PRIMARY SCIENCE PROJECT: DESIGN, IMPLEMENTATION AND DELIVERY

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ABSTRACT

A study assessing the status and quality of science teaching in schools commissioned by the Department of Education highlighted the lack of confidence by primary science teachers. To address these issues the Primary Science Project (PSP) is designed and implemented in schools in Western Australia. PSP is designed to develop student positive attitude and thus improved achievement through supporting teachers via a professional development scheme. A Science Support Teacher (SST) from each school receives extensive professional development to enable them to work shoulder-to-shoulder with their colleagues and to support teachers in their school to improve the science learning outcomes of their students. The achievements and failures of this project between 2007 and 2009 will be discussed in this paper.

BACKGROUND TO THE PROJECT

Numbers of national studies assessing the quality of science education in past two decades have highlighted scope for improvement. Status and quality of science teaching in schools commissioned by the DET in Australia highlighted the lack of confidence among primary science teachers that leads to gaps between actual and preferred science teaching (Goodrum, Hackling, & Rennie, 2001). Science is one of the areas of the curriculum where primary schools perceive the greatest decrease in time allocation (Hill, Hurworth, & Rowe, 1998). Much has been achieved in primary science and technology education over the past ten years but much more needs to be done (Stroker, 1997). Further a number of gaps were identified between ideal and actual primary science teaching (Goodrum, Hackling, & Rennie, 2000). Hackling (2006) claimed that primary teachers lack confidence in teaching science.

The national review of school science education conducted by Goodrum, Hackling and Rennie (2001), indicated that the teaching of science in Australian primary schools was very patchy. Research indicates that science is allocated less than 3% of curriculum time in Australian primary schools (Angus, Olney & Ainley, 2007) and Australian primary science achievement levels are significantly lower than Singapore, Taiwan, Hong Kong, Japan, Russia, Latvia, England and the USA (Thomson, Wernert, Underwood & Nicholas, 2008). Further concerns are raised by the national assessments of Year 6 students' science literacy (MCEETYA, 2005; 2008) conducted in 2003 and 2006 which indicate that more than 40% of students in the sample failed to achieve the proficient standard.

It is essential that young people's interest in science is captured and maintained through schooling so that they become scientifically literate and more students continue with their studies of science at university level in order to address the strong need for science related skills. The purpose of science in primary schools is to provide opportunities for students to know science as a body of knowledge, as a way to know the world and as a human endeavour, and to develop students' scientific literacy (MCEETYA, 2006). Purpose of primary science should be engaging young minds rather than developing future scientists (Tytler, 2007). Building a culture of interest in science will enable Australians to cope with a future that will be very much dependent on science and technology.

Australian economy is largely dependent on natural resources and it is timely to focus on boosting science learning as a way of building human capital- the key resource for knowledge base economy. Opening young minds to the wonders of the natural world, stimulating curiosity and creative thinking, and starting that journey towards scientific literacy require a strong and effective primary science program. Many primary teachers lack confidence and competence to teach science (Appleton, 1995; Palmer, 2001; Yates & Goodrum, 1990) thus r esulting in low teacher self efficacy to teach science effectively (Riggs & Enochs, 1990).

High quality teaching of science in Australian primary schools is a national priority in order to develop citizens who are scientifically literate and who can contribute to the social and economic well-being of Australia as well as achieve their own potential. A community with an understanding of the nature of science and scientific inquiry will be better equipped to participate in an increasingly scientific and technological world (Peers, 2006).Tytler, Osborne, Williams, Tytler and Cripps Clark's literature review (2008) found:...considerable evidence that, for the majority of students, their life aspirations are formed before the age of 14, with the implication that engaging students in science related pathways becomes increasingly difficult after the early secondary school years. Interventions and resources aimed at encouraging student engagement in Science thus need to be prioritized to engage and capture the imagination of students in the upper primary years (p. viii).

Primary Science Project

To address the issue of lack of confidence in teaching science by primary school teachers, the PSP was designed and implemented in schools in Western Australia. PSP is designed to develop student scientific literacy (especially positive attitudes and improved achievement) through supporting teachers via a professional development scheme.

In 2005, the PSP was introduced in 22 state schools in Western Australia (WA) and consequently expanded. In 2009, there were 50 SSTs which represent every district in WA and provide more personal help to teachers at their schools. One Science Support Teacher (SST) from each school receives extensive professional development to enable him/her to work shoulder-to-shoulder with teachers in the same school in improving the scientific literacy of students. Each support teacher is provided with eight days of professional learning per year by the science team in the DETWA Central Office. These SST's, work with other teachers in the school and region, to improve scientific literacy. Each term professional learning workshops for science learning are organised. A representative from PSP team visits each school at least once a year, to discuss with SST what he/she has done, is planning and whether there are any related issues. Further to visits PSP supports through ongoing email contact with SST's suggests activities, acts as an information clearing house and responds to the queries. Second, at school level SST's have three tasks (i) to work with teachers in their own school (Target Teachers) to improve their science teaching; (ii) Build interest in science throughout the school; (iii) provide Professional Development to teachers in other schools (outreach). Third, SST's further work with teachers in their own school. Typically the SST works with 1-3 teachers for a few terms, initially modelling how science is taught and then providing feedback, guidance and support. SST typically mirrors the role played by the PSP Central Office.Table 1. describes the form and levels of functioning of this project.

The outstanding features of the project are; the central coordination is supportive but not prescriptive; the informal SST network; continual feedback; and outreach programme. The interactions between SSTs and PSP Centre are open and honest. The trusts in these relationships have developed over a period of time. PSP gives autonomy and authority to teachers to design and implementation of science related activities in class/school. Many of the SSTs have developed close professional relationships during the course of PSP and thus share insights and ideas with one another. The on-going interaction between teachers and the SST and SSTs and PSP Central Office guarantees continual feedback and improvement throughout the school years.

Table 1. Overview of PSP

PSP Central Office Coordinator	• Provides professional learning workshops for SSTs each term • Visits each school at least annually to discuss with the SST what he/she has done, is planning, whether there are any issues, etc. • Through on-going email contact with the SSTs suggests activities, acts as an information clearing house and responds to queries.
School based SST's	SSTs have three tasks: • (i) to work with teachers in their own school (Target Teachers) to improve their science teaching ; • (ii) Build interest in science throughout the school; • (iii) provide Professional Development to teachers in other schools (outreach)
Target Teachers	• These are teachers in SST's own school. • Typically the SST works with 1-3 teachers for a few terms, initially modelling how science is taught and then providing feedback • SST guidance and support mirrors the role played by the PSP Central Office

Evaluation

Author worked as an external evaluator in the year 2008 and 2009 for this project. DETWA had collected a substantial amount of evaluation data regarding:

- Student Outcomes
- Science Support Teachers Skill and Confidence
- Professional Learning and Central Support
- Leadership

In a preliminary evaluation, students from schools participating in PSP reported positive attitudes towards science as compared to non-PSP schools (*Evaluation of Primary Science Project*, 2009).

Learning Environment Research: The study also draws upon and contributes to the field of learning environments (Aldridge & Fraser, 2008; Fraser, 2007; Koul & Fisher, 2005). Contemporary research on school environments partly owes inspiration to Lewin's (Lewin, 1936) seminal work in non-educational settings, which recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour. Since then, the notion of person-environment fit has been elucidated in education by Stern (Stern, 1970). Over the last four decades, learning environment research has become a firmly established form of research on teaching and learning (Fraser, 1998; Koul & Fisher, 2006). Various educational programmes have been evaluated by the author using learning environment instruments (Earnest & Koul, 2005; Koul & Fisher, 2005; Rennie, Sheffield, Koul, & Evans, 2006). In this study, the type of learning environments created in all the 50+ schools involved with PSP is evaluated.

Aim and Objectives:

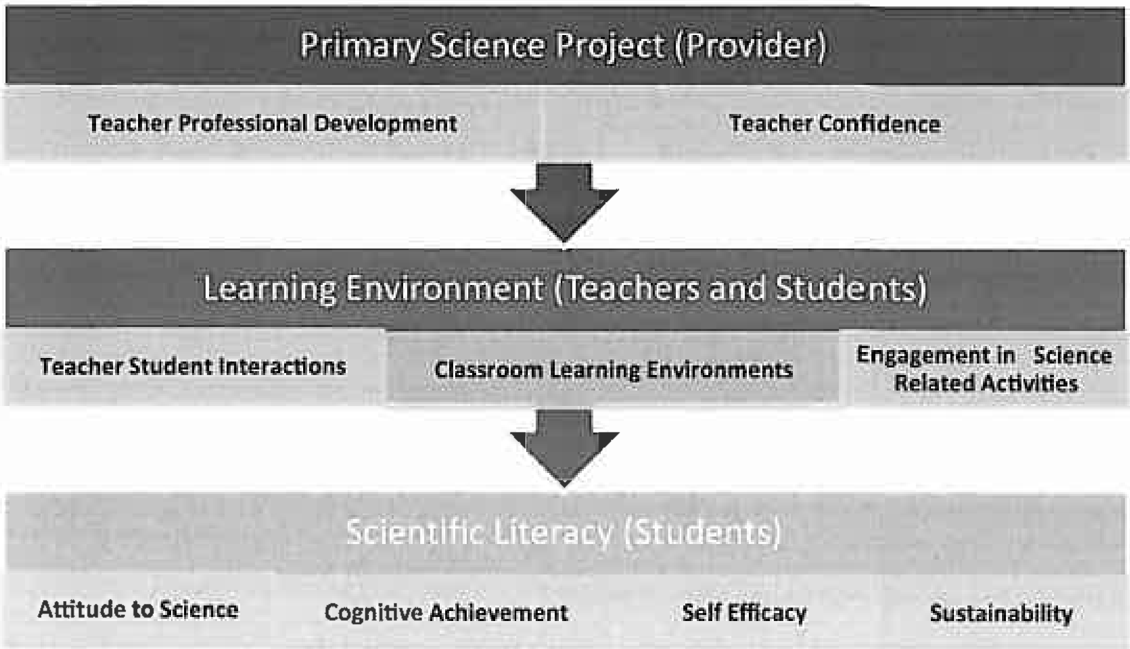
The overall aim of the study was to evaluate the effectiveness and sustainable functioning of the 'Primary Science Project' (PSP), a professional learning programme that provides teachers with the skills to teach primary science that is delivered by Department of Education Western Australia (DETWA). The objectives of this study are:

1. To investigate the confidence, conceptual understanding and teaching skills of teachers involved in PSP.
2. To evaluate the effectiveness of PSP in terms of:
    a) the learning environments created by participating teachers in their primary school science classes;
    b) the scientific literacy (both attitudes and achievement in science) developed by the primary school students taught by participating teachers; and
    c) the sustainability over numerous years of improvements in classroom learning environments and students' scientific literacy.
3. To evaluate the effectiveness of trained Science Support Teachers (SSTs) with regard to modelling what they have learnt and providing resources and support to the other teachers at their school.
4. To investigate associations between the learning environment and the scientific literacy

Approach and Training

The conceptual framework for this project is shown in the following model (Figure 2), which brings together the three constructs (namely, Primary School Project, Learning Environment, and Scientific Literacy). In order to achieve the research objectives, a evaluation model was drawn. In the light of past research evidence about problems in sustaining the positive effects of teacher professional development (Dori & Herscovitz, 2005) and PSP's commitment to make West Australian students scientifically literate, it was imperative that the study extends over numerous years and is extended to more schools.

Figure 2. Evaluation Model



***Combining Qualitative and Quantitative Methods*:** This study involved the use of both qualitative and quantitative methods, which have been used successfully in various learning environment studies (Koul & Fisher, 2006; Tobin & Fraser, 1998). A mixed-methods approach in studying the classroom learning environment at different 'grain sizes' was used to show how not only individual students and teachers could be investigated at the smallest grain size, but also at the class, school and system level to clarify whether particular teachers or students were typical of larger groups (Fraser, 2000). In keeping with these developments, multiple research methods (e.g., surveys, observations) and various grain sizes (student, gender group, year group, and class) was used in this study. However, in this paper only quantitative results are discussed.

Sample: The sample for this study included 20 public schools representing all districts in Western Australia. Data was collected in PSP participating schools in 2008 and 2009 from students in Years two to seven. Nearly 2,000 students provided quantitative data on a survey form developed by DETWA. Responses were recorded on a four point likert scale ranging from Never (1) to Nearly every lesson (4). The survey questionnaire consisted of 14 quantitative and two qualitative questions. Quantative questions were distributed in three sections namely, 'In my science lessons', 'My Teacher' and 'The science we do at school'. Some case studies were also included in this study.

QUANTITATIVE RESULTS

Student Perceptions

In the statistical analyses to establish students perception of their science classrooms mean and standard deviations for the quantitative data were the starting point. The very high mean scores reported in Table 2.suggest a very positive classroom environment, with the mean scores ranging between 1.82 and 3.34. Generally, the students perceive a very positive science classroom learning environment. Highest mean (3.34) on a four point likert scale for the question relating to enjoyment of science signifies that students enjoy science lessons. They also generally perceive that science is easy to understand, makes them think and teacher explanations helps them understand. These responses overall show that the PSP trained teachers create a desired learning environment in the classroom. Student responses show very little use of computers in teaching of science. This is a valuable reflection from student data. Some Computer incorporated activities can be designed in future in science teaching and learning.

Table 2. Mean and Standard Deviation for the question of survey.

Strand	Question	Mean	St. Dev
In my science lessons...	1. I watch the teacher do experiments.	2.54	0.96
	2. I work in groups to do experiments.	2.92	0.84
	3. I do my own experiments.	2.00	0.81
My Teacher...	4. Explains to help me understand	3.30	0.85
	5. Talks to me to find out what I understand about science.	2.61	0.89
	6. Tells me how I can improve in science	2.54	0.95
	7. Uses the computer to help us understand science.	1.82	0.95
	8. Asks us to investigate and find out things	2.95	0.91
	9. Asks us about our interests in science	2.18	0.92
	10. Shows us how the science we do at school can relate to our daily lives	2.52	0.97
The science we do at school...	11. Is easy to understand	3.02	0.82
	12. Is enjoyable	3.34	0.88
	13. Makes me think	3.16	0.87
	14. Involves us in community projects and activities outside of the classroom.	2.43	0.97

Level Differences: The associations between the students' perceptions of the questions on survey and the year level of the students were analysed. The year level differences in students' perceptions of classroom learning environment were examined by splitting the total number into corresponding year levels of all the 1,903 students involved in the study. A total of 1936 students participated in the study but 33 students did not mention their year level on the survey form.

To examine the year level differences in students' perceptions of science classes, the within-sample year subgroup mean was chosen as the unit of analysis which aims to eliminate the effect of sample differences due number of students being unevenly distributed in the sample. In the data analysis, each of the 6 year levels, mean scores for each year were computed, and the significance of year differences in students' perceptions of science classes were analysed using an independent F-test. Table 3 shows the scale item means, standard deviations, and F-values. The purpose of this analysis was to establish whether there are significant differences in perceptions of students according to their year level.

As can be seen in the Table 3, students' perceptions on all the 14 questions were found to be statistically significantly different. According to the results, year 2 (youngest in cohort) students most watched their teacher doing science experiments. While as the year 7 students (oldest in cohort) did most experiments in groups. Younger the student more they enjoyed science and thought that science makes them think.

Table 3. Item Mean and Standard Deviation for Year Level Difference in Students' Perceptions of the survey Questions.

Q No	Yr 2 N 10		Yr3 N 125		Yr4 N 498		Yr5 N 512		Yr6 N 375		Yr7 N 383		F
	Mean	St.Dev	Mean	St.Dev	Mean	St.Dev	Mean	St.Dev	Mean	St.Dev	Mean	St.Dev	
Q1	2.90	1.28	2.4	1.09	2.57	0.97	2.59	0.92	2.58	0.96	2.42	0.92	2.62*
Q2	1.90	1.28	2.51	0.98	2.74	0.78	2.95	0.86	3.05	0.78	3.17	0.75	23.9*
Q3	1.90	0.87	1.96	1.13	2.12	0.91	1.98	0.75	1.96	0.72	1.94	0.67	3.06*
Q4	3.30	1.16	2.92	1.13	3.34	0.86	3.42	0.77	3.25	0.78	3.26	0.82	7.71*
Q5	2.00	1.15	2.52	1.06	2.66	0.89	2.68	0.88	2.58	0.86	2.52	0.84	2.96*
Q6	2.20	1.22	2.54	1.17	2.55	0.91	2.52	0.93	2.52	0.95	2.60	0.92	0.61
Q7	2.00	1.41	1.48	0.93	1.91	0.97	1.87	0.92	1.74	0.90	1.82	0.97	5.04*
Q8	2.30	1.25	2.40	1.07	2.86	0.91	3.00	0.89	3.05	0.88	3.11	0.82	14.6*
Q9	2.30	1.33	2.33	1.06	2.26	0.93	2.25	0.94	2.14	0.84	2.00	0.86	4.92*
Q10	2.50	1.35	2.38	1.97	2.61	0.97	2.60	0.97	2.47	0.89	2.39	0.95	3.46*
Q11	2.80	1.22	2.76	1.11	3.05	0.81	3.00	0.78	2.99	0.79	3.13	0.79	4.12*
Q12	3.38	1.18	3.18	0.96	3.55	0.75	3.48	0.80	3.15	0.92	3.11	0.92	18.2*
Q13	3.38	0.51	3.02	1.02	3.21	0.86	3.20	0.83	3.15	0.88	3.07	0.86	2.11*
Q14	3.25	0.88	2.00	1.02	2.51	0.97	2.56	0.92	2.33	0.95	2.35	0.95	10.1*

*$P<0.05$ N 1936

Gender Difference: The associations between the students' perceptions of science classes and the gender of the students were analysed. The gender differences in students' perceptions of science classes were examined by splitting the total number into male (980) and female (890) students involved in the study. 66 students did not disclose their gender on the survey form.

To examine the gender differences in students' perceptions of science classes, the within-class gender subgroup mean was chosen as the unit of analysis which aims to eliminate the effect of class differences due to males and females being unevenly distributed in the sample. In the data analysis, male and female students' mean scores for each class were computed, and the significance of gender differences in students' perceptions of teacher interpersonal behaviour and science classroom were analysed using F-test. Table 4 shows the scale item means, standard deviations, F-values and Cohen's effect size r. The purpose of this analysis was to establish whether there are significant differences in perceptions of students according to their gender.

As can be seen in the Table 4, the gender differences in the perceptions of males and females were found to be statistically significantly different only on one question out of 14. Females in the survey perceive that teacher asks them about their interests in science more often than males in the survey and the difference is statistically significant.

Table 4. Item Mean and Standard Deviation for Gender Differences in Students' Perceptions of the Survey Questions

Q No	Males N 980		Females N 890		F	Effect Size r
	Mean	St.Dev	Mean	St.Dev		
Q1	2.55	0.96	2.51	0.94	1.24	0.02
Q2	2.92	0.83	2.92	0.84	0.27	0.00
Q3	2.02	0.82	2.00	0.78	3.19	0.01
Q4	3.25	0.86	3.35	0.82	3.23	0.05
Q5	2.59	0.89	2.61	0.87	0.41	0.01
Q6	2.59	0.96	2.50	0.93	2.87	0.04
Q7	1.84	0.98	1.80	0.92	0.61	0.02
Q8	2.93	0.91	2.97	0.91	0.35	0.02
Q9	2.23	0.93	2.13	0.89	8.49*	0.05
Q10	2.51	0.95	2.54	0.99	2.61	0.01
Q11	3.04	0.83	3.00	0.81	2.59	0.02
Q12	3.32	0.89	3.35	0.86	0.94	0.01
Q13	3.12	0.89	3.18	0.85	0.03	0.03
Q14	3.18	0.96	2.47	0.97	0.47	0.40

*$P<0.01$

Year Difference: The differences between the students' perceptions of science classes in year 2008 and 2009 were analysed. A total of 874 students participated in this study in the year 2008 and 1058 students participated in 2009.

In the data analysis, students' mean scores for each year were computed, and the significance of year differences in students' perceptions of teacher interpersonal behaviour and science classroom were analysed using F-test. Table 5 shows the scale item means, standard deviations, F-values and Cohen's effect size r. The purpose of this analysis was to establish whether there are significant differences in perceptions of students according to their gender.

The data analyses established that the year differences in the perceptions of students were found to be statistically significantly different only on five questions out of 14. Mean scores for these five questions in year 2009 are higher as compared to year 2008 confirming that continued support from department of education was helping students to perceive science more positively.

Table 5. Item Mean and Standard Deviation for Year Differences in Students' Perceptions *of the Survey Questions*

Q No	2008 N = 874		2009 N=1058		F	Effect Size r
	Mean	St.Dev	Mean	St.Dev		
Q1	2.42	0.94	2.64	0.96	3.19	0.12
Q2	2.91	0.87	2.93	0.81	5.76*	0.01
Q3	1.94	0.81	2.05	0.80	0.79	0.06
Q4	3.22	0.91	3.36	0.78	19.32*	0.08
Q5	2.50	0.88	2.70	0.88	0.09	0.13
Q6	2.51	0.97	2.57	0.93	3.35	0.03
Q7	1.66	0.91	1.95	0.96	0.00	0.15
Q8	2.81	0.94	3.08	0.87	18.45*	0.14
Q9	2.06	0.91	2.29	0.91	10.02*	0.12
Q10	2.35	0.97	2.67	0.95	0.17	0.16
Q11	3.01	0.85	3.02	0.80	0.88	0.00
Q12	3.30	0.90	3.36	0.86	4.07**	0.03
Q13	3.14	0.87	3.17	0.87	0.11	0.01
Q14	3.17	0.97	2.54	0.95	0.07	0.3

*$P<0.01$, **$P<0.05$

CONCLUSIONS:

Overall PSP is having a very positive effect. Notable changes include:

- shift from not teaching science to teaching science on regular basis;
- marked increase in teachers' confidence and enthusiasm;
- increased consolidation and integration of science activities with conceptual outcomes, moderation and other subjects;
- increased collaboration and peer learning among teachers;
- development of leadership abilities among the SST's;
- increased linkage with community in science activities

Factors Indentified for this Success:

- High level support provided by PSP team;
- Professional learning that addresses teachers concerns;
- Program is based on sound modelling principles;
- Flexibility
- Teaching materials-primary connections
- Continued participation in PSP

For the quantitative data statistically significant differences were found for 13 out of 14 questions on student views from different classes. Only one questions had statistically significant differences in student opinions when compared on the basis of Gender and four out of 14 questions had higher means and significant differences in year 2009 when compared with 2008.

Significance and Innovation

The significance of our research lies in the fact that a scientifically-literate society is imperative for future. Individuals should have an understanding of the only decisions that they make when they are at the doctor, voting, making purchases, listening to the news, reading information, etc. The PSP fosters significant and sustained improvements in science teaching and therefore students' scientific literacy. The strategy for achieving this is through a carefully-constructed and original model of professional learning for cohorts of primary school teachers.

Research indicates that effective professional development should be long term, allowing reflection, implementation of skills learned, and follow-up sessions for feedback and consolidation. Paradoxically, professional development offered by external (to education systems) providers is rarely long term (Rennie, Sheffield, Koul, & Evans, 2006). This research is significant because, by evaluating the effectiveness of PSP, it is likely to contribute to a better understanding of teachers' needs and values and to offer useful advice to the Education system. By exploring the factors that facilitate or hinder its effectiveness, our research contributes to the continuous improvement of PSP.

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