# AN EVALUATION OF A TEACHER DEVELOPMENT CONTRACT

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1993

# An Evaluation of a Teacher Development Contract

An administrative project submitted in partial fulfillment of the requirements

for the degree of

Masterate in Educational Administration

at Massey University

by

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1993

# ABSTRACT

This project reports an evaluation of a teacher development contract that was concerned with science teachers in primary and secondary schools in the Thames-Coromandel area. Teachers in the region were invited to become part of a group of twenty teachers, who met in a series of thirteen meetings and also participated in a series of classroom based visits. The teacher development programme was based on a Learning in Science Project (Teacher Development) course that was established as part of research into teacher professional development in science. The work was informed by a constructivist framework of teaching and learning.

Data was collected by pre- and post-course survey documents, observations made during classroom visits with the course participants and reflective writing exercises undertaken during the course. Data collection was negotiated with the participants and was voluntary. The enthusiastic involvement of the course members suggests that teaching in a manner that takes into account students' thinking creates a positive learning environment in the classroom. Results showing significant changes in teacher behaviours suggested that the different teaching approach presented was attractive to classroom teachers. Classroom observations supported the results of the surveys.

It was evident that along with these changes in classroom practice, teachers' views and theories concerning science teaching and learning developed in ways consistent with features of a constructivist approach to teaching and learning. Teachers expressed their support for what they saw as a new approach to teaching science and felt more confident with dealing with science topics. This was especially evident with the primary teachers on the course.

The teacher development programme in science, junior primary to form five, appeared to be successful in achieving its aims. These aims were to help teachers develop their ideas regarding the importance of on-going professional development, to help teachers learn about research findings on how students learn science and to develop their classroom practice to take into account students' thinking.

# ACKNOWLEDGEMENTS

I am grateful to the Education Department at Massey University for the support and guidance over the years of this degree study. I am particularly grateful to Associate Professor Wayne Edwards and my supervisor, Dr Janet Burns for their encouragement and assistance.

I also grateful to the teachers who volunteered for the teacher development course and gave freely of their time over the year of the study. They welcomed me into their classrooms and shared their activities and thoughts openly.

I would also like to thank:

Dr Beverley Bell, assistant director of the Centre for Science and Mathematics Education Research who encouraged me to bid for the teacher development contract and in the early stages of the course shared her thoughts and experience with me.

Dr Garth Ritchie, Research and Statistics Division, Ministry of Education, for his friendly advice and assistance with the quantitative data analysis.

Dr Susan Rodrigues, Dr Amarjit Singh and Mr Ernie Verbowski, all formerly of the Centre for Science and Mathematics Education Research who took time out of their own personal research programmes to have detailed discussions with me on many occasions, on all aspects of science education and teacher professional development.

The staff of Te Haeata, Hauraki Education Centre, Thames for their friendly welcome and constant help in ensuring the course environment was always positive and welcoming for all the course participants.

The Curriculum Functions group of the Ministry of Education for providing the funding for the course, especially Mr Steve Benson for his assistance in negotiating the contract.

Finally, special thanks are due to my wife Sharon and our children Zoë, Sam and Meredith for their love, encouragement and support over the course of this degree.

# CONTENTS


ACKNOWLEDGEMENTS iii

CONTENTS iv

LIST OF FIGURES AND TABLES vi

CHAPTER 1: INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION 1

1.2 OVERVIEW 2

CHAPTER 2: TEACHER DEVELOPMENT

2.1 INTRODUCTION AND BACKGROUND 3

CHAPTER 3: TEACHER DEVELOPMENT PROGRAMME

3.1 INTRODUCTION 6

3.2 SESSION DETAILS 7

3.3 COURSE ATTENDANCE 11

3.4 GENERAL COURSE COMMENTS 12

CHAPTER 4: METHODOLOGY

4.1 INTRODUCTION 15

4.2 METHODOLOGY REVIEW 15

4.3 EVALUATION METHODOLOGY 18

4.4 ETHICAL ISSUES 19

4.5 SUMMARY 19

CHAPTER 5: PARTICIPANT BACKGROUND

5.1 INTRODUCTION 20

5.2 PROFESSIONAL BACKGROUND 20

5.3 IN-SERVICE COURSE EXPERIENCE 21

5.4 REASONS FOR INVOLVEMENT IN THE COURSE 21

5.5 INTERESTS RELATED TO SCIENCE 23

5.6 SUMMARY 23

CHAPTER 6: CLASSROOM VISITS
6.1 INTRODUCTION 24
6.2 CLASSROOM OBSERVATIONS 24
6.3 LESSON DESCRIPTIONS 25
6.4 DISCUSSION 28
6.5 SUMMARY 29

CHAPTER 7: REFLECTIVE WRITING
7.1 INTRODUCTION 30
7.2 RESPONSES TO QUESTIONS 30
7.3 DISCUSSION 37

CHAPTER 8: SURVEY DATA
8.1 INTRODUCTION 38
8.2 QUESTION RESPONSES 39
8.3 DISCUSSION 77

CHAPTER 9: DISCUSSION
9.1 INTRODUCTION 80
9.2 METHODOLOGY 80
9.3 CLASSROOM VISITS 81
9.4 REFLECTIVE WRITING 83

CHAPTER 10: CONCLUSION
10.1 SUMMARY OF FINDINGS 85

APPENDICES
A.1 INVITATION LETTERS 88
A.2 REFLECTIVE EVALUATION 90
A.3 SURVEY DOCUMENTS 91

REFERENCES 108

# LIST OF FIGURES

Figure A: Teaching science in my classroom currently involves 39
Figure B: Reported changes in teaching skills 48
Figure C: Reported changes in views of helpfulness of learning activities 50
Figure D: Reported changes in beliefs about learning in science 53
Figure E: Reported changes in the value of science in the curriculum 58
Figure F: Reported changes in understandings of the science curriculum 60
Figure G: Reported changes in meanings of science 64
Figure H: Reported changes in importance of teacher development activities 72

# LIST OF TABLES

Course attendance 12
Background of participants 20
Table 1: Teacher mean ranked scores of teaching activities 40
Table 2: Teacher composite scores 41
Table 3: Teacher mean ranked scores on teaching skills 49
Table 4: Teacher mean ranked scores in learning activities 51
Table 5: Teacher composite scores 52
Table 6: Teacher mean ranked scores of views of learning 54
Table 7: Teacher mean ranked scores on science and technology 59
Table 8: Teacher mean ranked scores of views on science curriculum 61
Table 9: Teacher mean ranked scores on meanings for science 65
Table 10: Teacher composite scores 66
Table 11: Teacher mean ranked scores on the 'best teacher development' 73

# CHAPTER 1

## INTRODUCTION AND OVERVIEW

### 1.1 INTRODUCTION

Teacher development in New Zealand is increasingly being done under contract with the Ministry of Education. Contracts are advertised with selections made from the proposals put forward from contractors. This particular contract was to provide a programme of teacher development to assist teachers of science (junior primary to form 5) with reference to: the existing science syllabuses, recent developments in science education including research findings, the proposed National Curriculum and developments which will occur as a result of the government's Achievement Initiative in Science.

The programme was designed to provide instruction, support and feedback to teachers in primary, secondary and composite schools in the Thames-Coromandel area on the provision of effective science education programmes in the classroom. The support and feedback focussed on the sharing and implementation of effective learning strategies and assessment techniques for science education.

The programme included:

- consultation with the Ministry on current curriculum developments with particular reference to science education;
- the dissemination of information about the programme to all schools in the Thames-Coromandel area and inviting schools to become involved;
- the selection of a target group of 20 resource teachers;
- visits to each participating school to meet with the principals and teachers to discuss the organisation and proposed outcomes of the programme;
- twelve meetings for the teachers to develop strategies for on-going support and development (3 one-day meetings, 9 afternoon/evening meetings);
- a series of on-going visits to participating schools to work with the resource teachers on the implementation of effective strategies for the teaching and assessment of science;
- the provision and dissemination of appropriate resources for all teachers of science education in participating schools.

Written into the contract was the need for the programme to be evaluated. The contract document states that:

- the contractor shall conduct an on-going evaluation of the programme, and shall incorporate any modifications deemed necessary in further programmes with schools;
- in addition to the contractor's own evaluation, the Ministry reserves the right to evaluate the programme.

This present study arose out of this need to evaluate the programme and reports on that evaluation.

## 1.2 CHAPTER OVERVIEWS

Chapter 2 describes the background to the teacher development programme.

Chapter 3 presents the teacher development programme with each programme session detailed. Responses to a final teacher evaluation of the programme are presented and discussed.

Chapter 4 discusses the theoretical basis for the methodology of the evaluation undertaken.

Chapter 5 presents and analyses the descriptive data taken from the pre-course survey on the professional backgrounds of the course participants.

Chapter 6 describes the visits made by the author to the participant teachers in their schools and discusses some of the lessons observed.

Chapter 7 presents the results from the two reflective surveys answered by the participants at the end of two course sessions.

Chapter 8 presents the results and analysis from the fourteen questions in Section B of the pre- and post-course surveys. These are used to monitor and show the changes in teacher beliefs, values and current teaching practice and discuss the extent to which the programme aims were realised.

Chapter 9 discusses and reflects on the results of the evaluation.

Chapter 10 concludes the thesis. A summary of the evaluation is presented.

# CHAPTER 2

## TEACHER DEVELOPMENT

### 2.1 INTRODUCTION and BACKGROUND

It has long been recognised that for the successful implementation of new curricula, teacher professional development is needed (Frampton, 1991). In-service courses for teachers have long been used for teacher professional development and as Constable and Long (1989) note "short in-service courses are survivors ... and may be said to be flourishing and diversifying." In New Zealand as elsewhere, short in-service course are perhaps the most common teacher training/teacher development method encountered by practicing teachers. However, as Ingvarson (1992, p. 205) comments while these courses are available, "they seem to be a response to immediate and random priorities and pressures, and to be unrelated to each other." He argues, that for the aging and static population of teachers in schools there needs to be some purpose and direction in planning professional development and some recognition for what is good science teaching, teaching that supports quality learning.

Early science education research in New Zealand with the Learning in Science Projects (LISP) investigated how children learn science, provided descriptions of children's understanding in areas of science content (Osborne and Freyberg, 1985) and developed and evaluated new teaching approaches (Biddulph and Osborne, 1984: Cosgrove, 1989). However, while many teachers had attended in-service courses and knew of these findings, little significant impact was noted in science classrooms. While it was acknowledged that the new teaching approaches with the emphasis on learning represented an improvement in science teaching and learning, few teachers felt confident to put them into practice.

The Learning in Science Project (Teacher Development) (described in depth in Bell, (ed), 1993a) was set up to develop and investigate teacher development courses that would help teachers of science implement research findings on teaching and learning and also to investigate factors that help or hinder teacher development and change. Earlier work by Silvester (1989a, b) had shown that there was :

(a) the need for teachers to understand the need for change and the change process in teacher development (Claxton and Carr, 1987);
(b) the need for teachers to investigate their own problems and concerns (Hodson, 1988)

(d) the need to have ongoing and interactive courses that acknowledge the personal theories and practical knowledge of teachers (Hodson, 1988), where there is an atmosphere of mutual trust (Biddulph, 1987) and some collaboration with a support person (Baird and Mitchell, 1986).

The research findings of the LISP (Teacher development) courses reinforced these previous findings and also indicated that good teacher development had three inter-related aspects:

> Professional development which included the development of teachers' ideas about science education and the changes in their classroom practice.
>
> Personal development which included attending to feelings about teaching science and changing practice.
>
> Social development which included helping teachers work with other teachers beyond the programme itself. (Bell, 1993b)

The course developed as part of this LISP research was based on a constructivist view of learning for both teachers and learners. As such, the approach to teacher development followed was that teacher development is teacher learning, where learning is viewed as conceptual change. Some of the assumptions underlying this model of teacher development are detailed in Bell (1993b, p.5). For example:

> the process is one of empowerment, rather than continued dependency;
>
> successful teacher development has a focus on new teaching activities;
>
> the prime purposes of teacher development are to help teachers feel better about themselves as teachers and to improve teaching and learning outcomes in the classroom
>
> the contributions by the teachers to the course activities are important, encouraged and supported and teacher development is enhanced when discussion is built into the course
>
> the teachers will bring to the programme a range of different ideas, beliefs, experiences and concerns about science education and the development activities need to acknowledge and address these.

These assumptions are consistent with that expressed by adult educators (Knowles, 1989) on adult learning and in the design of the course his principles were considered. As he identifies (p.83) one of the first tasks was to help the teachers become aware what they

needed to know and be able to do in their classrooms to improve students' learning. Appleton (1992, p. 11) notes the relatively poor science discipline background of primary teachers and their lack of confidence to teach science stemming from this. Consequently, as Knowles identifies, it was necessary to have activities that tapped into their experiences and supported them through group discussion and problem-solving activities. Hardy and Kirkwood (1991) demonstrate that focussing on gender equity with students as learners in a constructivist context enabled primary teachers to gain confidence in teaching science.

As the teacher development course was non-credentialling, it was necessary to consider the motivation needed for teachers to continue to come to the course over a time period of many months. As Knowles suggests (1989, p.75) it was necessary to create a friendly and informal climate in the learning situation with good physical conditions. The teachers were wanting to improve their science teaching and needed to accept some responsibility for their learning on the course, learning that could be related to their own classroom experience. The teachers also needed to appreciate there was a sense of growth within the programme and that the course had a flexible plan.

In the following chapter, the teacher development programme of activities is described in some depth, with the general evaluative comments made by the teachers at the end of the course, presented and discussed.

# CHAPTER 3

## TEACHER DEVELOPMENT PROGRAMME

### 3.1 INTRODUCTION

The general aims for the course state:

To help teachers to develop their ideas of what professional development is and to adopt roles for the teacher of learning, researching, supporting and reflecting.

To develop teachers classroom practice to take into account students' thinking, and in particular, adopt the new roles for the teacher in the classroom, of listening, managing of learning, and responding to students' thinking.

To help teachers learn about research findings as to how students learn science.

To develop a constructivist view of learning and consider its implication for the way we view teaching, assessment of learning, the curriculum, knowledge and science.

The course was designed to enable teachers to take a critical look at their role as a teacher of science, to structure the reflection on their practice through discussion and provision of theoretical writings, to support them in the process of change through on-going interaction with other teachers and with feedback in their own classrooms by the course facilitator. The course was sourced from a teacher development programme which is described in some detail in Bell, Pearson and Kirkwood (1991) and Bell (1992, 1993).

The course has its foundations in a constructivist perspective of teaching and modelled initially the 'Interactive Approach' (Biddulph and Osborne, 1984). This approach has been characterised by having elements of exploration of children' ideas and questions about a particular topic, specific investigations of these questions and review and reflection (Bell, 1993). Constable and Long (1991, p 408) identify eight features that are consistent with a constructivist approach and which were considered and modelled during the course.

(a) The teacher starts a topic by eliciting learners' existing ideas.

(b) The teacher provides practical experiences which relate to and extend the learner's knowledge.

(c) In addition to practical experiences, the teacher provides separate opportunities for thinking.

(d) The teacher emphasises collaborative learning methods.

(e) The teacher helps students learn how to learn.

(f) The teacher provides a classroom environment which encourages the full exploration of ideas and their critical review, but where premature judgement is avoided.

(g) The teacher accommodates learner's prior ideas in his or her teaching.

(h) The teacher recognises, and intervenes to overcome, critical conceptual hurdles to help the learners restructure their knowledge.

These features were introduced and modelled for the teachers throughout the course. Details of individual sessions are summarised in the following paragraphs.

## 3.2 SESSION DETAILS

The course was designed to run for twelve fortnightly sessions, nine sessions from 4-7 PM and three all day sessions. A further all day session was added at the end of the course. All afternoon sessions started with an afternoon tea which was designed to allow social interaction before the course session proper got underway. Lunch was provided at the all day sessions and this again enabled teachers to share their activities informally. All sessions (apart from the first session) started with the course participants sharing with the group, their individual responses to the activities they had undertaken in their classrooms over the previous fortnight.

### Session One.

This session was designed to get teachers to experience some new learning in science, presenting them with familiar situations and getting them to view them differently. Three situations were presented; a balance activity, an investigation into the blind spot of the eye (Duckworth, 1991), and the activity 'Floating and Sinking' taken from 'Making Sense of Our World' Biddulph and Osborne, 1984. A 'post box' activity (Learning Media, 1990) was added at the end of the session to allow the teachers time to reflect on the learning's in the activities .

### Session Two.

In this session ideas on how to find out what students are thinking were presented. These included the techniques of the post box method and predict-observe-explain which had already been modelled as well as the techniques of interviews -about -instances (Osborne and Freyberg, 1985), surveys and concept mapping (Mason, 1992; Grant et al, 1990) These further techniques were modelled with them and a further activity given to them to trial in their classrooms. Notions of teaching and learning were explored with them and a series of photographs of classroom situations presented for them to discuss in relation to teaching and learning (Based on ideas and activities initiated by Bell , pers. comm. 1992).

## Session Three

The previous session had demonstrated ways of finding out what students were thinking and what their own personal knowledge and ideas were. The next step was to model for teachers and allow them to work with responses they could make to students that would help them clarify and extend student ideas with view to encouraging conceptual change. 'Viewfinders' (Bell, 1993b p61) or as described earlier as interlocutory questions by Duckworth (1987, pp 96-97) are responses that could be asked by the teacher, that would attempt to clarify for the teacher what the student is thinking and oblige the student to think a little further. For example, Why do you say that?, Could you give me an example?, How does that fit in with what she just said? These were discussed and practiced with the teachers in pairs, each taking turns to discuss their own classroom practice.

Setting up more open-ended activities in their science programmes was discussed with reference to the work of Jones et al (1992) and the notion of teaching science in context explored. The use of student 'thinking books' (Swan, 1988) was introduced and examples of their use discussed in terms of meta-cognition, getting students to reflect on their learning. A set of questions designed to get teachers reflecting on their own personal knowledge and theories about teaching and learning in science (Baird et al, 1991 )were given to the teachers at the end of the session. Results from this are presented and discussed in Chapter Seven.

## Session Four.

This session had originally been planned as a full day. Coming at the end of the first term meant that an afternoon session was substituted by request. The venue was also changed to allow the participants to visit a science fair held in the local school hall. The first part of a shortened session was spent on sharing the work that had been ongoing in their classrooms and an emphasis made on doing this differently and collecting data in classrooms. In this session teachers were asked to think about their views of learning and teaching. LISP findings were presented and discussed in relation to a constructivist view of learning. The book 'Learning in Science' (Osborne and Freyberg, 1985)) was given to teachers and specific parts discussed with them. Various activities designed to find out what students are thinking were modelled with them.
Information was presented on the Achievement Initiatives and parts of earlier drafts discussed in a preliminary way during the session.

## Session Five.

This was a full day meeting and started with sharing the activities, ideas and actions taken over the preceding month. The difficulties of changing practices and having different

teaching roles were explored in this session. Views of learning and teaching were again examined. Teaching science in context was introduced with a starter activity on sea shells with the science content emerging for the teachers during their discussions. How this content might fit into the various areas within the Draft Science Curriculum was discussed in this activity.

Clusters of teachers working with similar units of the curriculum were formed in the afternoon and common planning undertaken for the units. This was done in with reference to the activities modelled on the course, the open-endedness of the activities and how they might take into account the responses of the students at the various age groups they were teaching. A unit of work, 'Burning' (Biddulph, 1991) was given to them as a model and 'Making Sense of Our World' (Biddulph and Osborne, 1984) issued as a resource text.

**Session Six.**

After the sharing of their experiences at the beginning of the session, the various roles of the teacher in a constructivist classroom were examined (for details see Bell, 1993b). Teachers were asked to examine in light of their own practice what they were doing differently in the classroom and how they worked to manage the learning of their students. Further discussion on what they were doing and the new roles they were undertaking was looked at in light of descriptions in 'Making Sense of Our World' and 'Science in the Primary Classroom' (Barker, 1991).
Clusters of teaching involved in similar activities were reformed and the session ended with more co-operative planning.

**Session Seven.**

The session started with reporting back on the activities that teachers were engaged in with three questions in mind: what was I doing differently?, how was I interacting with students' ideas? and what told me that learning was occurring? Discussions were held on ways that they set up situations where students can interact, where they could use short responses to extend students' thinking and how they could set up ways within their classrooms so that they could have more time to interact with individuals.

Constructivist views of learning and teaching were again discussed and examples from a lecture from Driver (1992) presented.

The interactive teaching approach (Biddulph and Osborne, 1984) was formally modelled using a technology starter investigating irons (Kirkwood et al., 1989)

### Session Eight

The investigation into irons continued with all participants dissecting their iron and attempting to answer their own questions. Technology was explored as a context for bringing out scientific concepts and content. Their experience in having the interactive teaching approach modelled for them was discussed. Again, all this was set against their own views on teaching and learning and where changes in their views were occurring.

### Session Nine

The all day session started with participants discussing what they had been doing and what sense they were making of their science activities. It was possible to feedback to the group during this session a lot of the observations that the course facilitator had made in classrooms.

A summary of constructivist views was presented with a look at implications for curriculum and assessment. This discussion was based around a model of teaching and learning presented in a paper by White (1992), which contrasted a traditional view of the relationship between the teacher and learner with that of a constructivist view of the relationship. It was followed by an introduction to assessment techniques. The afternoon session was spent talking about the teacher's role in 'scaffolding' student thinking (Rosenshine and Meister, 1992) and excerpts from a paper by Fleer (1992) were worked through. The set of questions designed to have teachers reflect on their own personal knowledge and theories of teaching and learning was given out to end the session. These questions were a repeat of the questions given out in session three and were used to determine any change in teacher views. The data is reported in Chapter 7.

### Session Ten.

Data from the two sets of questions given out (Sessions 3/9) on the course was given back to the participants and an analysis of their responses discussed (See chapter 7).

Assessment techniques were discussed in groups and the parallel drawn after group presentations that what teachers had been talking about were also ways of interacting with student ideas. It was also pointed out that they were also engaging their students with 'meta-learning' (White and Gunstone, 1989), finding ways in which students were learning about how they themselves best learnt. Ways that they could encourage students to take responsibility for their own learning were investigated.

### Session Eleven

Most of this session was spent on an investigation of technology, what it meant, what were suitable activities for students and what science content emerges from a unit based

on technology ( Learning Media, 1992; Verbowski, 1992). While it was not possible to reference the Draft curriculum statement directly, it was still addressed indirectly with regards to the technological theme.

Ways of networking with other science teachers and with their own staff were also introduced and discussed with plans made between similar groupings.

### Session Twelve.

A summary of the course was presented and discussed with the participants during the first part of this all day session. Problem solving, co-operative learning and sharing of ideas, three main ways of promoting learning in classrooms were also presented and discussed.

The second session of the day was an investigation of writing and language in the science curriculum (Loane, 1992) and new models and ways of probing understanding were presented.(White and Gunstone, 1992)

The day ended with a sharing session, a review of teacher development and a look at how teachers could design their own, individual teacher development programme (Clark, 1992).

### Session Thirteen.

This session was an extra session requested by the participants to continue talking about some the issues raised in the previous course sessions. Initially there was a period of reporting from all participants about the work they had been doing and the changes they could recognise as coming from the course. Successes were discussed in depth as well as some doubts about the ability of teachers to keep working through all content areas in a constructivist manner.

The remainder of the day was spent in a presentation of teaching science in context (Rodrigues, 1993), with workshop activities following the presentation.

The course ended with firm plans made by the participants to network more extensively and to share ideas regularly.

## 3.3 COURSE ATTENDANCE

Twenty-two participants started the course with three teachers withdrawing. One of these came for two sessions and then found her workload at school too time consuming. Another teacher left her school to teach in Auckland. The third stopped attending after four sessions with no reason given. Data on the attendance at sessions of the other nineteen participants is given below.

**Course Attendance**

| Number of sessions attended | 13 (all) | 12 | 11 | ≤10 |
|---|---|---|---|---|
| Attendance of individual teachers at sessions | 5 | 5 | 6 | 3 |

Reasons for absences from the course sessions were generally personal, with one teacher going on her honeymoon and two other teachers having to take their husbands to hospital for surgery. On one afternoon two teachers reported genuinely forgetting after a hectic day at school.

## 3.4 GENERAL COURSE COMMENTS

At the end of the course, participants were asked to complete a second set of survey documents. This data will be presented in Chapter 8. However, a final question in survey 2 asked for comments on areas teachers felt were not covered in other survey questions and their full and frank thoughts of the whole course asked for. Thirteen of the eighteen participants who responded to the survey completed this question. Points raised in their replies are detailed below.

The timing of the course was commented on by five teachers; one teacher (15) feeling that the whole course could have been condensed into a few sessions, another (16) finding the 4-5 slot hard to concentrate in 'after a hard day at the workplace'. While another teacher found that ' at times I seemed a bit pushed to get to the 4-7 sessions, it took a bit of organising and training my family!' She also commented that

> the time span over which the course has operated has been of great benefit to my own learning. With frequent meetings over the course of a year I have been able to pick things up again and develop at my own pace. Sometimes I went all out to try out new ideas between sessions, on other occasions I just let it lie, but the ideas I was gaining never died, it was easy to pick them up again in the next session (17/S2)[1]

One teacher was more pragmatic in her evaluation, she noted that 'the fact people rarely missed sessions, arrived on time, and didn't leave early, shows that what went on was worthwhile' (11/S2).

The mix of primary and secondary teachers on the course was noted by two teachers, one teacher (1/S2) noting 'Have really enjoyed the mix of teachers from new entrants to secondary and to see how lucky we are in the primary service without a strict timetable'. The second comment came from a secondary teacher (20/S2) who 'enjoyed working with

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[1]The first number refers to the teacher code and the second, the survey number.

the primary teachers' getting to know two of his local primary teachers 'very well, a network has started and we share ideas and resources'.

The readings in the course were commented on with four participants finding that they had little time to read them although they were making the effort (1, 19/S2) and two other teachers finding that as well as time constraints, the content was 'a bit heavy going and perhaps it could be rewritten in lay terms so people like me with no science background could find it easier to read and comprehend.' (11/S2)

However, one teacher commented that;

> It has been really good to read excerpts from research etc. that we have been provided with. It is often difficult to obtain or acquire such readings for the ordinary classroom teacher and I have been able to pass key points from these readings back to other staff. (7/S2)

The emphasis in the course on reflecting on views of learning and teaching was important and recognised. One teacher commented:

> It has been excellent to reflect on my thinking and beliefs about teaching and learning — I haven't done this since college and I think it timely to do this now in my second year of teaching. (19/S2)

Other teachers found constructivist teaching approaches useful and commented that they could be applied across the whole curriculum, not just in science.

> I like the way this approach to learning can be applied across the whole curriculum. Children like to be challenged with a problem and devising solutions calls on both creativity and logic. (4/S2)

> I have found this course to be one of the most profitable I have been involved with. It has had far-reaching effects in my teaching approach in all curriculum areas. I have a lot more confidence in science areas and this is obvious in my teaching. (7/S2)

> This course has been of great benefit to my teaching in all curriculum areas. I have learned to regard teaching as a two way learning continuum
>
> child «—» teacher, not merely child«— teacher.
>
> The children enjoy this teaching method because they have the freedom to offer answers, without the fear of being wrong. this has given rise to more student participation in all events of classroom discussion. (13/S2)

One teacher felt there were deficiencies in the course. While commenting positively about many aspects of the course, she felt that there was not enough emphases on Maori students and science.

> I found we were consistently challenged throughout the course by assignments, activities, each other and by readings and theory, to consider equity in science learning for girls. I consider a similar challenge was noticeably absent in regard to Maori and science. I believe the role of the teacher developer must and should encompass a pro-active approach to making science more accessible and more beneficial to Maori students. I don't think we were challenged to demonstrate a commitment to changing in this area. (5/S2)

Overall, the course appeared to meet the needs of the participants and this was borne out by the consistent attendance at each session. Teachers came to the course with some understanding and knowledge of the interactive approach to teaching science. Several of them had been on previous short term courses or as recent graduates from Waikato School of Education had become acquainted with some current thinking in the teaching of science. The teacher development course itself was well designed, having been developed over two years of research and building on the professional background of many years of the directors of the project ( B. Bell and V. Kirkwood).

Some of the strengths of the course were that it developed and acknowledged collaborative strategies and provided a lot of time for teachers to discuss their ideas and experiences in a supportive environment. The whole course modelled the same features of constructivist teaching that teachers examined throughout the course. Consequently, some of the evaluative comments made by the teachers were expected. They enjoyed the course and the discussions and used the time to network with other rural teachers at neighbouring schools. While enjoyment and networking are positive outcomes for the teachers, the course aimed to change teaching practice. It is felt that these aspects were already commented upon by the teachers in the other questions in the surveys and that answers to this final question emphasised more personal concerns.

In the next chapter, the methodology of the evaluation is presented and discussed.

# CHAPTER 4

# METHODOLOGY

## 4.1 INTRODUCTION

Evaluation of the teacher professional development contracts is seen as both necessary and important by the Ministry of Education. While it is necessary to ensure good financial accountability of public monies spent on the contract, it is as necessary to ensure the effectiveness of the teacher professional development. Consequently, it is important to show which particular teacher professional development models are effective in supporting and changing teacher practice in the classroom and to demonstrate that any individual contract meets the required standards.

## 4.2 METHODOLOGY REVIEW

Tyler (1949) defines evaluation as "the process for determining the degree to which changes in behaviour are actually taking place." Teacher change is however, difficult to quantify in the behavioural terms he suggests. While there is a need to show an effective end-result (a summative evaluation) for the Ministry of Education, there is also the need to have an on-going evaluation (a formative evaluation) which allows for modification of the programme. Scriven (1973) suggests that the formative evaluation is best done by someone inside the programme with an independent person carrying out the summative evaluation. In a teacher professional development course without an external evaluator, Scriven's suggestion presents certain dilemmas.

Conversations were had with Ministry personnel about specific features required in the course evaluation and reference was made to five recently completed evaluations of teacher professional development contracts. Two of these were the final reports of teacher development courses in science (Forret and Wood, 1992; McKinley, 1992), and the others were evaluation reports of development contracts made by independent researchers (Gilmore, 1992; Nightingale, 1992; Poskitt, 1992).

Little formal evaluation had been done in the contracts in science. Forret and Wood (1992) worked as a team with one director facilitating the course sessions while the other director 'observed and entered into discussions.' They report that the observer kept a log of the sessions which was supplemented by discussions between the two directors after each session. This was to provide an on-going evaluation. A summative evaluation is presented in the report based on the observers log and the directors' perceptions. McKinley (1992) gave teachers on the contract a simple questionnaire (6 questions) and collated the replies without comment.

That little extra evaluation of the outcomes of these two teacher development contracts was required (or indeed required for the present contract), suggests that the Ministry of Education in selecting preferred contractors had already evaluated the worth of the programme. Much evaluation of small contracts appears to be not really required, a statement of financial accountability and a milestone reports detailing the work carried out seeming to be sufficient.

Reports from the external evaluations of large teacher professional development contracts were more elaborate. Issues for the Ministry of Education were conceptualised into research questions with the data collected reported to both the Ministry of Education and the contractor. The Ministry was interested in a summative evaluation of the particular model of teacher development, to see if there was a preferred model of teacher development that would deliver significant benefits to large numbers of teachers in a cost-effective manner. The evaluation was needed to inform policy formulation and decision making for future teacher development contracts. Generally, with large contracts, the programme of teacher development is repeated with different groups of teachers and early reporting to the contractors gave some formative evaluation data which allowed refinements to be made. Typically the evaluations were on-going, involved several questionnaires, interviews with resource teachers, attendance and participation at programme meetings and workshops by the researchers and observations in classes.

Poskitt (1992) presents a structure, the 'Stake model' (Stake, 1967), for the methodology of her evaluation. This model is described by Poskitt and Prebble and Stewart (1981) as having three kinds of data:

> *antecedent data,* information gathered before the programme that might affect the outcomes of the programme;
>
> *transactional data,* gathered from the on-going activities of the programme;
>
> *outcome data,* measurements of the changes that can be related to the programme.

In the present contract, it was considered necessary to show that any data collected had a purpose within the course itself. There was not a lot of time during the course sessions and course members could not be considered to directly benefit from detailed evaluations. It was felt that the data collection had to be done in a way that could contribute to personal growth as well as provide evaluative data. The course members did respond to the need for the course to be evaluated and undertook to complete survey documents (designed to give antecedent and outcome data), and to be visited twice during the period of the course to be observed teaching science with their classes (transactional data). A reflective writing

exercise was negotiated with course members at two separate sessions and again provided transactional data.

Constable and Long (1989, p. 198) note that 'evaluations must be created'. The challenge in this evaluation was to collect data that would show, firstly, if the content of the teacher development course designed as part of the Learning in Science Project (Teacher Development) research (Bell, Pearson and Kirkwood, 1991) would be appropriate for a group mainly composed of primary teachers and, secondly, to detail change in teacher practice and beliefs that took place as the result of the course. The need is to construct an evaluation which is fit for the specific purpose and in using a simple Stake model (Stake 1967, 1973), was a way in which a responsive evaluation could be made with the course facilitator functioning as both the inside evaluator (collecting feedback from the participants to modify the programme for their needs) and the external evaluator (collecting data to determine the extent to which changes in behaviour of the participants had been made).

Stake (1973, p 291-293) describes a responsive evaluation as one which is orientated more to programme activities than to programme intents, an evaluation that responds to participants requirements for information, and if the different value perspective's are referred to in reporting the success and failure of the programme. It is also an approach to evaluation that recognises the role of evaluator as that of a facilitator, an insider within the programme. As such it appeared to fit the structure required for the evaluation by the contractor/ course facilitator/ classroom observer (the one person)in the present contract.

In their evaluation of a science in-service course (Constable and Long, 1989, 1991), a course based on a constructivist framework like the present programme, they used ideas concerning educational change to start constructing the evaluation. They took as a framework of analysis, the ideas identified by Fullen (1982) of 'fidelity' and 'mutual adaptation'. The notion of fidelity is how faithfully teachers put any new innovation into practice and that of mutual adaptation, how the original ideas are changed by decisions taken in a teacher's own classroom situation.

The type of transactional and outcome data collected allowed a similar analysis to be undertaken in that the field observations gave information on how faithful teachers were in the initial stages of the course. Further observations revealed how much adaptation of the ideas had occurred in teaching practice. Analysis of the responses to the survey documents revealed how closely teachers had taken up the essential ideas underlying the course and again how their ideas had changed to include new (to them) ideas on learning and teaching.

## 4.3 EVALUATION METHODOLOGY

In keeping with the broad structure of the evaluation and to show how the aims of the contract had been met, three main data collecting methods were used with both quantitative and qualitative data to ensure that the interpretations of the data could be validated (Cohen and Manion (1985). All data collection methods were discussed with the teachers on the course and permission given to use the data in an evaluation of the course.

Two surveys were administered to the course participants. Both surveys were based on documents developed as part of the Learning in Science (Teacher Development) Project (Pearson and Bell, 1992, 1993).(Survey 1 documents are included in the appendices) The pre-course survey (survey 1) had questions seeking biographical information about the participants and their prior experiences of science and science education (Section A, data presented in chapter 3) as well as questions on their views of science, teaching and learning (section B, data presented in chapter 7). The post-course survey (survey 2) repeated Section B and asked the participants to evaluate the changes made to their teaching practice and in their views. This survey also asked for their general comments on the course (data is presented in chapter 3). The data collected was both quantitative and qualitative

Classroom visits were planned as part of the contract as well as the evaluation. These were designed to give support to the teachers, to assist them with new teaching strategies and to determine how easily teachers found putting new ideas and resources into practice. Observations were made during these classroom visits with a running log kept of teaching and learning activities. These were openly made and discussed with the teacher. Video and audio tapes were also made in some classrooms with the tape given to the teacher either to view and/or to listen to themselves. Two visits were planned to each teacher. All data collected was descriptive and is presented in chapter 6.

The use of reflective journals by the course participants (Holly and McLoughin, 1988) was initiated at the start of the course with a hardbound exercise book given to them for the purpose. It was planned to have teachers share their journals and to use them to reflect on their professional practice and their understandings of their practice. No teacher used their journal as anything other than a notebook during the course and consequently, another method was used to get teachers thinking and reflecting on their practice. A short reflective writing exercise (Baird et. al, 1991) was given at the third course session and again during the ninth session. It was designed to get the participants thinking and writing about their theories on teaching and learning in science and to identify and document changes they may have made. This was a voluntary exercise held at the end of the two sessions with the teachers being free to go if they wished. The documents were returned

to the participants with a summary of all teacher responses made and an interpretation of the changes in the views expressed. This data is presented and discussed in chapter 7.

Data from these three sources ensured that the course facilitator's interpretation and impressions of the programme and the changes in teacher views and practices, could be confirmed and validated by the participants. (Zuber-Skerritt, 1992).

## 4.4 ETHICAL ISSUES

As so much of the data collected was essentially data private to the teachers concerned, ethical principles needed thorough consideration. Brickhouse (1992) provides some guidelines that were followed throughout the research. The ethical ideal that she espouses is a "commitment to human caring, rather than to reliance on statements of principle' (p.98). Throughout the study, consent was sought from all the course participants at all times. Nothing was collected without their permission and while they were told that an evaluation of the course was needed by the Ministry, no teacher was pressured to complete or hand in any documents. Consent was also sought to use the data for this administrative project. Consent was obtained from all course participants.

All data collected was immediately coded on receipt and kept confidential. Where possible all data collected was returned to the participants. Observations made in the classrooms were descriptive of the activities only and to whether teachers were working in ways that were promoted on the course. Classroom management practices were not noted down. The feedback sessions with the teachers were again, only focussed on what the teacher was trying to achieve in the unit of work. The evaluation above all was designed to benefit the teacher as much as possible. Good relationships were established with the course participants and the shared experiences in the classroom added to the dialogue on learning and teaching promoted on the course.

## 4.5 SUMMARY

A framework for the evaluation is presented and discussed with reference to evaluations of other teacher development contracts. The methodology used in this study is described with explanation why each of the three main data collection methods were used. The next chapter presents and analyses the data on the professional background of the course participants and is taken from the pre-course survey.

# CHAPTER 5

## PARTICIPANT BACKGROUND

### 5.1 INTRODUCTION

The following is a summary of the first section of the pre-course survey. Participants were asked for biographical information, their teaching experience and reasons why they had volunteered for the course. It was felt that this data would enable a greater understanding of the following answers. Nineteen replies were received from the course participants.

### 5.2 PROFESSIONAL BACKGROUND

The teachers who volunteered for the course came from thirteen of the fifty two primary and secondary schools in the general Thames-Coromandel and Hauraki Plains areas. The course participants had taught in a range of schools previously with a variety of different teaching experiences.

**Background of participants**

| Teacher Code | Male/Female | Primary/ Secondary | Years Teaching | Specialisations |
|---|---|---|---|---|
| 1 | M | P | 27 | Science, Art, Language, Maths |
| 2 | M | S(HOD) | 18 | Science, Chemistry, Physics |
| 3 | M | S(HOD) | 14 | Science, Biology, Chemistry |
| 4 | F | P | 7 * | Primary Teaching |
| 7 | F | P | 5 | Primary Teaching |
| 8 | F | P | 2 | Primary Teaching |
| 9 | F | P(ST) | 10 | Primary Teaching |
| 10 | F | P(ST) | 14 | Primary Teaching, Science |
| 11 | F | P(DP) | 8 | Primary Teaching, Reading |
| 12 | F | P(STJC) | 19 | Primary Teaching, Science |
| 13 | F | P(ST) | 7 * | Primary Teaching, Biology |
| 14 | F | P | 3 | Primary Teaching |
| 15 | F | P | 18 | Primary Teaching |
| 16 | M | P(ST) | 26 | Primary, Biology, Earth Science |
| 17 | F | P(ST) | 18 | Primary Teaching |
| 18 | F | P(ST) | 19 | Primary Teaching, Reading. |
| 19 | M | P | 1 | Primary Teaching |
| 20 | M | S(HOD) | 18 | Science, Biology, Horticulture |
| 21 | M | S(HOD) | 8 | Science, Physics |

(DP Deputy Principal, HOD Head of Department, ST Senior Teacher)

(* Period of continuous service and in and out of teaching for 20 years)

## 5.3 IN-SERVICE COURSE EXPERIENCE

Participants were asked for their experience of in-service work in science over their career. Seven of the seventeen respondents to the question indicated that they had attended no in-service courses in science.

The other participants had been involved in a variety of different courses. Six teachers had gone to either one or two-day courses run by local science advisers on specific topics as marine education, mangrove ecology, junior science and F7 physics. Two teachers had attended Learning in Science Project (LISP) courses held locally many years previously. One teacher had been involved in the trialing of the Draft Syllabus. Only two teachers had attended a Teacher Refresher Course in science.

## 5.4 REASONS FOR INVOLVEMENT IN THE COURSE

Two questions in the pre-course survey (Survey 1) were 'Why are you doing this in-service course?' and 'What do you expect to gain from this course?' Answers to both questions were considered together as the responses complemented each other.

All the participants who completed the survey identified that they were involved in the course for their own professional development. Eight teachers specifically included comments about wanting to improve their own teaching, for example:

> I would like to improve the effectiveness of learning that occurs in my teaching programme. (3/S1)[2]
>
> I know the way I currently teach science is not how I want to teach it but I'm not sure how to put theories I know into practice. (5/S1)
>
> Need some input ie. want to teach science better. (10/S1)
>
> I expect it to enhance my teaching of science in the classroom. (13/S1)
>
> To further develop my science teaching. (15/S1)
>
> I'm feeling unhappy with my present style of teaching and would like an insight into another style. (21/S1)

Six responses mentioned wanting to increase the personal confidence of the teacher, for example:

> I lack confidence in my own scientific ability. (5/S1)

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[2]The first number refers to the teacher code and the second, the survey number.

To give me more confidence in carrying out my role as Science Leader in the school. (13/S1)

To become more confident and comfortable about taking science. (15/S1)

Because science is an area I lack confidence in generally. I have never specialised in any of the sciences either at High School or Training College. (17/S1)

Five responses mentioned that the school had supported their application for the course or had suggested that as they were resource teachers it would be a good course to come on, for example:

I was directed to do so with some reservations. (1/S1)

Feel a need to keep in touch with trends in science teaching particularly as I'm supposed to be school resource person! (10/S1)

I am interested in science and being the resource teacher for science at school, the more I can learn and understand about teaching science, the better I must be. (12/S1)

I'm seeking an HOD job somewhere and suspect that the teaching of science is leading in the direction this course espouses, so believe that doing this course will enable me to give a department better direction. (21/S1)

Changes in the curriculum and the science initiatives were also seen as reasons for coming on the course, for example:

My expectations are to get an insight into the new science initiatives. (1/S1)

I expect to gain knowledge in teaching methods and science knowledge. Familiarise myself with the science curriculum and the new initiatives.(11/S1)

Other reasons for coming on the course were just meeting new colleagues and finding out new ideas that would be inspirational, for example:

Meet new colleagues. (1/S1)

Friendship and professional guidance from colleagues. (11/S1)

We do not get many opportunities to discuss the learning of science with people outside the primary sector and I look forward to hearing the other peoples' points of view. I expect to get ideas to inspire me! (12/S1)

Expectations for the course were that they would get new strategies for teaching science and an improvement of the learning in the classroom. For example:

From this course maybe I will get strategies for putting theory into practice, confidence in myself and ways to boost science in our school. (5/S1)

I wish to learn some ideas about putting a 'developmental' programme for science into practice in my classroom. (13/S1)

Ideas to excite the children in my class. (14/S1)

In summary, the teachers on the course had volunteered to come knowing the on-going nature of the course and that there would be some assistance to them within the school. They identified the need to have some professional development in their science teaching and were anticipating that this would be a benefit for them personally. They expected to gain confidence and new strategies for teaching science as well as meeting new colleagues. There was also the expectation that they would get ideas that would be inspirational to them and exciting for their students. It is important to recognise this particular aspect of teacher development, that many teachers having the opportunity to participate in teacher development course do so with the expectation of 'being inspired' even though there are personal costs associated with the disruption to their daily routines.

## 5.5 INTERESTS RELATED TO SCIENCE

Sixteen replies were received to this question indicating the interests that teachers had in science or science related activities. Their interests were varied and followed a predictable pattern of general interest choices. For example, seven teachers identified watching TV programmes such as Our World and Towards 2000. Conservation, bush walking and gardening were also popular. Astronomy was an interest of three teachers with one teacher identifying an extensive reading in this and other areas of science. Only three teachers identified practical science as an interest and were involved in bird breeding, electronics and sea shore studies.

Two of the teachers belonged to the Waikato Science Teachers Association, the others had no other professional affiliations other than union memberships.

## 5.6 SUMMARY

Teachers on the course were generally experienced primary teachers drawn from both large and small rural schools. Almost half of the course members indicated they had no in-service experience in science. They had volunteered for the course for their own professional development, wanting to improve their own teaching of science, to gain personal confidence in science and more generally, to get new ideas and inspiration from the other course members and the course itself. Most course members had some general interests in science with a few having specific hobbies with science related activities.

In the following chapter, the visits to schools are described with details of the classroom observations and work with teachers.

# CHAPTER 6.

## CLASSROOM VISITS

### 6.1 INTRODUCTION

Visits to all participating teachers in their schools were planned as part of the teacher development programme. While talking about classroom practice on the course encourages reflection and does give personal support and feedback to the participants (Bell, 1992), it is felt that reflection on practice best happens with feedback tied to the specifics of classroom content and context. It was planned to observe all the teachers on the course in action in their classrooms and talk with them after the lesson. It also allowed evaluative data to be collected on how the teachers put new ideas and teaching methods into practice.

An initial visit was made to each participating school to meet with the principals and the teachers volunteering for the course. During this visit , the time allocation for in-school work was mentioned and an offer was made to the principal to talk with other teachers and at full staff meetings as well as working with individuals in classrooms. When the course was underway, arrangements were made to visit schools the end of course session. With the exception of one school where it had been unable to schedule a visit, most other participating schools were visited at least twice with three schools being visited for a third time. Four principals took up the offer of the author talking about the work of the course at full staff meetings and a further principal encouraged the author to work with teachers at all levels in the school.

### 6.2 CLASSROOM OBSERVATIONS

The timing and the specific object of the visits to the classrooms were negotiated with the participants. It was suggested that either video- or audio tapes could be made of the teacher's interaction with the pupils to allow the teacher concerned an opportunity to view or listen to themselves in action. It was felt that this would enable the teacher to reflect more easily on what they had planned to do and see /hear the response from the pupils. The use of radio transmitting and receiving equipment gave the necessary clarity to the tapes of the teacher interactions and enabled the teacher to focus on their responses to the pupils without the general background noise of the classroom.

Twenty four different classes were observed over the course of the contract. The primary classes (16) were visited twice, the different secondary classes (8) generally once only. (Timetabling meaning different classes were seen on each visit). In the first series of

visits, less than half of the teachers were interested in having recordings made of their interactions with the students. Two video recordings and eight audio recordings were made. In the second series of visits in the third term no recordings were requested and all teachers visited were happy with verbal feedback on their practice. Generally during these visits the teacher made use of the course facilitator as a resource in the classroom to enable them to spend more time with individuals in group work or to help work with the class.

In all classes the teachers were either working with one of the resources from the course or they were using interactive methods demonstrated on the course. In many cases the teachers had changed their class programme around to demonstrate science activities during the visit. During most visits, arrangements for cover had been made with the principal for the teacher concerned to spend time discussing the lesson. Where this had not been arranged, time was taken after school for discussions.

It is readily obvious in classes where teachers are working in ways that takes into account students' thinking, that there is much thinking on the spot by the teacher. This is not to suggest that planning is not evident in the work of the teacher, rather that the very nature and variety of the experiences the students bring to the activity demand a diversity of responses and decision making. This wide variety of experiences surprised teachers in most instances.

## 6.3 LESSON DESCRIPTIONS

Examples of the lessons observed are detailed below.

### Torches

A junior school teacher chose this unit on torches (Barker, 1991) as a science experience with five and six year olds. She had informed parents through personal contact and newsletters and asked them to give their child a torch to bring to school. At the beginning of the lesson the class explored the reasons why they might need to use a torch. They then investigated what was needed to make a torch go and taking the torches to pieces identified all the parts. The task was then to put the torches back together and get them working with the planned expectation that some of the torches would not work as the batteries would be around the wrong way. This then led to a discussion on the correct way to have the batteries in the torch and a redefining of the pupils' descriptive term for the positive terminal (the humpy bit on top) using correct terminology. The lesson ended with the pupils drawing and colouring in diagrams of torches.

Throughout the lesson pupils' ideas and observations were sought, their ideas valued and affirmed and most importantly built on and added to in the lesson. In discussions with the teacher after the lesson, she noted that the unit was the first time she had attempted the topic and that it had been carefully planned with most of her specific objectives met. While she wasn't sure that the torches would necessarily 'not work' after being pulled to pieces, it was a likely expectation and consequently further activities were planned around this point. It was important to her that the correct terminology be introduced in an appropriate manner and that this was successful was observed in the way several of the pupils self-corrected when describing the battery, referring to the 'humpy bit' as the positive.

Soils

This unit of work was introduced during an observation of a fourth form horticulture class. The initial activity was the introduction of three types of soils and the class were asked what they noticed about each type. Words describing the soils were written up on the board and each word explored as to what the understanding the class had for the term. After this starter the class moved outside to look at a soil profile recently exposed by the gardener. Coming back into the class all students were asked to write down four questions they had about soils. All responses were pooled and a class list of questions drawn up on the board. At this stage the teacher added in his questions to the list. Students were then asked to identify specific questions they would like to find answers for and individual work got underway.

Asking the students to come up with questions of their own, questions that they had about soils was something the teacher was unsure about. He hadn't done this before and had felt that the important things he wanted to cover would be missed by the students. However, in the event that they were, he felt he had the opportunity to add in his 'questions' to the students' list and have them accepted. What he was surprised at was the inexperience of the students in formulating questions and their general inability in designing how they could find answers. What he was pleasantly surprised by was the interest the students showed in working through what had been in the past a 'slow and tedious' part of the course.

Electricity

The teacher had planned to do weather and had only picked up electricity because the principal was using the weather resources with another class. The initial activity with the F1/2 class was to get a bulb glowing when given one wire and a dry cell. The class was split into working groups and when they had accomplished this 'simple' task had a sheet

of predictions to make about other diagrams of circuits that would/would not make the bulb glow. Ideas of electrical energy and the output from various household appliances were also investigated in this initial lesson.

The teacher was amazed how long some groups took to get their bulb glowing. She commented that several of the boys especially were from farms and 'practical' in their work on the farm and in their other interests. Yet some of these students took twenty minutes or more to get the bulb glowing. It was this insight into the thinking and abilities of the students in her classes that she found interesting. She had felt she knew them well as individuals and yet finding out what ideas they had was a new experience. She also gained a lot of confidence in her own ability to introduce topics into her class that previously she would never have contemplated.

Volcanoes

Two S.2/3 classes were working together studying volcanoes. A video had been used as a starter activity and then the students' before-views and knowledge about volcanoes sought. Questions about volcanoes were collected and categorised. Resource material had been ordered from the National Library and students had also been encouraged to bring resources from home. Students were grouped and had their own questions to research and present to the class.

During the lesson, the teachers spent their time with individuals and groups exploring what ideas and knowledge the students were gaining and what further questions were emerging. The teachers were acting as resource providers as well as challenging ideas, extending the students thinking and generally managing the learning that seemed to be occurring. They had planned for a geologist to visit the following week. In discussion after the class the teachers commented that they were less concerned about students knowing specific facts and more concerned that the students developed process skills. An emphasis they both took in their interactions with the students was to get the students to state their ideas which they then worked at extending where appropriate.

Inheritance and genetic variability.

This unit was introduced with a fourth form class by starting with a concept map based on a series of terms written on the board. Students were given a piece of paper and asked to arrange the terms in a way that made sense to them with lines showing relationships drawn between the terms. After a lot of discussion, debate and argument between students these individual maps were collected in with the advice to the students that they would get them back at the end of the unit to see how much learning had gone on.

The term variation, was then explored with the students with the teacher also adding into the discussion questions for the students to consider. When a list of variations was established, individual students were given the opportunity to research an item from the list or something else that interested them and could be considered an inherited variation.

The teacher was in control of the learning process throughout the lesson although he presented few facts and wrote little on the board. He got students using activities designed to probe their understanding and talked with them about their learning and the reasons for the activities he chose. The class were motivated, organised and enjoying their work. Speaking to the class while the teacher was absent for a spell, they commented that they looked forward to the discussions in science, 'being one subject where they were allowed to voice their own ideas.'

Similar activities were seen in a sixth form class with the same teacher; an extensive use made of concept maps, students researching questions that they had decided on, reference books used by students instead of text-books, individual and group presentations to the whole class with the teacher taking more of a resource role in the room.

In other visits to primary schools, teachers were using resources given to them on the course. In one school in particular, where three teachers had come on the course they were all using the same unit 'Floating and Sinking' (Biddulph and Osborne, 1984). They were at three different class levels (New entrants, Standard 2, form 2) and felt happy in planning together, organising resources and discussing the different results.

## 6.4 DISCUSSION

As observations and visits to the classrooms started in the second term after session 4 of the course, it was not possible to determine what changes had been made. However, teachers were using techniques modelled on the course and it was obvious that they used them frequently. The activities that the students were engaged in seemed to be richer for students in that; they were initiated in ways that were inclusive of all students, decision making was encouraged, students were expected to design their own investigations, lots of discussion took place, the activities seemed to be enjoyable and generally were open-ended.

Teachers commented that having visits from the author meant that they were prompted to use the activities and techniques from the course. However, it was difficult to arrange convenient times for all teachers and this proved a problem on occasion. In many primary schools it appeared that science is taken in rotation with another subject and this meant that some teachers admitted to doing little science during a term, maybe two three week units of work at the most (amounting to about 12 - 18 weeks per year). Timetabling also

proved to be a problem and although some visits to primary schools were short, generally a whole morning or afternoon was spent with the teacher.

Staff meetings were spoken to at four separate schools and the work done on the course explained. In all cases it helped the course participant raise the profile of science in the school and give some indication of what resources were available. It proved to be an advertisement for the course and some of the workshop activities modelled gained good interest.

## 6.5 SUMMARY

Teachers were generally engaging in new activities for them, activities that involved them in finding out what students were thinking. They were also finding that working in this way involved them in teaching skills to students, skills of information gathering and processing, skills that they had assumed the students would have had. They were engaged more in meta-learning activities (White and Gunstone, 1989) 'learning students how to learn'.

No teacher commented on not having control of the learning process, although, their initial fears were that involving students may have caused some loss of control in class situations. The benefit of having the facilitator present was that they could get immediate feedback on their experiences and someone present with whom they could share some of the excitement of their new ways of working. It also represented a chance to plan further actions. It is interesting that the majority of the primary teachers observed were using units of work and resources given to them on the course. The secondary teachers were adopting constructivist techniques and implementing them in small ways in their general programme.

Staff meetings were addressed about the nature of the course and some workshop activities carried out with the teachers. The value of talking at staff meetings is questionable. Staff in rural schools often had farming activities to attend to at the end of the day and meetings were rushed. Travel to schools in rural areas is time consuming and on several occasions when visits had been arranged to observe individual teachers, school events as cross country running, and general sports events took precedence.

In the following chapter, the analysis of the two sessions of reflective writing on the teachers' personal theories of teaching and learning is presented and discussed.

# CHAPTER 7

## REFLECTIVE WRITING

### 7.1 INTRODUCTION

In an article on the importance of reflection in improving science teaching and learning, Baird et al (1991) reported on the use of structured personal reflection - in which teachers are asked to concentrate on their more general life experiences as a teacher and as a learner. This so-called phenomenological reflection was designed to complement reflection on practice in the teachers classroom. While teachers were asked to comment in the journals that had been given to them at the start of the course, few appeared to be using them in a consistent manner to record their views and observations. It was therefore decided to structure their reflection using an evaluation form similar to that reported by Baird et al (1991) and repeat the same evaluation later in the programme.

The first phenomenological reflection took place at the end of Session Three and was repeated at the end of Session Nine. Teachers were given the option of completing the form, writing freely about the course or leaving early. (A sample reflective form is included in the appendix.) In both sessions the questions were answered by all teachers present. Sixteen teachers filled in the first reflection form and seventeen teachers filled in the second form. Thirteen teachers filled in both forms. A collated set of responses was given back to the teachers at the session following the collection of the data.

The majority of the responses were quite insightful and when the two sets of responses were compared, differences emerged that indicated the intellectual development of the teachers over the course period.

### 7.2 RESPONSES TO QUESTIONS

#### Question One: 'What is it, to be a teacher of science?'

In answer to this question in the first reflection, the responses showed a focus on teaching activities and a 'traditional' view of science teaching.

> The same as being a teacher of reading, maths, sports/PE, music, art, language etc.
> A responder, reactor and setter up of situations that make the subject exciting and necessary. (1/1)[3]
> A balancing of the many constraints, requirements, needs that arise both internally and externally, such as:

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[3]The first number refers to the teacher code and the second, the number of the reflective evaluation.

Is the content which is laid down being put across?
Helping pupils learn how to learn and develop skills.
Maintaining an environment where learning can take place. (2/1)

A big responsibility to make sure the children get that certain body of knowledge. A burning desire to spark off an interest and enthusiasm for science and the knowledge, skills, attitudes of a scientist. A need/desire to help kids learn how to learn, and to realise science is not the great mystery for academics, but the explanation behind everyday things. (5/1)

To be a motivator - to stimulate and get children fired up and keen to find out. To be a resource and a model in collation and presentation of ideas. To be exciting! (12/1)

It means taking science units three or four times a term choosing the units from the school prescription. (15/1)

I see it as one of the areas I have to cover in the curriculum. I do not regard it as a strength area in my teaching. (18/1)

Challenging, rewarding, interesting, practical and infinitely variable. I continually look for new and different ways of presenting material - I have yet to find the best way, perhaps I never will. (20/1)

In the second reflective evaluation the participants seemed to have moved from seeing themselves as teachers discussing activities, resources and teaching roles to being more concerned about learning and their role in helping students learn. They appeared to be more interested in working with students and focussed on their learning.

Being an interactor, a listener, a guider and at times a provider. (1/2)

An opportunity to help others develop their mental pictures in a logical framework, see inconsistencies and modify ideas to account for them. (2/2)

Interesting, fulfilling, challenging. Lots of work (planning, preparation) because of a scanty knowledge base. I didn't realise how little I knew until I came to teach science I hadn't ventured into before. The course and discussions have given me confidence and ideas on new topics and it has been interesting learning from the kids and from reading about lots of new science. (5/2)

To be open minded and to listen to the children, to encourage them to question intelligently and to add questions of my own. To pose problems, situations and give experiences that will develop both the knowledge, and the process of acquiring knowledge in the children. (12/2)

Helping children make sense of their world and developing their knowledge in certain areas. 15/2)

Working with the children and now not having to know all the answers. (18/2)

To have fun and work with students thoughts and ideas. (20/2)

**Question Two: 'What is science teaching?'**

Many responses to the second question were reasonably similar in both evaluations and several of the teachers referred in their responses to the previous question. Where there were changes evident, again the shift seemed to be from a focus on teaching to a focus on learning. For example, the paired responses of several teachers show the general growth and development of teachers' thinking.

> It's discovery learning. It's providing a vast amount of resources (including me), in the hopes that something will trigger a desire to find out more. It's just an extension of all other learning. It's inextricably bound up with the rest of the programme. (5/1)
> Facilitating a change in thinking. The facilitating has been made easier and more focussed by things learnt on the course. The change is what I now know is important where before I wasn't acknowledging existing concepts, now I am using them and helping progression from there. (5/2)
>
> Teaching about the world around them. Science teaching for me is thus an integral part of my teaching. (10/1)
> Focussing childrens' attention on aspects of the world around them. Encouraging them to observe what's there and assist them to make sense of it. (10/2)
>
> Teaching or aiding learning in those areas of knowledge commonly called science under our present curriculum. To hopefully promote further learning or investigation. 16/1)
> Teaching children the syllabus in a new and more challenging way for them and me. By taking into account their thinking and providing scaffolds we both end up with a more happier and positive result. (16/2)

The first evaluation was done after the third session and it is felt that there had already been some movement in the teachers' thinking about science teaching. However, common phrases used in the first responses were not as evident in the second evaluation. For example, there seemed to be a 'process' view of science teaching in the first set: 'embarking on a journey', 'discovering/imparting knowledge', 'fostering of childrens' natural inquisitiveness', teaching children to learn process skills', a 'hands-on activity', 'providing a role-model of scientific inquiry'.

In the second set, teachers seemed to have developed a more constructivist view of science teaching and the phrases differed, for example: 'stimulating pupils to think about and modify their concepts, 'helping students understand or revisit understandings in greater depth', 'making sure everyone's opinions are listened to and valued', 'going from what the children know and moving outwards in their directions and mine', 'try to listen to childrens' ideas and help them to clarify these', 'interacting with students in a meaningful way'.

**Question Three: 'What is science learning for my students?'**

Initially their responses were that science learning was 'fun' and 'experiment, observe, result, predicting, classifying, measuring, conclusion', a process view of learning. In the second evaluation the responses showed that there was now a view that learning in science is more about students making sense through 'discussion, linking, exploring, making sense of everyday things, questioning, adding to, changing their ideas' – again a more constructivist view of learning. Paired responses showing the changes in views are given below.

> An enriching experience. a chance to find out something that interests them.(1/1)
> Making sense of the world around us through a growing understanding. (1/2)
>
> At non-exam levels – developing skills (learning skills, research skills, manipulative skills, language skills etc) and ideas.
> At exam levels – absorbing content, but mainly applying basic ideas to familiar and unfamiliar situations. Problem solving. (2/1)
> They confront their ideas. First they must clarify what it is they think, then challenge their ideas and either substantiate or modify them. (2/2)
>
> I think it is in a box on the timetable, they have been conditioned to doing 'projects' in a 'project book'. they don't want to share their research because they would rather own it. Ideas – similar attitude. Attitudes very slow to change.... If they were to classify all the things they think they have learnt this year in 'science' I think it would be tiny. (5/1)
> I think it is both a topic and an attitude about anything. When it is a topic, it experiments, discussions, predict/observe/explain. When it is an attitude we as a class have towards anything that comes up, they possibly do more incidental science learning although it is not labelled as such. An example would be: topic – Olympics, question – What makes the Olympic flame burn perpetually? (5/2)
>
> Enjoyable (hopefully) on going, about observable everyday happenings. Helping them to develop process skills they will continue to use and apply to other situations. (14/1)
> Linking new knowledge to previous ideas. Making sense and learning more about everyday things. Developing an observant, inquiring mind. (14/2)
>
> Manipulating chemicals and equipment. Observing, thinking, discussing, collecting data, learning good habits. (20/1)
>
> My students hopefully have fun, contribute thoughts and ideas, and through these gain knowledge, skill and understanding of the world around them. (20/2)

**Question Four: 'What is the most important feedback in science teaching**

Feedback is important to teachers, especially feedback on how well they are performing in the classroom. Fourteen of the seventeen responses in the first evaluation identified the most important feedback coming from their students. All of the sixteen responses in the second evaluation mentioned students as important sources of feedback. A difference was evident in the replies. This was expressed in that the teachers were not so exam orientated/

right answer directed in terms of the feedback they sought in science teaching. The feedback comes directly from the student – communication, on-task, discussion, increased interest, active involvement and most noticeably comments about 'seeing evidence of childrens' thinking changing based on what they have experienced/discussed' (19/2) Paired responses are given below.

> Wanting to do something again – the expectation that it is going to be exciting. (1/1)
> Growing confidence reflected in the pupils ability to question and so appears to be more curious and knowledgeable about the subject, attitude, carrying an interest long after a topic has been completed. (1/2)
>
> Can they produce the 'right answers' when called on to do so. Have they managed to develop at the same time. (2/1)
> Pupils developing rational explanations of the way the world works, and using these as a basis to work from when tackling new topics and problems. (2/2)
>
> Knowing one is on the right track. (4/1)
> Hearing from children their interpretation of the way things are, the way things operate, the way things act and react. (4/2)
>
> Most important feedback is the enthusiasm to get on and 'do' more/learn about something else etc. (13/1)
> The way children communicate their willingness to go on and discover more. In thinking books, when the 'most important or interesting thing I learned today' was something about science. (13/2)
>
> Questions, the enthusiasm to explore further, the gaining of the desired knowledge. To promote extra thought and break into new ground they have not previously been on. (16/1)
> To see more children actively involved in each topic, to see children remembering more about what they learnt and experienced, to see them want to continue out of school learning. (16/2)
>
> I know a lesson has gone well if students have got consistent results (they understand my method), they score well on my check test next period, they are on task most of the time, the latter of which is the best indicator for me. (20/1)
> A continued interest of my pupils in science. (20/2)

### Question Five: What is the worst aspect of science teaching?

Teachers' concerns were similar in both evaluations. Time, the perceived constraints of the syllabus (exams), insufficient resources, the apparatus not on hand, were all seen as real concerns. In the second reflective evaluation, exams were not seen as a major problem and teachers were identifying more personal concerns about insufficient knowledge to answer or direct childrens' questions appropriately. Paired answers are given below.

> Syllabus(exam) constraints are a strait-jacket to real learning and development. (2/1)
> The difficulties of effectively achieving these outcomes with large numbers of students, the straight-jacket of the syllabus, and particularly the depression caused

by students who cannot be motivated or coerced into taking responsibility for their learning. (2/2)

One never seems to have enough knowledge to reach a satisfactory conclusion. One question always leads to another. Thinking is always time consuming and would be more satisfying if one could tap a good science resource. (4/1)
Having insufficient 'knowledge' to 'scaffold' well. Being unable to think quickly enough 'on my feet' to guide the children's thinking towards the scientifically desirable end. (4/2)

Lack of adult to child supervision for 'dangerous' activities limits my planning. The cost of experimental expendables, setting up equipment – what do we need to spend the money on to be the most use. (5/1)
Getting all the equipment assembled for practicals. Having a carpet to worry about. Too many kids to give quality time to. (5/2)

The most bothersome aspect of science is that the apparatus is not always readily at hand (in primary school). Sometimes we need to research through books rather than have 'hands on' opportunities. (13/1)
The worst aspect is the dilemma of acceptable amount of planning. It is difficult to plan for the 'unknown' before getting into a topic. Day to day planning seems to be the most productive/constructive as it's geared along paths the children want/need to go. It also makes the setting up of practical experiments since there is only one day to the next lesson. (13/2)

From my point of view it is having to take the physics and chemistry side of science. (15/1)
Finding suitable activities that will develop or answer their questions considering my lack of knowledge in many areas. (15/2)

The fact that all students know they must eventually sit an exam and that their parents also know this and are expecting a more closed teaching approach similar to the one they experienced. (17/1)
The limited background which I myself possess still (though to a lesser degree than I previously thought) makes me feel that my own interaction with children in learning situations is less effective than it could be. (17/2)

The worst aspect is the time restraint. Having to complete a unit simply because another class wants the textbooks, or finishing early and wondering what to do while waiting for the next unit resource. (20/1)
Dealing with unproductive moods of students. (20/2)

### Question Six: What has answering the five questions made me think about?

Answering the questions in the two reflective forms appeared to be useful in getting teachers to reflect on their practice. Responses in the first set indicated that a process of finding out where they were at in their practice, what they were doing in the classroom was underway. They seemed to be asking questions, problematising their practice and seeking some understanding in what they were doing. In their answers to the second set, there seemed to be a greater confidence in what they were doing and a greater reflection on their roles as teachers. They appeared to be not quite as negative about their teaching and there seemed to be a greater comfort in what they were doing with their classes.

Obviously the questions gave them a chance to reflect on their work and relate their thoughts. There was also a greater confidence in thinking about learning and accepting problems. Sample responses are included below.

**Set One**

Myself as a teacher and that science is only one interrelated part of the total primary school curriculum. I must constantly remind myself that I am a teacher and not a teacher of science. (1/1)

What are the best ways to 'cheat the system'? How much developmental learning can be carried out without compromising pupils' chances in exam situations? (2/1)

What I am really trying to do when I teach science. (3/1)

Think about my class of students and whether or not and how I get through to them. (12/1)

I have thought about how I can more involve myself with encouraging the children to be more investigative and not take one view as 'the ' correct one. To extend ideas by using the 'view finders'. I love the ideas of the 'thinking book'. I feel it would be very useful during evaluation of my teaching. (13/1)

What I do, would like to do, what the children can do and how I can hopefully improve our lot for the future. Reflect. (16/1)

The learning process. How children learn and how we can gauge what they have learnt. (17/1)

Evaluate again my position on the open - closed continuum you spoke of today. I like to think I am slowly progressing away from the closed end. (18/1)

It has made me think about why I started teaching , what I give to the students and what I expect to get back in return. (20/1)

Am I able to be honest in appraisal of myself? (21/1)

**Set Two**

Learning is ongoing - reaching understanding is like peeling away the layers of an onion - is the ultimate an absolute truth? (4/2)

You often make me verbalise previously vague philosophies, and I find it thought provoking and it is good to feel challenged in such a non-threatening way. I am constantly challenging myself to find better ways to do things (not only in Science). (5/2)

It has made me realise that there actually has been quite a different approach by me and the kids lately to Science, which I need to continue. I feel more confident and would now like to think about passing concepts from this course on to the rest of our school - staff meetings, visiting other classrooms etc. (7/2)

Rather than looking at each individual topic in Science and evaluating it's success/draw backs, looking at the whole of my science programme, what things are similar in all my topics. (8/2)

The balance between the content of what's learnt and the process of learning. (10/2)

They have made me think about the way this course has relayed to me, the much more effective way that this Constructivist teacher method is in the teaching of children. (13/2)

How I teach, techniques used, children's ideas and reactions to work and ideas. (14/2)

My ideas about learning in Science have changed since the beginning of the course. I have taught more science this year than previous years. (17/2)

Probably that I am more confident than previously and do not get 'upset' if things don't turn out the way I had thought. I don't use the reason that my own scientific knowledge is lacking as much as before, as an excuse for not taking science.(18/2)

It has made me reflect on what I do, and what I would like to do, in teaching science. (19/2)

It has made me think seriously about the job I'm doing and why I'm doing it. (20/2)

## 7.3 DISCUSSION

Baird et al (1991, p. 169) note that teacher development must take account of and build on the general elements of 'intellectual competence and performance', those related to personal awareness, sense of self and professional purpose. They felt that there were indications that this sort of development was facilitated through personal reflection based on thoughtful, considered introspection. It is obvious in the answers to both reflective writing exercises carried out on the course that this development was occurring in the participants thinking about teaching and learning of science and that this was based on their own practice in the classroom as well as the theoretical aspects presented in the course sessions.

The following chapter presents the results of the pre- and post course survey questions. Each of the fourteen questions is analysed and discussed separately.

# CHAPTER EIGHT

## SURVEY DATA

### 8.1 INTRODUCTION

The survey documents were based on those used in the Learning in Science Project (Teacher Development) (see Pearson and Bell, 1992). The initial survey was designed to collect baseline data on the course participants teaching backgrounds, and their views on teaching, learning and science. Participants were also asked to describe their teaching practice and a series of recently taught science lessons. A second survey was given at the end of the course to document changes in participant's views and teaching practice.

This chapter reports the responses to the second section of the surveys. The question format required either written accounts to the question stem or the noting of options on a rating scale (1 — 5). Responses from both surveys have been compared to document the changes in teacher views and practices. The main themes covered by the questions were:

current teaching practice
views of science teaching
views of learning science
personal views of learning
reasons for science and technology in the curriculum
understandings of the curriculum
understandings of science
experiences of teacher development.

Each question is discussed separately with a qualitative analysis on the written answers performed, categorising each answer. A statistical analysis using the Wilcoxon signed rank test for paired comparisons was performed on the responses to the questions to determine changes to teacher ranking. The Wilcoxon test takes into account the absolute size of the shifts involved and their direction and is considered more sensitive than other similar tests. The exact probability of the summary values of the ranks (T) was calculated using tables of the signed rank combinations giving $T \leq$ the sample rank value, and a table giving the total number of signed rank combinations.

$$\text{ie } P(T \leq t) = \frac{\text{number } (T \leq t)}{2^n}$$

## 8. 2 QUESTION RESPONSES

### Question 15/3: Teaching science in my classroom currently involves

Teachers were asked in both surveys, to rate on a 1-5 scale (always, mostly, often, sometimes, never) their usage of a number of activities which were part of their current teaching practice. Individual responses made to each question stem were tabulated. Changes in the scaling responses of individual participants were noted and these changes added to give an indication of overall movement in each question stem (Figure A). The bar sizes give an indication of the number of changes recorded between the two surveys. For example, in response to the first stem 'Teacher-led discussion' eight participants changed their scaling responses from the first survey. Six indicated they now spent less time on teacher led discussion while two indicated they spent more time. The overall movement in the scaling indicates a move towards more constructivist teaching practices.

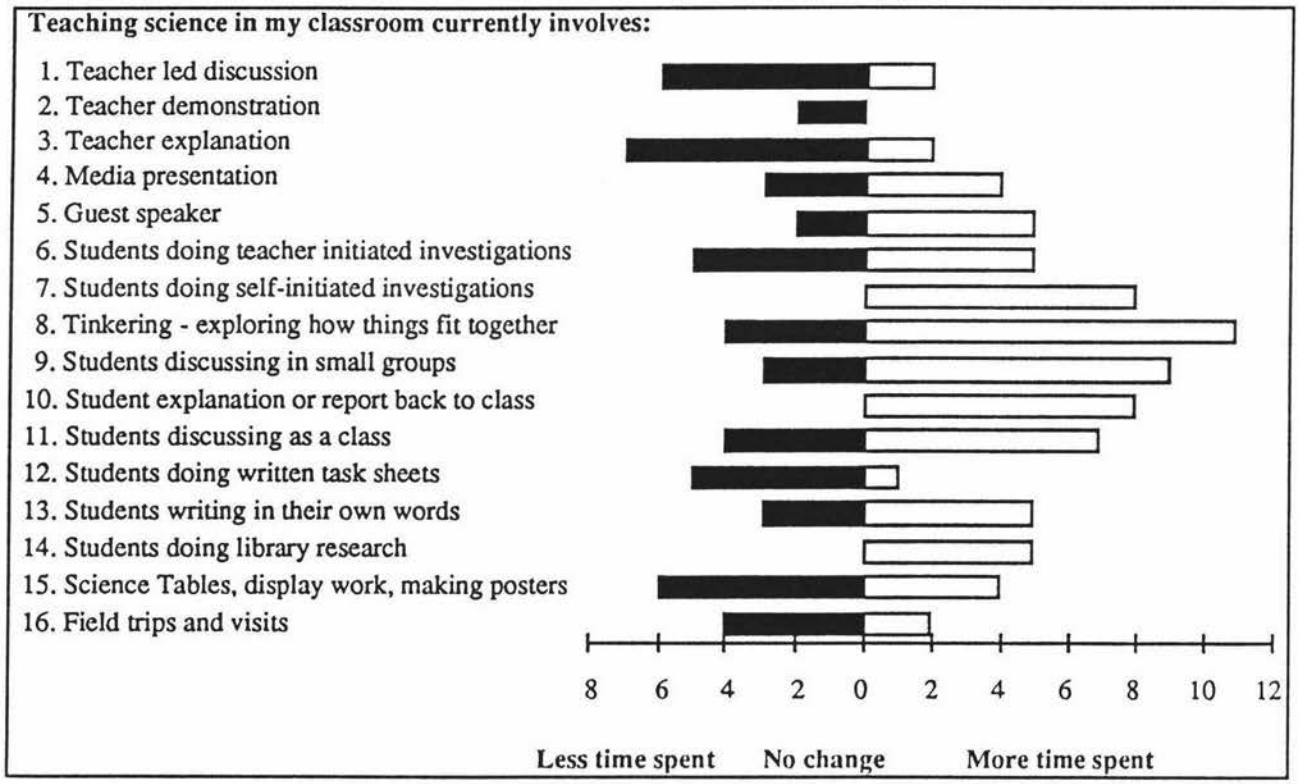


**Figure A: Teaching science in my classroom currently involves**

In the overall classroom activities there was a trend towards student-centred activities and away from teacher-centred activities. More time was being spent on : media presentations, guest speakers, students doing self initiated investigations, tinkering(exploring how things fit together), students discussing in small groups, student explanation or report back to the whole class, students discussing as a class, students writing in their own words, and students doing library research.

Less time was being spent on; teacher led discussion, teacher demonstration, teacher explanation, students doing written task sheets, science tables, and field trips and visits. There was no overall change in responses to students doing teacher initiated investigations.

To give an indication of how usual each teaching activity was, all the scaled responses were scored (1-5), summed and averaged (Table 1). A statistical analysis was made to determine the significance of the reported changes. (This data is recorded in the T values and probability columns in Table 1. While some T values are low, usually denoting significance, if the number of changes were also low as shown by the overall shift then the change could not be considered significant.)

**Table 1: Teacher Mean Ranked Scores of Teaching Activities**

| Teaching science in my classroom currently involves: | Survey One Mean scores | Survey Two Mean scores | Shift | T values | Prob. |
|---|---|---|---|---|---|
| 1. Teacher led discussion | 2.81 | 3.17 | 0.36 | 25 | NS |
| 2. Teacher demonstration | 3.63 | 3.76 | 0.13 | 1 | NS |
| 3. Teacher explanation | 3.06 | 3.61 | 0.55 | 19 | 0.04 |
| 4. Media presentation | 3.94 | 3.94 | 0.00 | 84 | NS |
| 5. Guest speaker | 4.44 | 4.22 | 0.22 | 44 | NS |
| 6. Teacher initiated investigations | 3.00 | 2.94 | 0.06 | 279 | NS |
| 7. Students doing self-initiated investigations | 3.94 | 3.22 | 0.72 | 1 | 0.01 |
| 8. Tinkering - exploring how things fit together | 3.94 | 3.33 | 0.61 | 970 | 0.03 |
| 9. Students discussing in small groups | 3.18 | 2.78 | 0.40 | 417 | NS |
| 10. Student explanation or report back to whole class | 3.29 | 2.72 | 0.57 | 1 | 0.01 |
| 11. Students discussing as a class | 3.29 | 2.94 | 0.35 | 423 | NS |
| 12. Students doing written task sheets | 3.94 | 4.22 | 0.28 | 5 | NS |
| 13. Students writing in their own words | 3.59 | 3.33 | 0.26 | 59 | NS |
| 14. Students doing library research | 4.00 | 3.67 | 0.33 | 1 | 0.04 |
| 15. Science Tables, display work, making posters | 2.76 | 3.00 | 0.24 | 221 | NS |
| 16. Field trips and visits | 3.41 | 3.41 | 0.00 | 18 | NS |
| Number of replies | 19 | 18 | | | |

NS: Not significant at the 0.05 level.

There are some activities with significant shifts (statistically). Teachers were explaining less (stem 3), students were doing more self initiated activities (stem 7 and 8), talking about their own work more (stem 10) and being involved in library research (stem 14).

An index of teacher behaviour was constructed (Ritchie, 1992) to give an indication of the change in individual teacher's practice. Question items (Figure A) were given positive or negative weightings dependent upon whether the behaviours described would be expected from teachers with a constructivist approach to teaching science. For example, items like 'teacher led discussion' were given negative weightings and items like 'students discussing in

small groups' were given positive weightings. A composite score was obtained by adding the weighted items and used to obtain the shift towards the constructivist practices promoted during the course (Table 2).

**Table 2: Teacher Composite Scores**

| Teacher Code | Survey 1 | Survey 2 | Change |
|---|---|---|---|
| 1 | 31 | 39 | 8 |
| 2 | 28 | 30 | 2 |
| 3 | 29 | 30 | 1 |
| 4 | 32 | 34 | 2 |
| 5 | — | 37 | |
| 7 | 32 | 34 | 2 |
| 8 | 35 | 36 | 1 |
| 10 | 30 | 34 | 4 |
| 11 | 32 | 34 | 2 |
| 12 | 28 | 32 | 4 |
| 13 | 31 | 39 | 8 |
| 14 | 32 | 30 | -2 |
| 15 | 21 | 26 | 5 |
| 16 | 27 | 32 | 5 |
| 17 | 36 | 44 | 8 |
| 18 | 33 | 40 | 7 |
| 19 | 34 | 38 | 4 |
| 20 | 27 | 37 | 10 |

Seven teachers had very consistent responses (movements of 1-2 places), five a moderate change in teaching practice (movement of 4-5 places) and five a marked change (movement of 7-10 places). While a difference between primary and secondary teachers was expected, it was not evident. Those individuals with marked changes in their responses also indicated in conversations during the course and visits to their school, that they found the course aims consistent with their feelings about the teaching of science and teaching in general. All were long service and experienced teachers. This is consistent with the findings of Ritchie (1992), that experienced teachers changed significantly more in a constructivist direction than did less experienced teachers and may be related to a greater ease in risk taking with new teaching approaches.

In summary, teachers indicated that there were changes in their current teaching practice after the course. They identified these changes as being more student-centred and consistent with the stated aims of the course, to promote more constructivist teaching practices.

**Question 16/4: Describe what you understand and feel about teaching science**

Following a question on current teaching practice, course participants were asked to detail their understandings and feelings about science teaching, to indicate changes in their views over their career (survey 1) and over the course (survey 2). There were 16 responses to this question in survey 1 (out of 19 completed survey documents) and 18 responses (all participants) in survey 2. In survey 2 replies were more specific about particular views now held.

In the first survey, six comments were made about understandings of teaching science. Four teachers saw teaching science as a way for students to understand the world around them, for example:

> Teaching science is the chance for children to be helped to understand the world around them — both natural and created (1/S1)[1]

> Teaching science is about helping children find out about the biological and physical worlds. I think that through science children should develop an interest in their immediate environment (15/S1)

> To help children come to a better understanding and increased knowledge of the world around them both natural and chemical. to help them to reach these conclusions in a way that they discover as much as possible for themselves from teacher directed studies or experiments. (16/S1)

Two teachers understandings were related to skills and attitudes they hoped the children would develop through the teachers efforts.

> Teaching science is encouraging a 'way of thinking'. To present situations which interest children and lead them to observe, discuss, question, experiment and find out. to try and explain why and record and report back observations are skills to be encouraged in students. Although the content of what is taught is important I feel how they find out is as important. (12/S1)

> Teaching science involves the teacher gathering resources and making them available to students. The students should initiate their own inquiries about a given topic and be guided by the teacher in their efforts to use the resources available. (17/S1)

Feelings about teaching science were reported in ten replies. Two teachers reported negative feelings.

> It's mostly like hitting your head against a brick wall. I started by thinking that pupils would be keen, willing and able to develop and learn, much as I was in school. This very quickly changed. Mostly it's trying to put across the simplest basic principles with minimal resources to a reluctant or at least unretentive audience. (2/S1)

> It has always been an area of insecurity in my teaching as I felt I did not have a sufficient or good enough personal background knowledge. It was always the part of the curriculum that was first to go when time was limited. I wanted to be able to give

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[1] The first number is the code number of the teacher, S1 is the first survey response.

> the students the 'right' information and/or answers. When I did take science I tried to include experiments but usually 'did' them myself. ... I know I feel a sense of dissatisfaction after some units and think perhaps so do some of the children — it's been fun but hard to say what they have 'learnt'. (18/S1)

Other teachers commented positively in their feelings about science. For example:

> Was very uncertain and actually negative at beginning of career. Have turned very positive and see a real need to teach and turn kids on to science. (7/S1)

> I enjoy teaching science. I see it as a subject that has obvious everyday relevance to the pupils and thus they are very easily motivated. (10/S1)

> I have found the more you do the easier it becomes. That children really enjoy finding out things and experimenting. That if you incorporate science into all areas of the day it makes more sense and that science is actually fun. (11/S1)

> I enjoy teaching science, especially to able students. (20/S1)

> I like to arrange for classes to have fun as often as possible. (21/S1)

Eight teachers stated changes in their views of teaching science over the course of their career. Commonly the change was from teacher centred class activities towards slightly more student centred activities. For example,

> I am now allowing the children more control of their learning, more discussion. (14/S1)

> My view of teaching science has changed somewhat from an emphasis on factual knowledge to now an emphasis on children investigating their world for themselves. (15/S1)

> My views have changed from a completely teacher led lesson and blackboard notes to one of providing ideas, questions, material, trips and experiments so that children can get first hand knowledge and experience of what we are about. To make it more interesting by my enthusiasm in the topics. (16/S1)

> Early in my teaching history, my teaching was to get kids to rote learn individual items. Now I like to get links between items across — the inter-relatedness of many units of work is important. (21/S1)

In the first survey a majority saw science teaching as helping children come to an understanding of the world around them and also in acquiring valuable process skills. As expected a majority of the course members had positive feelings about teaching science. Some of the participants reported changes in their views over their career realising that it was important to consider the interests of the children in their classes.

Eighteen replies were received for this question in the second survey. The replies were more detailed with often a page of writing detailing changes in views and teaching practice. All replies were positive about teaching and the changes made in teaching practice. In the replies

there appeared to be a strong focus on facilitating learning rather than teaching, with the emphasis on finding out childrens' ideas. For example,

> 'Teaching' science. I see my role now as a facilitator of investigation. The 'teaching' involved, is to enable children to undertake investigation in as much depth as possible. ... I am aware from my own point of view, that my current understandings are the sum of all previous experience, and that altered understanding progresses slowly as one examines new information and slots it into one's current thinking. So it is for children, who need many opportunities to observe, touch, smell, hear, taste, draw, take apart, put together, model, talk about, listen to in order to both expand their knowledge and reflect on it. (4/S2)

> It needs to be kid centred. Activity based learning is fun and therefore effective. Discussion between students is an effective teaching method (I knew that) and also an effective assessment method (I hadn't thought of that) (5/S2)

> For me, teaching science involves motivating the children to discover the 'answers' to their own questions themselves. Through initial starters then following experiments, children produce their own questions they want answered. It is then up to me, as the teacher, to provide the wherewithal for the children to discover an answer. I am a resource person now, not the 'giver' of all the answers. Before I began this course I was giving the answers as I believed them to be and the children expected me to provide the answers. There was a right and a wrong.
> This course has taught me skills to guide the children to take more responsibility for their own learning in all other curriculum areas. I have learnt more efficient ways of questioning children, encouraging them to become more critical of 'answers' given to them. (13/S2)

> Teaching science for me now is finding out what children's ideas and knowledge on a topic is and finding out what they want to know, then providing activities that help clarify, develop or extend these ideas. I am now trying to focus my attention on what the children already know and letting them drive the lessons more. (15/S2)

> The biggest change for me is the sharing and learning together aspect, rather than the old chalk and talk methods. The taking into account childrens' learning and ideas, the questioning, the more emphasis on self discovery and experimentation. The more enjoyment we both get out of it. The added interest the children have, how they extend their studies to home and out in all directions from the base topic. The added learning that appears to take place. (16/S2)

> I feel now that teaching of science should involve the teacher taking careful consideration of the way children think. I think that teachers of science should take care to discover what concepts the children already have on a particular topic. With this knowledge the teacher should then provide experiences and resources which will help the children to add to, change or modify their existing views. I feel that the teacher of science should endeavour most often to engage her students in activity based learning situations where the students can interact with resources and their peers whilst carrying out their investigations.
> At the beginning of the course I was committed to activity based learning, classroom learning centres and the extensive use of a variety of resources to develop students' ideas. However not considering myself a specialist in science I tended not to apply these principles as often to science teaching as I did in other areas where I was more confident. This course has revealed to me that by using these methods I too can be a science specialist and it is an exciting feeling. (17/S2)

> Since attending this course I think my understanding of science has changed considerably. I do not feel so constrained by the syllabus. I feel more at ease with

> getting ideas from the children and working with suggestions that they have. There is less emphasis on 'teaching' and more on facilitating their learning by finding out what they want to know and gathering resources for them to explore their queries. (18/S2)

> I have found using pupils ideas in the teaching of science to be a great stimulus in the classroom and motivator of my pupils. I have used it at all levels F 1-6. I feel my science lessons are more interesting and I have enjoyed sharing the ideas about using students ideas in lessons with other members of staff. (20/S2)

Changes were evident in the perception of teaching roles. For example, there were comments on facilitation (4, 18), on the teacher 'sharing and learning' with the pupils (11, 16), and in generally encouraging their pupils to share their ideas (2, 3, 5, 7, 11,12, 14, 17).

In summary, views of teaching science and perceptions of teaching practice developed over the period of the course in ways that were consistent with the general aim of the course; to develop teachers' classroom practice to take into account students' thinking and to develop new roles for themselves of listening and responding to students' thinking. Teachers wrote positively about the changes and the greater enjoyment they had in teaching science.

**Question 17/5: Describe a recent science lesson that you have taught**

Teachers were asked to describe a recent lesson or series of lessons that were indicative of their current practice. A difference in the descriptions was anticipated. Seventeen replies were received for both surveys.

In survey one, the general descriptions were of traditional activities with the teacher determining the structure of the lessons. Many of the primary teachers on the course described 'topics' they were taking with their classes, topics that were often a centre of interest with a variety of activities covering different curriculum areas. In most descriptions detail was given of the content that the teacher wanted to cover and the various activities they had chosen for the pupils. For example, one teacher described a series of a 'mainly maths' topic on shapes in geometry that was planned to extend from flat shapes to solid shapes, through nets and building boxes to crystals. When the content had been covered it was planned to build boxes to hold certain objects and after that to make some crystals. (1/S1)

In the second survey, the same teacher described another series of lessons that started with an exploration of his pupils ideas about machines, some questions about simple machines and then a series of practical activities conducted outside to illustrate some of the points raised in discussion. The teacher noted that a 'planned learning situation had been completely deflated' by the knowledge and problem-solving skills of the pupils. (1/S2)

Descriptions of lessons in survey 1, showed more planning with the content to be covered detailed. For example, one teacher took a unit on 'Ants' where every step was detailed.

> Ants. Experiences.
>
> 1. Ant trails. make one
> how do they find their food
> what do they do with it
> where do they take it to
>
> 2. Going out and observing ants.
> with magnifying glasses
> where are they found
> parts of the body
> how exactly do they walk
>
> 3. Building an ants colony
>
> Because the children are J2, the activities were done as a whole class. ... Other areas of the curriculum covered included reading, art, language and maths.(8/S1)

In the second survey the same teacher wrote a unit on birds because the pupils had saved a nest of baby birds from dying. Her planning included students writing previews, organising a visiting speaker, a trip to a bird sanctuary and independent activities for children requiring further attention. (8/S2)

Similarly, another teacher in survey 1 gives a detailed account of a series of lessons on electricity.

> Lesson 1. What needs to be plugged in to make it go?
> appliances in houses, discussion of power cuts
>
> Lesson 2. A walk outside. Where does the power come from?
> powerlines, power poles, danger live cable signs, meter boxes
>
> Lesson 3. Static electricity experiments
> rubbing plastics and alkathene on wool, comb in hair
>
> Lesson 4. Small circuits, battery, switch, light bulb. Make and break circuits and drawing the circuit. (12/S1)

In the second survey her description of lessons is quite different and

> Neither planned nor expected. While weeding their rock garden the children began to follow an ant trail. As they got further under the rocks and upset the ants sufficiently for them to pick up the eggs and carry them to safety, the weeding was forgotten. They began to dig and unearth the nest while one raced back to the classroom to get plastic 'ant farm' containers.
> They carefully caught a heap of ants and eggs and desperately searched for the queen.
> The next day the ants had collected all the eggs into one area and the children had books and pictures all around the table. They fed the ants on anything sweet they could find.
> Four of the children have decided to make a book of their own about ants based on their digging and their observations. (12/S2)

The primary school teachers were familiar with an integrated topic approach to teaching science. The resources they used were often publications that stressed an interactive approach (eg The Sunshine series on science ) In the first survey responses indicated little mention of determining children's thinking and working with their ideas, a basic element of the interactive approach to teaching science. In the second survey, 15 replies noted use of childrens' ideas for planning the lessons. Seven teachers also noted the use of concept maps as specific tools to assist this process of finding out what ideas were held.

Lessons descriptions in the second survey showed more open-ended work with contextual rather than content based topics. For example, in survey 1 one teacher wrote:

> Topic: Measuring motion
> Students were put into groups and asked to measure the motion of one of the four objects.
> a) trolley going uphill
> b) trolley going downhill
> c) pendulum
> d) spring
>
> They had to produce a distance/time graph and a speed/time graph. One member from each group was to report the results to the class.
>
> Prior knowledge given.
> Practice with ticker timers and practice with tapes and graph construction. (20/S1)

In survey 2, the description of the lessons from the same teacher were quite different.

> Topic: Bridging the gap
> Introduction: Students asked to draw five different types of bridges on hand out paper. These were passed around the class and ideas shared. I then asked them to write five questions they had about bridges. a brainstorm session followed and this set the scene for future work. We looked at photographs of a variety of bridge types, shapes and sizes and this answered some of their questions eg. longest bridge, widest etc.
>
> Lessons 2/3: I introduced a lot of mini projects, eg. which shapes are stronger (round, square, triangular), effects of folding paper on strength, does water-logging affect timber strength, reinforcing concrete, arch strength in bridges (many of them came out of the previous lesson). The students worked in pairs and were given two periods to come up with answers which they read and discussed with the rest of the class.
>
> Lessons 4/5: I then told the class they had to build a bridge. We discussed specifications and listed these simply; length, materials carrying capacity.
>
> Lessons 6/7/8/: Was devoted to construction. Some students had working drawings, others simply learnt by trial and error. Cans of spray paint finished off a noisy, busy time.
>
> Lesson 9: We wanted to test the bridges. I asked the students to tell me what things we could look for in assessment. We came up with the following: size, length, originality, workmanship, completeness, painting, ability to withstand wind, ability to withstand earthquakes, safety factors. Students wanted to carry out their own tests and felt it was meaningful to have a range of testing methods. Each person assessed each bridge and the results were averaged and recorded. (20/S2)

Overall, the teachers written descriptions of their teaching practice at the end of the course were different from that at the beginning of the course. More activities undertaken were centred on class interests with efforts being made to determine thinking of individuals. Planning was not as detailed and was ongoing. Topics covered were often more open-ended and contextually based rather than content orientated. These reported changes are consistent with the previous questions on the change in teacher views of science teaching and their current teaching practice.

### Question 18/6: To me being a teacher of science involves

This question required the course participants to complete 'I think that being a teacher of science involves' and rank 23 different teacher behaviours (1 very important — 5 not important). The data was statistically analysed and is presented in terms of reported changes over the period of the course (Fig B).

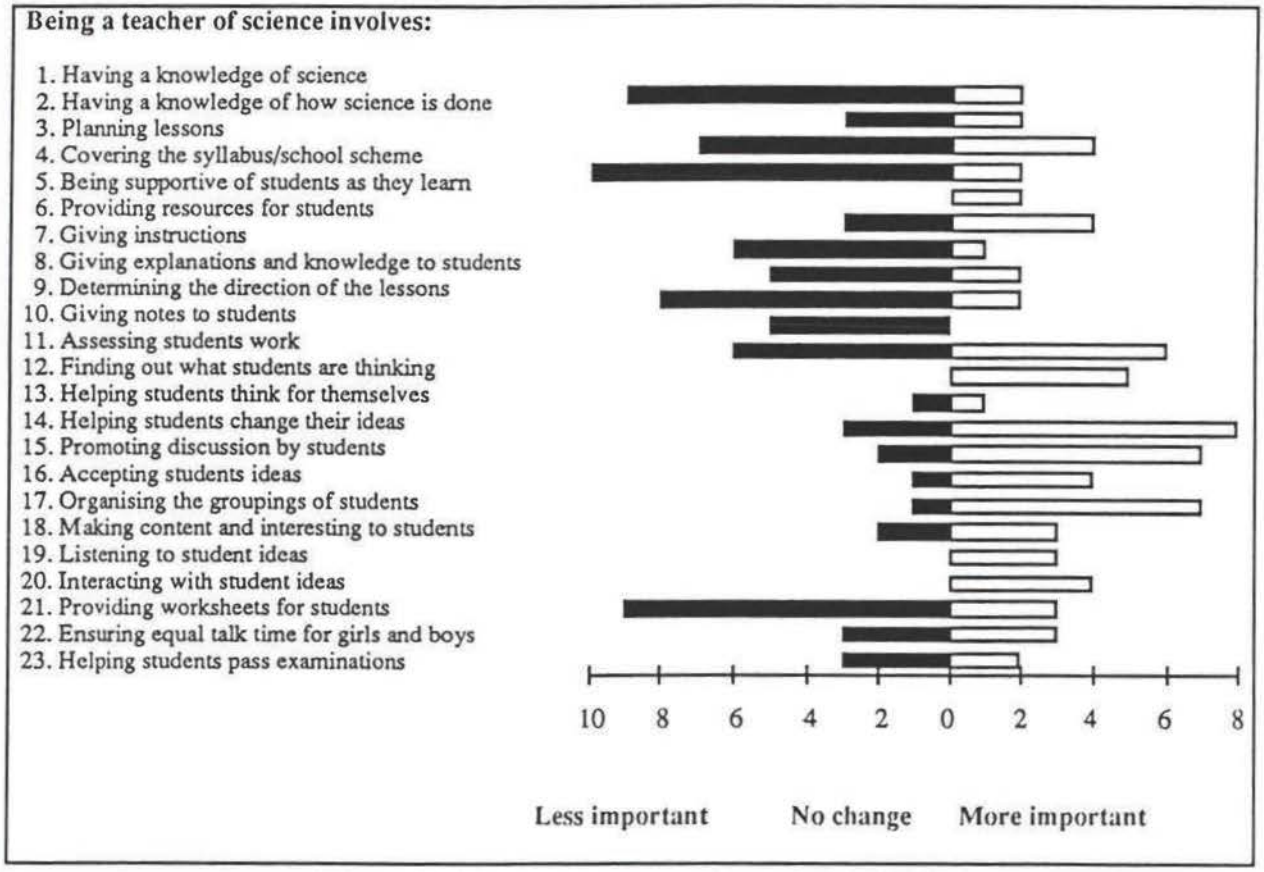



**Figure B: Reported changes in teaching skills**

The traditional teaching activities of: having a knowledge of science, having a knowledge of how science is done, planning lessons, covering the syllabus/school scheme, giving instructions, giving explanations and knowledge to students, determining the direction of the lessons, giving notes to students, providing worksheets for students, were generally seen as less important at the end of the course.

Providing resources for students, finding out what students are thinking, helping students change their ideas, promoting discussion by students, accepting students ideas, organising the groupings of students, listening to student ideas, interacting with student ideas were all seen as more important. These activities were promoted through discussion on the course and are consistent with constructivist teaching practice. The mean scores give an indication of the importance teachers put on each item and the general shift in the scores (Table 3).

**Table 3 Teacher Mean Ranked Scores on Teaching Skills**

| Being a Teacher of science involves | Survey One Mean scores | Survey Two Mean scores | Shift | T values | Prob. |
|---|---|---|---|---|---|
| 1. Having a knowledge of science | 2.32 | 2.78 | 0.46 | 55 | 0.03 |
| 2. Having a knowledge of how science is done | 2.22 | 2.44 | 0.22 | 7 | NS |
| 3. Planning lessons | 2.10 | 2.22 | 0.12 | 374 | NS |
| 4. Covering the syllabus/school scheme | 2.47 | 3.17 | 0.70 | 55 | 0.01 |
| 5. Being supportive of students as they learn | 1.20 | 1.00 | 0.20 | 1 | NS |
| 6. Providing resources for students | 1.47 | 1.28 | 0.19 | 52 | NS |
| 7. Giving instructions | 2.50 | 3.00 | 0.50 | 5 | 0.04 |
| 8. Giving explanations and knowledge to students | 2.95 | 3.28 | 0.33 | 19 | NS |
| 9. Determining the direction of lessons | 3.05 | 3.44 | 0.39 | 43 | 0.04 |
| 10. Giving notes to students | 4.16 | 4.61 | 0.45 | 1 | 0.03 |
| 11. Assessing students work | 2.53 | 2.67 | 0.14 | 1986 | NS |
| 12. Finding out what the students are thinking | 1.79 | 1.22 | 0.57 | 1 | 0.03 |
| 13. Helping the students think for themselves | 1.21 | 1.11 | 0.10 | 2 | NS |
| 14. Helping students change their ideas | 2.41 | 1.59 | 0.82 | 69 | 0.03 |
| 15. Promoting discussion by students | 1.74 | 1.33 | 0.41 | 42 | NS |
| 16. Accepting students ideas | 1.5 | 1.28 | 0.22 | 5 | NS |
| 17. Organising the groupings of students | 3.48 | 2.94 | 0.54 | 6 | 0.02 |
| 18. Making science content relevant and interesting | 1.48 | 1.5 | 0.02 | 13 | NS |
| 19. Listening to students ideas | 1.32 | 1.06 | 0.26 | 1 | NS |
| 20. Interacting with students ideas | 1.42 | 1.11 | 0.31 | 1 | NS |
| 21. Providing worksheets for students | 3.74 | 4.22 | 0.48 | 265 | NS |
| 22. Ensuring girls and boys equally share the talk | 1.72 | 1.59 | 0.13 | 27 | NS |
| 23. Helping students pass examinations | 3.72 | 3.75 | 0.03 | 13 | NS |
| Number of replies | 19 | 18 | | | |

NS : Not significant at 0.05 level.

Eight of the 23 question stems recorded statistically significant shifts. For many of the identified teaching skills, the course merely reinforced the values the teacher held. For example, stem 12 'Finding out what students are thinking' in the first survey had a score of

1.79 showing that the majority of teachers ranked this as important to very important in their teaching practice. In the second survey there was a significant shift recorded (five teachers changing the ranking) towards very important.

In summary, significant changes were recorded in teachers' views of what being a teacher of science involves,. These are consistent with reported changes to their teaching practice.

**Question 19/7: In my experience, learning science is helped by these activities.**

This question required participants to rank 20 different activities on a five point scale (always mostly, often, sometimes, never) of helpfulness to student learning. The data is presented in Figure C and in Table 4.

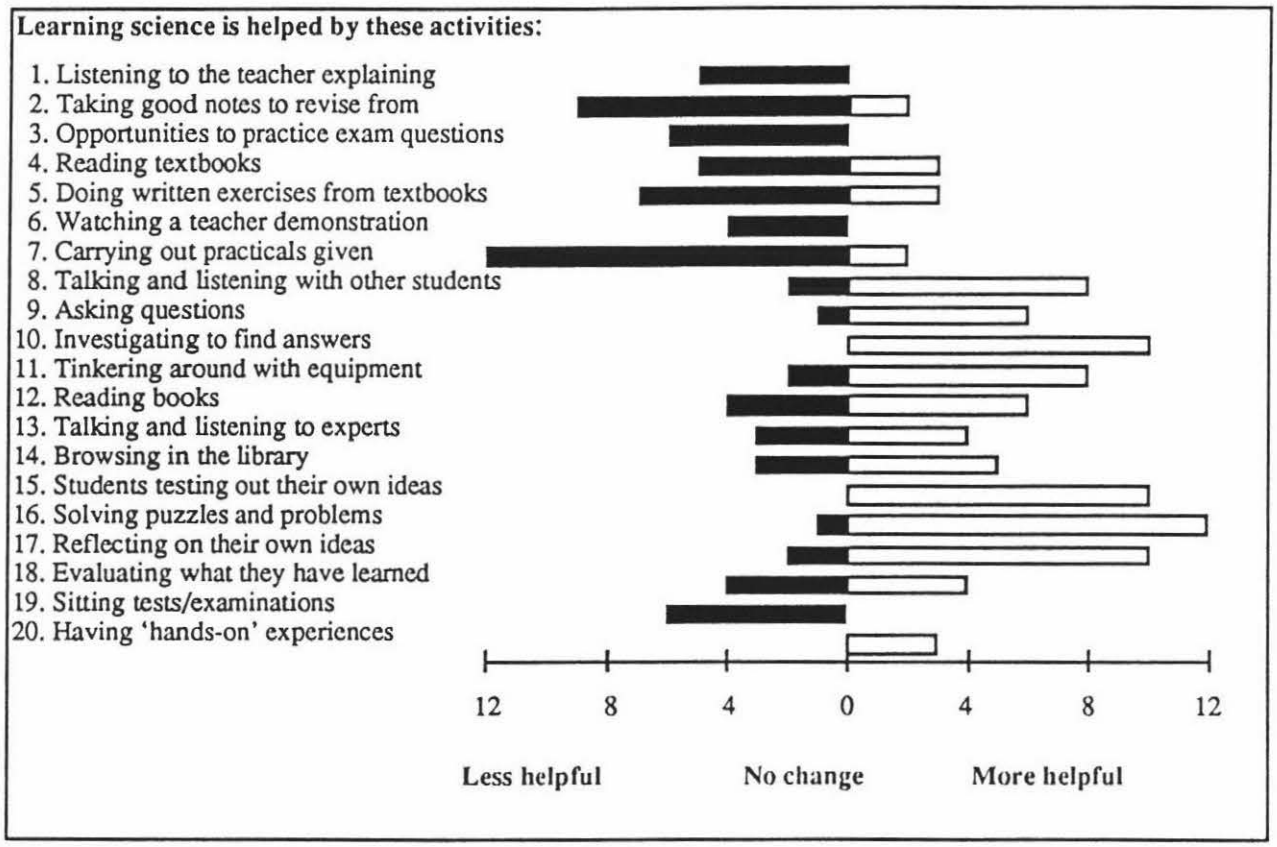



**Figure C: Reported changes in views of helpfulness of learning activities**

Significant changes were recorded in over half of the question stems. The changes identified traditional teaching activities as less helpful to learning. Student centred or initiated activities were seen as more helpful. For example, question stems 1 - 7 (listening to the teacher explaining, taking good notes to revise from, opportunities to practice exam questions, reading textbooks, doing written exercises from textbooks, watching a teacher demonstration,

carrying out practicals given) were reported as increasingly less helpful to learning in science. The general shift was from often/sometimes to sometimes/never.

Question stems 8 - 17 (talking and listening with other students, asking questions, investigating to find answers, tinkering around with equipment, reading books, talking and listening to experts, browsing in the library, students testing out their own ideas, solving puzzles and problems, reflecting on their own ideas) were increasingly seen as more helpful. However, the shift is only on average within one ranking. The majority of participants were teaching in primary school and could be expected to have informed views and experiences about the sort of learning activities that are helpful to learning ( for example, collaborative group work, class discussions, centre of interest topics, working from where the child is at) The ranked scores are given in the following table.

**Table 4: Teacher mean ranked scores in learning activities**

| Learning science is helped by: | Survey 1 Mean scores | Survey 2 Mean scores | Shift | T values | Prob. |
|---|---|---|---|---|---|
| 1. Listening to the teacher explaining | 3.35 | 3.72 | 0.37 | 1 | 0.04 |
| 2. Taking good notes to revise from | 3.82 | 4.39 | 0.57 | 42 | NS |
| 3. Opportunities to practice exam questions | 4.20 | 4.44 | 0.22 | 1 | 0.02 |
| 4. Reading textbooks | 3.71 | 4.00 | 0.29 | 19 | NS |
| 5. Doing written exercises from textbooks | 3.94 | 4.28 | 0.34 | 119 | NS |
| 6. Watching a teacher demonstration | 3.71 | 4.00 | 0.29 | 1 | NS |
| 7. Carrying out practicals given | 2.53 | 3.22 | 0.69 | 289 | 0.02 |
| 8. Talking and listening with other students | 2.18 | 1.89 | 0.29 | 54 | 0.05 |
| 9. Asking questions | 1.59 | 1.22 | 0.37 | 5 | 0.04 |
| 10. Investigating to find answers | 1.71 | 1.06 | 0.65 | 1 | 0.01 |
| 11. Tinkering around with equipment | 2.00 | 1.56 | 0.44 | 43 | 0.04 |
| 12. Reading books | 3.18 | 2.94 | 0.24 | 192 | NS |
| 13. Talking and listening to experts | 2.82 | 2.94 | 0.14 | 37 | NS |
| 14. Browsing in the library | 3.59 | 3.50 | 0.09 | 70 | NS |
| 15. Students testing out their own ideas | 1.94 | 1.28 | 0.66 | 1 | 0.01 |
| 16. Solving puzzles and problems | 2.41 | 1.67 | 0.74 | 14 | 0.01 |
| 17. Reflecting on their own ideas | 2.06 | 1.41 | 0.64 | 70 | 0.02 |
| 18. Evaluating what they have learned | 2.00 | 1.76 | 0.24 | 161 | NS |
| 19. Sitting tests and examinations | 3.94 | 4.44 | 0.50 | 1 | 0.02 |
| 20. Having 'hands-on' experiences | 1.24 | 1.06 | 0.18 | 1 | NS |
| Number of replies | 19 | 18 | | | |

NS: Not significant at 0.05 level

Views on activities that helped the learning of science moved towards views that would be consistent with constructivist teaching practice (Table 4). Individuals' responses were scored

to give an index of change from initial views of what helps learning in science. Items were weighted, scored and summed to give an overall index. This data is presented in the following table.

**Table 5: Teacher Composite Scores**

| Teacher Code | Survey 1 | Survey 2 | Change |
|---|---|---|---|
| 1 | 74 | 82 | 8 |
| 2 | 51 | 61 | 10 |
| 3 | 68 | 76 | 8 |
| 4 | 75 | 81 | 6 |
| 5 | — | 80 | |
| 7 | 67 | 78 | 11 |
| 8 | 75 | 71 | -4 |
| 10 | 67 | 77 | 10 |
| 11 | 76 | 76 | 0 |
| 12 | 75 | 78 | 3 |
| 13 | 61 | 77 | 16 |
| 14 | 77 | 74 | - 3 |
| 15 | 65 | 79 | 14 |
| 16 | 65 | 65 | 0 |
| 17 | 72 | 85 | 13 |
| 18 | 63 | 79 | 16 |
| 19 | 74 | 82 | 8 |
| 20 | 66 | 78 | 12 |

Five teachers showed consistent responses scores (± 5), six a moderate movement (6 - 10) and six large movements (11 - 16). There was no obvious difference between the index scores of primary and secondary teachers, or between male and female teachers. Four teachers showing marked changes in their teaching practice also noted large changes in their views on what helps learning in science.

In summary, significant change was evident in the perceptions of activities that help students learn science. This change was consistent with that reported in their teaching practice and represented a move towards student-centred and initiated learning.

### Question 20/8: To me learning science involves students

In this question, teachers were asked to indicate the importance of beliefs about the way students learn science. Question stems were on beliefs about learning that all teachers would hold, for example 'Learning science involves students enjoying their work', as well as indication of more constructivist beliefs about learning. Data is presented in Figure D and Table 6.

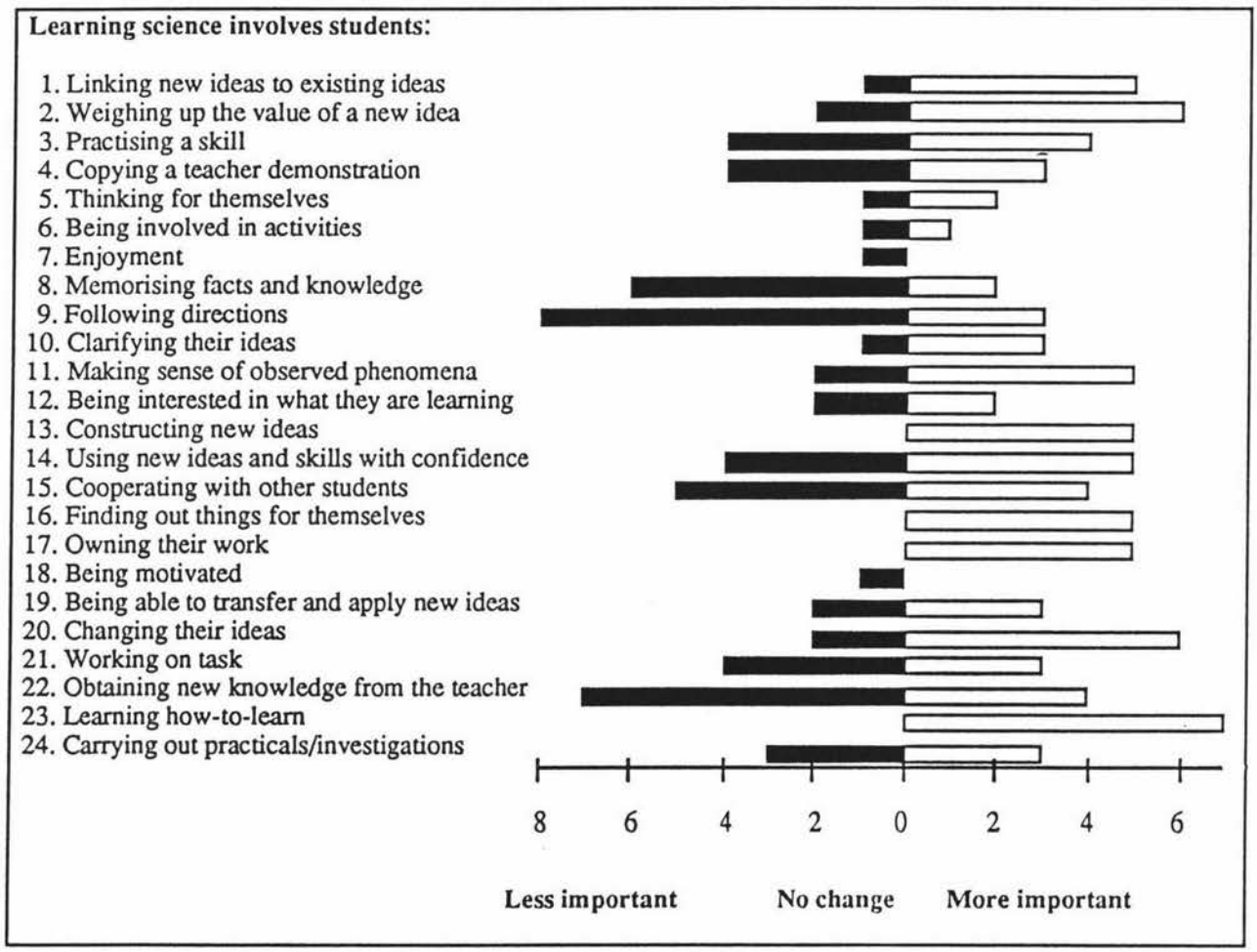



**Figure D: Reported changes in beliefs about learning in science**

Items which had students in some way responsible for their own learning were regarded more important. For example, linking new ideas to existing ideas, weighing up the value of a new idea, thinking for themselves, making sense of observed phenomena, changing their ideas, constructing new ideas*, finding out things for themselves*, owning their work*, learning-how-to-learn*, were all ranked as more important. Changes in ranking of the starred items (*) indicate statistical significance.

**Table 6: Teacher Mean Ranked Scores of Views of Learning**

| Learning science involves students | Survey One Mean scores | Survey Two Mean scores | Shift | T values | Prob. |
|---|---|---|---|---|---|
| 1. Linking new ideas to existing ideas | 1.47 | 1.11 | 0.36 | 5 | NS |
| 2. Weighing up the value of a new idea | 1.68 | 1.28 | 0.40 | 25 | NS |
| 3. Practising a skill | 2.53 | 2.44 | 0.09 | 135 | NS |
| 4. Copying a teacher demonstration | 3.72 | 3.78 | 0.60 | 52 | NS |
| 5. Thinking for themselves | 1.16 | 1.06 | 0.10 | 3 | NS |
| 6. Being involved in activities | 1.26 | 1.17 | 0.09 | 2 | NS |
| 7. Enjoyment | 1.10 | 1.17 | 0.07 | 1 | NS |
| 8. Memorising facts and knowledge | 3.61 | 3.94 | 0.33 | 146 | NS |
| 9. Following directions | 2.63 | 3.00 | 0.37 | 417 | NS |
| 10. Clarifying their ideas | 1.42 | 1.22 | 0.20 | 3 | NS |
| 11. Making sense of observed phenomena | 1.58 | 1.39 | 0.19 | 37 | NS |
| 12. Being interested in what they are learning | 1.26 | 1.22 | 0.04 | 9 | NS |
| 13. Constructing new ideas | 1.67 | 1.22 | 0.45 | 1 | 0.03 |
| 14. Using new ideas and skills with confidence | 1.67 | 1.90 | 0.23 | 167 | NS |
| 15. Co-operating with other students | 1.68 | 1.78 | 0.10 | 385 | NS |
| 16. Finding out things for themselves | 1.42 | 1.06 | 0.36 | 1 | 0.03 |
| 17. Owning their work | 1.38 | 1.06 | 0.32 | 1 | 0.03 |
| 18. Being motivated | 1.16 | 1.06 | 0.10 | 1 | NS |
| 19. Being able to transfer and apply new ideas | 1.42 | 1.24 | 0.18 | 13 | NS |
| 20. Changing their ideas | 1.83 | 1.33 | 0.50 | 25 | NS |
| 21. Working on task | 1.83 | 1.67 | 0.16 | 52 | NS |
| 22. Obtaining new knowledge from the teacher | 3.05 | 3.17 | 0.12 | 591 | NS |
| 23. Learning how-to-learn | 1.79 | 1.33 | 0.46 | 1 | 0.01 |
| 24. Carrying out practicals and investigations | 1.32 | 1.41 | 0.09 | 27 | NS |
| Number of replies | 19 | 18 | | | |

NS: Not Significant at 0.05 level

Memorising facts and knowledge, following directions and obtaining new knowledge from the teacher were all seen as less important.

Many of the activities, were regarded by the teachers as important in the first survey and little movement was expected in them. Nineteen of the question stems had mean scores below two in the first survey and the shift was minimal (14 shifts $\leq 0.2$). However, overall movement indicated a shift to constructivist beliefs. This is consistent with the findings on the teachers' experience of activities that help learning in science.

**Question 21/9: Describe what you understand and feel about learning in science.**

These survey questions asked participants their views about learning in science and how these had changed over the course of their career (survey 1) or over the course (survey 2). Thirteen replies only were received in the first survey with seventeen replies received in the second survey.

In the first survey, one emphasis reported in the replies was that children learn by 'doing' science.

> They learn by doing but in the practical classroom the theory doesn't always work! There are so many limitations to this in the classroom but if you have the energy and interest (and necessary gear!) they will always learn more by doing than reading/watching etc. (7/S1)

> I understand that like all other things/ subjects, science is learnt by doing it rather that watching or listening. (11/S1)

Learning science was also seen as following 'scientific method' with an emphasis on process skills that children needed to gain.

> I feel the classic prediction, observation, measuring, grouping, hypothesising and experimenting skills important and worth promoting. Probably the most important I would suggest is observing, I would put that as the key to the others. (10/S1)

> Learning in science is problem solving, discovering, experimenting and exploring. Thinking creatively students can put forward their own explanations and reasons and predictions, take risks, think about them and accept failure with success. Being able to research, find out more, summarise. To observe and record with precision and accuracy. (12/S1)

> Children need to learn process skills and ways to organise ideas to come to own conclusion rather than gaining lots of facts from teacher or books. (14/S1)

Few comments were made about learning being understanding and the acquisition of knowledge. This was qualified by a change in views over the course of teaching careers. Some personal lack of knowledge was commented by two teachers as inhibiting their science teaching.

> Learning in science is about children developing much greater understanding of the world they live in. this used to be based around set scientific answers and getting the 'right' answer but now is more pupil driven. As I feel my scientific knowledge is limited I have tended to avoid teaching some aspects of science. (15/S1)

> Main change for me has been the change in approach from straight lecture type knowledge acquisition or from bland textbooks that gave little or no opportunity to question or experiment, to the present day methods of pupil interaction, teacher provoked questions and discussion. (16/S1)

> I guess I still feel that learning refers to the acquisition of knowledge but I am trying to modify this. The benefit of being in a 'hands-on' situation and having to

> find out for oneself is a challenging one for me in the classroom. I don't like being in a situation where the children ask for help and /or answers and I can't respond in a way which fosters the children into another learning situation. I want to tell them the answer. (18/S1)

> Initially in my career, I thought I was to provide all to investigation ie. I didn't believe the kids could come up with their own conclusions. Now I suspect many kids can draw correct conclusions (if encouraged to ) which indicates they can learn themselves rather than me topping up their store of knowledge. (21/S1)

In the second survey, an overwhelming emphasis in the greater number of replies was that learning involved an interaction with prior knowledge and ideas held. Almost all the replies indicated that the child needed to be in charge of their learning. This identified change in understanding of learning had also changed the ways that teachers saw their practice. An important inclusion was ways in which children could explore, share and interact with ideas through discussion and class activities.

> Learning is the modification of old ideas and the development of new ones and linking them to existing knowledge. In science it particularly relates to mental models or pictures of how the world works and linking the internal ideas to the external reality.
> My view of learning has changed principally in understanding the roles of the participants in the learning process and the principle that it is the learner who is responsible for his/her own learning. (2/S2)

> This course has convinced me that the best learning takes place when children are in charge of their own learning. Having first clarified their present understanding, they may then, through observation, experiment, discussion(with peers and experts), research and reflection, modify or deepen that understanding. New concepts cannot be stamped on a learner's mind; rather the learner through the activities mentioned above, modifies his/her thinking in a meaningful way. This is a gradual process and the problem may need to be revisited many times by the learner. I believe willingness to do this comes with ownership of the problem and in a relaxed and non-threatening environment. (4/S2)

> Learning occurs when you are actively involved with the activities. thinking about and discussing your own ideas and changing or adding to them is going to mean something in the future much more than being told something,
> Active participation + Active learning = Science learning. (7/S2)

> Science appears to be an effective way children can actively learn. that is they already have some knowledge and with a variety of methods – talking, listening, trying, thinking, trying and finding out, children actually learn. The trick is to be involved while all this is happening so you can take part. (11/S2)

> The children enjoy and want to become involved in activities and discussions. They need to realise they can contribute and have worthwhile ideas. (12/S2)

> To me it is now child centred, where, what the child thinks, is the focus for building further work (activities). Hence the child further develops and extends their thinking. It is more interesting for the child as he/she can directly relate to the content as they already have the prior knowledge necessary to go onto the next step. The discussion at the end, follow-up/reporting back, is the most valuable in assessing what the child has learned. Any gaps in other children's thinking may also be clarified by contribution from other children.

> It allows for a lot of cooperative work where much discussion/interaction is necessary for ideas to be clarified during the activities. (13/S2)

> Learning in science occurs when children are involved in the activity and have had a chance to discuss and clarify their own ideas.
> My ideas have changed towards letting children learn more from each other and exchange of ideas between children. Encourage children to help answer other childrens' questions rather that teacher always being centre of discussion. (14/S2)

> Learning in science is about children developing their own ideas and making sense of their world. If it is enjoyable they will be self-motivated to think about what they are doing, develop or extend their ideas. this is a very powerful form of learning as if it is child directed it has so much more meaning for them. (15/S2)

> I have learnt, seen, experienced children learning through a greater variety of means and methods than previously. I have had to look and think carefully about what learning really is, and if any has taken place, and the different ways we can assess it. - (16/S2)

> I have long been convinced of the need to provide students with experiences and resources which will both initiate their inquiries and assist their investigations. However because of my own lack of confidence with science (inherited from secondary school experiences 25 years ago), I have always been very slow to tackle science in any depth at all. So that my activity based and resource based learning programmes have not really addressed the learning needs of my students in science. Because of this course I have consolidated and modified my ideas about the way in which children learn. I have been given the confidence to give the children opportunities to interact with scientific ideas. I have ceased worrying about whether or not I know the answer, my main concern is how can I guide my students towards finding the answer. The children in my class have certainly enjoyed this interactive approach and I have definitely become a lot more aware of their thinking and the way in which learning becomes more meaningful. (17/S2)

> I don't think my fundamental philosophy has changed but I do think my understanding of learning in science has become clearer — a much more accurate, complex understanding of the processes involved — especially of the need for children to interact with their own and others ideas, with their peers and with the teacher. I think my understanding of my role in all this has become much clearer, — of the different ways I can assist and guide the learning process. (19/S2)

> Learning is building new knowledge on top of old. I feel my view of learning has changed so that I encourage students more to share their ideas so that we can construct, try out, test and evaluate them. The feedback they get from this is self motivating and students feel they are achieving. (20/S2)

Teachers' experiences with their classes, reading about learning and discussions on learning during the course sessions changed the views on learning in science. Teachers identified these changes as a greater awareness of the prior knowledge that children had and the need to have classroom situations where this knowledge could be identified, shared and explored. Teachers see this as more enjoyable for the children and themselves, and more effective in the learning of science. All these are consistent with constructivist views on learning. It was noticeable in the second set of replies that teachers demonstrated more fluency in discussing their understandings of learning in science.

**Question 22/10: I believe the following are reasons for including science/technology in the school curriculum**

In this question, teachers were asked to rank using a five point scale, (1 very important, 5 not important) reasons for the inclusion of science and technology in the school curriculum. The data is given is Figure E and Table 7.

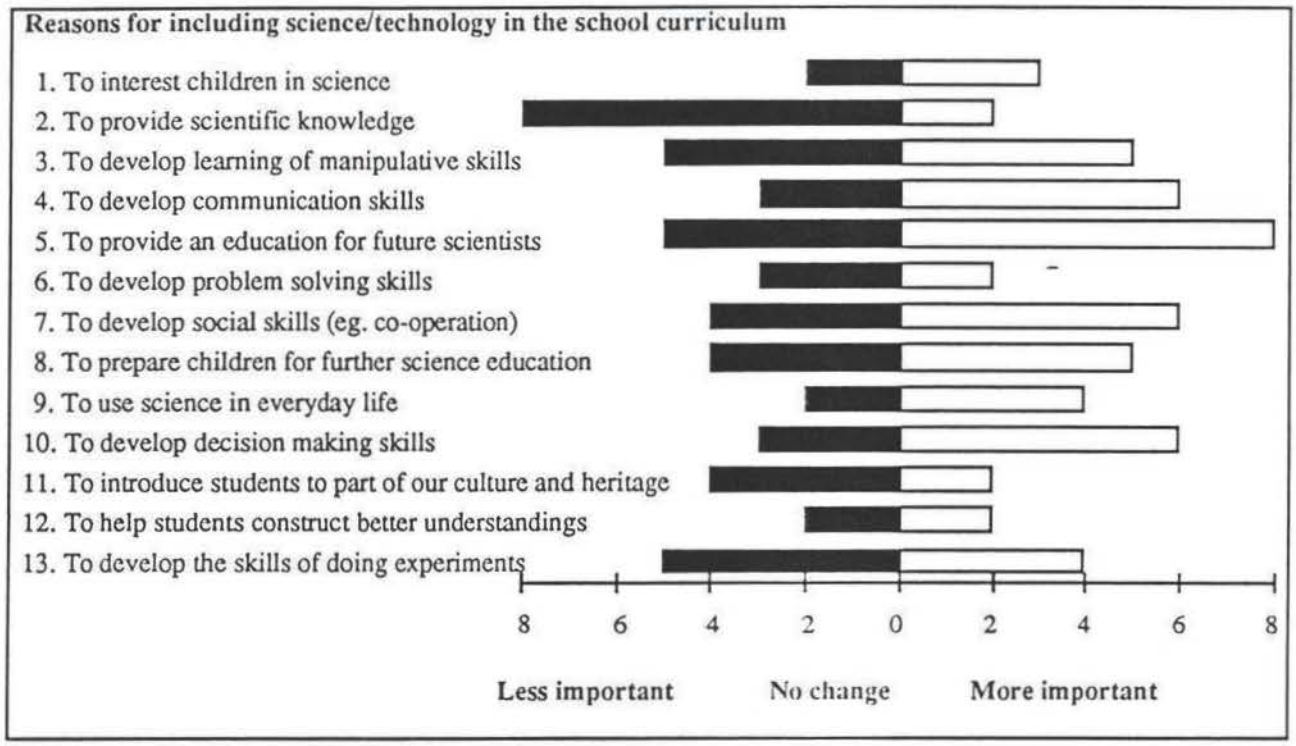



**Figure E: Reported changes in the value of science in the curriculum**

There were several changes in teacher views on the value of science in the curriculum. Only one was statistically significant (item 2, Fig E). This was seen as less important in the second survey. There were positive shifts in the value of science providing useful skills as developing communication skills and developing social skills. Providing an education for future scientists was also seen as more important. To interest children in science, to use science in everyday life, to help students construct better understandings of their biological and physical world were seen as important to very important in the first survey and confirmation of this importance was expected.

The inclusion of science in the curriculum was regarded as being important to very important (Table 7). This is understandable considering the participants were science specialists. Shifts in areas emphasising process skills, suggest primary trained teachers had a broader view of the value of science in the curriculum.

**Table 7: Teacher Mean Ranked Scores on Science and Technology**

| Reasons for including science and technology in the school curriculum | Survey One Mean scores | Survey Two Mean scores | Shift | T values | Prob. |
|---|---|---|---|---|---|
| 1. To interest children in science | 1.53 | 1.39 | 0.14 | 10 | NS |
| 2. To provide scientific knowledge | 2.26 | 2.61 | 0.35 | 54 | 0.05 |
| 3. To provide learning of manipulative skills | 2.53 | 2.41 | 0.12 | 320 | NS |
| 4. To develop communication skills | 2.22 | 1.88 | 0.34 | 70 | NS |
| 5. To provide an education for future scientists | 2.72 | 2.48 | 0.24 | 2037 | NS |
| 6. To develop problem solving skills | 1.47 | 1.39 | 0.08 | 13 | NS |
| 7. To develop social skills(eg. co-operation) | 1.95 | 1.83 | 0.12 | 394 | NS |
| 8. To prepare children for further science education | 2.17 | 2.06 | 0.11 | 82 | NS |
| 9. To use science in everyday life | 1.47 | 1.33 | 0.14 | 18 | NS |
| 10. To develop decision making skills | 1.97 | 1.66 | 0.31 | 77 | NS |
| 11. To introduce students to part of our culture and heritage | 2.05 | 2.10 | 0.05 | 27 | NS |
| 12. To help students construct better understandings of their biological and physical worlds | 1.21 | 1.16 | 0.05 | 9 | NS |
| 13. To develop skills of doing experiments | 2.55 | 2.70 | 0.15 | 127 | NS |
| Number of replies | 19 | 18 | | | |

NS: Not significant at 0.05 level

### Question 23/ 11: My understanding of the phrase 'Science Curriculum' includes

In this question teachers were asked to rank items on how they considered them as part of the science curriculum. Data is presented in Figure F and Table 8.

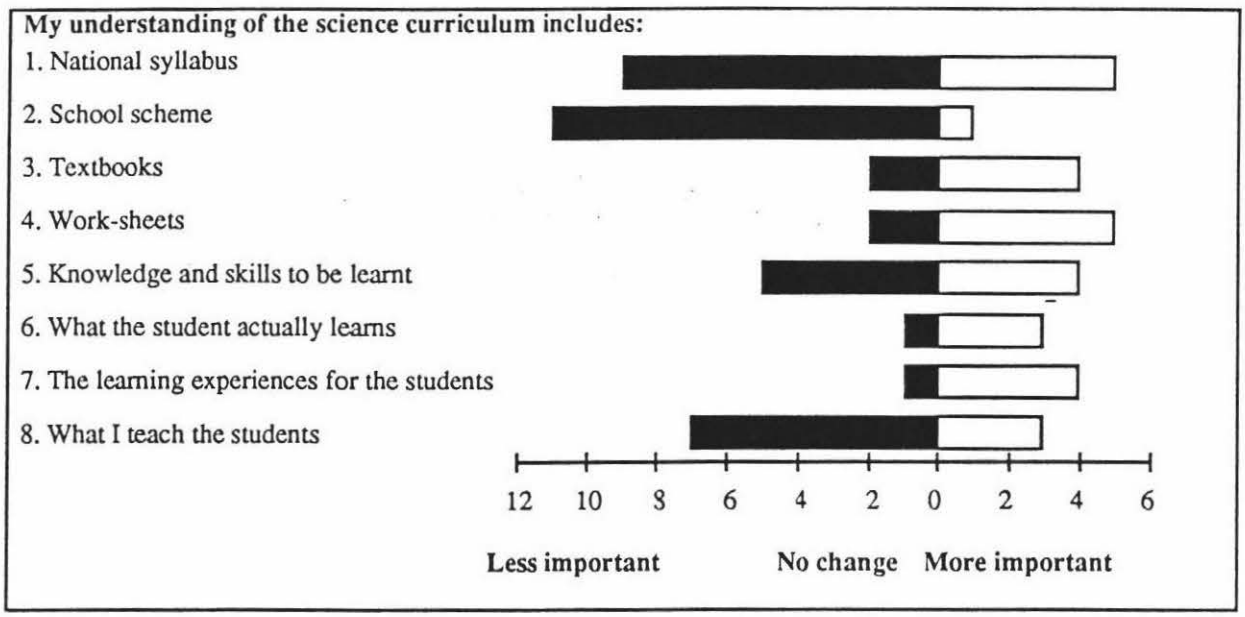



**Figure F: Reported changes in understandings of the science curriculum**

Significant changes were evident for the National syllabus, and the school scheme. These were regarded as less important by the teachers after the course. Similar changes were evident in their regard to knowledge and skills to be learnt and what they 'taught' the students. Viewed as more important was what the student actually learns and the sort of learning experiences the students received. Text books and worksheets were seen as slightly more important.

In their understanding of the science curriculum, teachers had developed a view of the curriculum that was broader than that traditionally held. Industrial action did not enable the new curriculum documents or the draft syllabus and achievement initiatives to be addressed. Informal discussions indicated teachers had reflected on the thrust and direction of these documents.

**Table 8: Teacher Mean Ranking of Views on Science Curriculum**

| Science curriculum | Survey One Mean scores | Survey Two Mean scores | Shift | T values | Prob. |
|---|---|---|---|---|---|
| 1. National syllabus | 2.00 | 2.47 | 0.47 | 1863 | NS |
| 2. School scheme | 1.58 | 2.05 | 0.47 | 14 | **0.01** |
| 3. Textbooks | 4.22 | 3.83 | 0.39 | 18 | NS |
| 4. Work-sheets | 4.16 | 4.06 | 0.10 | 24 | NS |
| 5. Knowledge and skills to be learnt | 1.94 | 2.22 | 0.28 | 92 | NS |
| 6. What the student actually learns | 1.72 | 1.33 | 0.39 | 5 | NS |
| 7. The learning experiences for the students | 1.56 | 1.28 | 0.28 | 5 | NS |
| 8. What I teach the students | 2.56 | 2.78 | 0.22 | 221 | NS |
| Number of replies | 19 | 18 | | | |

NS: Not significant at the 0.05 level

**Question 24/12: Describe what you understand about the science curriculum.**

Course participants were asked the extent to which their view of the science curriculum had changed during their career. Thirteen replies were received to this question in the first survey with fifteen replies in the second survey. The contract specified discussion and interpretation of the curriculum statements and the achievement initiatives. Teachers made it clear that they were unable to take part in any discussion because of industrial action. Consequently, any comments on curriculum were peripheral and little change was expected in teacher views.

Response in the first survey indicated that the curriculum was viewed as imposed on them and generally related to a set of topics. Comments indicated pupils should be exposed to needed knowledge, attitudes and skills. For example:

> Categorised into 4-5 main sections. Lots of stuff — too much to cover so actual requirements are vague. To me it seems that there is a lot of picking and choosing and teachers cover mainly their interest/ability areas. (7/S1)
>
> Science curriculum is housed in those topic booklets that tell you what to do and how. (11/S1)
>
> A series of topics to be studied at various levels as set out by the powers that be. A guide line for teachers to follow so that if adhered to all children should have covered a wide course of scientific knowledge and understandings during their school career. (16/S1)
>
> The science curriculum gives the teacher a prescription of skills and attitudes which the children should be encouraged to develop and a list of suggested study topics which teachers can use to develop these skills and attitudes in their students. (17/S1)

> I see a science curriculum as being a broad outline of what teachers cover at each level in schools. (20/S1)

> An outline of content, skills, experiences that kids should receive in Science. Often it was a pain in the backside to actually find a way to present these goals. In particular, I would ponder for a long time how to tie the curriculum in with lessons. I feel if I get through 80%, it's very good going. (21/S1)

Four respondents expressed change in views. One teacher commented "the new initiatives are going to be restricting on what will be taught as teachers will be interested in just attaining the levels" (1/S 1) Another noted that the curriculum had changed to include technology (13/S1). Two had a view that the curriculum now changed "to focus more closely on the child than before." (16/S1) and "to reflect the local needs of students in the community." (20/S1)

In the second survey, the replies were longer. Two main areas that were mentioned. The first focused on the need for the curriculum to be skills based. Examples are given below:

> It needs to be skills based rather than topic based. Topics need to be flexible enough within the school scheme to allow for a range to be chosen according to class need, interest and gender and racial equity in choice. I thought the curriculum included Biology, Chemistry and Physics. I now think there is no need to label any of it. (5/S2)

> For me the science curriculum refers to the range of experiences that can be used to develop scientific interest and awareness of basic (current) scientific ideas and an understanding and awareness of the scientific world around them. (10/S2)

> That it is not just a set of topics or themes to be taught but a whole range of ideas and investigations that children 'learn' from, solve problems with and find out about things that interest and concern them. I used to think science curriculum was in those little level books. (11/S2)

> The main thrust is of course, science learning that takes into account children's thinking. The use of predict, observe, discover. the ability to spread it into all subjects each and every day instead of an isolated topic. (16/S2)

> The science curriculum emphasises the process of learning not the product, which is good news. (17/S2)

> I think I believe the science curriculum to be a guide and not a set prescription. ... The learning experiences that children are exposed to and challenged with and how they tackle these and then make conclusions is of more importance. I don't think I feel as tied as previously. (18/S2)

The second theme encompasses an approach that focusses on children's ideas.

> I now think exploring kids' ideas is more important than sticking to a school scheme ... using it as a guideline to help cover all the skills kids need to progress. (5/S2)

> I see the science curriculum as being driven more by children's ideas and interests than anything else — their interests and concerns are the guiding force. Over the course of a year one should try, though to cover the major areas of science (though I am not sure how this should be done). (19/S2)

> The science curriculum is skill knowledge, interpretation of knowledge and attitudes we want students to have after a period of time. My view of the science curriculum has changed in the recognition of pupil input into the learning process through their own ideas, thoughts, and attitudes. (20/S2)

Several teachers saw the curriculum as a set of topics which a student needed to learn. For example:

> What the students show a need to learn while keeping to the standard syllabus to ensure progress through secondary school. (7/S2)

> I understand it to be the topics and areas to be covered through each year. It considers the learning of knowledge, skills and attitudes also taking into account the needs and influences of the local community. (12/S2)

> In the junior school the children need to be introduced to a wide range of topics. If children experience topics each year they add to their ideas and knowledge. (14/S2)

> The science curriculum that I follow is still what is in the school scheme. (15/S2)

In summary, while the course itself did not address the curriculum directly, there was still some change in the understandings of the science curriculum of the teachers. Views detailed the need to work with children's ideas and interests with a focus on learning experiences in the classroom.

**Question 25/13: In terms of my meaning for the word 'Science'**

In this question a series of statements about science and scientific knowledge were used to determine the views of teachers. They were asked to rank the statements on a five point scale from strongly agreeing to strongly disagreeing. Data from the surveys is presented in Figure G and Tables 9 and 10.

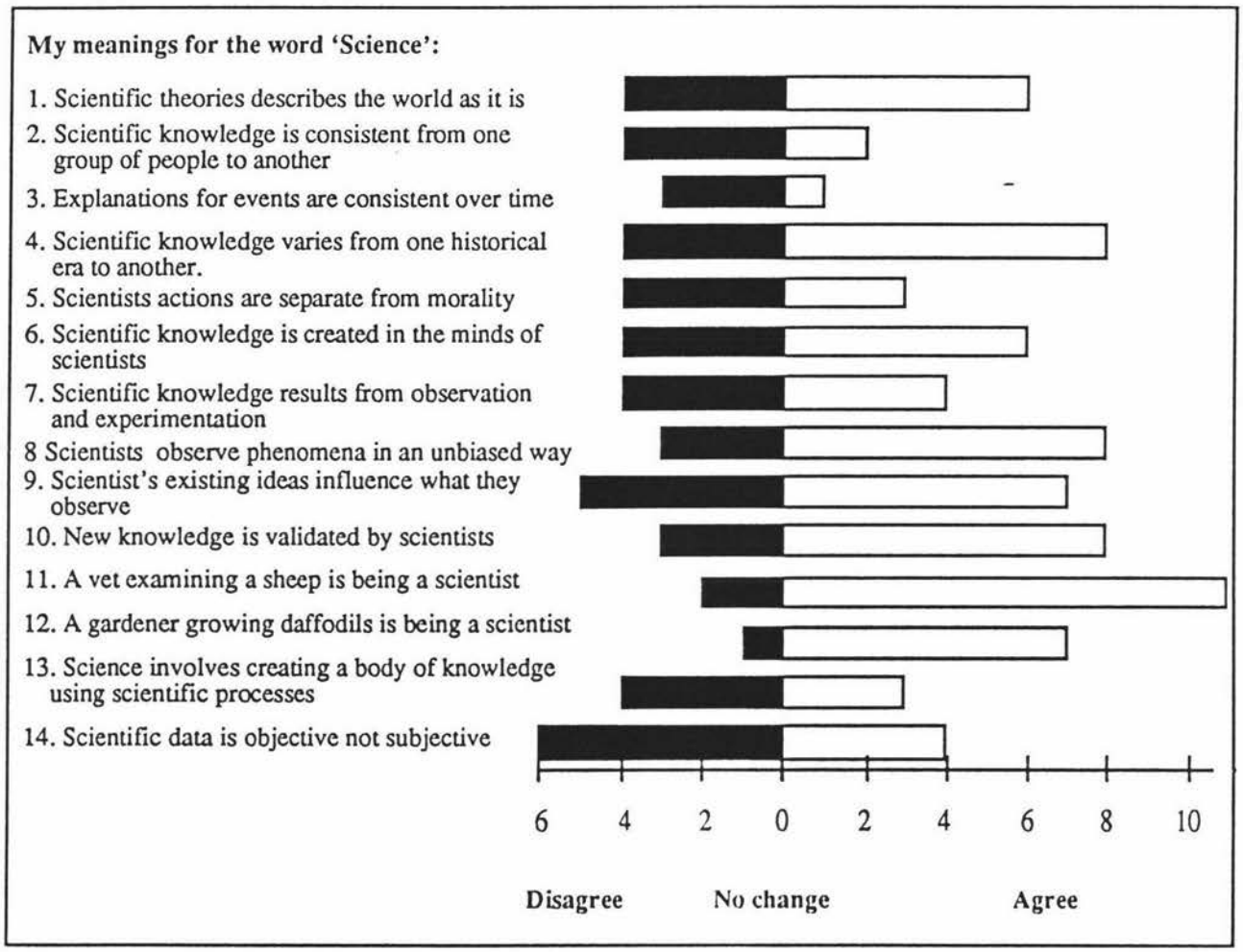



**Figure G: Reported changes in meanings of science**

The majority shifts in the mean scores were consistent with the emphasis on constructivist views of science and science knowledge, but there were several inconsistencies in the data. For example, while there was no shift in the mean score of the statement 'Scientists observe phenomena is an unbiased way' more teachers did indicate that they disagreed with this statement. A similar response was made to the statement with more agreement expressed with the view that 'scientists existing ideas influence what they observe'.

**Table 9: Teacher Mean Ranking of Meanings for Science**

| Meaning of Science | Survey One Mean scores | Survey Two Mean scores | Shift | T values | Prob. |
|---|---|---|---|---|---|
| 1. Scientific theories describes the world as it is | 3.07 | 3.17 | 0.10 | 433 | NS |
| 2. Scientific knowledge is consistent from one group of people to another | 3.93 | 4.06 | 0.13 | 18 | NS |
| 3. Explanations for events are consistent over time | 4.13 | 4.39 | 0.26 | 2 | NS |
| 4. Scientific knowledge varies from one historical era to another | 1.94 | 1.44 | 0.50 | 310 | NS |
| 5. In conducting an experiment scientist's actions are separate from the morality of the situation | 3.50 | 3.75 | 0.25 | 60 | NS |
| 6. Scientific knowledge is created in the minds of scientists | 3.36 | 3.22 | 0.14 | 552 | NS |
| 7. Scientific knowledge results from observation and experimentation by scientists | 2.06 | 2.17 | 0.11 | 108 | NS |
| 8. Scientists observe phenomena in an unbiased way | 2.94 | 2.94 | 0.00 | 851 | NS |
| 9. Scientists' existing ideas influence what they observe | 2.00 | 1.83 | 0.17 | 417 | NS |
| 10. New scientific knowledge is validated when it is accepted by other scientists | 2.37 | 1.89 | 0.48 | 126 | NS |
| 11. A veterinarian examining a sick sheep is being a scientist | 2.00 | 1.28 | 0.72 | 88 | 0.01 |
| 12. An amateur gardener growing prize daffodils is being a scientist | 1.94 | 1.44 | 0.50 | 7 | 0.03 |
| 13. Science involves creating a body of knowledge using scientific processes | 1.87 | 2.00 | 0.13 | 37 | NS |
| 14. Scientific data is objective, not subjective | 2.40 | 2.47 | 0.07 | 394 | NS |
| Number of replies | 19 | 18 | | | |

NS: Not Significant at the 0.05 level.

An index of teacher shifts was compiled to show the overall shifts in teachers' views. Items were weighted positively or negatively, and summed (Table 10). The overall shifts were significant ($t = 14$, $P \leq 0.001$), but individual shifts were small ( $\leq 5$). This it is felt indicates that while teachers may have changed their beliefs and views on how they taught science, their views and understandings of science remain unchanged.

Discussions on the nature and knowledge of science were secondary to the main aims of the course and not addressed directly. Readings were given out to the teachers and discussion undertaken in response to these readings. Teachers commented they found the ideas in the readings difficult and time was scarce for them to spend on this professional reading. Comments were made that they needed another in-service day just to read and think on some of the ideas contained in the readings. For some of the teachers involved with the course, travelling time and pooling of travel did allow discussion of issues that arose during the sessions and from the ideas contained in the readings. This was reported during one of the sessions.

**Table 10: Teacher Composite Scores**

| Teacher Code | Survey 1 | Survey 2 | Change |
|---|---|---|---|
| 1 | 39 | 39 | Nil |
| 2 | 35 | 36 | 1 |
| 3 | 26 | 34 | 8 |
| 4 | 34 | 36 | 2 |
| 5 | — | 41 | |
| 7 | 32 | 36 | 4 |
| 8 | 36 | 40 | 4 |
| 10 | 39 | 40 | 1 |
| 11 | 33 | 30 | - 3 |
| 12 | 32 | 35 | 3 |
| 13 | 31 | 35 | 4 |
| 14 | 40 | 35 | 5 |
| 15 | 28 | 31 | 3 |
| 16 | 28 | 30 | 2 |
| 17 | 37 | 36 | - 1 |
| 18 | 30 | 32 | 2 |
| 19 | 39 | 39 | Nil |
| 20 | 40 | 43 | 3 |

n summary, there was little movement in the views and understandings held by teachers on he nature of science and scientific knowledge. Few teachers indicated that they had read nany of the articles given out during course sessions with 'lack of time' being the reason.

**)uestion 26/14: With regards to science,**

**ı) What do you understand by the term science?**

n the first survey, sixteen replies to this question were received. Ten participants expressed n understanding of science that related to 'a study of the world around us' or 'facts and nowledge of our world'. For example:

> How the world and everything in it works. (7/S1)
>
> Looking at the world around us with the intent to understand "why". (8/S1)

> Study of the world around us — and ourselves. (10/S1)
>
> Science is a knowledge of the physical and natural world around us. Becoming aware and making sense of our world. (12/S1)
>
> I understand the term 'science' to mean the body of knowledge or facts that explain our world. (15/S1)
>
> Science refers to mankind's interaction with and understanding of his environment. (17/S1)
>
> Theories and understandings about the natural world. (19/S1)

Five referred to this understanding of our world and the set of particular process skills often associated with 'scientific method'. For example:

> The best available explanation of the universe based on and developed through the "scientific method". (2/S1)
>
> Setting up experiments to assist in understanding. (8/S1)
>
> A studied approach too things in our world with emphasis on maths, physics, chemistry etc. Why things happened in the way and the order that they do. Experimenting and making new discoveries. (16/S1)
>
> Using equipment, collecting and analysing data, using models and theories to help understand the world, predicting on established data, questioning, an accumulated body of knowledge, making sense of the world, a way of solving problems, mastering skills, persevering, being honest. (20/S1)

In the second survey, seventeen replies were received with a change in emphasis in many of these replies. Five replies emphasised understanding the world around us. For example:

> Science is all around, it is the world we live in, plants, animals, ecology, physics and chemistry. things natural and man made that contribute to our existence. (1/S2)

Two replies emphasised the process skills and scientific method.

> Learning, investigating, solving problems about everyday things and new and unusual things. (11/S2)

Overwhelmingly, the replies referred not only to understanding facts but also a search for meaning, making sense and a way of explaining phenomena. For example:

> A set of themes and models to explain the observable universe, backed by independently repeatable investigation and experiment which predict further previously unknown phenomena. (2/S2)
>
> The term 'science' to me, suggests a search for meaning in the natural and physical world. for each of us it is an ongoing process as current understanding is further shaped by new information. It is the relentless pursuit of a central 'truth'. It is the application of acquired knowledge. (4/S2)
>
> A way of explaining how and why things happen in the worlds around us. (5/S2

Science is making sense of the world. It is ideas and theories which explain and give reason to our physical and natural environment. (12/S2)

Science is an attempt by human beings to understand their biological and physical worlds. (17/S2)

Science is the body of understanding and beliefs that people hold about natural phenomena. (19/S2)

Overall, there seemed a shift in the participants views on their understandings of science. The shift was away from knowledge and facts about the world to making sense and explaining phenomena in the world.

**) How do you feel about science?**

Participants clearly expressed their feelings about science. Nine replies only were received in the first survey (out of a possible 19) identifying feelings of interest in science and/or enjoyment of science. For example:

It is interesting and exciting to look at science. 8/S1)

I enjoy it, find it stimulating. (10/S1)

I enjoy it. It is an opportunity to have fun times inside and outside the classroom. It stimulates good oral language, art work and written language. (12/S1)

Interested, aroused to discover more about things. Helps me understand my world and why some things happen like they do. (16/S1)

A similar number of replies identified feelings of concern, confusion, a sense of personal inadequacy and worry about teaching science. For example:

Interested but very confused at times. (7/S1)

I feel limited by how much I do know and how much is still to learn. (8/S1)

I enjoy most aspects of science, but I have difficulty "grasping" advanced technicalities, therefore try to avoid working in such areas. (9/S1)

I would like to feel confident about science but sense wariness of it. (13/S1)

I have never felt confident about my knowledge of scientific facts. (15/S1)

Very inadequate. (18/S1)

Very interested in some aspects, very uninterested in others, intimidated by others when I don't understand it. (19/S1)

In the second survey, sixteen replies were received (out of eighteen). All the replies expressed more positive feelings about science. Participants enjoyed science and two expressed feelings of being 'comfortable' (1, 2/S2). Change was evident in the replies as shown below.

> I enjoy it now and find it quite exciting. (11/S2)
>
> I enjoy science and always have. The difference now being that it is more demanding 'teaching' it, because the resources need to be gathered in a short time span in order for the children to investigate their line of thinking. More demanding for the teacher but more enjoyable for the children. (13/S2)
>
> Good, excited, keen to work on it with the children and staff. (16/S2)
>
> I feel very positive about science. I am keen to undertake new science learning units as much for the new learning I will gain, as for the new learning my students will gain. I am quite excited about making scientific observations and finding explanations for them. - (17/S2)
>
> A lot happier than previously when to have the right answer seemed to me to be paramount. I think I have more confidence to tackle this subject. (18/S2)

Overall, negative feelings about science were not expressed in the second survey and teachers were confident about their classroom science programme.

**c) Has your view changed during your teaching career/ during the course**

Eight replies only were received in answer to this question in the first survey. Five made reference to a personal change that had come about for a number of reasons.

For example,:

- as a maturation process.

> Yes — I used to think it was boring, pretty useless stuff actually. Now I think it is vitally important. The change happened gradually and probably through maturity, both personal and teaching as much as anything. (7/S1)
>
> I choose to become more involved in 'things relating to science' in our world eg. visiting exhibitions. (9/S1)

- as partly a result of teaching.

> Looking more at how children learn rather than what children learn in science. (8/S1)
>
> From fear and a lack of confidence to a desire to use science within my classroom. A desire to know the answers myself plus my own children's questions and inquiring minds. (11/S1)
>
> Just been more aware of it in later years because of my job and the way it has been outlined, resources, changes in curriculum etc. (16S1)

• a change coming from ongoing reading

> Yes — I no longer believe science has at this time accumulated all the right/correct ideas. In the reading I have done around my subjects, I have found that ideas/theories change as new information or links comes to light. (21/S1)

A change in views was also identified as coming from new ideas in teaching and learning.

> Only in as far as in primary school it should be a 'hands-on' approach with the teacher acting as facilitator. These changes have probably come about by interaction with younger teachers coming out with new ideas and attending courses which put forward these ideas. (18/S1)

One teacher shifted from viewing science as knowledge to transmit to seeing science as a process.

> Early on I valued the idea that science as a body of knowledge and science as passing exams was important — over-ridingly so. Perhaps it was my university cramming that caused me to have this attitude. I now value the methods of science and the skills associated with the subject. Attitudes such as perseverance and honesty have greater value too. (20/S1)

In the second survey fourteen replies received indicated a change in views during the course. Four indicated a change from seeing science as a body of knowledge to seeing it as an interpretation of the world around. For example:

> I think I viewed science as a body of knowledge awaiting discovery, totally objective in nature and therefore beyond dispute. Now I see it more as a view of the natural and physical world. We interpret what we see in the light of our present knowledge, our cultural conditioning, our accumulated experience.
> I think I reached this conclusion through exchanges and discussions with other teachers and realisation that historically divergent thinkers have had a battle to get new theories accepted. Scientists themselves acknowledge that present theories are the best we have to work with and confess that ultimately they will be superseded. (4/S2)

> I thought it was hard and now I find it is challenging. I thought it was a finite body of knowledge I had to find out about and pass onto kids. Now I see it as a bunch of theories, ideas, some information which I and the kids have and can share and we can develop from where we are; whatever path we take for developing is not wrong. If we don't get to where a scientist might have got, then we might not be wrong. I have changed because of discussions with others on the course, ideas from the course and from trying things out in class.
> (5/S2)

> I think the course has reminded me and reinforced a long held view that like beauty, knowledge is in the eye of the beholder. It has made me happier about teaching science at F1/2 level where previously I had found too much of a difference between syllabus expectations and where the pupils were at to feel comfortable with what I was doing. The course has given me support for starting where the students are. (10/S2)

> Yes, my views have changed. I see science more as something personal that people hold, than as an immutable, set-in-concrete set of scientific 'rules' proclaimed by

> scientists. Although, there are some generally agreed-upon scientific understandings underpinning our body of knowledge. (19/S2)

Six indicated a change in views coming from changes in the ways the classrooms operated. For example:

> I now take science regularly. I look at things around me with a view to using them in science. The change may have taken place because I have tried some lessons that I know nothing about and using what the whole group knows we actually learn something. I have found the children's positive responses to science investigations very inspiring and their enthusiasm and my own pushes us further. (11/S2)

> They occurred because of the course, by the other teachers on the course sharing their own experiences and ideas with us. By the other people who came and added their input to the whole science field. By trying all the ideas out with my class and seeing other teachers and their classes involved in similar pursuits. (16/S2)

> Yes, for children to display an enquiring mind and be guided to make more enquires, to help them to learn for themselves. I think these changes came about by listening to others talk about what they did with their classes and by being exposed to the constructivist view of handling science. (18/S2)

Two identified a personal change in the way they saw science.

> Since being on this course I now don't feel so threatened by my lack of scientific knowledge when teaching science. Personally I have found myself far more interested in things that occur and I'm now wanting to know the answers or reasons to gain an understanding for myself. (15/S2)

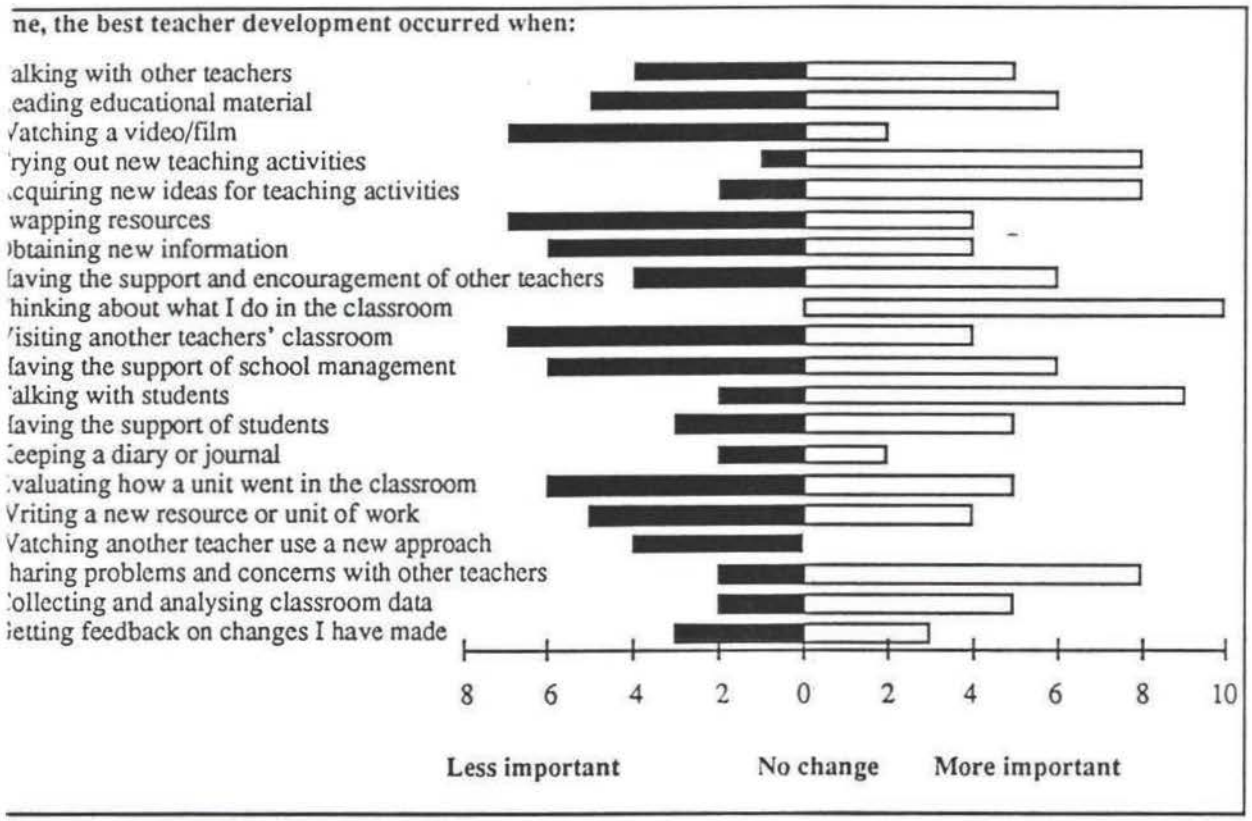
> Yes my view of science has changed. Previously I was very passive about science even negative on occasion I think. Now I am actually quite excited when I observe something in my environment. I really want to follow up my observations and find out a bit more. I also want to share my findings and observations with my students and other teachers too. Previously I felt that science was something scientists did. It was a bit mysterious and I definitely didn't perceive science as being all around me as I do now. (17/S2)

Teachers did identify changes in their views on science. These changes came about from discussions with other teachers, work in their classrooms and material presented on the course.

In summary, changes were evident in the understandings, feelings and views that teachers held about science. Science was seen as less of a body of knowledge and more as a way of explaining the world around them. Feelings about science were positive and teachers indicated they were taking more science in their classrooms. There were strong indications that these changes came about because of the discussions held on the course, the ideas presented to the teachers as part of the course work, and the work that the teachers did in their own classrooms.

**ıestion 27/15: Based on my experiences, the best teacher development occurred for me as a teacher of science when**

this question teachers were asked to identify teacher development activities experienced d rank them (1 very important — 5 not important). Data is presented in Figure H and ble 11.




**igure H: Reported changes in importance of teacher development activities**

ıere were five statistically significant changes with the biggest shift in 'Thinking about ıat I do in the classroom'. 'Talking with students about their ideas' also gained in ıportance. Both these activities were encouraged during the course. Exercises given to ıchers had a strong emphasis on questioning their own practice and determining the ıdents views.

ther significant shifts; trying out new teaching activities, acquiring new ideas for teaching tivities and sharing problems and concerns with other teachers, were initially seen by many ıchers as very important and the course reinforced this for them. Keeping a diary or a ırnal was not seen as important for teacher development by the majority of teachers.

**Table 11: Teacher Mean Ranking on the 'Best Teacher Development'**

| Teacher Development | Survey One Mean scores | Survey Two Mean scores | Shift | T values | Prob |
|---|---|---|---|---|---|
| 1. Talking with other teachers | 1.83 | 1.67 | 0.16 | 210 | NS |
| 2. Reading educational material | 2.94 | 2.72 | 0.22 | 851 | NS |
| 3. Watching a video/film | 2.76 | 2.84 | 0.18 | 33 | NS |
| 4. Trying out new teaching activities | 1.67 | 1.22 | 0.45 | 10 | 0.02 |
| 5. Acquiring new ideas for teaching activities | 1.71 | 1.33 | 0.38 | 43 | 0.04 |
| 6. Swapping resources | 2.0 | 2.11 | 0.11 | 374 | NS |
| 7. Obtaining new information | 2.33 | 2.17 | 0.16 | 252 | NS |
| 8. Having the support and encouragement of other teachers like myself | 1.78 | 1.67 | 0.11 | 433 | NS |
| 9. Thinking about what I do in the classroom | 2.00 | 1.17 | 0.83 | 1 | 0.01 |
| 10. Visiting another teacher's classroom | 2.28 | 2.46 | 0.18 | 476 | NS |
| 11. Having the support and encouragement of the school management | 2.17 | 2.00 | 0.17 | 417 | NS |
| 12. Talking with students about their ideas | 2.47 | 1.67 | 0.20 | 43 | 0.02 |
| 13. Having the support and encouragement of students | 2.39 | 2.11 | 0.28 | 40 | NS |
| 14. Keeping a diary or a journal | 3.53 | 3.39 | 0.14 | 10 | NS |
| 15. Evaluating how a unit of work went in the classroom | 2.06 | 1.94 | 0.12 | 851 | NS |
| 16. Writing a new resource or unit of work | 2.50 | 2.47 | 0.03 | 302 | NS |
| 17. Watching another teacher using a new teaching approach | 2.47 | 2.75 | 0.28 | 1 | NS |
| 18. Sharing problems and concerns with other teachers | 1.94 | 1.35 | 0.59 | 33 | 0.03 |
| 19. Collecting and analysing classroom data | 3.00 | 2.82 | 0.18 | 24 | NS |
| 20. Getting feedback on the changes I have made to my teaching | 2.43 | 2.25 | 0.18 | 19 | NS |
| Number of replies | 19 | 18 | | | |

NS: Not Significant at the 0.05 level.

**Question 28/16: Describe what you understand and feel about teacher development in science.**

Participants were asked to indicate changes in their views over their teaching career (survey 1) and as a result of the course (survey 2).

In the first survey ten of the fourteen replies to this question mentioned the importance of ongoing professional development to improve the teaching of science and the role of the teacher. Development was seen as something that is given to teachers who had 'gone stale' or needed 'revitalising'. The need to gain new ideas, new techniques and teaching methods was common as was the need to explore negative attitudes towards science and to make them more positive. For example:

> It's very important. There are so many people out here with fairly negative attitudes towards science and they need education as to its importance for students. But to be able to teach it confidently they need to discover techniques and be helped to find confidence about the subject matter. (7/S1)

> To see the need and develop the ability to change our role as a teacher — from presenting teacher centred experiences more to student centred. To present situations where the learning is student initiated and controlled, teacher becoming a resource person, a stimulator, a co-ordinator rather than a dominator and teller. (12/S1)

> Teachers need to be given fresh ideas and methods of conveying these. Also reminding of things already learnt. We need inspiring sometimes to become inspiring for children. If a teacher is confident and enjoys a topic this will be conveyed to the children. (14/S1)

> Teacher development in science is about developing in teachers a positive and motivated attitude towards the teaching of science. It is also about developing and keeping up to date with the latest methods of teaching science. (15/S1)

> Teacher development in science involves teachers reviewing and revising their current practices in the light of new data. It also involves teachers experimenting with new approaches and sharing their experiences with others in similar situations. (17/S1)

> I understand it to be something that will increase my understanding of how children learn and give me the skills and ability to greatly enhance learning. I feel a little sceptical — can it help me actually improve my classroom practise? I hope so. (19/S1)

> It is essential to revitalise teachers after they go stale. I believe teachers go through stages which have plateaus on which we can go stale. Help is needed to recognise these times, given a teacher an injection (development?) to allow them to return to their classrooms with different skills to add to their repertoire to teach effectively. Teacher development is ongoing and should not end at any stage in their careers. (21/S1)

Other replies indicated that too few in-service course were held in science and there was a need for courses in order to improve the quality of science teaching (1, 2, 8).

In the second survey, teacher development was seen as personal development in the sixteen replies to this question. Comments were made on specific parts of the course that had aided this development. Interaction, discussion and sharing of ideas with other teachers was seen as an important part of this development. The on-going nature of the course was also mentioned. For example:

> Teacher development is the opportunity for a teacher to be given the opportunity to take a look at their teaching in light of new or current thinking on the subject and if they feel the need then take it on board. It is important to feel that the development takes into account the teachers' thinking. I think we must avoid having development for the sake of development.
> Although this course has been long and involved much travelling, I have felt it has been what I would personally call development as it has made me take a look at my overall teaching. I think it has had more influence on the way I now teach maths, language than on science. But then we do need literate scientists who can compute their findings. - (1/S2)

> It can be achieved by sharing ideas and putting them into practice. You don't need a whole lot of written assignments to prove you have learnt something but it is good to have colleagues give feedback. I enjoyed stimulating discussions with colleagues without having to reach a consensus. I am glad of the length of the course as it has allowed knowledge to consolidate and be reinforced. The continual revisiting of ways we have changed our teaching has prompted me to keep on trying. (5/S2)

> Perhaps I now see the important aspects of teacher development being developing an understanding of how children learn and refining my teaching philosophy rather than just the emphasis being on the acquisition of practical ideas although these are still important. (10/S2)

> I feel the ideas promoted in the teacher development in science can be used in other areas within our school system. I tell people I'm involved in teacher development with science as the medium, ie developing me as a teacher what I do and say and science just happens to be the area chosen. I would put my name forward for another teacher development course, because the growth and knowledge I've gained in this course have been invaluable.
> — knowledge of how to teach
> — knowledge of how children learn
> — knowledge of how children can be taught
> — listening and sharing with others from all areas of the education system. (11/S2)

> Being able to compare ideas and work with other teachers is of paramount importance to teacher development. We learn best by trial and error so if we can also learn by others' trials and errors we must gather more expertise to use in our own classrooms. Theory is not the answer to anyone's professional development. Practice is all important, and this includes the sharing of ideas of fellow teachers. (13/S2)

> I have seen and learnt how we can all develop no matter what age or stage we are at by involving and employing new methods, revamping old ways, by involving the children much more by questioning, discussion and experimentation. It has changed quite a lot when I sit down and analyse it. The use of new ways in other topics has been tried and tested successfully. (16/S2)

> Teacher development in science has for me, after taking this course, two main parts. Firstly I see it as myself being exposed to new ideas, and secondly my interaction with these new ideas and my colleagues on the course. It is this interaction with both the ideas and my colleagues which has really sped up my own teacher development I feel. I have been able to try out new ideas, evaluate them, make changes, and share all these developments with others in similar situations. The feedback gained from other course members in sharing sessions has been the single biggest motivation or me to try out new ideas. these sessions have also helped me to clarify my thinking to consolidate previously learned concepts and also to embrace new concepts. I now think about my teaching techniques a lot more and relate them directly to the ways in which children learn. I do not take things related to children's learning for granted as I once did. (17.S2)

> I have found this course very challenging and rewarding and it has made me take stock of not just how I 'teach' science but also how I approach other subjects too. So there has been considerable teacher development going on. I have developed a confidence to let the children have more control of their learning. I like the on-going contact and build up of ideas over the year. It gives one time to digest the new material and ideas and time to try things out, make mistakes, but able to discuss with others what they have done and then try them again. Much more satisfactory that 1, 2 day course or week long course where one lacks that follow up period. (18/S2)

> Teacher development in science must involve plenty of time to try new approaches, to reflect, to discuss with colleagues, try to improve on previous attempts. also reading research findings and thinking's, discussing with other teachers. I think the mix of theoretical and practical is important and especially the long-term nature of the course giving time for thinking and practise it develop. (19/S2)

Many of the participants used this question to give an evaluation of the course as well as how the experience had changed their views. A final example detailing these changes is given below.

> Prior to this course I had little or no guidance in the teaching of science and pretty much followed suggested lesson plans found in resources. My teaching was largely about the delivery of information in the course of discussions and hands-on experiences and I'd have probably thought that swift correction of children's misconceptions as fairly important. through this course I have come to understand my own learning processes better — that deeper understanding of a subject is facilitated by:
>
> 1) establishing ones present thinking on it,
> 2) asking questions
> 3) handling, experimenting, observing, researching
> 4) thinking about problems, observations, 'unknowns' and constructing possible solutions, meanings and explanations
> 5) listening to and sharing these ideas with peers, teacher, experts
>
> As a learner I feel less threatened and more valued by this approach. I have time and opportunity to thresh out ideas and thinking in the light of new information. As a teacher, I no longer feel I must know all the answers. I too can participate in the learning process — listening, challenging, helping find information and set up experiments and trials. (4/S2)

In summary, course participants views and understanding of teacher development in science changed. They saw the course programme as a useful for their own teaching, enabling them to take a fresh look at their classroom practice with a greater emphasis on working with

children's ideas. They enjoyed and commented on sharing ideas and experiences with other teachers and the support and feedback they received from the group. There was a movement away from seeing teacher development as something that was done to revitalise teachers to a view that teacher development was essentially personal development. The on-going nature of the course was a factor in promoting this change in view. The time allowed for in the course, for the sharing of practical knowledge and experiences was seen as a valuable part of the course.

## 8. 3 DISCUSSION

Course participants were surveyed before and after the teacher development course with documents designed to give an indication of the movement in views and teaching practices that could be attributed to the course. The course was designed to promote a constructivist approach in the teaching of science and consequently, any movement towards the key features of this approach was considered important (features described in chapter 3). Constable and Long (1991) found that the notion of 'fidelity'(faithfulness to the ideas promoted) was a useful framework of analysis for an evaluation. In this study, it was hoped that movement towards the constructivist approach to teaching promoted on the course would be evident in the responses to the question stems and signify a change in the views of the course participants.

Analysis of the survey responses showed that there was significant change in the ways that the teachers said they were teaching science (questions 15/3, 17/5). Classroom activities in science were more student centred with the majority of teachers indicated they were recognising student input and listening and responding to students' thinking. Similar outcomes were evident with teachers on the LISP (Teacher Development ) courses. (Pearson and Bell; 1992, 1993). Some differences were noted in the significance of some items of teaching practice eg. Teacher demonstration (q. 15/3, item 3) In the LISP course (mainly secondary teachers) there was a highly significant shift away from demonstrations while in the present course (mainly primary teachers), there was no change evident. Teacher demonstration was identified by primary teachers as not part of their teaching practice and no change was expected.

In recording their feelings about teaching science (questions 16/4) the replies in the second survey were much more detailed with a strong focus on facilitating learning rather than teaching. It was also obvious in the replies that primary teachers acknowledged they felt more comfortable with and got greater enjoyment out of teaching science. These responses were

consistent with outcomes with primary teachers on a similar teacher development course (Hardy et al, 1990).

Along with the reports of changes in practice, the responses showed changes in the views on teaching held by the participants (questions 18/6). There were significant shifts away from traditional views eg. 'teaching science involves covering the syllabus '(q. 18/6, item 4) and shifts towards constructivist views eg. 'teaching involves finding out what the students are thinking' (q.18/6, item 12). Many of the question stems were readily identified as elements of good teaching practice in the primary school especially and while teachers initially indicated they believed being a teacher of science involved using these teaching skills eg. 'interacting with students' ideas' (q.18/6, item 19 scored as very important), there was little indication that this was happening in their practice.

Significant change was evident in the teachers perceptions of activities that are helpful to learning in science (questions 19/7) and the importance of beliefs about the way students learn science (questions 20/8). Again the changes identified traditional teaching activities as being less helpful to learning and features of constructivist teaching as being helpful to learning. Changes in beliefs about the way students learn science appeared to be reinforced by the course. Many of the activities were seen as important and could be considered part of general primary school practice. All question items scores moved towards constructivist beliefs about the features that are important or not to learning in science. This changes is consistent with that reported in other courses (Pearson and Bell, 1993). In free response answers (questions 21/9) the detailed replies in the second survey indicated that changes in the understandings of learning in science came from teachers' experiences with their classes and the reading and discussions on the course.

Little change was evident in the views that teachers held about the importance of science and technology in the school curriculum (questions 22/10) or indeed their understandings of the science curriculum (questions 23/11, 24/12). While the issue of the value of learning scientific knowledge was explored during the course (and seen as less important in the second survey), a industrial ban on discussing curriculum documents meant that other issues were not explored. To some extent also, the thrust of the course was to discuss teacher classroom practice and during course sessions, anything that was seen as academic received little time in discussion. This was again evident in change in meanings of science. While there was little significant change in the structured responses (questions 25/13) in the free responses (questions 26/14) some change in emphasis was evident. There was a shift away from seeing science as a body of knowledge and facts about the world to a focus on making sense and explaining phenomena in the world. Teachers reported being more comfortable about science and identified that this had come about from the experiences of the course.

The final questions in the surveys were on teacher experiences and understandings of teacher development (questions 27/15, 28/16). The question items were to identify elements of the course that the teachers had found useful in their professional development. The significant changes related to talking with other teachers and acquiring new teaching ideas. These changes were expected and could be considered to be the outcome of any good teacher development course. Change that could be related to the emphasis in the course on a constructivist teaching approach was the identification that good teacher development could come from talking with students about their ideas.

For many of the teachers on the course, many of the ideas presented were not unfamiliar to them. Many resources for the primary school in mathematics, language, reading, social studies presented similar 'interactive approach' (Biddulph and Osborne, 1984) ideas. Constable and Long (1991) note that familiarity with ideas will colour the way an idea is presented. For many of the primary teachers on the course, the only unfamiliar idea for them may have been that science could be taught in a similar fashion to that of other subjects; providing experiences, finding out what students were thinking and working with those ideas. Overall, the responses to the survey questions demonstrate a faithfulness to the constructivist approach promoted on the course.

In the following chapter, the evaluation methodology, the participants, and the results from classroom visits and the reflective writing exercises carried out as part of the course are discussed.

# CHAPTER 9

# DISCUSSION

## 9.1 INTRODUCTION

Throughout the entire course both informal and formal data were collected in the form of reflections and field notes by the author at the completion of each course session, notes on conversations with teachers, observations in classrooms and from the survey documents. The challenge in the evaluation was two fold. Firstly, there was a need to collect data that would show how the course participants took up the original ideas, how they adapted practices modelled on the course for their own classrooms and to detail changes in teacher practice and beliefs. Secondly, as course facilitator and director as well as course researcher, it was necessary to show that these roles could be combined in ways that considered the needs of the participants, the need to produce a valid evaluation and the ethical issues raised when researching alongside teachers in a teacher development course. This chapter considers these issues in discussing the evaluation methodology, the classroom visits and the reflective writing carried out on the course.

## 9.2 METHODOLOGY

All but one of the course participants were visited in their own schools before the course began. At this time the course content and structure were explained to both the teacher concerned and the principal of the school. They were told the aims of the course, that it was a course designed to get teachers collecting data in their own classrooms and reflecting on their own practice and that the course would be evaluated for several reasons. The teachers understood that it was necessary to show the Ministry of Education that teacher development had occurred and as well, that having support and coaching from the facilitator in the classroom aided this development. The teachers were also told that as the course would be running parallel to a similar course comprised of mainly secondary teachers and that some of the data would be useful for comparison purposes. At all times teachers were told there was no personal obligation to provide any data.

While the formal survey documents had been shown to provide valid data on the development of teachers (Pearson and Bell, 1992), in the context of this course it was felt that visiting schools and observing in teacher classrooms would give further insight into the reported changes. It was thought that visits would also show to what extent the teachers were faithful to the ideas promoted on the course and as familiarity developed

with the teaching approach, to what extent individual teachers adapted the original ideas to fit their own teaching context. Again, teachers were asked if it was suitable for the facilitator to make notes in the classroom and in reviewing the lesson or lessons with the teacher afterwards, the teachers were asked if the notes could be used in the evaluation. The facility of audio taping or video taping was offered to all teachers to help them reflect on what they were trying to do in their classroom. These tapes were not used as data and remained the property of the teachers. Discussions were held with the teachers on the tapes and several teachers referred to them during course sessions.

Teachers appeared to be unconcerned by the different roles held by the author in the course. The course itself modelled a constructivist approach and while there were specific exercises to work through and a sequence to the course shown by other research (Bell, 1993) to be important in promoting teacher change, much of the time was spent in collaborative discussion on what was happening in the teachers' own classrooms. Each session had opportunities for personal teaching issues to be raised, both in small group work and in the wider group setting. In the course context, the author was seen as a facilitator, providing resources for teachers and leading the discussion at times. Working in schools proved to be an extension in that the role was one of supporting the teacher. Several schools used the visit for a full staff meeting to review their science programme.

Inevitably the good rapport established with all the teachers developed into personal friendships with several of them. The isolation of small rural schools meant that visits were looked for and used to provide support and feedback in a number of areas. As one teacher in a very isolated school commented "Normally all the energy goes out of a small community, it is good to have energy coming into the school" (1).Care was taken with these visits to only collect data in the classroom and then only when negotiated with the teacher.

As already noted the teachers on the course were all volunteers and their support was essential in ensuring the course ran successfully. They were aware that an evaluation of the course was taking place and were even prepared for an external evaluator to be present. Collecting data and facilitating the course proved possible and it is thought that the data obtained permitted a valid evaluation to be carried out.

## 9.3 CLASSROOM VISITS

Support for teachers in classrooms is considered necessary if new approaches and innovations in teaching are going to succeed (Huberman and Miles, 1984). This has been recognised in many of the recent teacher development contracts in New Zealand

(Frampton, 1991) and supporting teachers formed an important part of the present contract established with the Ministry of Education. That support is necessary was also commented upon during the author's classroom research with the Learning in Science Project (Teacher Development) where teachers frequently sought feedback on what they were trying to achieve in the classroom. It was planned to visit each teacher twice during the course and help them to reflect on what they had achieved. Visits started after the first four sessions of the course.

In the early visits to primary schools it was common to see the teachers teaching with units of work that had been given to them as useful resources (eg. Barker, 1991; Biddulph, 1991). It was in using these resources that had been modelled on the interactive approach (Biddulph and Osborne, 1984) that the teachers became familiar with the approach. Constable and Long (1991, p. 417) write about the importance of a demonstration of strategies as a means of getting hold of the ideas behind the strategies. These resources provided a good demonstration and teachers, working with the resources, raised questions about the interactive approach that were addressed during the classroom visit. During the early visits video recordings made with two teachers proved to be illuminating for the teachers concerned. A radio microphone on the lapel of the teacher gave the teacher access to the dialogue they had with students and feedback on how they accessed student ideas.

Visits were only able to be arranged to two of the secondary teachers on the course. In the initial visits, both teachers were bringing elements of a constructivist teaching into their normal programme. They were finding out students' existing ideas using methods modelled on the course (eg. brainstorming, concept maps), providing practical experiences that related to the existing ideas and emphasised collaborative work in groups. The approach was not particularly comfortable for them with one teacher noting that he "didn't feel as if he was earning his money as he wasn't writing a lot of notes on the board" (21). While there was some recognition that working in this way was more difficult with some class levels, the practice was similar in all the classes observed .

In the second series of visits both primary and secondary teachers were engaging with students' ideas more easily. They had moved beyond being concerned with managing the approach with few concerns about resources being available. They were interested in finding ways that would help them evaluate the learning going on in the classroom and indeed were talking with their students about learning. Several of the teachers on the course who had some responsibility for science in their school were organising or had run in-school development for their own staff. The above data is in agreement with a Stages of Concern model for detecting change (Hall and Loucks, 1978) detailed by Constable and Long (1989). Initially concerns about personal management were addressed with the

majority of the teachers moving onto concerns about outcomes. Change was evident in the teacher actions and practice in the classroom.

Classroom visits were planned to give support to the teachers in the classroom. It was felt that the visits served this purpose well, helping teachers adjust and adapt their teaching practice. Visits were important to see what problems were and be able to reflect this back in group discussions. Often what had happened with one teacher could be answered by another with a similar experience. They were also important in an evaluation of the course and teacher change.

## 9.4 REFLECTIVE WRITING

Promoting reflective practice in teachers is seen as an important part of many teacher development courses and was aimed for on the present course. However, as Smyth (1992) argues much of the literature says very much about how this can be achieved in a way that actually helps teachers concentrate on what is worthwhile in teaching. He goes on to state that reflective practice could well focus on teachers describing — what do I do, informing — what does this mean, confronting — how did I come to be like this and reconstructing — how might I do things differently? For teachers who had very traditional experiences of science, to get them to reflect in this manner on their personal theories and experiences in the classroom underpinned the present teacher development course.

Journal keeping was introduced to the teachers at the first session and a reading given out on the use of a journal writing for professional development (Holly and McLoughlin, 1988). While the journals were useful to some of the teachers who did make notes during the course sessions and kept a log of their classroom activities, all the teachers acknowledged that keeping a journal was time-consuming and often they had nothing to write. Consequently, it was planned to set aside a time during a course session for teachers to 'describe' their personal theories about teaching of science and what it was to be a science teacher (Baird et al, 1991). It was explained that the writings would be given back to them with a general summary of all the individual answers and that the exercise would be repeated at a later session. While it was not a 'Free Writes' session, as advocated by Butler (1991) and Edwards (1991), teachers were free to fill in the evaluation form if they wanted and in any way they chose.

The use of the structured reflection form proved to be a useful exercise. Differences were noted between the two sets of replies to all questions on the form. Initially teaching of science was described in a traditional manner with a focus on getting across a body of knowledge to the students. The second set of writings showed there was more emphasis

on different teaching roles and on working with students' ideas. There was also a greater use of a constructivist vocabulary with phrases as 'stimulating pupils to think about and modify their concepts', making sure everyone's opinions are listened to and valued', and 'listening to children's' ideas and help them to clarify these'.

Learning in science was described as 'having fun' and many teachers had a process view where science learning involved 'predicting, classifying, measuring'. In the second set the emphasis was on students making sense through 'discussion, exploring, questioning, changing ideas', again a more constructivist view. Feedback on their teaching changed from being outcome orientated, 'examination successes, do they have the right answer', to feedback directly from the student in terms of 'increased interest, active involvement and seeing evidence of thinking changing based on discussions and experiences.

Concerns about science teaching did not appear to change much overly much. However, using the Stages of Concern model of Hall and Loucks (1978, quoted in Constable and Long, 1989) as a framework for analysis, some differences did emerge. Initially concerns were on personal uncertainties about the demands of science teaching and the management of the resources and equipment needed. For a few of the teachers attention focused more on the student outcomes and what was needed to increase these outcomes. The lack of movement in the sort of concerns may indicate that teachers had not taught enough science units to overcome some of the perceived problems. Teachers did indicate that for many of them, a science unit was timetabled for three weeks twice a term and that did not alter even during the course.

It was obvious that answering the questions had made them think about their practice, describe it to some extent and attempt to inform, confront, and reconstruct their teaching (Smyth, 1992). In the second set of writings they appeared to have more confidence in what they were doing and a greater comfort in teaching science. They were also more confident in discussing learning and used a different vocabulary. This reflective writing exercise was thought to be useful in the teachers' professional development and also a useful tool in evaluating teacher change.

The following chapter summarises and concludes this report.

# CHAPTER 10

# CONCLUSION

A summary of the findings is presented and discussed.

## 10.1 SUMMARY OF FINDINGS

The teacher professional development contract appeared to be successful. The initial target group of twenty teachers was exceeded although two teachers subsequently withdrew from the course and a third teacher left the district. While thirteen schools (eleven primary and two secondary schools), were initially involved with the contract, this number represented only a quarter of all the schools invited to participate. It was beyond the scope of this study to ascertain the reason for the low response to the invitation. Attendance was high at all sessions with the majority of participants missing only one or two of the thirteen course sessions.

The course was based on the programme developed as part of the Learning in Science Project (Teacher Development). The course developed and acknowledged collaborative strategies of teaching and learning and modelled the same features of constructivist teaching that were promoted on the course. Participants acknowledged that they enjoyed the course and were able to discuss their concerns regarding the teaching of science in a relatively informal and supportive environment. The course materials and teaching approach were more familiar to many of the primary teachers and both they and the secondary teachers received the ideas on teaching and learning in science very positively.

It is felt that the data collection methods (classroom visits, reflective writing, surveys) allowed an accurate and valid evaluation of the course. The majority of the participants supplied data willingly and welcomed visits to their classrooms. During the visits the teachers entered into discussions freely and made extra time available to talk about their views on learning and teaching in science. It was obvious in these visits that the teachers were using the resource materials handed out on the course and in the later visits, were seen to be adapting the teaching approaches to other teaching situations.

Participants were generally primary teachers with poor backgrounds in science and little science in-service experience. They had volunteered for the course wanting to improve their teaching of science and to gain some personal confidence in science. The reflective writing exercise carried out at the end of two of the sessions permitted teachers to express their personal views about teaching of science and science learning. The second set of responses gave an indication of the changes in teacher views which suggested a

development of ideas and their ready acceptance of the constructivist approach to the teaching of science.

Analysis of the two surveys confirmed the change in teacher views on teaching and learning in science. There was a significant movement towards constructivist ideas with teachers indicating they were recognising students' input, taking into account students' thinking and responding to students in ways that encouraged conceptual change. They acknowledged that they felt more comfortable with and enjoyed teaching science more. Teachers also noted that good professional development came from discussing students' ideas in the classroom.

It is felt that the teacher development programme provided support and feedback to the participant members of the course and in many cases to other teachers in their schools, for the provision of effective science education programmes in the classroom. The course focussed on the sharing and implementation of effective learning strategies for science education and these assisted teachers to achieve the aims of the science syllabuses, junior primary to form 5.

# APPENDICES

**University of Waikato** Centre for Science and Mathematics Education Research
Te Whare Wānanga o Waikato

Private Bag 3105, Hamilton, New Zealand
Fax 64-7-838-4219
Phone 64-7-838-4101



Wednesday 19 February.

The Principal

Dear Colleague,

The Centre for Science and Mathematics Education Research has been contracted by the Ministry of Education to deliver a teacher development programme in Science ranging from junior primary to form 5, in the Thames-Coromandel schools.

The programme aims to implement research findings on learning and teaching science with the delivery of the programme following recent research from the Learning in Science Project (Teacher Development). Account will be taken of existing syllabii, the Achievment Initiatives in science as well as the National Curriculum documents.

The development course is on-going throughout the year and will require attendance at twelve sessions to be held in the Thames Education Centre. There will be three whole-day sessions and nine afternoon sessions from 4-7 PM. In addition, there will be a series of on-going visits by the project director to participating schools, to work with and provide classroom based support for teachers on the implementation of effective strategies for the teaching and assessment of science. Visits may also involve working with the whole staff at your request.

I am writing to you to extend an invitation to your school to nominate a teacher or teachers for this programme of Teacher Development in Science. All resources and meals will be provided with the costs being met by the contract and a contribution will be made towards travel expenses.
Participating schools will be required to provide two teacher release days for every teacher participating on the programme. The remainder of release time is provided in the contract.

From the nominations received 20 participants will be chosen. Preference will be given to pairs of teachers from the larger schools so that support and feedback is available in the school, and from one teacher in smaller schools where support would be available from a neighbouring school. A visit will be made to each selected school to make contact with the staff before the course begins.

If you have any further inquiries or would like to be involved please contact me at the University of Waikato (0-7- 838-4101 Direct Line ).

Yours faithfully,

John Pearson

John Pearson
Project Director

**University of Waikato** Centre for Science and Mathematics Education Research

Te Whare Wānanga o Waikato

Private Bag 3105, Hamilton, New Zealand
Fax 0-7-838 4272
Phone 0-7-838 4101



Tuesday, March 3, 1992

The Principal

Dear Colleague,

I wrote to you two weeks ago concerning a teacher development programme in Science ranging from junior primary to form five.

The Ministry of Education (Curriculum Functions) has contracted the Centre for Science and Mathematics Education Research to deliver the development programme based on research findings of the Learning in Science Projects and taking into account recent developments such as the National Curriculum documents and the Achievement Initiatives.

The development course is on-going throughout the year and will require attendance at twelve sessions to be held in the Thames Education Centre, generally on a Wednesday. There will be three whole-day sessions and nine afternoon sessions from 4-7 PM. In addition, there will be a series of on-going visits by the project director to participating schools, to work with and provide classroom based support for teachers on the implementation of effective strategies for the teaching and assessment of science. Visits may also involve working with the whole staff at your request.

All resources and meals will be provided with the costs being met by the contract and a contribution will be made towards travel expenses.
Participating schools will be required to provide two teacher release days for every teacher participating on the programme with three extra days of release time provided in the contract.

There are a few places left on this course. It is unlikely to be repeated in the Thames-Coromandel area. If you are interested in nominating a teacher or teachers for this course please contact me by the 10th of March.

Yours faithfully,

John Pearson

John Pearson
Project Director

## REFLECTIVE EVALUATION FORM

NAME_____

DATE_____

Please answer each of the questions by thinking deeply about YOURSELF
Answer in terms of how you are now. (And any changes that the course might have made in your thinking)

1. What is it, to be a teacher of science? (Base your answer on how you feel.

**For me,** it is

2. What is science teaching? (Base your answer on what you do now)

**For me,** it is

3. What is science learning for my students?

4. What is the most important feedback in science teaching?

**For me,** it is

5. What is the worst aspect of science teaching?

**For me,** it is

6. What has answering the five questions above made me do/ think about?

**Survey Documents**

# Teaching That Takes Into Account Students' Thinking

# A Professional Development Course for Teachers

## Survey One[1]

## March 1992

There are no right answers. Please feel free to write as fully as you can.
If there is insufficient space please write on the back!

PLEASE COMPLETE AND RETURN

[1] Survey Two did not include the biographical questions in Section A

## PART A BACKGROUND

1. First Name Surname

2. What schools have you taught in and classes taken?

3. How many years have you been teaching for?

4. At the moment, what do you consider yourself a specialist in ?

(Tick as many as appropriate)

| | | | | | |
|---|---|---|---|---|---|
| (a) | primary | ☐ | (e) | chemistry | ☐ |
| (b) | secondary | ☐ | (f) | physics | ☐ |
| (c) | science | ☐ | (g) | earth sciences | ☐ |
| (d) | biology | ☐ | (h) | other<br>Please specify | ☐ |

5 What teaching qualification (s), have you?

6. What tertiary qualifications (university, teachers' college, polytechnic) concerned with science or technology have you been awarded?

7. Are you doing a present course of study for qualification(s)? (Please give details)

**8.(a)** Have you any other qualification(s) relevant to teaching? (Please give details)

**8.(b)** What professional affiliations do you have?

**9.** Have you been involved in any areas of responsibility within the school(s)? (For example, HOD, Board of Trustees member, textbook co-ordinator).

**10.** Have you ever been involved in other inservice programmes (do not include teacher-only days) that relate to learning in science:

**11.** Why are you doing this inservice course? What do you expect to gain from this course? (You might have a variety of reasons. List those most important to you)

**12.** Do you have any interests/activities/hobbies outside school that you see as related to science/technology (e.g. watching 'Fast Forward', listening to the 'Science Programme', reading the 'New Zealand Geographic', collecting shells). If so, what are they?

**13.** What has been your experience of science or technology in school? (What was science or technology like? How did you feel about it? What was your experience of it?)

(a) in primary school

(b) in secondary school

(c) in tertiary institution(s)

**14.** Have you ever considered or had

(a) a career in science or technology. Yes/No If so which one(s)?

(b) an occupation that you think requires an understanding of science/technology or uses scientific/technological skills Yes/No
If so which one(s)?

## PART B. TEACHING AND LEARNING SCIENCE

**15. Teaching science** in my classroom currently involves

Please circle the most appropriate number on the scale

| | always | mostly | often | sometimes | neve |
|---|---|---|---|---|---|
| teacher led discussion | 1 | 2 | 3 | 4 | 5 |
| teacher demonstration | 1 | 2 | 3 | 4 | 5 |
| teacher explanation | 1 | 2 | 3 | 4 | 5 |
| media presentation (video, film, slide etc) | 1 | 2 | 3 | 4 | 5 |
| guest speaker | 1 | 2 | 3 | 4 | 5 |
| students doing teacher-initiated investigations | 1 | 2 | 3 | 4 | 5 |
| students doing self-initiated investigations | 1 | 2 | 3 | 4 | 5 |
| tinkering (e.g. exploring how things fit together) | 1 | 2 | 3 | 4 | 5 |
| students discussing in small groups | 1 | 2 | 3 | 4 | 5 |
| student explanation or report back to the whole class | 1 | 2 | 3 | 4 | 5 |
| students discussing as a class | 1 | 2 | 3 | 4 | 5 |
| students doing written work (task sheets, note taking) | 1 | 2 | 3 | 4 | 5 |
| students writing in their own words (poem, report of an investigation) | 1 | 2 | 3 | 4 | 5 |
| students doing library research | 1 | 2 | 3 | 4 | 5 |
| science table/display/poster | 1 | 2 | 3 | 4 | 5 |
| field trips and visits | 1 | 2 | 3 | 4 | 5 |
| other activities (please describe) | 1 | 2 | 3 | 4 | 5 |

16. Describe what you understand and feel about **teaching science.** To what extent, has your view of teaching science changed during your career?

**17.** Describe a recent science lesson or series of science lessons that you have taught.

**18.** To me **being a teacher of science** involves:

Please circle the most appropriate number on the scale

| | **very important** | | | | **not important** |
|---|---|---|---|---|---|
| having a knowledge of science | 1 | 2 | 3 | 4 | 5 |
| having a knowledge of how science is done | 1 | 2 | 3 | 4 | 5 |
| planning lessons | 1 | 2 | 3 | 4 | 5 |
| covering the syllabus/school scheme | 1 | 2 | 3 | 4 | 5 |
| being supportive of students as they learn | 1 | 2 | 3 | 4 | 5 |
| providing resources for students | 1 | 2 | 3 | 4 | 5 |
| giving instructions | 1 | 2 | 3 | 4 | 5 |
| giving explanations and knowledge to students | 1 | 2 | 3 | 4 | 5 |
| determining the direction of the lessons | 1 | 2 | 3 | 4 | 5 |
| giving notes to students | 1 | 2 | 3 | 4 | 5 |
| assessing students work | 1 | 2 | 3 | 4 | 5 |
| finding out what the students are thinking | 1 | 2 | 3 | 4 | 5 |
| helping the students think for themselves | 1 | 2 | 3 | 4 | 5 |
| helping students change their ideas | 1 | 2 | 3 | 4 | 5 |
| promoting discussion by students | 1 | 2 | 3 | 4 | 5 |
| accepting students ideas | 1 | 2 | 3 | 4 | 5 |
| organising the groupings of students | 1 | 2 | 3 | 4 | 5 |
| making the science content relevant and interesting for students | 1 | 2 | 3 | 4 | 5 |
| listening to students ideas | 1 | 2 | 3 | 4 | 5 |
| interacting with students ideas | 1 | 2 | 3 | 4 | 5 |
| providing worksheets for students | 1 | 2 | 3 | 4 | 5 |
| ensuring the girls and the boys equally share the talk time | 1 | 2 | 3 | 4 | 5 |
| helping students pass examinations | 1 | 2 | 3 | 4 | 5 |

**19.** In my experience, **learning** science is helped by these activities:

Please circle the most appropriate number on the scale

| | always | mostly | often | sometimes | never |
|---|---|---|---|---|---|
| listening to the teacher explaining | 1 | 2 | 3 | 4 | 5 |
| taking good notes to revise from | 1 | 2 | 3 | 4 | 5 |
| opportunities to practise exam questions | 1 | 2 | 3 | 4 | 5 |
| reading textbooks | 1 | 2 | 3 | 4 | 5 |
| doing written exercises from the textbook or task sheets | 1 | 2 | 3 | 4 | 5 |
| watching a teacher demonstration | 1 | 2 | 3 | 4 | 5 |
| carrying out practicals following the instructions given | 1 | 2 | 3 | 4 | 5 |
| talking and listening with other students in groups | 1 | 2 | 3 | 4 | 5 |
| asking questions | 1 | 2 | 3 | 4 | 5 |
| investigating to find answers | 1 | 2 | 3 | 4 | 5 |
| tinkering or playing around with equipment | 1 | 2 | 3 | 4 | 5 |
| reading books | 1 | 2 | 3 | 4 | 5 |
| talking and listening to experts | 1 | 2 | 3 | 4 | 5 |
| browsing in the library | 1 | 2 | 3 | 4 | 5 |
| students testing out their own ideas | 1 | 2 | 3 | 4 | 5 |
| solving puzzles and problems | 1 | 2 | 3 | 4 | 5 |
| reflecting on their own ideas | 1 | 2 | 3 | 4 | 5 |
| evaluating what they have learnt | 1 | 2 | 3 | 4 | 5 |
| sitting tests/examinations | 1 | 2 | 3 | 4 | 5 |
| having 'hands-on' experiences | 1 | 2 | 3 | 4 | 5 |

**20.** To me **learning science involves students:**

Please circle the most appropriate number on the scale

| | very important | | | | not important |
|---|---|---|---|---|---|
| linking new ideas to existing ideas | 1 | 2 | 3 | 4 | 5 |
| weighing up the value of a new idea | 1 | 2 | 3 | 4 | 5 |
| practising a skill | 1 | 2 | 3 | 4 | 5 |
| copying a teacher demonstration | 1 | 2 | 3 | 4 | 5 |
| thinking for themselves | 1 | 2 | 3 | 4 | 5 |
| being involved in activities | 1 | 2 | 3 | 4 | 5 |
| enjoyment | 1 | 2 | 3 | 4 | 5 |
| memorising facts and knowledge | 1 | 2 | 3 | 4 | 5 |
| following directions | 1 | 2 | 3 | 4 | 5 |
| clarifying their ideas | 1 | 2 | 3 | 4 | 5 |
| making sense of observed phenomena | 1 | 2 | 3 | 4 | 5 |
| being interested in what they are learning | 1 | 2 | 3 | 4 | 5 |
| constructing new ideas | 1 | 2 | 3 | 4 | 5 |
| using new ideas and skills with confidence | 1 | 2 | 3 | 4 | 5 |
| co-operating with other students | 1 | 2 | 3 | 4 | 5 |
| finding out things for themselves | 1 | 2 | 3 | 4 | 5 |
| owning their work | 1 | 2 | 3 | 4 | 5 |
| being motivated | 1 | 2 | 3 | 4 | 5 |
| being able to transfer and apply new ideas | 1 | 2 | 3 | 4 | 5 |
| changing their ideas | 1 | 2 | 3 | 4 | 5 |
| working on-task | 1 | 2 | 3 | 4 | 5 |
| obtaining new knowledge from the teacher or book | 1 | 2 | 3 | 4 | 5 |
| learning how-to-learn | 1 | 2 | 3 | 4 | 5 |
| carrying out practicals/investigations/experiments | 1 | 2 | 3 | 4 | 5 |

**21.** Describe what you understand and feel about **learning in science.** To what extent has your view of learning changed during your career?

**22.** I believe that the following are reasons for including science/technology in the school curriculum:

Please circle the most appropriate number of the scale

| | very important | | | | not important |
|---|---|---|---|---|---|
| to interest children in science | 1 | 2 | 3 | 4 | 5 |
| to provide scientific knowledge | 1 | 2 | 3 | 4 | 5 |
| to develop learning of manipulative skills | 1 | 2 | 3 | 4 | 5 |
| to develop communication skills | 1 | 2 | 3 | 4 | 5 |
| to provide an education for future scientists | 1 | 2 | 3 | 4 | 5 |
| to develop problem solving skills | 1 | 2 | 3 | 4 | 5 |
| to develop social skills (e.g. co-operation) | 1 | 2 | 3 | 4 | 5 |
| to prepare children for further science education | 1 | 2 | 3 | 4 | 5 |
| to use science in everyday life | 1 | 2 | 3 | 4 | 5 |
| to develop decision making skills | 1 | 2 | 3 | 4 | 5 |
| to introduce students to part of our culture and heritage | 1 | 2 | 3 | 4 | 5 |
| to help students construct better understandings of their biological and physical worlds | 1 | 2 | 3 | 4 | 5 |
| to develop skills of doing experiments | 1 | 2 | 3 | 4 | 5 |

Other reasons (please state)

**23.** My understanding of the phrase **'Science Curriculum'** includes:

Please circle the most appropriate number of the scale

| | **very important** | | | | **not important** |
|---|---|---|---|---|---|
| national syllabus | 1 | 2 | 3 | 4 | 5 |
| school scheme | 1 | 2 | 3 | 4 | 5 |
| textbooks | 1 | 2 | 3 | 4 | 5 |
| work-sheets | 1 | 2 | 3 | 4 | 5 |
| knowledge and skills to be learnt | 1 | 2 | 3 | 4 | 5 |
| what the student actually learns | 1 | 2 | 3 | 4 | 5 |
| the learning experiences for the students | 1 | 2 | 3 | 4 | 5 |
| what I teach the students | 1 | 2 | 3 | 4 | 5 |
| Other responses(please specify | 1 | 2 | 3 | 4 | 5 |

**24.** Describe what you understand about the science curriculum. To what extent has your view of t science curriculum changed during your career?

**25.** In terms of my meaning for the word **'Science'**

Please circle the most appropriate number on the scale

| | strongly agree | | | strongly disagree | |
|---|---|---|---|---|---|
| Scientific theories describes the world as it really is. | 1 | 2 | 3 | 4 | 5 |
| Scientific knowledge is consistent from one group of people to another | 1 | 2 | 3 | 4 | 5 |
| Explanations for events are consistent over time | 1 | 2 | 3 | 4 | 5 |
| Scientific knowledge varies from one historical era to another | 1 | 2 | 3 | 4 | 5 |
| In conducting an experiment scientist's actions are separate from the morality of the situation | 1 | 2 | 3 | 4 | 5 |
| Scientific knowledge is created in the minds of scientists | 1 | 2 | 3 | 4 | 5 |
| Scientific knowledge results from observation and experimentation by scientists | 1 | 2 | 3 | 4 | 5 |
| Scientists observe phenomena in an unbiased way | 1 | 2 | 3 | 4 | 5 |
| Scientists' existing ideas influence what they observe | 1 | 2 | 3 | 4 | 5 |
| New scientific knowledge is validated when it is accepted by other scientists | 1 | 2 | 3 | 4 | 5 |
| A veterinarian examining a sick sheep is being a scientist | 1 | 2 | 3 | 4 | 5 |
| An amateur gardener growing prize daffodils is being a scientist | 1 | 2 | 3 | 4 | 5 |
| Science involves creating a body of knowledge using scientific processes | 1 | 2 | 3 | 4 | 5 |
| Scientific data is objective, not subjective | 1 | 2 | 3 | 4 | 5 |

**26** With regards to science,

**a** What do you **understand** by the term 'science'?

**b** How do you **feel** about science?

**c.** Has your view of science **changed** during your teaching career? If so, please describe these changes and how and why you think they occurred.

27. Based on my experiences, the **best teacher development** occurred for me as a teacher of science when:

Please circle the most appropriate number of the scale

| | very important | | | | not important |
|---|---|---|---|---|---|
| talking with other teachers | 1 | 2 | 3 | 4 | 5 |
| reading education material | 1 | 2 | 3 | 4 | 5 |
| watching a video/film | 1 | 2 | 3 | 4 | 5 |
| trying out new teaching activities | 1 | 2 | 3 | 4 | 5 |
| acquiring new ideas for teaching activities | 1 | 2 | 3 | 4 | 5 |
| swapping resources | 1 | 2 | 3 | 4 | 5 |
| obtaining new information | 1 | 2 | 3 | 4 | 5 |
| having the support and encouragement of other teachers like myself | 1 | 2 | 3 | 4 | 5 |
| thinking about what I do in the classroom | 1 | 2 | 3 | 4 | 5 |
| visiting another teachers' classroom | 1 | 2 | 3 | 4 | 5 |
| having the support and encouragement of the school management | 1 | 2 | 3 | 4 | 5 |
| talking with students about their ideas | 1 | 2 | 3 | 4 | 5 |
| having the support and encouragement of students | 1 | 2 | 3 | 4 | 5 |
| keeping a diary or journal | 1 | 2 | 3 | 4 | 5 |
| evaluating how a unit of work went in the classroom | 1 | 2 | 3 | 4 | 5 |
| writing a new resource or unit of work | 1 | 2 | 3 | 4 | 5 |
| watching another teacher use a new teaching approach | 1 | 2 | 3 | 4 | 5 |
| sharing problems and concerns with other teachers | 1 | 2 | 3 | 4 | 5 |
| collecting and analysing classroom data | 1 | 2 | 3 | 4 | 5 |
| getting feedback on the changes I have made to my teaching | 1 | 2 | 3 | 4 | 5 |
| listening to what other teachers have done | 1 | 2 | 3 | 4 | 5 |
| thinking about teaching and learning | 1 | 2 | 3 | 4 | 5 |

28. Describe what you understand and feel about teacher development in science.
To what extent has your view of teacher development changed during your career?.

THANK YOU FOR COMPLETING THIS SURVEY

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