They should also include background information and how to explain these concepts to kids (students) in age appropriate terms.*

All participants interviewed were shown examples of the new Primary Connections materials being developed by the Academy of Science in Australia previously described in the introduction. These were greeted with considerable enthusiasm by all of the participants, both in-service and pre-service, who felt that they would benefit substantially from the new resources. For example one in–service teacher commented:

I think this [resource] would be really helpful…you can never have too many ideas and resources. When it's a book like this, you can just pick it up and everything you need is there. I think this is great. I do have problems trying to come up with science units especially when I'm not that confident in the strand, but this just sets it all in detail and its sequential, very helpful.

Another in-service teacher responded to the new resources as follows:

It's terrific. This is how we should get lessons with the new curriculum. It's much more practical to have a sequential unit with how to integrate it. They are all ready for teaching so you don't always have to reinvent the wheel.

Conclusions

In relation to the three research questions, the findings indicated that in general, the primary science was being rather inadequately implemented in classroom in this particular area of rural and regional Australia. Teachers appeared to believe that science was important and should be investigative and 'hands on', however there was evidence that a lack of confidence in certain aspects of science, specifically in physical science, was a significant impediment to effective teaching, and that some science strands were being neglected. A number of teachers also cited limited resources, particularly 'ready to use' teaching materials together with a syllabus that provided very limited guidance as further impediments to implementing the primary science curriculum appropriately. Consequently, they believed that primary science could be improved significantly through the development of comprehensive teaching resources, and those interviewed felt that the new Primary Connections materials would address this issue effectively, by providing structured and comprehensive lesson plans and lesson sequences that were easy to deliver and adapt.

Many of the "generic" problems that afflict primary science referred to in the introduction are clearly still prevalent in regional NSW, Australia. Perhaps of most concern is the apparent limited exposure many of the pre-service teachers have to teach science during their practicum. This may be a reflection of the low status (5^{th} rank out of the six KLAs) science seems to have amongst in-service primary teachers. Unfortunately, this may be causing a "cycle" in which the reduced opportunities of many pre-service primary teachers to experience effective science teaching could have resulted in their reluctance to teach science after they qualify, as Summers (1992) found in his research.

The response of all primary teachers in the study to the new Primary Connections initiative and resources was very encouraging and suggests that it may have considerable potential for mitigating some of the issues such as poor resourcing, lack of confidence and conceptual knowledge referred to in both the literature review (e.g. Appleton, 2002; Corrigan & Taylor, 2004) and by the teachers in this study. Certainly if as the penultimate quote suggests, "…you can just pick it up and everything you need is there…", it may be a potentially effective initiative.

However, there has been some anecdotal criticism that for this very reason Primary Connections is too prescriptive. Although some educators might initially view these "ready to teach" units as rather prescriptive and restrictive, we believe that the initiative is a good one. Confident, competent teachers of primary science can adapt the materials and add their own ideas. However, we believe the key issue is that resources will provide less confident teachers with ready to teach materials that are based upon sound theoretical principles. Each unit of work links science and literacy, activities are inquiry oriented and includes student planned investigations, continuous formative assessment is used to support learning, the 5Es teaching and learning model provides the backbone to the delivery sequencing, a focus on cooperative learning strategies permeates throughout the activities and teachers are provided with support and background information. This should ensure that much more primary science is taught and the teaching is more effective – something that must be viewed as an improvement on the present situation where as evidenced by this study, there is still only limited science being taught in many primary schools, with some pre-service teachers reporting that they had no opportunity to teach or even observe science lessons. Our beliefs are supported by research. For example, Edwards (2007) found that:

> *The framework helped students organise their previously unpractised pedagogical understandings in ways that ensured they incorporated an appropriate range of teacher-initiated and student-led learning within an inquiry based, constructivist regime. Many primary school teachers commented that the ability to learn science content alongside the children and tap into their interests and ideas was a highly*

enriching experience; one which challenged their previous ideas of what constitutes an effective classroom learning environment (p53).

Finally, as with most new initiatives in education, effective implementation often depends upon effective professional development. Certainly, as Coll and Taylor (2008) pointed out after reviewing a range of international science curriculum initiatives, curriculum reform is generally costly, but the money invested in developing curricula frameworks and new resources, is often wasted because inadequate professional development means that teachers fail to implement the changes effectively. Because of the geography of Australia, and the large distances teachers have to travel, face-to-face in-service training for new initiatives can be extremely expensive. To address these problems, the Primary Connections resources come supported by a comprehensive training package of training materials including a Digital Video Disc (DVD) showing teachers using the resources in primary classrooms, and a regional based facilitator network is also being coordinated by the Australian Academy of Sciences. This should ensure that all teachers receiving the Primary Connections materials have sufficient training and support to implement the program effectively.

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Appendix A

(In-service Teacher Survey)

Science in the Primary Classroom

There are no right or wrong answers to these survey questions. I am simply looking for your personal views and perspectives on the topic of teaching science in the primary classroom. Gender of participants and approximate years of teaching will be indicated by survey findings; however no details that would allow participants to be personally identified will be used in the publishing of these findings. All confidentiality will be respected.

Please indicate you have read the above information and are willing to participate in this survey by placing a cross in this box ☐

Please circle the answers you wish to select.

Please indicate whether you are: **male** or **female**

How many years have you been teaching? ______________

Please circle basis on which you are employed:

Full Time **Part Time** **Casual**

Questions	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1. I feel comfortable with my own understanding of most scientific concepts in primary science.	1	2	3	4	5
2. I feel comfortable teaching most scientific concepts in primary science	1	2	3	4	5
3. Most of my experiences in teaching science have been positive.	1	2	3	4	5
4. Science lessons should be mostly investigative and hands on.	1	2	3	4	5
5. Science lessons should be student centred.	1	2	3	4	5

Questions	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
6. I integrate science with other KLA's	1	2	3	4	5
7. I teach scientific concepts within a sequential unit to build students knowledge	1	2	3	4	5
8. I teach science as a one off lesson to go with the theme of another subject.	1	2	3	4	5
9. I feel I have access to effective teaching strategies for science lessons.	1	2	3	4	5
10. I feel I have effective classroom management strategies for science lessons	1	2	3	4	5
11. I feel classroom management is harder during science lessons.	1	2	3	4	5
12. I think that science is an important KLA	1	2	3	4	5
13. I feel that I am supported in teaching science at school.	1	2	3	4	5
14. I find the K-6 Science and Technology Syllabus and Documents to be helpful when planning for and implementing science.	1	2	3	4	5
15. I have access to the equipment and resources I need to teach science effectively.	1	2	3	4	5
16. My school takes a whole school approach to the teaching of science.	1	2	3	4	5
17. I am happy with the way I teach science in the primary classroom.	1	2	3	4	5

Questions	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
18. I feel I would benefit from more professional training in teaching science.	1	2	3	4	5
19. I plan and implement for an equal amount of teaching time for each strand in the K-6 Science and Technology Syllabus.	1	2	3	4	5

Strands of the K-6 NSW Science Curriculum

- Built Environments
- Living Things
- Products and Services
- Information and Communication
- Physical Phenomena
- Earth and its Surroundings

Of the Strands mentioned above, which do you feel **least** confident in teaching? Why?

Which Strands do you feel **most** confident in teaching? Why?

What are some of the obstacles you encounter when implementing science lessons?

On average how much time per week is allocated to the teaching of science in your classroom? What is the reason for this?

What would help make the teaching of teaching science more effective for you?

____

____

Please number the following KLA's in order of preference of teaching.

1 most preferred through to **6 least preferred**

Science and Technology		**PDHPE**	
English		**HSIE**	
Mathematics		**Creative Arts**	

Please indicate whether or not you are prepared to be interviewed concerning these questions at a later stage in this research by circling either:

yes or **no**

If you answered yes please provide your name and contact details in the spaces allocated below:

Name: ________________________________

Email: ________________________________

Phone no: _____________________________

In no way will the personal information you may have provided above be used to personally identify you in the publication of these research findings.