

CHAPTER 5

RESEARCH FINDINGS OVERVIEW

Findings from the group as a whole are discussed first in chapter 5, where semi quantitative results are discussed in some detail and some qualitative results provided as examples of identity construction.

5.1 Introduction

In this chapter, I present an introduction to the results using findings from the whole group (case study and non case study participants alike) as examples. Regarding the semi quantitative findings, pre course and post course scores on both the content knowledge and STEBI-B (BT) questionnaires are offered despite the fact that the courses are not examined as interventions. However, some preliminary remarks are made concerning trends and tendencies. Then examples of students' writings and other artefacts are provided as discussion points with respect to the qualitative part of the study.

5.2 Findings

5.2.1 Group as a Whole

5.2.1.2 Semi - quantitative methods

Numbers of participants are given where indicated.

5.2.1.2.1 Knowledge of scientific content.

5.2.1.2.1.1. Scientific understanding of the term 'Animal'.

Question: Which of these are animals?

The table set out below illustrates the percentage correct answers to the above question. It should be noted that responses total over 100% because the question was one of free choice and multiple answers were required.

5.2.1.2.1.1.1 Pre Course Scores

As can be seen from Table 5.1, the majority of the students participating in the study were sure about the status of zebras and dogs (obvious land mammals) as 'animals'. However, it remains unclear why fewer than 100 % of the participants considered these organisms 'animals'. Whales, as aquatic creatures, appear less obvious and humans are not considered animals by many of the student teachers surveyed.

Animal	% Correct	
	<i>Pre Course</i>	<i>Post Course</i>
Spider	40	66
Worm	61	65
Zebra	88	98
Frog	48	83
Butterfly	4	59
Fish	50	97
Dog	88	94
Whale	50	97
Human	60	87
Chicken	66	85

**TABLE 5.1 Percentage Distribution of correct answers to the question
"Which of these are animals?"
N = 46**

Fish, frogs and invertebrates were considered non-animal by over half the sample which is cause for concern. The chicken - possibly birds in general - was considered an animal by about two-thirds of the sample.

These results are similar to those of other educationists who conducted research among both children and adults. For instance Bell and Barker (1982) found that under 50% of their sample considered a fish, boy, frog, snail, snake or whale as an animal. A significant percentage of primary teacher trainees (25% to 35%) also appeared unsure of the scientific taxonomic status of worms and spiders. These findings suggest that people's misunderstandings are fairly widespread. Of significance is the implication that some explication of scientific classification is needed before student teachers are qualified and embark on a teaching career which may include natural science.

5.2.1.2.1.1.2 Post Course Scores

At the end of the methods course, it was clear that some student teachers had changed their views about animal classification. The correct classification of invertebrates like spider, worm and butterfly as *animals* showed a marked increase. The same can be said for fish, frog and chicken. A few students still seemed either reluctant to classify humans as animals, or remained unclear about the criteria for doing so. These findings resonate

with those of Haslam (1991) and Tema (1989) both of whom conducted research in southern Africa.

Biological classification is not a particularly difficult concept which may explain the apparent modification in understanding indicated by the findings reported above. However, students require some explanation of criteria used by taxonomists, not only as regards the animal kingdom but the other kingdoms as well. Students also need to be guided towards an understanding that science is *a way of seeing the world* and *a human activity*. If we learn about science then we learn what scientists or the scientific community thinks or believes at present. It is important that educators make this point and do not lead their pupils to believe that they are being presented with a universal truth.

5.2.1.2.1.2 Scientific Understanding of Plant Nutrition

It should be noted that responses total over 100% because some students included several responses in a single answer. This was a question of the open-ended type and therefore students simply wrote down what they considered were suitable responses.

5.2.1.2.1.2.1 Pre Course Scores

In this initial investigation, *only one* student teacher provided a scientifically accurate response to the question. Photosynthesis is taught in schools in various grades (and at various levels of difficulty) from Grade 5 or Grade 6 onwards. It is a matter of concern that many participants appear to have had fragmented understanding of the concept.

Many students, it appears, were aware that sunlight plays a role in plant nutrition. The precise nature of that role is less clear. Soil, and to a lesser extent water, are considered of some importance in the process. Roth (1985); Eisen *et al.* (1988); Bell (1985); Simpson *et al.* (1982) Barker *et al.* (1989) all report similar findings, viz. that many people believe that plants obtain their food from the soil and / or other inorganic sources like water. It seems that many persons from a range of ages are unaware that plants obtain raw materials from the environment.

Response	% Mentions	
	<i>Pre Course</i>	<i>Post Course</i>
Sun	28	21
Soil	21	11
Water	17	22
Photosynthesis	13	28
Nutrients	5	11
Chlorophyll	2	9
Leaves	2	21
Oxygen	2	5
Minerals	2	3
Air	2	2
Carbon dioxide	2	16
Correct answer	2	27

**TABLE 5.2 Percentage distributions of answers to the question
'How does a plant obtain its food?'
n=46**

It is possible that the respondents who offered the term 'photosynthesis' understood the details of plant nutrition, but I believe it is unlikely, given that ten of them suggested other terms (soil, minerals, nutrients) as well. Furthermore, it is unclear what is meant by 'nutrients' and further research into students' use of terminology is indicated.

The 'miscellaneous' incomplete or incorrect responses (chlorophyll, oxygen, air, leaves and others) appear quite idiosyncratic but are not entirely unknown. For instance, Simpson and Arnold (1982) report uncertainty about the role of chlorophyll and Ozay and Oztas (2003) comment on poor understanding of the role of carbon dioxide during photosynthesis among secondary students. Driver, Child, Gott, Head, Johnson, Worsley, and Wylie (1984) also Eisen *et al.* (1988) report a similar confusion about the nature and use of the gas. A small proportion the student teachers participating in the present research seemed unaware of the differences between air, oxygen and carbon dioxide.

5.2.1.2.1.2.2 Post Course Scores

The post course scores illustrate a mix of changed ideas and retained ideas. Although the percentage of correct answers increased quite markedly in the post test, other, partial or incorrect answers still appeared in students' responses. The role of the soil remains unclear, as does the meaning of the word 'nutrients'. The word 'photosynthesis' appears quite frequently but in these cases, understanding of the process appears nebulous. Leaves, chlorophyll and carbon dioxide are mentioned more frequently than in the pre test

but their functions in the process are opaque. Marmaroti and Galanopolou (2006) report similar findings.

Of interest at this point is how plant nutrition is described in the RNCS for Grades 4 to 6. The full extract follows:

*Green plants produce their own food and grow by **using water and substances from the air and soil.** Energy from light is needed to change these simple substances into food and plant material. Green plants are the only organisms that can produce food in their own bodies.*

The statement is at best misleading and requires explication for full understanding. Many students are not clear about how photosynthesis, using carbon dioxide and water, is responsible for the synthesis of carbohydrates **and then**, how the carbohydrates are converted to proteins using nitrates from the soil. If the two processes, carbohydrate production and protein production are collapsed and conflated, misunderstandings are bound to occur.

5.2.1.2.1.3. Causes of the Seasons

5.2.1.2.1.3.1 Pre Course Scores

Response	% Distribution	
	Pre Course	Post Course
The path of the Earth round the sun	30	24
The position of the Earth in relation to the sun	24	9
The Earth's spin	15	28
Winter / Spring / Autumn	10	0
The weather	8	0
Lines of latitude and longitude	4	2
<i>The tilt of the Earth</i>	3	41
Miscellaneous	4	2

TABLE 5.3 Percentage distributions of answers to the question
'What causes the seasons?
n=46

It should be noted that responses total over 100% because some students included several responses in a single answer. Although the students' explanations for seasonal

change are quite diverse, most of them are also all generally at odds with the accepted scientific explanation. Of all the responses provided at this stage, only 3% had a mention of the tilt of the Earth. The 'path of the Earth round the sun' was regarded as an *incomplete* answer because the tilt is not taken into account although the Earth's revolutions do have some bearing on seasonal change.

The response 'the position of the Earth in relation to the sun' is likely to be a misconception caused by, among other factors, a common and misrepresentative drawing, found in many textbooks, atlases and also on some educational charts. As can be seen from Figure 5.1, the drawing represents Earth and the sun, illustrating the Earth's elliptical orbit and exaggerates the distance between the Earth and sun at different times of the year. For people with little conception of massive distances in time and space, such a figure could be very misleading. Of course, careful and closer examination of the figure may cause one to rethink, because the Earth **appears** closer to the sun during autumn than in summer. Lived experience tells us otherwise. Once again, this situation provides an indication, if not evidence, of the need for teacher mediation as discussed in chapter two.

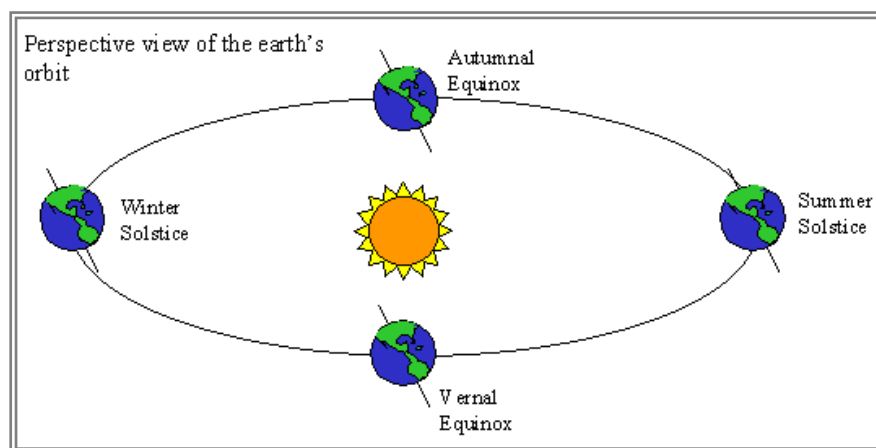


FIGURE 5.1 Common diagram of the Earth's orbit (Northern Hemisphere)

<http://www.timezone.com/library/tmachine/tmachine0006>

Students who suggested 'the Earth's spin' were possibly confusing the causes of the seasons with the cause of day and night. Other responses appear random and confused.

5.2.1.2.1.2.2 Post Course Scores

It came as a shock to find that, even after detailed model making and model use, 24% of the students participating in the study were of the opinion that seasons are due (only) to the path of the Earth round the sun. Even more alarming was the finding that the students holding the erroneous idea that seasonal change is due to the Earth's *spin* (rotation) had increased from 15% to 28%. The number of students looking to the *position* of the Earth for an explanation of seasonal change decreased from 24% to 9% of the sample

In contrast, after the methods course, 19 students (41% of the sample) appeared to recognise the Earth's tilt as being primarily responsible for seasonal change. This figure shows a marked increase in correct answer from the pre test. As encouraging as this finding may be, it is still disconcerting that many of the participating students maintained, or worse, developed misconceptions about the movements of the Earth and their consequences.

It would appear that more time and a variety of strategies - at several educational levels - are needed when phenomena such as these are handled. Similar suggestions are made by Atwood and Atwood (1997). It would be surprising to learn that none of the students participating in the study were taught about the seasons while they themselves were in school. However, even among those who had been taught about the changing year, the students' lack of knowledge retention, or more likely, lack of understanding, remains cause for concern¹⁰⁷.

At this time, physical geography - referred to as 'Planet Earth and Beyond' - occupies a significant proportion of the present Intermediate Curriculum. It is imperative that these, and all other, student teachers, when they graduate, are able to explain common events such as seasonal changes. It should be stated, however, that some of the students participating in this research hold cultural - traditional ideas about stars and planets which are very much at odds with western scientific thinking¹⁰⁸. Science teachers find themselves in something of a quandary under these circumstances, not wishing to show disrespect to the cultures of students, but also being obliged to teach about ideas accepted by the scientific community.

¹⁰⁷ If student teachers experience difficulty with understanding the complexity of the seasons, one can assume that similar difficulties would be experienced in understanding the phases of the moon.

¹⁰⁸ A similar case in point in this country concerns HIV / AIDS where debate rages around the issues of the possible causes of and medication for this infection.

5.2.1.2.1.4 Magnetic Properties of Materials

It should be noted that responses total over 100% because the question involved unrestricted choice. It should also be noted that only findings regarding metals are reported here because all students were aware that the other substances or objects mentioned are non-magnetic. To my knowledge there are no reports of misconceptions regarding the magnetic properties of non-metallic objects and substances in the literature.

5.2.1.2.1.4.1 Pre Course Scores

From the above results it can be inferred that at the start of the methods course, many of the students believed that metals in general or shiny metals in particular have magnetic properties. Lead is quite dull and is generally not considered magnetic. The students may, of course, have been confused by common parlance and been thinking of graphite as 'lead'. Most of them, however, did not consider gold to be magnetic, possibly from personal experience.

Object (all metallic)	% Distribution	
	Pre Course	Post Course
Magnet	72	93
Iron nail	84	98
Copper wire	48	26
Lead pipe	32	20
Gold jewellery	26	17
Steel pin	90	97
Silver coin	82	28

**TABLE 5.4 Percentage distributions of positive answers to the question
'Which of these can be picked up by a magnet?'**
n=46

5.2.1.2.1.4.2 Post Course Scores

After the practical experience during which the students experimented with magnets and other objects, most of them appear to have corrected misconceptions without much difficulty (Finkelstein 2005). According to the findings above, iron (nail), steel (pin) and another magnet are recognised by the majority of student teachers to have magnetic

properties. The positive responses with respect the other non-magnetic metallic objects which were previously thought by some to be magnetic decreases quite markedly.

These findings are not surprising when one considers the practical activity undertaken by the students during their methods course. They tested the objects provided (and others) for magnetic properties and found out by trial and error whether their predictions were correct or not. Discovering that a silver object is not attracted to a magnet does not require as much reorganisation of concepts as does, for example, contemplating invisible objects like gas particles or, indeed, gases in general. It is to these invisible particles that I now turn.

5.2.1.2.1.5 Origin of water droplets

5.2.1.2.1.5.1 Pre Course Responses

The initial answers to this question are fairly typical (Osborne and Cosgrove 1983; Nussbaum 1985; Thorne 1990). By far the most frequent response is the single word 'condensation'. This kind of answer illustrates knowledge of a word without the knowledge of exactly what the word denotes. Condensation is a process and not a physical entity as the use of the term might imply. I suggest that answers of this nature result from excessive reliance on the use of definitions and rote learning.

The word 'condensation' appears on several occasions as illustrated in Table 5.4. Responses 1, 3 and 6 all refer to condensation in one way or another. It seems that these participants know that condensation has something to do with the appearance of the water droplets. They seem very unsure of the mechanism. It is, of course, possible that some of the respondents do understand the process referred to. For example, 'condensation of air' may mean 'condensation of water vapour in the air or atmosphere' but there is no clear reasoning evident. In any event, teachers are expected to use language wisely in order to explain events to their learners.

5.2.1.2.1.5.2 Post Course Responses

Nineteen students (41% of the sample) gave a scientifically acceptable answer to the question in the post test, which is quite promising. Nevertheless, the other 27 students (comprising 59% of the sample) are still unclear about the mechanisms involved in an everyday event. As mentioned in connection with the previous question, understanding that invisible gas¹⁰⁹ particles move closer together until the liquid state is reached, and that

¹⁰⁹ The gas is water vapour in the atmosphere.

these particles appear on the outside of a container of a cold substance, requires some mediation. This mediation is sadly lacking in many cases. During the methods course, mediation is provided by using concrete models such as sticky dots to represent molecules.

Response	% Distribution	
	Pre Course	Post Course
Condensation	33	25
From the water in the can	12	9
Condensation and temperature	8	4
Evaporation	8	13
<i>Scientifically correct answer</i>	6	41
Condensation of ice	6	0
Miscellaneous (no answer, I do not know, evaporation and condensation)	27	22

**TABLE 5.5 Percentage distributions of answers to the question
'Where do the droplets come from?'
n=46**

It should be noted that responses total over 100% because some students included several terms in a single answer.

These findings are very similar to those of previous years (and to those in the literature). They certainly suggest that certain pre service primary teachers experience some difficulty with a number of scientific views. It should also be noted that only five commonly misunderstood concepts / theories were investigated in this piece of research. Many more remain untested and unremediated.

It is not surprising that many primary school student teachers (and others) dislike science and are unwilling to teach it. A non-science identity is almost inevitable in cases where the person has muddled and unclear understanding of concepts in science. Therefore, I would argue that diagnostic tests of this nature should be an integral part of similar methodology courses in the sciences. It follows, then, that some remediation of identified alternative concepts is also an essential ingredient of such a course.

5.2.1.2.2 Science Teaching Self-Efficacy

As explained in chapter four, participating students completed an eight-item paper and pencil instrument which was derived from the STEBI – B instrument designed by Enochs

and Riggs (1992), and which I have named STEBI – B (BT). The table below sets out the distribution of responses to the given statements.

STATEMENT	SA		A		PA		PD		D		SD	
NUMERICAL WEIGHTING	6		5		4		3		2		1	
Pre Course / Post Course	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
I know enough to teach science	3	7	4	8	17	17	7	9	7	3	8	2
I like doing science experiments	13	14	13	14	7	8	6	6	4	1	5	3
I will generally teach science effectively	4	6	10	8	15	17	6	5	5	5	6	5
I enjoy answering unexpected questions	4	4	9	11	11	12	9	12	12	4	1	3
I like learning about science concepts	10	13	9	10	13	12	6	6	6	4	2	1
I look forward to teaching NS on School Experience	10	13	14	14	11	12	6	4	3	2	2	1
I will be able to excite learners about science	5	7	12	11	16	19	6	4	5	5	2	0
I look forward to helping learners understand difficult science concepts	9	8	11	13	12	14	5	7	6	3	3	1
TOTALS	58	72	87	89	100	111	48	53	47	27	28	16

TABLE 5.6 Distribution of responses to STEBI-B (BT)

n=46

SA=strongly agree; A=agree; PA= partly agree; PD=partly disagree; D=disagree; SD=strongly disagree

From the table, it is clear that at the start of the methods course, the highest percentage of students overall provided answers falling into the 'partly agree' category. Exceptions to this overall trend are responses to the statement 'I like doing science experiments' the majority of which fell into the 'strongly agree' and 'agree' categories; and responses to the statement 'I look forward to teaching natural science on school experience' the majority of which fell into the 'agree' category. In any event, the majority in these cases accounts for

barely one third of the responses. Nevertheless, these issues will be discussed in chapter 8.

5.2.1.2.2.1 I know enough about science concepts in order to teach it to grades 4–7

5.2.1.2.2.1.1 Pre Course Responses

This finding is interesting for a number of reasons. Despite statements by many students that they do not wish to teach science, at the start of the methods course, 59% of the respondents appeared to believe that they knew enough science to be able to teach it in the primary school. Perhaps they believe that one does not need to know much about science to teach it competently at the primary level. It is also possible that they believed (from their own experiences) that science is generally taught in a very pedestrian way by simply transmitting content or by reading from or copying drawings from a textbook or other reference material¹¹⁰.

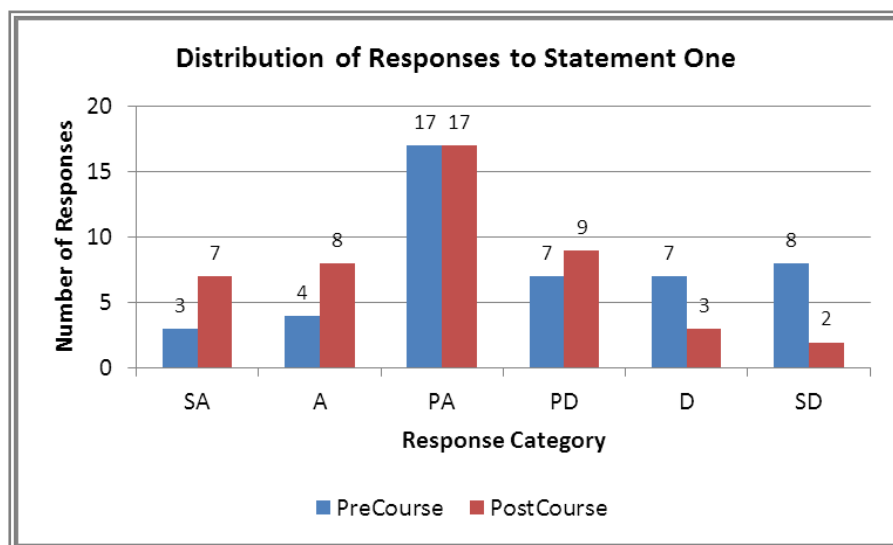


FIGURE 5.2 Distribution of responses to the statement
I know enough about science concepts in order to teach it to grades 4 – 7
n = 46

5.2.1.2.2.1.2 Post Course Responses

These responses did not change markedly from the pre course responses, but a general trend can be identified. This trend is a shift from the 'negative' to the 'positive' side of the graph. The 'strongly agree' and 'agree' responses (that the student knows enough about natural science in order to teach it) have doubled in number, the 'partly agree' and 'partly disagree' responses have remained about the same and the 'disagree' and 'strongly

¹¹⁰ Personal experience in many schools suggests that the type of teaching science described is indeed the norm

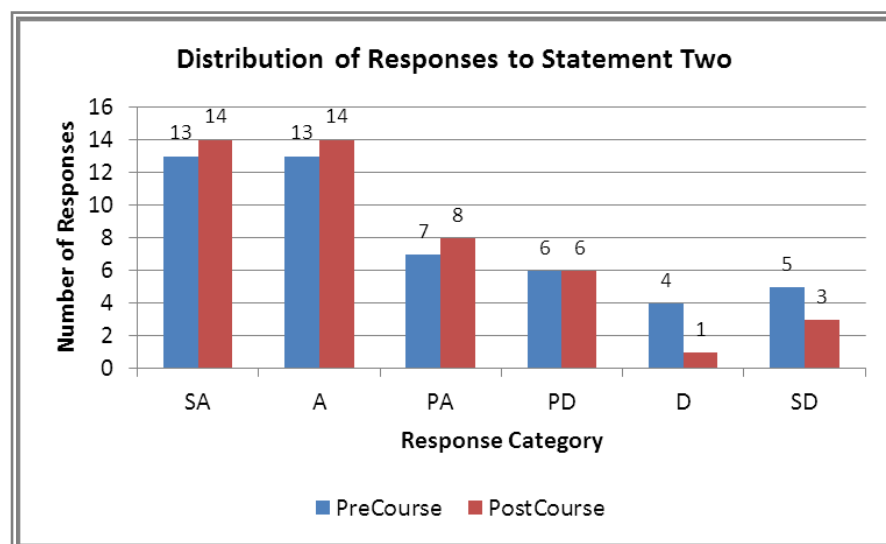
disagree' both dropped to under half the original number. More compelling evidence is needed to convince one that the stated self-efficacy about science knowledge and teaching ability is indeed congruent with observed behaviour.

5.2.1.2.2.2 I like doing science experiments

5.2.1.2.2.2.1 Pre Course Responses

From the data it appears that at the start of the course, about 33 (72%) of the respondents claimed to enjoy doing experiments, the others are unsure but only about 9 (12%) actually do not enjoy conducting experiments. This finding resonates with some of the comments made in the critical incidents related by the students. One can capitalise on such a preference by structuring a hands-on methods course which is what is done in many courses at this university.

It is also valuable to encourage students to do likewise with their own learners. In this way, methods instructors are acting like 'old timers' or master practitioners, inducting 'newcomers' or older members into the practices of the community. This is easier said than done because organising and setting out teaching and learning materials is very time-consuming. Added to which is the harsh reality that many South African schools are very under-resourced.



**FIGURE 5.3 Distribution of responses to the statement
'I like doing science experiments.'**

n = 46

5.2.1.2.2.2.2 Post Course Responses

These responses show similarities to those of the previous question, possibly not quite as marked. On the whole there appears a general, if slight, shift to the positive side of the

continuum. Dislike and strongly dislike categories decreased noticeably. However, I must reiterate that teachers and teacher educators must be especially vigilant that pupils and students are constructing new knowledge and not just 'having fun'.

5.2.1.2.2.3 I will generally teach science effectively.

5.2.1.2.2.3.1 Pre Course Responses

The findings illustrate a fairly even spread of responses with about two thirds (63%) of the sample on the positive side and the highest percentage in the 'partly agree' category – which suggests some ambivalence. In general there appears less certainty about teaching *effectively* despite many thinking they know enough about science to teach it at elementary level.

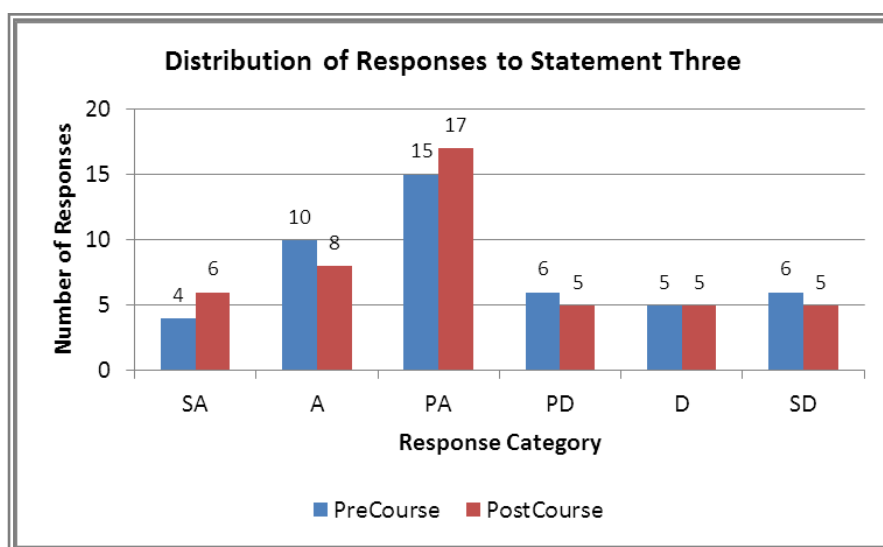


FIGURE 5.4 Distribution of responses to the statement
'I will generally teach science effectively.'
n = 46

5.2.1.2.2.3.2 Post Course Responses

Between pre and post tests, there appears little difference; with responses on the negative side remaining virtually unchanged and one positive category (agree) dropping from 10 students (22% of the sample) to 8 students (17 of the sample). However, as mentioned before, these numbers are very small and any change may well be insignificant. In their responses to both tests, the students were arguably showing awareness of what it means to teach effectively – and possibly considering a pedestrian method an acceptable survival strategy.

5.2.1.2.2.4 I enjoy answering unexpected questions.

5.2.1.2.2.4.1 Pre Course Responses

Unexpected questions are terrifying to the inexperienced or insecure teacher so it is not surprising that few students claimed confidence at the start of the methods course. What is surprising is that just over half the responses appear on the 'agree side' of the graph. Very few students in the sample selected the 'strongly disagree' option, perhaps illustrating a degree of open-mindedness. It is also possible that they were considering other disciplines where they have greater experience and confidence.

5.2.1.2.2.4.2 Post Course Responses

As with the other post course findings, there appears to be a slight shift towards more confident responses in that, most notably, those providing a 'disagree' category dropped markedly from 12 student participants (26%) to 4 student participants (9%). Changes in the other categories were quite slight.

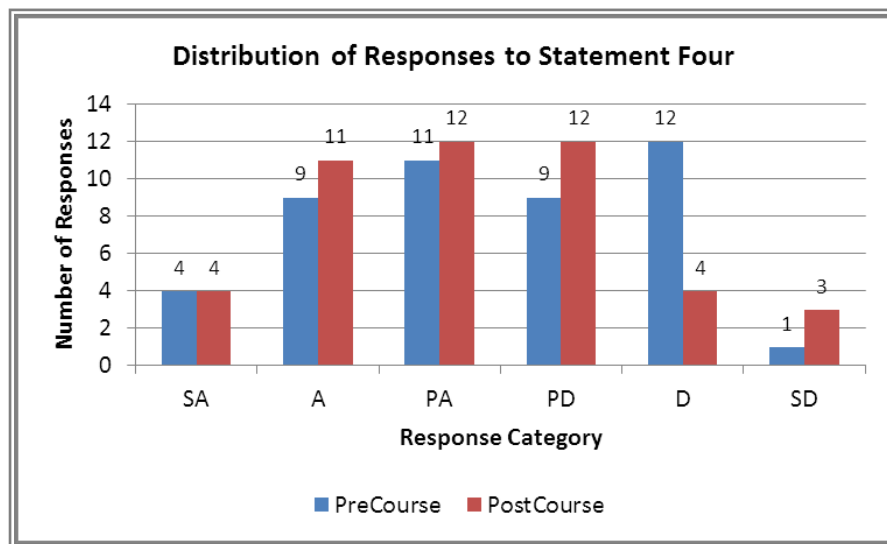


FIGURE 5.5 Distribution of responses to the statement
'I enjoy answering unexpected questions'.
n = 46

5.2.1.2.2.5 I like learning about science concepts

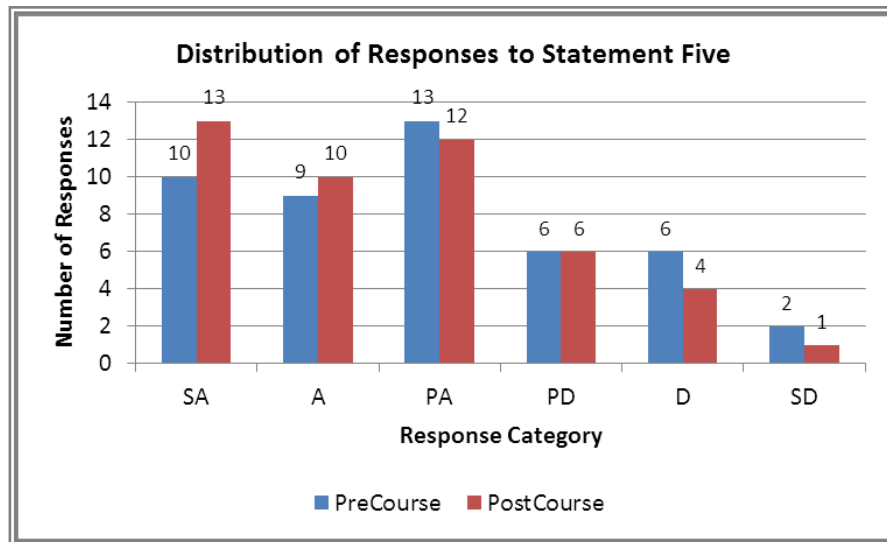


FIGURE 5.6 Distribution of responses to the statement
I like learning about science concepts
n = 46

5.2.1.2.2.5.1 Pre Course Responses

With varying degrees of enthusiasm, 32 participants (almost 70% of the sample) responded that they enjoy learning about science concepts. This response is surprising given the fact that many of these students claim to dislike science. It is possible that they like learning about science so that they are able to teach about it at an elementary level. They may also mean that they like learning about certain aspects of science only, and are not referring to the entire science discipline.

5.2.1.2.2.5.2 Post Course Responses

After the methods course, the number of student teachers claiming to dislike learning about science concepts (partly disagree, disagree and strongly disagree to the positive statement) dropped from 14 to 11 or from 30% to 24%. These changes may indicate the start of a trend but much more work with a much larger sample of participants is needed before one can make any claims.

5.2.1.2.2.6 I look forward to teaching natural science on school experience

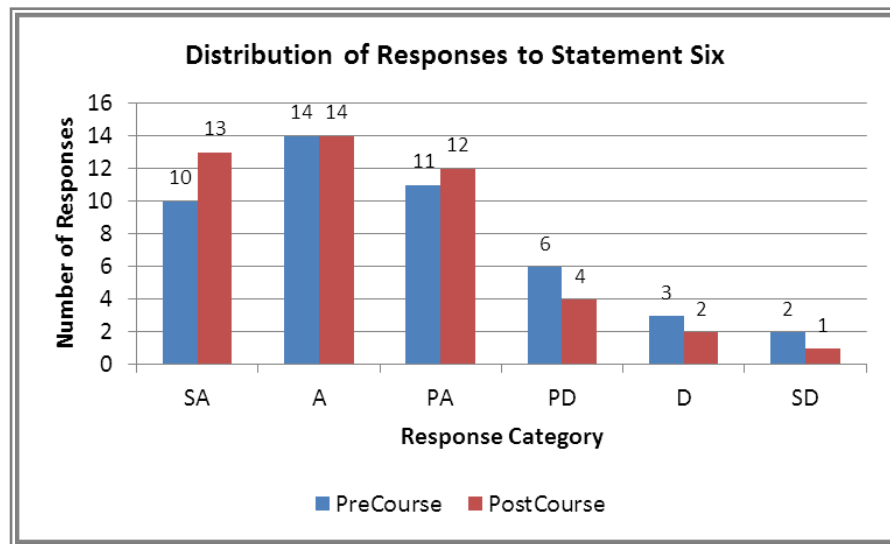


FIGURE 5.7 Distribution of responses to the statement
I look forward to teaching natural science on school experience
n = 46

5.2.1.2.2.6.1 Pre Course Responses

At the start of the methods course, three quarters (76%) of the students in the sample claimed to look forward to teaching natural sciences on School Experience. This finding contradicts to some extent my own experiences where students on School Experience actively avoid teaching natural science when they know that they will be assessed. It is possible that they look forward to teaching experience in general and they acknowledge that science is part of the package. It is also possible that some of them are saying what they think I want to hear.

5.2.1.2.2.6.2 Post Course Responses

As with most of the other STEBI B - BT findings, little change was noted between pre test and post test scores. There is, however, a slight trend towards a more positive self-efficacy in terms of science.

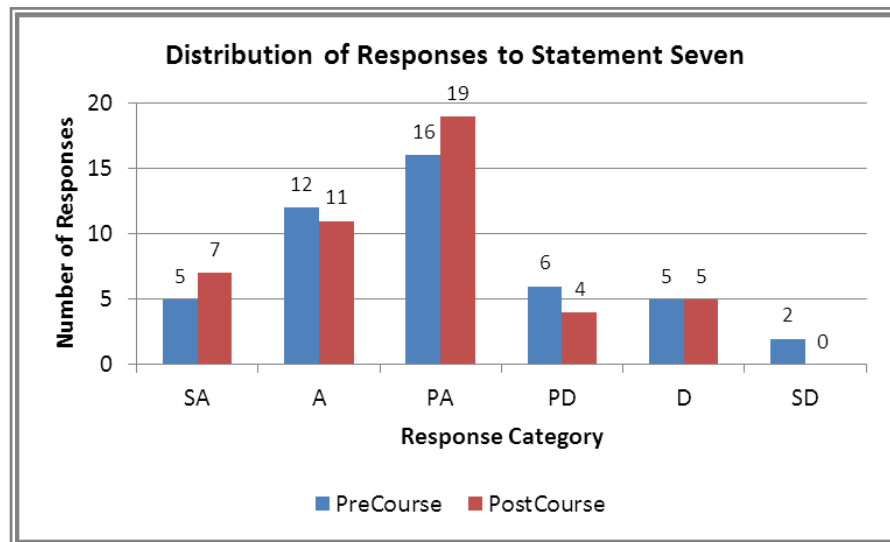
5.2.1.2.2.7 I will be able to excite learners about science

5.2.1.2.2.7.1 Pre Course Responses

The responses are generally more positive than negative with the highest percentage (35%) in the 'partly agree' category.

5.2.1.2.2.7.2 Post Course Responses

Little striking change is noted.



**FIGURE 5.8 Distribution of responses to the statement
'I will be able to excite learners about natural science'
n = 46**

5.2.1.2.2.8 I look forward to helping learners understand difficult science concepts

5.2.1.2.2.8.1 Pre Course Responses

Teachers, by their very nature and calling thoroughly enjoy helping people. It would appear that the majority of the participants share this enthusiasm. I see the teacher identity coming through very clearly. However, under the circumstances described, it must be acknowledged that their success (in practice) may not equal their (stated) enthusiasm.

5.2.1.2.2.8.2 Post Course Responses

As with many of the other items of this test, very slight changes were seen within the group as a whole. A slight tendency towards a more positive science identity may have started to occur. However, identities are in flux and no long-lasting modifications are claimed.

Several of the unexpected or surprising responses (statements 2.6 and 2.7 in particular) resonate to some extent with findings reported by Yerrick, Ambrose and Schiller (2008: 3) who comment that some pre service science teachers participating in their research showed evidence of 'both overconfidence and insecurity'.

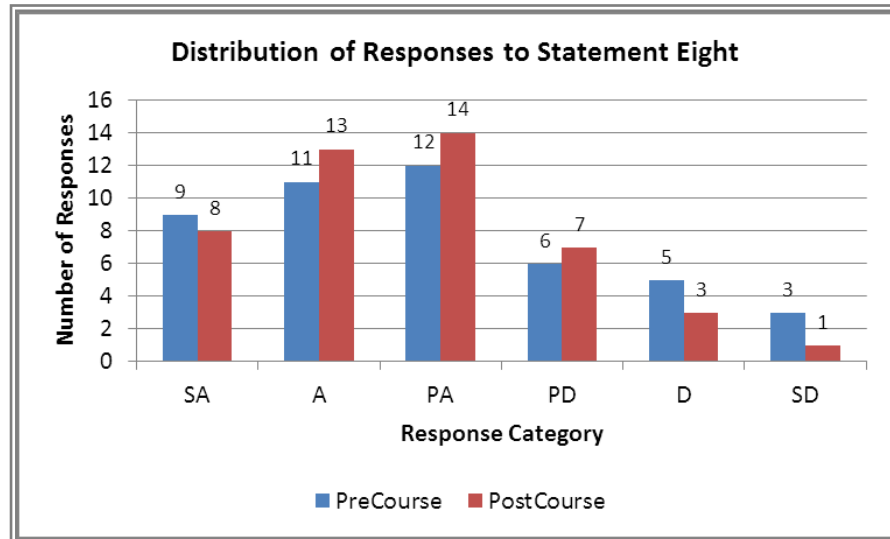


FIGURE 5.9 Distribution of responses to the statement
'I look forward to helping learners understand difficult science concepts'
n = 46

5.2.1.2.2.9 Total Responses

The findings from the semi-quantitative aspects of the research are presented in pre course and post course format. It should not be inferred, however, that the methods course in question is to be considered an intervention, nor should it be inferred that any generalisations are made. Pre course data, particularly those concerning content knowledge simply suggest that many of the students participating in the research experience difficulties with science concepts. The post course data are provided in the interests of thoroughness.

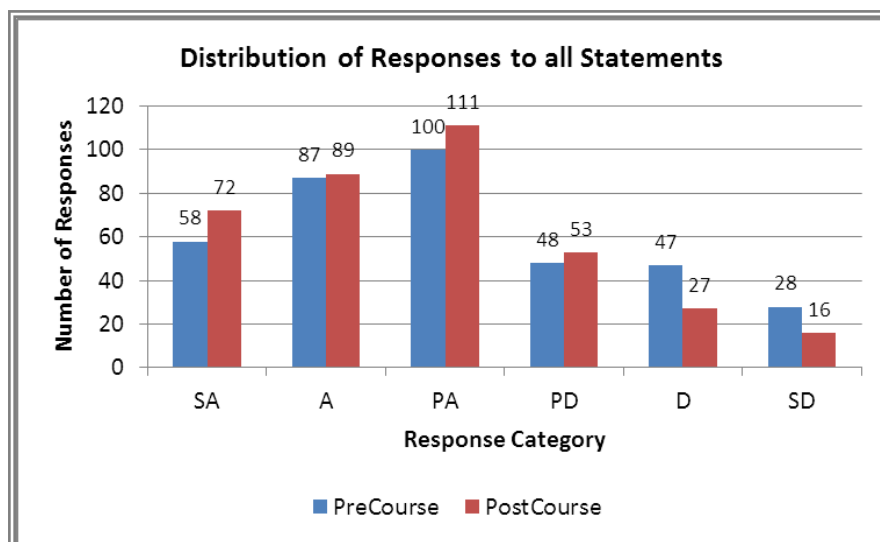


FIGURE 5.10 Distribution of responses to all statements
n = 46

In confirmation of what has been asserted above, these *findings in total* suggest that there is a slight overall tendency towards a more positive self efficacy. A positive change in science self efficacy may lead to a more positive science and science teacher identity.

However, what these findings cannot reveal is the ways in which individual student teachers author their own individual science and science teacher identities. Information pertaining to lived experiences can be obtained only by the detailed personal narratives provided by qualitative research methods. It is to the qualitative findings that I now turn.

It is to be noted that only nine of the students who participated in the research were selected for detailed case studies. Their scores on the above questionnaires will be dealt with appropriately during the discussion of each case.

5.2.2 Qualitative methods

Identity resides in what we say about ourselves and our activities and what others say about us. The following sections report various types of comments and responses by the student teachers during their methods courses. Some of these comments have little or nothing to do with science and science teaching, but reveal many of the issues and cultural practices of the students at the time. Issues and practices which interest us, in turn, reveal elements of our complex identities. For this reason, although some remarks and incidents may appear trivial, they are mentioned as sources of insight into students' identities.

5.2.2.1 Informal Conversational Interview

This selection of comments includes those from both case studies students and non-case study students.

When shown an example of genetic –multicoloured - maize

'I am going to tell my family about this during supper tonight'.

When constructing an Earth model with *papier mache*

'I wish all science was this much fun.'

I was slightly ambivalent about this remark, being pleased that the student was comfortable in the workshop, but not wishing to create an inaccurate idea about science.

However, after speaking with him, I gathered that he was just ‘enjoying himself¹¹¹.’ In previous chapters, I have discussed the issues of ‘fun’ and ‘learning’ several times.

The following comment from a student is alarming

‘I asked for a transfer from the school because the teachers hit the children¹¹².’

This comment was followed by a response from another student:

‘One day a parent came in and hit the teacher when I was in the class. I ran away!’

There remains a great deal of violence in our schools and society.

Other comments are on a more personal level, such as

‘This is me at my sister’s wedding.’

‘Tomorrow is my 21st birthday.’

And quite unsolicited from another female student came the remark:

‘My baby’s father doesn’t want to marry me.’

These and many other comments provided me with some idea of the students’ experiences and reminded me of their lives, their difficulties and the complex formation of their identities.

5.2.2.2 *Written Science Histories or Critical Incidents*

I include the critical incidents of some of the students not selected for case studies because these incidents provide insights into a wide range of experiences – some quite idiosyncratic. As explained in the previous chapter, I grouped these reported incidents into four categories, namely, positive, neutral, mixed and negative. I am aware that the responses are all very different, therefore no generalisations are claimed. I also acknowledge that some critical incidents may have little bearing on identity construction, but some experiences were quite profound in that they influenced students’ lives, albeit for a short time period. At this point, I want to make a few remarks about trends within the group. A summary of all critical incidents as reported to me is found in Appendix 9. A selection from these incidents is discussed below.

¹¹¹ The workshop was very noisy with students painting each other as well as the model ‘Earth.’ I do allow some frivolity from time to time.

¹¹² The issue of corporal punishment is a site of struggle in this country.

5.2.2.2.1 Positive Experiences

'I remember in Grade 11 when our teacher was demonstrating what happens when you burn metals. He burnt this substance (I think it was magnesium) and it gave off brilliant white sparks. I will always remember how excited I was to see how metals burnt.'

'I remember an exciting experiment we did outside. There was a big bang but what I liked most of all was the teacher's passion.'

'I loved science! I was always interested and we had a very good teacher. The experiments helped overcome my misconceptions, and helped us understand the world'

It is noteworthy that all these 'happy memories' involve an 'experiment' whether in the form of a demonstration or other practical work. These comments resonate with many students' responses to the STEBI B (BT) statement *'I like doing experiments'*. I wonder, however, if this type of experience is enough to draw a person towards science for its own sake.

5.2.2.2.2 Mixed Experiences (Mixed Feelings)

'I dropped sciences in grade 9, this was not because I did not enjoy it or that I was doing badly. I was advised that science past grade 10 was almost impossible by older friends and family. My most vivid memory of school science would have to have been the whole of grade 8 science because I had the worst teacher ever. She was extremely strict and was uninterested in doing more than the text book stated thus making it unbearably boring.'

'Looking at a leaf under the microscope was the only practical we did and we got too excited. We became naughty and started looking at crisps and the teacher got angry. Otherwise science was boring and hard to understand'

'I liked chemistry with a lot of experiments. I hate physics. I hate maths. I hate calculations.'

These 'mixed feelings' incidents reveal that science can be 'boring', teachers can make a difference as can peers and 'significant narrators' (Sfard and Prusak 2005) and once again, practical work is exciting. It is unfortunate that in many cases practical work is the exception rather than the norm. Anecdotal evidence and personal experience confirm the belief that it (practical work) can encourage chaos. However, this result is not inevitable if it is a commonly used science teaching strategy. The third comment makes me smile

because it is so unequivocal, but from an identity point of view, the student is certainly defining him/herself in terms of what s/he is not – i.e. definitely *not* a numbers person.

5.2.2.2.3 Neutral Experiences

I enjoyed making crystals in primary school but I don't understand how they form.'

'All I can remember is a demonstration of evaporation when I was on School Experience.'

'I learned a rhyme about how to mix acids but I forgot the rhyme.'

The incidents reported above show no strong feelings either way. It seems that something took place, which was perfectly acceptable while it lasted but left little lasting satisfaction about science. It seems that the students in question were exposed to some sort of 'conjuring trick' (a pretty crystal, an appropriate demonstration, an amusing mnemonic), the significance of which faded as time went by.

5.2.2.2.4 Unpleasant Experiences and Memories¹¹³

These are all so different that I have chosen to deal with them individually.

'I cannot remember much except that the laboratory smelled and made me sick all day.'

To a sensitive nose, one imagines that a well-used and not-often-cleaned laboratory may smell unpleasant. It is regrettable that nothing else in the student's science history was memorable.

'I was disliked by the teacher who humiliated me by making me do examples in front of the class, and I couldn't do them.'

This comment is cause for concern. Here is a report of another 'significant narrator' who played a role in creating an 'imagined world' where learning about science could be associated with disgrace and shame. This type of experience would not encourage anyone to select science as a discipline.

¹¹³ There are so many of these, it is difficult to choose a representative selection.

'Our teacher told us that our black minds were not good enough to do science. He only praised the white students. I hate science till now.

This reported experience hardly needs discussion. I cannot imagine what the black students went through under this person's guidance but it seems very likely that science was not among their favourite subjects.

'In Grade 8 we had to do research on factories in Piet Retief¹¹⁴, and how they affect the environment. We had to walk from the location¹¹⁵ to town and it nearly killed us. In Grade 9 we had no science teacher for 4 months and had to make up a lot later. I wasn't good at it.

Although the reported incidents¹¹⁶ do not seem to be caused by deliberate ill will, they illustrate the power of structural influences on a person's life and learning. Because the student is black, s/he and her/his family were obliged to live in a township which was on the outskirts of the town and the family therefore had to commute long distances. This story is an example of a potentially good science experience – conducting research on factories and the environment – which became a burden to certain members of the school. Many students have reported similar circumstances. Under-resourced and overcrowded schools are usually the worst affected.

Having no teacher for all or part of the year is a common experience. Many teachers opt to leave a poorly equipped school or one in an unfavourable environment if other opportunities arise. The pupils tried to study science in the absence of a teacher as far as possible, but such an effort is very demanding. The net result for the student in question was clearly and unsurprisingly a negative science identity. In his own words he claims 'I wasn't good at it.'

It appears from the comments made by the participants that the memories of school science that they hold are, in general, not pleasant. Science seems to have been experienced by many as difficult, dull and boring. Aspects of science involving numbers were also feared and disliked. Some teachers seem to have added to the discomfort by sexist / racist and other, similar, behaviour.

¹¹⁴This is a small town in the northern part of Kwa Zulu Natal which is named after an Afrikaner hero.

¹¹⁵This word has strong connotative meanings in South Africa. In the past, African townships were known as 'Native Locations' or simply 'locations'. Therefore we deduce that the writer is a black person who lived in a township which was situated far away from the city and the suburbs.

¹¹⁶One incident is the research on factories, and the other is the absence of a teacher for much of the school year.

5.2.2.3 Structured Tasks

5.2.2.3.1 A Short Paper and Pencil Questionnaire regarding what the student expected from the course.

A number of students' comments are transcribed (verbatim) below and further details are included in each case study.

'I would like the course to provide me with a positive attitude towards science because I was not all that bad in high school.'

'Teaching resources.'

'A rounded and lateral look at the sciences as a whole.'

'A better background knowledge so we could teach primary school natural sciences knowing the basics of the syllabus.'

'Information on how to draw up lessons with experiments.'

'More information.'

'Appropriate basic knowledge and concepts.'

'Simple explanations to concepts so that I can understand.'

'Knowledge about science – well rounded.'

Several random examples have been cited, and it is clear that many of these students were interested in acquiring more information (knowledge) about the sciences. Some requested science teaching practice and skill development and a few hoped to improve their attitude to science and science teaching. Although some students were apprehensive about and resistant to science, I believe that a well structured science methods course could be a worthwhile route to enhanced confidence.

5.2.2.3.2 Responses to drawings of science lessons (See Appendix 4)

A summary of the case study groups' responses appears in Appendix 11. The actual written comments are reproduced with each individual case study. Unsurprisingly, the comments are quite individualistic and generalised analyses of these are difficult to construct. However, *on the whole*, students were critical of lesson (Figure 1); possibly

somewhat less critical of lesson (Figure 2) and, with few exceptions, uncritical of lesson (Figure 3).

5.2.2.3.3 Drawings of themselves as science teachers

A descriptive summary of the case study groups' drawings appears in Appendix 12 and a coded summary of each drawing appears in Appendix 13. The actual drawings are reproduced and fully discussed with each individual case study. In this case, too, students' views of themselves are highly idiosyncratic. Drawings from several students are included below for descriptive purposes.

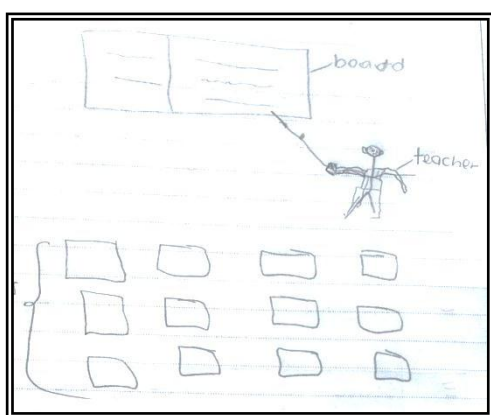


FIGURE 5.11 Didactic teacher identity

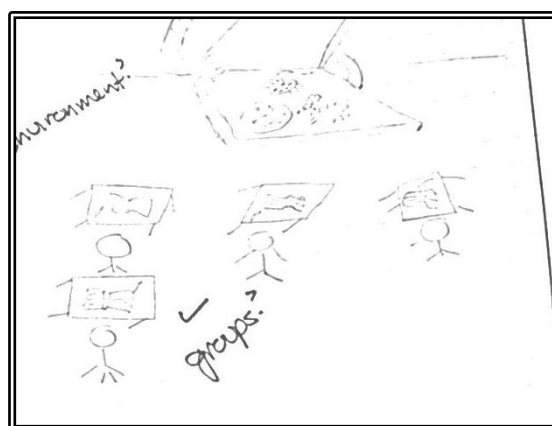


FIGURE 5.12 Hybrid science teacher identity

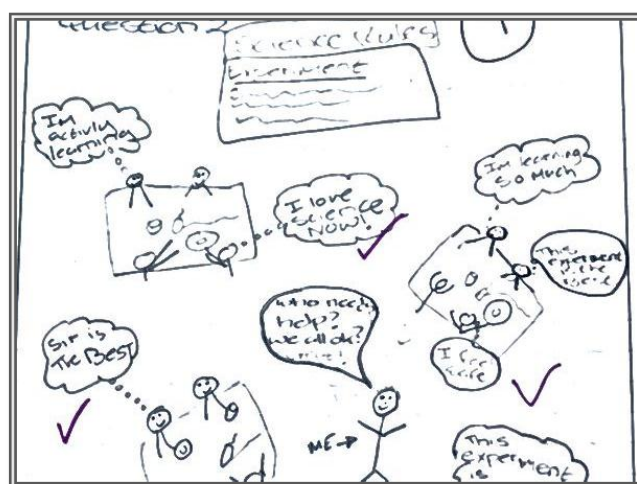


FIGURE 5.13 Inquiry science teacher identity

Figure 5.11 This student provided an example of what I would categorise as ‘didactic (science) teacher identity’. There are no ‘science indicators’, so the lesson could pertain to any discipline. However, pupils’ desks are in straight rows and the teacher is situated in a dominant position, so this drawing was considered a didactic (science) lesson. As can be seen from *Figure 5.12* the student has represented a large teacher in the front of a room, holding a box of specimens for the children to examine. Her speech bubble reads ‘Come closer so you can see’¹¹⁷. The teacher has made some effort to provide stimulus material for the children, but the children themselves appear to be absorbing information quite passively. For these reasons, the drawing is considered a ‘hybrid’ science lesson; not purely didactic but poor evidence of learner involvement.

Figure 5.13 shows an indoors lesson, possibly a laboratory exercise where pupils are working in groups, engaged on some activity, free to discuss the material with their peers. Their speech bubbles indicate comments of a very positive nature such as ‘I love science NOW.’ and ‘I’m actively (*sic*) learning’¹¹⁸. The teacher is very clearly acting as facilitator, positioned centrally among the pupils. This drawing illustrates a lesson where learners are actively engaged with the material and therefore very *unlike* the transmission stereotype. It demonstrates many features of an inquiry science lesson and was therefore regarded as an inquiry science lesson.

This range of drawings provides an excellent example of one of the strengths of qualitative research in that rich, descriptive aspects of individual storied lives, real and imagined, may be obtained. Numbers and statistics, however useful, are less appropriate here. However, despite the small sample size, some discussion is conducted in the final chapter.

5.2.2.3.4 Responses to a letter from a ‘parent’ (See Appendix 5)

A summary of the key issues raised appears below. Transcriptions of the students’ letters are included and discussed with each individual case study.

STUDENT	THANKS	DAMAGE	PEDAGOGY	PUPIL	SAFETY	OTHER
Janet	Expressed	Apology	Well explained with conviction	Disobeyed instructions	Structures are in place	Make an appointment
HA	Expressed	Apology	Explained briefly	Disobeyed instructions	Structures are in place	You can buy new clothes
NZ	Expressed	Apology	Simply stated as per policy	No comment	No comment	You have a problem
JR	Not	No comment	Explained	No comment	No comment	No corporal

¹¹⁷ Not visible on these pages

¹¹⁸ These are the student’s own written comments which may not be visible at the current magnification.

	expressed		briefly			punishment
BN	Expressed	No comment	Explained briefly	Disobeyed instructions	Structures are in place	Talking is allowed
Shanti	Expressed	Apology	Simply stated as per policy	Will learn responsibility	No comment	Offer to pay for damages
ZR	Not expressed	No comment	No reference made	No comment	No comment	No comments
VR	Expressed	No comment	Explained briefly	No comment	No comment	No corporal punishment
MF	Not expressed	No comment	Explained briefly	No comment	No comment	No comment
SL	Not expressed	Apology	Will demonstrate / do woodwork	No comment	No comment	No comment
Gareth	Expressed	Apology	Explained briefly	He is a good boy	No comment	No comment
Heather	Expressed	Will investigate	Well explained with conviction	A pleasure to teach	No comment	No corporal punishment
HF	Expressed	No comment	Simply stated as per policy	No comment	Will take extra care in future	No comment
KS	Not expressed	No comment	Well explained with conviction	He enjoys school	No comment	No corporal punishment
DC	Expressed	No comment	Well explained with conviction	Disobeyed instructions	No comment	Make an appointment
FN	Expressed	Will investigate	Explained briefly	He enjoys school	No comment	No comment
HY	Not expressed	No comment	Explained briefly	No comment	Matches are dangerous	There is personal supervision
HT	Not expressed	No comment	Explained briefly	He enjoys school	You should have supervised	No corporal punishment
Sarah	Expressed	No comment	Well explained with conviction	No comment	No comment	No comment
Ntsako	Expressed	No comment	Well explained with conviction	No comment	No comment	No corporal punishment
VM	Expressed	Apology	Explained briefly	No comment	Pupils are supervised	No corporal punishment
Siza	Expressed	Apology	Explained briefly	No comment	Will obtain laboratory coats	No comment
NN	Expressed	Apology	Explained briefly	No comment	Structures are in place	No corporal punishment
CJ	Not expressed	Apology	Well explained with conviction	He enjoys school	There is no danger	No corporal punishment
Xoleka	Expressed angrily	Angry apology	Simply stated according to policy	Disobeyed instructions	No comment	No corporal punishment Do not issue instructions
MB	Expressed	Apology	Simply stated according to policy	No comment	Safety is ensured	Should I really hit your child?
DL	Not expressed	No comment	No reference made	No comment	No comment	No comment

SB	Not expressed	Apology	No reference made	No comment	Will take extra care in future	We will demonstrate in future
Martin	Expressed	No comment	Well explained with conviction	Should experiment	No comment	Criticism of parenting style Please make appointment
SE	Expressed	No comment	Well explained with conviction	Will learn more	No danger	Please make appointment

TABLE 5.7 Summary of students' responses to letter from 'parent'

Despite the small sample size, one can comment that many of these particular students (over half), expressing good manners, thanked the 'parent' for her communication, some apologised for the damage to property (half the number) and a few (fewer than half the number) explained the philosophy behind the pedagogy of inquiry science teaching and learning.

5.2.2.4 Teaching Experience

Summaries of students' teaching experiences appear in the following sub-chapters together with details of their choices and constraints.

5.2.2.5 Structured Tasks during the Learning Area (Natural Sciences) Course

The numbers here are very small so these tasks are all analysed and discussed in the appropriate place with individual case studies.

5.3 Summary

In this chapter I have presented an overview of the research findings, and made preliminary comments about these findings. The following chapter will describe findings from the case studies.