# Students' perceptions of learning science:

## The light and pedagogy of a social classroom

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# ABSTRACT

This study investigated the perceptions and expectations of students in a Year 7 science class in an attempt to elicit and make sense of what constitutes a learning environment conducive to engagement with science learning, and what role the teacher's pedagogy might play in its development.

Ethnographic methods were employed for the whole school year to construct interpretations of students' lived experiences of science, obtained through focus group interviews with students each term, and contextualised through weekly observations of science lessons and regular teacher discussions. Insights were gained into how interaction with the social and physical classroom environment, and between familiar and unfamiliar experiences and knowledges, influenced the quality of engagement with learning. Exploration of the meanings of the common evaluations of "science as fun" and "science as interesting" shed light on how students perceived their science learning experiences.

The role of the teacher's pedagogy was seen to be twofold in affecting student learning: *instructional*, where the teacher used appropriate methods that enabled students to "understand," and *relational*, where the teacher was seen to relate to the students in a passionate, helpful and comforting way. A teaching repertoire that catered for and responded to the students' learning needs and the maintained a supportive relationship were both perceived as being essential ingredients for an effective learning environment and for promoting prolonged engagement with learning science.

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# STATEMENT OF AUTHORSHIP

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis presented by me for another degree or diploma.

No other person's work has been used without due acknowledgment in the main text of the thesis.

This thesis has not been submitted for the award of any other degree or diploma in any other tertiary institution.

Signed ..............................................

Date..................................................

# PROLOGUE

On returning to my hometown after ten years I see Portland as I always have, but the meaning I attach to what I see has changed. There is a sense of familiarity, walking down the streets, remembering the cracks in the pavement, knowing where to stand for the best view of the harbour, meeting again those familiar smells, revisiting those routines that have become so ingrained in my behaviour and unconscious mind.

But these familiarities take a new shape. Those aspects of my existence in the Portland environment become overshadowed by the other familiarities in my life. My learning that has come from institutions and from life's experience now intertwines with my view of my old high school and the associated expectations placed upon me, and I can now view my school, once my entire existence and source of hope, as simply a starting point, a sling-shot whose role it was to thrust me into a convoluting myriad of enlightening paths.

This new glimpse of the old, in turn, overshadows my present life. My ability, depth and choices of learning are again injected with these memories, and the meanings I hold now are re-nourished. My view of Portland and the meaning I place on its parts are a mixture of the experiences I had when I was younger and those from my current path. On surveying the things of my past, my view is shaped by what is important to me now.

# Chapter 1. INTRODUCTION

## 1. The Problem of Student Disengagement in Year 7 Science

Despite the impact of educational reform in science education over the past 30 years, the disparity between the science education being offered and the needs and interests of students continues to be of growing concern (Goodrum, Hackling & Rennie, 2001). Students during the first year of secondary school face restructuring of what to expect from a learning environment, including that of school science. Where primary school science programs are often dependent on the science expertise of a generalist teacher, secondary science offers the promise of "real" science equipment in a "proper" laboratory and a teacher who "knows science." For those making the transition from primary to secondary science this constructs expectations of what they may experience.

In this first year of secondary science it has been reported that, as the year progresses, an eager group of students can become less attentive, and negativity and apathy can dominate their attitudes towards science, with science lessons being perceived as "boring" (Biggs & Moore, 1993; Speering, 1995). A change in student perceptions and expectations appears to have occurred. A downturn in motivation is a common concern of the middle years of school (Biggs & Moore, 1993), with both environmental and contextual factors, and pubertal change considered to impact on this decline (for example, Anderman & Maehr, 1994). The quality and value of learning comes into question when students lose their motivation to be engaged with science, as the benefits of learning are annulled by negative attitudes and behavioural patterns (Anderman & Maehr, 1994).

As a new science teacher, I observed this gradual change in some of my students in a Year 7 class. On discussing this issue with other teachers, I was amazed by the overwhelming majority that expressed similar concerns. I thus became committed to gaining insight into the relationship between student engagement with learning and the construction of a learning environment that limits the emergence of apathy and negativity towards science and that fosters active minds and interests. The following study arose out of that commitment.

## 2. Research aims, questions and focus

The initial aims of the study were threefold. The first aim was to identify the specific *experiences* that may contribute to how students perceive science. Experience was considered to be not pre-conceptual but "lived" in that when an experience is recognised by an individual then it has, by this recognition, meaning (Kolb & Fry, 1975; Wadsworth, 1984). The second aim was to explore the *change* in *expectations* and *perceptions* of school science of a group of students had over the school year regarding the teacher, themselves as learners, others in and outside of their class, and the environmental and physical aspects. The third aim was to monitor how the *meaning* of their experiences appeared to influence *change* in student perceptions and expectations over time.

I accordingly constructed three ***research questions*** before both entering the field and engaging with the literature:

*Research Question 1*

> *What experiences do a group of Year 7 students have during science lessons?*

*Research Question 2*

> *How do their expectations and perceptions of science change throughout the year?*

*Research Question 3*

> *How may the meaning of the experiences during science lessons be seen to be contributing to changes in these expectations and perceptions?*

These research questions provided an initial framework within which to enter the classroom as a research site and gave some structure to an otherwise open-ended research process. As the study progressed, themes began to emerge and develop into lines of inquiry[1]. When data collection was completed, these various themes presented themselves as material for potentially numerous theses, so some decisions needed to be made.

In deciding what line of inquiry to pursue in order to represent the core of the student experience I felt that an acknowledgment of how they see themselves as learners was warranted. The final analysis drew on current and past experiences of learning at school and focused on the students' perceptions of what keeps them engaged with learning science. Because the teacher featured prominently in students' reflections on their learning, an exploration of students' perceptions of their learning experience incorporates how students depict the role of the teacher's pedagogy in keeping them engaged.

Thus the findings presented in this thesis are a selection from a much larger set of findings and are constructed from the inquiry into two aspects of the students' experience of learning: their perceptions of a learning environment they consider to be conducive to becoming engaged with science learning; and the role that pedagogy plays in this. Two ***emergent research questions*** reflect this selection:

- What is it about the experience of learning that keeps students engaged with learning science?
- What is the role of the teacher's pedagogy in building a learning environment conducive to student learning of science?

These emergent research questions are framed within and respond to the initial research questions. These two areas of the student experience and developing perceptions and expectations were constantly foremost in my mind during fieldwork and when planning and executing interviews, but were not formally constructed until data gathering had been completed. These emergent research questions guided my attention to particular

[1] Such themes included students' perceptions of the nature of science, the learning environment, the science subject in comparison to other subjects, the many personalities, roles and guises of the teacher, students' affective response to school science, a comparison of students' primary and secondary experiences of school science, the social group consisting of students, teacher and researcher and interactions among them, and what keeps students interested and engaged in science learning.

perceptions and expectations voiced by students. They determined the experiences that I selected in attempting to answer the research questions.

It should be noted that this study is not concerned with the academic achievements or learning outcomes of the students, but attempts to access the constructed perspectives, or "children's realities" (Oldfather, 1994), that are considered to be essential for understanding students' prolonged engagement with learning. As asserted by Bruner (1990, quoted in Oldfather, 1994),

> A culturally sensitive psychology is and must be based not only upon what people actually *do*, but what they *say* they do and what they *say* caused them to do what they did. It is also concerned with what people say others did and why. And above all, it is concerned with what people *say* their worlds are like. (p.16)

Listening to students' voices "acknowledges that they have something to say" (Clandinin & Connelly, 1994, p.423) about their personal experiences as they participate in the social construction of meaning (Lensmire, 1998). As we listen to their voices, the environmental and contextual factors that are seen to influence their attitudes become apparent. The sociocultural dimension of the classroom becomes a stage on which the perceptions are re-constructed.

I initially designed the study as an ethnography, intending to reconstruct this classroom culture by being particularly attentive to student perceptions of their experiences. As I began to listen to the students' voices there was a shift in focus towards understanding the meaning that these experience had for students. The purpose of this study was, therefore, to understand the meaning of the student experience by accessing and contextualising these experiences from within the social setting of the classroom. An ethnographic methodology that acknowledges the social construction of meaning was adopted to gain an understanding of the context of the experiences which the students perceived and from which they formed expectations. I, therefore, decided to do a case study of a single class of students and their teacher.

## 3. The Setting and Selection of Participants

The research was carried out during the 2001 school year at an independent school in a provincial city in Victoria, Australia. The following section outlines the school setting, the classroom setting, and a description of the participants.

## 3.1. THE SCHOOL SETTING

The participating co-educational college caters for the education of three year old pre-schoolers to Year 12 students, organised within three schools – Junior school (Pre-school to Year 6) at the "Junior Campus," and the Middle (Year 7 and 8) and Senior (Year 9 to 12) schools located at the "Senior Campus." In 2001, there were 602 students at the Senior Campus, a number of them entering the school from primary schools in the city and surrounding rural communities. The school offers boarding facilities for both boys and girls at the secondary level and an overseas exchange program. Students are generally of high socio-economic background.

A common practice at the school is to engage the students in evaluating their teachers in terms of meeting their learning requirements. These "student surveys" are intended to provide feedback for the teachers and inform "best practice." This commitment to improving teaching practice through internal research constituted my rationale for choosing this school as the study site. In the year following collection of the data and while the thesis was being written, I was appointed to a part-time science teaching position at the school; this has enabled me to add an "insider's" view of the teaching environment to my findings as a researcher.

Four seventy-minute science lessons per ten day cycle are allotted for science at Year 7. Each day includes a 15 minute "House" session where students meet in their "Homeroom" to discuss matters, such as sport and daily notices, and a "Study" period of 25 minutes set aside after lunch for students in house groups to begin homework.

In Victoria, the school year is divided into four relatively equal terms, term one and two occurring in the first semester, terms three and four in the second semester. The school year begins at the end of January and ends in the middle of December. Data collection for this research occurred throughout the entire school year.

The Science curriculum, as with all Key Learning Areas (KLAs), is outcomes based, using the Victorian Curriculum and Standards Framework (CSF) as the basis for assessment and curriculum development. The Science Department supports two full-time laboratory technicians who often demonstrate more difficult procedures for classes. Teachers of science at the same year level co-ordinate their units so that common assessment can be achieved.

## 3.2. THE PARTICIPANTS

One Year 7 science class of 25 students and the science teacher participated in this research. As the participant-observer, I saw myself as a co-participant of the study. During 2001 the *science teacher*, Miss Baker (pseudonym), was in her third year of teaching, having begun her teaching career at this school in 1999. She acted as Head of a Middle School House and was the house teacher for the researched class, responsible for the pastoral care of the students and meeting with them as a class during most House and Study sessions. Miss Baker admits to a strong commitment to developing herself as a teacher, with a teaching philosophy largely centred on recognition of the individual learner. When approached by the Head of Science regarding my request for a research class and teacher, she was eager to be a participant in the study.

Miss Baker had only one Year 7 science class so the choice of students was pre-determined. The *research class* consisted of 15 girls and 11 boys, of about 12 years of age, and all of Anglo-Saxon background and heterogeneous learning abilities. Some students had recently entered the school from a range of feeder schools in the city and surrounding regional and rural areas. Twelve students volunteered to be involved in the interviews, eight girls and four boys. Selection of students for the focus-group interviews will be discussed in Chapter 3. Anonymity of student, teacher and school was maintained by assigning pseudonyms in the "thick description" and the thesis (although some students took much pleasure in sharing their pseudonyms!).

## 3.3. THE CLASSROOM SETTING

Two classrooms were used by this Year 7 class during Science. Three of the four lessons per cycle were spent in a "science room" constructed as dual science laboratory and traditional classroom, split by folding doors (that were usually opened). One of the four lessons occurred in a "classroom" that also served as their "homeroom." During the year, both rooms were decorated with students' work or simple decorations, most of which were produced by the students. Miss Baker changed these wall coverings throughout the year. When discussing the classrooms, students most commonly remarked on the science room, commenting on its distance from the middle school, that it was uncomfortable as it was often hot and stuffy, and that there was often a shortage of chairs. These classrooms acted as the immediate setting of the observations and three of the four interview sessions, and are believed to have contributed to the research in a contextual way.

## 4. Structure of the Thesis

This chapter has provided an introduction to the study with particular reference to orienting the study towards responding to the problem of student disengagement in Year 7 science, the specific development of research aims, questions and focus in response to this problem, and contextualisation of the setting and participants of the study.

Chapter 2, "Classroom Culture and the Experience of Science Learning," reviews the literature relating to and setting the parameters of the research, specifically issues of transition from primary to secondary school; the educational context of current science education reform in the shape of "scientific literacy;" the cultural phenomenon encompassing the classroom culture and students' lifeworlds, and applying the terms "academic tribes" and "Discourse" to this research; the focus of the study as learning in the classroom, reviewing some of the theories of learning considered pertinent to this study; and the vehicle of the research considered as the interplay between experience and perceptions. The significance of my study in contributing to the understanding of student experiences is discussed.

The research design is described in Chapter 3, outlining the choice of ethnographic methodology, constructionist epistemological and interpretivist theoretical stances, and methods used to collect, analyse and interpret data from the year long study of a single classroom.

Chapter 4 is the first of two chapters presenting and discussing the findings, and is entitled "The Light of Science" to capture the illuminating effect of learning. This chapter responds to the first of the emergent research questions: What is it about the experience of learning that keeps students engaged with learning science? Student perceptions of how learning is best achieved highlight the social and interactive nature of the classroom culture. The meaning of two words in the teenage discourse that were commonly used to describe science at the beginning of the year ("interesting" and "fun") is explored. Together, a picture has been drawn of what constitutes a Discourse (Gee, 1996) of learning that may promote prolonged engagement with science learning.

In an attempt to explore the role of the teacher in the students' learning experience, Chapter 5, "The Pedagogy of Science," discusses two dimensions of the teacher's pedagogy that students signify as influencing their engagement with learning. The second emergent research question is dealt with here: What role does the teacher's pedagogy play in building a learning environment conducive to student learning of science? Two dimensions of the teacher's pedagogy appeared to be represented in students' discussions of what the teacher can do to maintain their engagement with learning, described by this research as "instructional pedagogy" and "relational pedagogy."

Throughout these two chapters, the students' words that provided the analytical prompts resulting in the interpretations are maintained in varying degrees, as my intention at the beginning of the research was to give voice to those whom teachers wish to inspire. Through the use of individuals' single words, phrases, sentences, or compilation of varying responses, I have attempted to provide an account of the experiences that acknowledges the students as experts of their perceptions and experiences. The result has been an interpretive account of one aspect of the overall culture of this classroom: a Discourse (Gee, 1996) of science learning as experienced by the science learners.

Chapter 6 concludes the account of the research, drawing together the findings from student perceptions and from the literature to demonstrate learning as a social construction, where students rely on interaction with and within the physical and sociocultural classroom context to keep them engaged with learning science. Comments on the significance of the methodological choice to listen to the students within the classroom context in order to gain some understanding of what helps them to learn are expanded here.

## 5. Reflections on the study

This study is representative of one classroom and its students and teacher, so generalisation beyond this classroom is inappropriate. The significance of the study lies in attention to this one classroom as a single *case*. The advantage of a *case study* (not as a methodological choice but as a "choice of what is to be studied") is that "it draws attention to the question of what specially can be learned from the single case" (Stake, 2000, p.435). My aim was to understand classroom culture by concentrated inquiry into what was occurring in this classroom with these students and their teacher, and into the meanings that these occurrences had for the students. The perspectival characteristic of this ethnographic approach adds to the significance of the study as the meanings of the words that participants used and the behaviour they exhibited are interpreted within the context from which they are generated.

Some final words in introducing to the reader my part in the research act. The direction of my inquiry was grounded in the data with emerging patterns influencing the observation focus. Reflexivity played an important role in situating me as researcher within the data and exploring the rationale for pursuing certain lines of inquiry. Therefore, reflexivity features prominently throughout the report.

The next chapter outlines how this study intends to access students' perceptions of and meanings attached to their experiences of learning during their first year of secondary science.

# Chapter 2. CONSTRUCTING A RESEARCH DESIGN

## 1. Introduction

The chapter contains an outline of the research design employed by this case study to gain an understanding of the Year 7 science experience, from the students' perspective and contextualised by the events of the classroom. The research design was constructed within the set of research questions related to the experiences that this group of students had during science lessons; how their expectations and perceptions of these experiences changed during the year; and how the meaning of these experiences could be seen to be contributing to the changes in the perceptions and expectations.

My attention to the cultural aspect of the classroom suggested the choice of an ethnographic methodology. The study was situated within a constructionist epistemology and made sense of through an interpretivist theoretical perspective. These are outlined, followed by a description of the research methods employed and an account of the various forms of analysis that led to the emergence of lines of inquiry as identified in Chapter 1 and of which two are presented in this thesis.

## 2. Ethnographic Methodology and the Research Process

Choosing an ethnographic methodology for this research came quite naturally. Ethnography has its roots in social anthropology, where the emphasis is on the description of peoples and culture (Denscombe, 1998) and is particularly focused on the native's perspective (Crotty, 1998; Woods, 1996). Ethnography provided an approach for the investigation of the culture of the classroom, with the emphasis on giving students the opportunity to explore for themselves and communicate to the researcher the meaning of their experiences in school science.

Sensitivity to context and the interrelated nature of the classroom as a social system was maintained throughout all stages of the research. The research adopted an holistic approach, seeking to identify "processes, relationships, connections and interdependencies among the component parts" (Denscombe, 1998, p.69). I identified with the term "researcher as instrument" (Denscombe, 1998) as I was mindful of my part in affecting the progress and findings of the research. In particular, I was aware of how handling rapport, trust, attention to authority and power relations determined how well fieldwork proceeded (Athanases & Heath, 1995). On ethical grounds I chose to adopt a completely overt role in which the purposes and procedures were explained to the participants from the beginning. I felt this was necessary in order to gain their trust and co-operation during both classroom observation and interviews. As a "participant-observer" and interpreter of their words, I attempted to remain "anthropologically strange" so as to resist becoming an "insider" where I would be "inhabiting the same taken-for-granted way as existing members" (Walsh, 1998, p.218). A balance needed to be found between "participant as observer," where the emphasis is on establishing an honest field relationship, but which carries the danger of reactivity and the researcher going native; and "observer as participant," where observation is favourable to participation, but which can result in a restriction of understanding the native's perspective (Walsh, 1998, p.222). I remained a "marginal native", where "marginality is a poise between a strangeness which avoids over-rapport and a familiarity which grasps the perspectives of people in the situation" (Walsh, 1998, p. 226). The threat of going native emerged at various stages. For example, when I assumed a teacher role in the classroom by teaching and helping students I was able to appreciate how a teacher may respond to these students, and could experience first hand the students' response to me as teacher. However, I had to remain conscious of these interactions so as to recognize their significance. Reflection on how I interacted with the co-participants was important after these instances.

I sought to uncover meanings and perceptions on the part of the members of the classroom, viewing these understandings against the backdrop of their overall worldview or "culture" (Crotty, 1998). During interviews I allowed the students to reflect on and draw in elements of their "lifeworlds" that they perceived as intersecting with their school science experience. Immersion in the field enabled me to draw on my own rich personal experiences of the classroom culture in order to gain understanding of the key features of the meaning-perspectives of the students and teacher (Waldrip & Taylor, 1999). A commitment to reflexivity pervaded the ethnographic study so as to monitor the researcher's role in constructing meaning through interpretation (as was identified in Chapter 1 and discussed later in this chapter).

This investigation into student perceptions considered them to be experts of their own experiences and interpreters of their experiences. I have found it imperative to maintain their "voice" throughout data collection, analysis and synthesis of the thesis. In ethnographic research, van Manen (1990) claims, "the lived-experience or existential quality of personal experiences are sacrificed for the cultural, social, or scenic focus" (p.178). He does, however, acknowledge Geertz's (1973) method of "thick description" as being more interpretive and analytic than mainstream ethnographies. On this basis, building a "thick description" as cultural representations and their meanings (Denzin & Lincoln, 2000a) allowed me to capture the experiences of individual students during interviews and contextualise them through observations. I am presenting such experiences as examples of the "types" of individual experiences that may be indicative of the socially constructed classroom culture.

## *2.1. THE GROUNDING OF THE RESEARCH AND THE ROLE OF LITERATURE IN THE RESEARCH PROCESS*

The approach to theory was grounded in the sense that the building up of the "thick description" (Geertz, 1973) allowed for emergent lines of inquiry that contributed to the development of the research foci. During such a process, theory is "*generated* rather than solely tested" (Walsh, 1998, p.220, italics added). For my research, experiences and emerging meanings (inferred or provided during interviews or observations) often led to a re-focus or channelling of my sensitivities during observations, or to the development of questions to be explored in subsequent interviews. The Grounded Theory approach (Glaser & Strauss, 1967) requires a researcher to enter the research site "without a rigid set of ideas that shape what [the researcher] focuses upon during the investigation" (Denscombe, 1998). Walsh (1998) states that "the focusing of research questions cannot really be started until initial data have been collected" (p.223). Even though I entered the site with a problem in mind and some initial research questions, I remained open minded to the kaleidoscope of happenings and meanings that emanated from the observations and interviews.

While my research approach and generation of theory were grounded in the empirical world, an account of how the literature informed and interacted with the evolving research and developing theory is important to consider. Consistent with my commitment to reflexivity I have attempted to identify my focus of attention as I interacted with the research, considered here as "sensitivities," and how these sensitivities were shaped by documented theory and other empirical studies. A thorough review of the literature was done during and following data collection and data analysis, not before. An account of how my sensitivities were shaped by my interaction with the literature takes the form of a modified "confessional tale" similar to Van Maanen's (1988) *Tales of the field.* Writing "confessional tales" is a genre that pays particular attention to the way the researcher interacted with the participants while immersed in their culture. I am "confessing" the way that my sensitivities while being in the field and working with the data were seen to be influenced by my interaction with other research and theory. This "confession" is attached as Appendix 1.

The data shaped the theoretical framework as the research proceeded, although in no way do I contend objectivity when first entering the field; indeed, no research can be done in a "theoretical vacuum" (LeCompte & Preissle, 1992). The intention was not to be *unduly influenced* by other studies, but to allow the research itself to direct the lines of inquiry. I remained open to discovering new factors of relevance rather than restricting the scope and vision of the research to supporting or refuting hypotheses or existing theory (Denscombe, 1998).

Such a trajectory of initial limited interaction with the theoretical frame is supported by Becher (1984), who stated in relation to his qualitative work on academic tribes:

> I have attempted to avoid any firm preconceptions about the nature of the information to be sought, allowing the data themselves to yield up consistencies and to dominate the forms of explanation offered to account for them. Grounded approach (Glaser and Strauss, 1967) offers more assurance than does a theoretical stance based on a particular set of axioms that the range of evidence taken into consideration will not be intentionally or subliminally restricted. (p.150)

As a result of this methodological stance, exploration of the literature prior to fieldwork was restricted to the characteristics of and methodology for conducting an ethnography (Carspecken, 1996; Goetz & LeCompte, 1984; Maykut & Morehouse, 1994; Miles & Huberman, 1984), some studies dealing with elements of transition from primary to secondary school (Ferguson & Fraser, 1998; Speering, 1995), readings about cultural border-crossings in school (Aikenhead & Jegede, 1999), and general readings on school science, such as inter- and intra- group interactions among students (Windschitl, 2001). My sensitivities to certain aspects of the school science environment may have been influenced by this literature to some extent during the broadly focused initial observations (prior to the first round of interviews in the third week of the year).

## 3. Social Constructionist Epistemology

This research was carried out on the basis that knowledge claims of what constitutes reality are consistent with the constructionist paradigm. Constructionist epistemology holds that meaning is constructed by an individual within the sociocultural context, where "'reality' and the individual knower" are socially constructed (Bredo, 2000). This epistemology often underpins social research, such as ethnographic studies, including educational research where the socio-cultural nature of the classroom and the school is under study (Crotty, 1998).

Constructionism states that meaning is constructed, not discovered, when a subject interacts with the object. This departs from the objectivist paradigm by claiming that meaning does not exist within the object apart from the mind. Constructionists believe that meanings are *constructed* as we interact with the world that we are interpreting. This interactive construction of meaning separates constructionism from subjectivism, which says that an object has no meaning until the "subject" ascribes meaning to it (Crotty, 1998). Constructionists believe that they have something to work with, the object has a part to play in the construction of meaning, such that objectivity and subjectivity are "indissolubly bound up with each other" (Crotty, 1998, p.48).

This construction of reality includes a social dimension. Crotty (1998) calls this "social constructionism"[2], which he describes as

> [t]he view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context. (p.42)

[2] In differentiating constructionism and constructivism, Crotty (1998) states that Piagetian constructivism is "an individualistic understanding of the constructionist position" (p.58).

Any attempt to explore the cultural character of the classroom demands the acknowledgment of the social construction of "meaningful reality." As Crotty (1998) further states:

> [W]hile humans may be described, in constructionist spirit, as engaging with their world and making sense of it, such a description is misleading if it is not set in a genuinely historical and social perspective. (p.54)

By "meaningful reality," Crotty is not restricting social construction to ideas and emotions, but subsumes objects and actions, both "social" and "non-social" in nature. For example, a person makes meaning of a tree by drawing on the socially constructed conceptual schemes in order to make sense of it. In other words, our society teaches us how or whether to see the tree (Crotty, 1998). This appears to concur with Vygotsky's (1978) theory of the process of internalisation (see Chapter 2), where through the development of socially constructed knowledge, people are able to share common experiences. In the subjective paradigm, such an occurrence is not possible because each individual imposes their own meaning on an experience, which may or may not be consistent with another person's conceptual frame, calling in question the possibility of shared experience and shared reality (Bredo, 2000; Crotty, 1998). Knowledge of reality for the constructionist is not subjective, but intersubjective[3], being orchestrated and constrained by the societal setting (Crotty, 1998).

Woods (1996) holds the view that "[s]ocial organisation provides a framework inside which people construct their actions" (p.34). Social organisation shapes situations and provides sets of symbols that guide the imposition of meaning onto experience, that is, for interpreting situations (Geertz, 1973; Woods, 1996).

## 4. Interpretive Theoretical Perspective

This research operates from the perspective that both the participants and the researcher are interpretive beings, and that the experiences that are captured through fieldwork and

[3] Howe and Berv (2000) discuss intersubjectivity as arising from Kant's attempt to synthesise empiricism and rationalism on the basis that a conceptual scheme without sensory data is empty, and that sensory data without a conceptual scheme is blind. Kant's version of constructivist epistemology came out of a reaction to "the two half-way constructivisms of empiricism and rationalism" (p.21) and introduced the notion of intersubjectivism.

interviews are students' interpretations of reality, constructed through their own interpretive lens, then interpreted by the researcher, and then by the reader. The *interpretive theoretical perspective* predominates the theoretical frame of this research (Carr & Kemmis, 1986; Crotty, 1998).

Erickson (1986) states that "[h]umans ... create meaningful interpretations of the physical and behavioural objects that surround them in the environment," and that "we take action toward the objects that surround us in the light of our interpretations of meaningfulness. Those interpretations, once made, we take as real – actual qualities of the objects we perceive" (p.126). Reality is constructed through the interpretive lens of the person as they are *situated in and informed by their social world.* Students' perceptions of their lived experiences are considered by this research to contribute to and be constructed by the dynamic and socially constructed classroom context, as well as the various lifeworlds of the students.

This study has been attentive to students' "lived" experience (van Manen, 1990), both what the experience of learning *is* for them, and the *meaning* of these experiences as ascribed by them. "Lived" experiences are considered to be not pre-conceptual but are already meaningful.

In the twentieth century the significance of language in the process of the social construction of meaning was recognised (Howe & Berv, 2000), where language was seen to be embedded in the social practices or forms of life (McCarty & Schwandt, 2000). Language is considered "representational" and "constructive," and exists as the means by which people socially construct their worlds (Filmer, Jenks, Seale, & Walsh, 1998, p.24). Geertz (1973) asserts that "the concept of culture...is a semiotic one" (p.5), a system of signs, or "symbols" (p.17). The semiotic nature of the classroom was seen to be partly bound by the words that students used to describe science. Language variations across people's contexts require a researcher to become fluent, or at least be familiar with, the participants' meanings of words. After all, people's definitions of reality and what constitutes their world are expressed in particular linguistic patterns (Goetz & LeCompte, 1984). To learn the language or idiom of the participants is a fundamental role of ethnography, as understanding a culture "requires near-native fluency in the language as well as extensive and intensive participant-observation" (Goetz & LeCompte, 1984, p.95). Goetz and LeCompte (1984) argue that, when researching adolescents, it is impossible to move beyond "polite indifference" unless the researcher has "careful grounding in adolescent argot" (p.96). Being familiar with the discourse of the participants is also important for constructing interview questions to ensure that the respondent and interviewer are sharing the same language (Goetz & LeCompte, 1984). In order for me to "hear" and "understand" the social world under study, my language and that of the students had to find some common ground. In order to understand student perceptions of their experiences, I attempted to access and interpret the meanings of common words in the adolescent discourse which are embedded in their culture.

## 5. Research Method: Building the "Thick Description"

Building a "thick description" (Geertz, 1973, p.7) provided a more contextualised and grounded approach for this research. A "thin description" that records only what the participants are doing would have been inadequate to capture the contextualised meanings of the students' experiences or to be attentive to the motives and intentions of the participants that define and give meaning to their actions (Carr & Kemmis, 1986). Observation was, therefore, combined with informal and semi-structured interviews in order to capture the meaning structure of actions as perceived, interpreted, and reconstructed first by the students and then by me as researcher.

TABLE 1: *Data Collection Strategy for Field Study*

| Event | Setting | Actors | Processes |
|---|---|---|---|
| Participant-Observations | Science lesson Classrooms | Year 7 class and teacher | Student and teacher observations, building of class context, sometimes triangulated with tape and additional observer. |
| Semi-structured Interview | Interview Room | Focus groups (2 or 3 students) | Eliciting students' perceptions and expectations of science: taped |
| Informal interviews | Various | Key Informants (school staff and administrators) | Gathering contextual information (such as school ethos, curriculum design and materials) |
| Informal discussions | Various-classroom, in transit, staffroom etc. | Teacher | Gathering contextual information (teaching philosophy, background, content from unobserved lessons), feedback of findings, member-checks, Miss Baker's impression of the class |
| Field observations | Generally out of class | Class, individual or groups of students | Opportunistic or planned observations of participant interaction in a different context |

Several qualitative methods were employed to follow one Year 7 science class through the 2001 school year. These data collection strategies are summarised in the Data Collection Strategy for Field Study[4] (Table 1). The Strategy identifies data collection methods (Event) used to gather data from where (Setting), with whom (Actors), and of what type (Processes). There was potential during any of the "events" to collect artefacts that included curriculum documents and class handouts that were subsequently analysed using a proforma sheet (Miles & Huberman, 1984) to record their significance (see Appendix 2 for artefacts proforma). Appendix 3 provides a summary of the data collected that formed the "thick description".

Two record books were used to record the findings (Carspecken, 1996). One was a notebook (field journal and primary record together) that contained the classroom and field observations, the informal discussions, and notes taken during the informal interviews where required. The semi-structured and informal interviews were usually recorded on tape, and did not require written notes in most cases. The other was a reflexive journal that served to record my analytical notes after an event and my reflexive "wanderings," both being crucial in beginning the construction of meanings associated with the events, experiences and words. See Appendix 4 for an example of where reflecting after a lesson that I taught enabled me to be aware of how the behaviour of the students influenced my sensitivities during observations.

The procedures and techniques employed by each of these events are explained in detail below. Organisation of the data is also discussed.

## 5.1. PARTICIPANT-OBSERVATION

Participant-observation has the potential to be either a positivist or non-positivist method, depending on the purpose of the continuous narrative description (Erickson, 1986). Researchers with a positivist or behavioural orientation exclude from interest the meaning of actions from the actors' point of view. The non-positivist, interpretive orientation of the "thick description" employed for this research makes pertinent the meaning that the participants place on their actions (Erickson, 1986). In order to access such meaning and

[4] Adapted from Miles & Huberman, 1984

in keeping with the ethnographic tradition, I maintained a long-term and repeated residence at the site (Goetz & LeCompte, 1984). The class was observed during one of the two 70 minute science lessons for the week. I planned my first observation with the first science lesson for the year so that I would be journeying Year 7 science with them from the beginning to the end. At the beginning of the first lesson I introduced myself, the research and my intended attendance throughout the year. During these sessions my overall aim was to observe and write down student responses to the teacher, peers, activities and use of equipment, involvement in science-based non-curricular activities and gauging students' reactions to the content of the lesson. Some lessons were taped then transcribed in conjunction with the observational notes. Observations were compiled to form the Primary Record, a part of the "thick description" (Carspecken, 1996). The focus of the observation was either decided before entering the lesson or responded to the mood or activities of the class. Examples of observation focus include: individual student focus for short periods; overall focus following the mood of the class; teacher focus, such as where she directed her attention and how students interacted with her; and group focus, for example, friendship groups, interactions within and between groups during theory and practical lessons.

The technique used in making observations was informed by Carspecken (1996), and Goetz and LeCompte (1984). Prior to entering the field, I set out a list of instructions or procedures that would guide my preparation before entering the classroom; my conduct and presence in the classroom, such as sitting near choice groups that are being observed, and including a detailed procedure for making observations; and steps that I needed to consider after an observation. The observations were typed up, usually in conjunction with the tape recording to co-ordinate the speech acts given by the recording and those noted in the field journal, into an "observation proforma" that maintained a consistent layout and attention to the required detail, including: an observation code, date, period and time, room, whether it was taped, and a general distinguishing comment of the lesson; description of the context, such as events prior to and after the lesson; observation method and focus; overview of the content; map of room with seating arrangements of students and myself; and observation notes taken during the class giving reference to time, student and teacher speech acts, and observations of student and teacher behaviour. Observer comments were also made speculating on meanings of observations. (See Appendix 5 for notes on conducting observations and setting up the Primary Record, along with a proforma used in typing up the observations.) In order to improve clarity of my method in making observations, I have included an example showing the manner in which the observations were typed up (Fig. 1).

The experiences captured during observations were compiled in an attempt to reconstruct elements of the Discourse of the science class. The observations gave insight into the experiences, including the teacher's pedagogy that appeared to be important in influencing what students expect from and think about science.

| | |
|---|---|
| | [44] Andy gets up and talks to Daniel, drapes himself over him.<br>[45] Betty asks for help from Daniel. Betty explains what has happened. Daniel offers some help then leaves. Vanessa asks Betty to help her after Daniel leaves. |
| 11.10 | [46] Fred is still with Ken. Ken is continually chatting.<br>[47] Daniel wanders around to help. Sam to Daniel: *Daniel, how do you...?*<br>[48] Nancy and April are looking at each other's work on the screens. Nancy then starts typing while April is looking and pointing things out on Nancy's screen.<br>[49] Betty: *Right Vanessa, how did you do that again, I've forgotten.*<br>[50] Vanessa: *Could you help me first?*<br>[51] Betty: *Yeah, just tell me the instructions you said before.* (Vanessa turns and tells Betty the instructions. Nola helps Betty as Betty types it in).<br>[52] Betty: *It's not working.* (Vanessa comes over, fixes it and it works. Vanessa turns to Joan and helps her.)<br>...<br>[64] Nola is working next to and with Amy. Nola seems neither unhappy nor happy with her progress, [OC: she appears to just accept the task and keep plodding on.] |

FIGURE 1. Example of observation and recording procedures as identified in an extract from Observation number 10. No tape recording to inform observation notes. 11.10 = time noted at this point; [44] = numbering of paragraphs to assist easier retrieval during coding; students names as pseudonyms; speech acts identified by italics (this was not always the case), with "Name:" identifying the speaker; [OC: ...] = observer comments as mental notes about my interpretation of events. Note also low inference language of observations.

### 5.2. SEMI-STRUCTURED FOCUS GROUP INTERVIEWS

Interviews with focus groups of two to three students allowed me to explore students' perceptions and expectations of science and the meanings of their experiences that may have contributed to their formation. I was particularly sensitive to the types of experiences that students considered to maximise their individual styles of learning.

During the third lesson I asked for volunteers to participate in forthcoming interviews, and every student was given a plain language statement (Appendix 6). For ethical reasons students and their parents were required to offer informed consent prior to the commencement of interviews, and assured of confidentiality of data and the anonymity of all participants and the school. Failure to be included in the focus-group interviews for some students was simply due to them forgetting or losing their consent forms. The reliance on student volunteers perhaps contributed to the imbalance of the female to male ratio, as more girls seemed to be comfortable with the idea of participating in an interview than did boys. I resisted pressuring students into participating, as I did not want to damage my rapport with them and increase the chance of reactivity.

Twelve students volunteered to be involved in the interviews, eight girls and four boys. Not all students were available each interview round, so a range of ten to 12 students was represented each round. (See Appendix 3 for a summary of numbers of students involved in the interview sessions). Placing students into groups was partly pragmatic, depending on who was available on the day, and partly strategic, where attempts were made to maintain all-girl and all-boy groups, and to group students according to friendships and student associations. Sometimes students requested to be in groups with certain people. Therefore, over the four interview rounds, the members of the groups were not fixed. I decided to use focus groups rather than individual students because I felt that students would feel less threatened. I hoped that they would prompt each other's thought processes during group interaction so that differing perspectives could come in contact (Maykut & Morehouse, 1994).

A total of four focus-group interview sessions, or rounds, were conducted. The first round occurred between the third and sixth week of term one[5], the second during the first weeks of term two, the third during the first weeks of term three, and the fourth in the last few weeks of term four. Each of the four or five interviews per interview round followed the same Interview Schedule; however, due to individual differences among students of the groups no two interviews followed exactly the same progression of questions. Some interviews proved to be more fruitful than others, as is characteristic of the semi-structured interview (Goetz & LeCompte, 1984; Minichiello, Aroni, Timewell, & Alexander, 1995). Although the focus of the interviews was directed by particular lines of inquiry that emerged through previous observations or interviews, the broad areas of interest directing the interviews can be stated as follows:

1. How important they think the science subject is.
2. How much of the science covered so far they have already done at primary school and at home.

[5] I had not received ethics clearance for conducting interviews until week three.

3. What they expect to happen during science lessons for the remainder of the year.
4. Whether they enjoy science (Yes/No) and what about science they do and do not like.
5. What helps them learn: how the teacher can help, types of activities.

The interviews were semi-longitudinal, as the findings of one interview often influenced the focus of the next so that I was able to explore the emerging themes and gather student insight, clarification of terms and meanings of experiences highlighted during observations and previous interviews. Interviews were audio-taped and transcribed by me into an interview transcript proforma (Appendix 7), and included contextual information similar to that of observations. A copy of the interview transcript with pseudonyms was given to each member of the groups. See Appendices 8-11 for copies of Interview Schedules for each Interview Session.

### 5.3. *INFORMAL INTERVIEWS*

Informal interviews were conducted at various times throughout the year, depending on availability of interviewee and interviewer, and as the need arose. The purpose of these interviews was to gather contextual information from "key informants" (Goetz & LeCompte, 1984) at the school, namely Miss Baker, the Head of Science, and the Vice-Principal responsible for the professional development of staff. These interviews followed an informal set of guiding questions specific to the role of the informant and given to the interviewee before the interview was conducted.

### 5.4. *INFORMAL DISCUSSIONS*

The informal discussions with Miss Baker provided insight into her state of mind and were often reactive to the current events or in the form of a relaxed chat about how things were going. These sometimes offered potential contextual information for insights that students shared during the focus group interviews. They also provided me with an opportunity to do some member checking by sharing patterns that were emerging in the data. My commitment to reflexivity was important in this respect as Miss Baker stated at various times that she was reacting to my presence in the class and my feedback by being more reflective of her teaching practice than she might otherwise have been.

### 5.5. *Field Observations*

Opportunistic observations of students out of the classroom provided the opportunity to capture student activities in a different context, where the expectations and cultural norms may be different. They also allowed me to mix with the students in a role other than explicit observer. I generally wrote observations of these incidents as reflections shortly after the event in order to make our interactions seem more natural and less intrusive for the students.

### 5.6. *Organising the Data*

The interviews and observations were transcribed and spiral bound by school term, each data collection event forming separate sections in the bound document. For example, the term 1 "thick description" document contains the observations, followed by the field observations, informal discussions, informal interviews, and finally the focus groups interviews. By the end of the year I had four separately bound documents, collating the data both chronologically and according to type. Copies of each document are kept on disc and hardcopy.

## 6. Research Analysis Design

Data analysis in this research has been a progressive and constant process of defining lines of inquiry. Choosing the method of analysis most appropriate to my purposes and my style required moving through a number of recommended methods (e.g., Maykut & Morehouse, 1994; Miles & Huberman, 1984; Patton, 1990; Strauss & Corbin, 1990; van Manen, 1990) until I had accumulated a process that was informed yet constructed for this study. Four stages of analysis can be identified. The first was the preliminary analysis that was instrumental in providing a conceptual framework that directed the research for the rest of the year. The second stage was the intensive *macro*, grounded theory analysis of the transcripts from the interviews, discussions and observations through categorical coding and thematic analysis. The third stage involved the intense thematic analysis at the *micro* level that led to the convergence of the various data sources and the construction of meaning for the chosen experiences. A fourth stage, which is not described in detail below, occurred during the writing of the thesis, as it was during this act of writing that clarity and a final analysis occurred (van Manen, 1990).

Literature assumed a number of roles in informing the analysis, some of which were described in the "confessional tale" in Appendix 1. Chapter 3 draws in some of these references as it outlines literature that I considered relevant to classroom culture and the experience of science learning; however, this chapter was mainly synthesized after an intensive analysis following data collection. Other literature that informed the developing themes (particularly Chapter 4) or directed the analysis (partly in Chapter 5) is detailed in those chapters. The following sections attempt to highlight the various stages of analysis and identify the methodological literature used to decide procedure. In summary of the whole process, the analysis took a number of different forms, and was not restricted to a single procedure but drew on other frames of reference in order to construct meaning. Such an approach is affirmed by LeCompte and Priessle (2000) who state that "[e]thnographers may use insights from several frames to structure their research and interpret its findings" (p.848).

### 6.1. STAGE ONE: PRELIMINARY ANALYSIS

There were two phases of the preliminary analysis: (1) discovery, and (2) construction of the emergent conceptual and contextual framework.

*PHASE 1. DISCOVERY:* This was the initial part of the analysis and was done in the form of interpretive reflections after the observations were made. I recorded in detail the recurring ideas, questions and thoughts that emerged from the data, enabling identification of potential themes, relationships, experiences, ideas and concepts within the data (Maykut & Morehouse, 1994).

*PHASE 2. EMERGENT CONCEPTUAL AND CONTEXTUAL FRAMEWORK:* The next phase of analysis began after the seventh observation session, the class's seventh week at school. The initial step was to construct a "conceptual framework" (Appendix 12) using the ideas that emerged during the discovery phase (Miles & Huberman, 1984), from which "categories" were identified that would be later used in coding. The conceptual framework made concrete my interpretive understanding of the relationships between concepts that I inferred to be influencing the students' perceptions and expectations of science. In addition, a "contextual framework" (Appendix 13) was constructed during this process to embody the aspects of the context within which my research was conducted at this stage. The framework consisted of three overlapping spheres of classroom, school and community contexts, and served to make concrete the various contexts that I recognised as acting on the research in some way at that time. Both frameworks served to orient the research process towards the experiences of the students, while allowing for the context to be maintained and giving me some focus in attempting to understand the classroom culture.

### 6.2. STAGE TWO: A GENERATIVE MACRO ANALYSIS

A number of methods were examined for analysing the data. Initially I formed a categorised set of starter codes (Appendix 14) as described by Miles and Huberman (1984) in response to the categories identified from the conceptual framework. Bogdan and Bilken (1982) gave examples of an accounting scheme to ensure that the full spectrum of data was considered in the coding and to help me identify areas in my data collection that were thin or lacking. Carspecken (1996) with Miles and Huberman (1984) provided details of the reconstructive analysis, with examples of low level (objective, low in terms of abstraction and inferences) and high level (pattern, theme) coding. Later I toyed with the coding procedures of the Constant Comparative Method (based on Strauss and Corbin's (1990) grounded theory method) as described by Maykut and Morehouse (1994) but found it too rigid as it did not allow me to move freely within the texts of the "thick description." I decided on adapting the "grounded theory" method of analysis (Strauss & Corbin, 1990) to provide a more manageable and *generative* process for categorising and coding the data that drew on insights gained from previously tried methods. At the *macro level*, where great volumes of data were coded and categorised, the content of the text became the focus of analysis. This intensive process began after all the data had been collected and transcribed, so that the analysis could be more focused. However, there were various stages during the research where analysis and the development of theory became pertinent, thereby allowing the analysis to be considered ongoing and being consistent with my stated "emergent" research design.

*IMPORTANT ANALYTICAL STAGES OF THEORY DEVELOPMENT:* Theory development occurred intermittently, although my ongoing attendance at the site meant that I was continually engaged with the concepts and patterns of the data. Having achieved some focus from my development of conceptual and contextual frameworks, I decided that the next important analytical event would involve a categorising and mapping of the first round of interviews. Student responses and my interpretive meanings were mapped, showing the relationship between: students' primary, secondary and home experiences, their perceptions and expectations of their experiences, the building of a conceptualisation of what constitutes the "science tribe" (the culture of school science), and the relationship between the importance of school science and the nature of science. Another crucial time for the research occurred in term 1 when I identified and developed two particular lines of inquiry, or themes, after the first round of interviews and explored further in the second round: student perceptions of the nature of science, and construction of students' meanings of the words "fun" and "interesting" as descriptors of the science experience. Subsequent exploration of these themes involved data from the first and second round of interviews, and some from the third interview round, contextualised within an intuitive[6] feel for the observational data. These analyses were written up as a conference paper (Darby, 2001) presented in early December where I had an opportunity to share my analyses in a forum that provided stimulating feedback. This assisted in broadening my literature and contact base, and informed the subsequent analytical phase. The preparation of this paper required me to partly analyse some of the data, and ensured that the analysis at the end of the data collection could be partly focused on themes already firmly developed. I did, however, remain open to new insight and patterns of meaning.

### 6.2.1. Analysis of the Interviews:

Formal analysis of the interview data began while reading through the transcripts where I made interpretive notes in the margins and assigned sections of the transcript to a coding category or categories[7]. Some categories related to the broad questions pre-determined by the interview schedule; others were emergent categories, which were added to the coding

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[6] Woods (1996) discusses the notion of "intuition" as involving "a host of factors to do with such things as principles, knowledge and experiences" (p.25). Similarly, I drew on experiences from the observational data (with some searching through the primary record) that I intuitively felt represented the themes of "nature of science" and "fun and interesting."

[7] "Categories" are groups of excerpts from the data that refer to the same idea, such as where students provided meanings of the word fun. "Codes" are the shortened label given to the category, such as "FUN." "Coding" refers to the process of moving the data within a category into the codes using the Nvivo computer program.

list as I read through the transcripts. Consistent with qualitative analysis and coding, "many passages can serve many purposes, patterns or themes," therefore, "several readings of the data are necessary before they can be completely indexed" (Patton, 1990, p.382).

A more detailed coding process was made easier by the organising and search capabilities of NVivo software (Rouge Wave Software, 1999-2000). Data was organised into the categories and codes making sure context was preserved, especially where it appeared leading questions interfered with development of student responses. The coding for each interview formed a coding report that was imported into Word and organised into a more readable form. Like codings across the interviews were brought together; for example, a set of extracts relating to students' perceptions of learning from term 3 interviews. Codes for each interview session related to the questions and responses, rather than being constricted by one set of codes that may or may not encompass the ideas presented. By analysing the data in this segmented way, changes to student perceptions as the year progressed were easier to identify.

The next stage of analysis was to read through the compiled coding reports, again identifying salient features of the data relating to that particular code. This was done while referring back to the interview transcripts, to maintain connectedness with the data, looking back at initial notes, forming ideas grounded in the data. These were noted in the margins for later reference. Some of these ideas were further developed and explored in the thematic micro analysis that occurred after data collection had ceased.

### 6.2.2. Analysis of the Observations

The observational data was more difficult to analyse due to its sheer volume. Attempts to analyse some earlier observations with the starter list of codes generated by the preliminary analysis proved to be ineffective and was abandoned as it seemed time-consuming, too divergent and undirected. Another attempt to make sense of the observation transcripts occurred near the end of the data collection, guided by a smaller, more focused list of codes (Appendix 15) than the initial starter list, and was structured according to three lines of inquiry that I had selected near the end of data collection. Some of the codes from the starter list were preserved, but subsumed within these foci. The three lines of inquiry emerged out of my search for: students' perceptions of the science classroom as a "science tribe"[8]; occurrences of the scientific world entering the classroom; and any mention of scientists. The "science tribe" was the most diverse and encompassed the findings presented here, with categories relating to: school science as being different from other subjects, students showing signs of learning, teaching style, characteristics of the laboratory, particular use of language such as the words fun and interesting, transition issues, the teacher's pedagogy, especially her management techniques, and interactions between members of the class. Codes capturing contextual and reflexive issues and characteristics of individual students were also applied; others were added when something arose that was considered significant but could not be placed in an existing code.

### 6.3. Stage Three: Convergence of the Various Analyses- Micro Thematic Analysis

The more intensive act of finding meaning and generating theory from the text within the codes involved a complete immersion within all the data. By this stage the data had been categorised and some themes had already been constructed. I was not content to simply present the various categories of experiences and perceptions but was driven to find something that tied together or captured the essence of this science experience for the students. Van Manen (1990) highlighted for me that, in order to gain a reflexive understanding, the experiences and perceptions within the transcripts needed to become fixed in some way. This "fixing" began with the macro categorical analysis. The "mining for meaning" (van Manen, 1990, p.86) within and across these categories required me to interact with the words and with my impressions of my own experiences, hear the words of the students again, and find some common and distinctive qualities within the text. At this *micro* level the varieties of meanings that emerge, what van Manen calls "themes," can be heard and given significance (van Manen, 1990). At this stage of full immersion I organised the categories and themes thus far discovered as labels in a concept map, and attempted many combinations of linkages, hierarchies, ordering, and exclusions and inclusions to construct the meanings, or themes, within these experiences. It was during this intensive reconstructive phase of microanalysis that the experiences of the "nature of

[8] Taken from Becher's (1989) notion of academic tribes (see Chapter 2).

science", "learning" and "pedagogy" were chosen and others were sidelined[9]. Within the framework of the initial research questions, I defined a set of emergent research questions to guide my thoughts and theory development. For each of these questions, two "focus questions" further directed the structure of the analysis. The emergent research questions with their focus questions were:

*What is it about the experience of learning that keeps students engaged with learning science?*

1. What do the students say about how learning is best achieved in science?

2. Since students have used the words interesting and fun in response to their learning experiences in science, what do the students mean by these terms and how does the use of these terms indicate opportunities for learning?

*What is the role of the teacher's pedagogy in building a learning environment conducive to student learning of science?*

1. What do the students say about what the teacher can do to improve learning?

2. What do the students say about the way the teacher teaches and how this impacts on what they expect and think of science?

Analysis of these categories of experience continued at the thematic level, drawing on previous themes and relationships from across the spectrum of categories to construct the meaning from selected indicative experiences and students' interview responses. Through being involved in dialogue with the text, this intensive search for meaning involved "the experience of themes as emerging lived meanings in life" (van Manen, 1990, p.88) and was the heart of my research experience.

## 7. Issues of Trustworthiness and Authenticity

My intention was not to construct the culture in a way that could be generalised or reproduced across Year 7 science classrooms, therefore, the positivist criteria of validity, reliability and objectivity become inappropriate. The constructionist basis of my research

[9] The justification for this choice is outlined in Chapter 1. Bear in mind that the first of these experiences (nature of science) was later removed from the thesis.

demands that the "[t]raditional positivist criteria of internal and external validity [be] replaced by such terms as *trustworthiness* and *authenticity*" (Denzin & Lincoln, 2000b, p.158). The notion of trustworthiness was an early attempt to "resolve the quality issue for constructivism" (Guba & Lincoln, 1994, p.114) but continues to largely parallel positivist criteria (Woods, 1992). In judging the "goodness or quality" of my inquiry, authenticity becomes appropriate as it moves towards how useful my research is to the reader. Woods (1992) describes authenticity as marked by "criteria of fairness, enlarging personal constructions, improved understanding of the construction of others, stimulating to action, and empowering action" (p.59). I prefer to judge my work against a measurement of *understandability* as my purpose was to allow the reader and myself to "understand rather than to convince" (Wolcott, 1994). In keeping with the interpretivist and constructionist traditions I am prepared to admit that mine is possibly not the only interpretation of the students' experiences and perceptions. As explained by Geertz (1973),

> The fact is that to commit oneself to a semiotic concept of culture and an interpretive approach to the study of it is to commit oneself to a view of ethnographic assertion as, to borrow W.B. Gallie's by now famous phrase, "essentially contestable." (p.29)

### *7.1. Triangulation*

Initially I designed the research to allow for triangulation of data sources to ensure "validity" in the sense used by Carspecken (1996) and Goetz and LeCompte (1984), two references strongly influential in guiding the research process at the beginning. On encountering the emerging debate surrounding the appropriateness of the positivistic criteria of validity and reliability, the triangulating methods were adopted with the purpose of *understanding* as best as I could what the students had to say rather than to claim that my constructions were "true." Triangulation through the multiplicity of data sources served to keep data at a high quality through rigorous, rich, "thick description", and ongoing, grounded interpretation of data. Other efforts of triangulation included: member checks where Miss Baker and I discussed some of my interpretations, adding to them the teacher's perspective; member checking with students during interviews by probing their intended meanings and sharing my interpretations of past interviews at times that were not considered to sway the responses of the interviewees; an additional observer (second year Bachelor of Education student) who assisted with observations throughout the year[10]; and discussions with my supervisors providing another perspective on the data. Efforts were made to elaborate on student perceptions by using salient themes identified from an interview or observations and to structure subsequent student interviews or observation focus in accordance with these findings. These strategies enabled me to generate authentic accounts of salient aspects of the classroom culture within the limitations of my interpretive and reflexive frame and to proffer adequately warranted claims of the processes active in understanding student engagement with learning science.

### *7.2. REACTIVITY OF THE PARTICIPANTS*

Carspecken (1996) describes that the mere presence of an observer can affect the behaviour of the participants. Maykut and Morehouse (1994) refer to this as "reactivity." Modifications of behaviour could have implications for my study by distorting my impressions of the science culture. Carspecken (1996) states that prolonged engagement should reduce this effect. In an attempt to deal with this I assumed a multi-dimensional role within the classroom. I acted as observer, interviewer, assistant teacher and team teacher as I taught some lessons or parts of lessons during the year. The following is an extract from my journal in term 2 that reflects my efforts to reduce the reactivity of the students:

> I have sat in the class with and without the tape recorder, sometimes I don't write anything, just rely on the tape recorder and record reflections after the lesson, I tape them only from a distance rather than walk around with the tape recorder, and when students are in groups I ask for their permission to sit amongst them and record observations; ... and most importantly, I make sure I conduct myself ethically by not prying into their personal conversations, and by ensuring that the teacher does not divulge grades or progress of individual students without the consent of that student.

Commitment to reflexivity (next section and Chapter 1) played an important role in monitoring and honesty about the reactivity of participants. I am confident that I remained

[10] The additional observer attended the class two times in the year and made observation notes following the same observation instructions as me. Through discussion with me, the additional observer provided a fresh perspective on the classroom. For example, the additional observer noticed that the teacher provided extensive guidance to students when completing scientific reports, highlighting for me the tendency of Miss Baker to provide assistance in learning. This influenced subsequent observation focus and perhaps the final analysis of the teacher's pedagogy.

sufficiently "anthropologically strange" to enable the findings of this study to reflect the perceptions of the students involved.

### 7.3. REFLEXIVITY MODEL – WHY I SEE WHAT I SEE

The perceptival characteristic of this type of research demands that the researcher employ the reflexive model within the development of the research. Alvesson and Skoldberg (2000) define the act of reflexivity as "interpreting one's own interpretations, looking at one's own perspectives from other perspectives, and turning a self-critical eye onto one's own authority as interpreter and author" (p.vii). Interpretation of our observations is shaped by who we are (Peshkin, 2000). Reflexivity played an important role in situating me as researcher within the data and exploring the rationale for pursuing certain lines of inquiry. Being reflexive also meant considering the context from which I approached the research: how my experiences, values and biases influenced what I saw and the interpretation of what I saw - basically my "sensitivities" during fieldwork and analysis. The number of experiences that I can "see" is limited by my "mono-sensory" perception and as such I have attempted to triangulate with tape recordings, interviews and discussions with the teacher to provide alternative perceptions of the same situation. (An example of this was shown in Appendix 4).

## 8. An Epilogue to the Research Act: Evolution of Student Perceptions, the Research, and the Researcher

This act of researching was an evolutionary process, where evolution has occurred in multiple branches: student perceptions, the research process, and the researcher. The research was interested in how the students' perceptions and expectations of science evolved during the year given past science experience and the entire school experience. Experiences were considered the tangible element from which perceptions were constructed and which caused the perceptions and expectations to evolve. In the same way, the research trajectory was an evolution with evolving lines of inquiry and changing foci. It was also an evolution for me as a person, a researcher, and a creative being: beginning with the tentative and unfamiliar research process and evolving into a confident and directed researcher who has a story to tell; getting to know and interact personally with the participants and the setting, yet remaining as an outsider attempting to gain some insight into that which typifies this classroom culture (in other words, attempting to be *in* the culture, but not *of* the culture); and, emerging from beneath the bamboozling enormity of the "thick description" through pure persistence, finding the emancipatory act of writing where creative endeavour allowed for the demystification of abstract thought, in order to create a concrete synthesis of "what is in there". Like Woods (1996), I came to understand that knowing how to do it can only come from doing it.

## 9. Summary

The methodological approach guiding this research was ethnographic, which allows for investigatory strategies conducive to cultural construction (Goetz & LeCompte, 1984) consistent with my intent to capture and represent the world view of the participants being investigated. The research design, in keeping with the nature of ethnographic methodology, was emergent. The research is situated within a constructionist epistemology, where the intersubjectivity involved in making meaning within and informed by the historical and sociocultural setting is consistent with my attempts to reconstruct the culture of the classroom. Interpretations of students' lived experiences and their meanings required an interpretivist theoretical perspective. The significance of their language in constructing and interpreting meaning has been recognised.

A variety of ethnographic research methods were applied to build up my interpretation of the culture of this science classroom: *participant-observation*, *semi-structured interviews, informal interviews* and *informal discussions,* and *field observations*. Both the written transcripts and my intuitive feel for the data formed the basis of the analysis. The analysis was on-going, informed by various techniques and grounded in the empirical world of the classroom and student interpretations. Within this ongoing process, three stages of analysis were identified, differentiated by their purpose and procedure: a preliminary analysis early in the research; a generative macro analysis; and an intensive micro thematic analysis. It was during this intensive search and construction of meaning that the lines of inquiry presented in this thesis were isolated and structured. The final stage of analysis occurred during the act of writing this thesis.

Issues of trustworthiness and authenticity have been discussed, stating my preference for a judgement of understandability to represent my intent to capture the culture as I saw it and to present my interpretations in an understandable way. I was committed to understanding the perceptions of the students, so triangulation of research methods and measures to reduce the reactivity of the participants allowed me to attempt to access the behaviour, perceptions and meanings in a rigorous manner.

# Chapter 3. A CONSTRUCTED EXAMINATION OF "CLASSROOM CULTURE" AND THE "EXPERIENCE OF SCIENCE LEARNING" IN THE LITERATURE

## 1. Introduction

Many theoretical influences have been encountered at various stages along the research trajectory to construct and situate the conceptual framework and to provide a language for making sense of students' experience of learning in the culture of the science classroom. As stated in Chapter 2, various authors (some represented in this chapter) have influenced the direction of the study at various times throughout the research process, some directing the inquiry, others serving to clarify my ideas and assist in theory development. I chose no to begin a thorough review of the literature as presented here until the latter stages of data collection so that the "voices" of the students could be heard more clearly.

This chapter serves to explore the literature relating to and setting the parameters of the research, the parameters being:

- issues of transition as students move from primary to secondary school, the beginning of the journey for both the Year 7 students and this research;
- an appraisal of science education, and in particular the role of scientific literacy in current science education reform, thereby defining the educational context within which the participants of the research operate;
- culture as described in education research, presenting a framework for its use in this research; and
- the interplay between perception and experience as the vehicle of research.

## 2. The Transition from Primary to Secondary School – The Beginning of the Journey

As stated in Chapter 1, students entering Year 7 science for the first time enter the classroom with a myriad of previous experiences of science both in and out of school. As a result it would be quite reasonable to presume that students have expectations of what may happen, the knowledge they expect to learn, how it is to be learned, and the way it is to be taught. In examining issues associated with the transition from primary science to secondary science as represented in the literature, it is important to not make inappropriate claims of the influence this one subject is having on their perceptions of schooling (Ferguson & Fraser, 1998; Speering, 1995). Other mechanisms are pertinent, namely emotional, social, intellectual, and physical developmental changes and needs occurring at this time (Anderman & Maehr, 1994; Biggs & Moore, 1993; Wavering, 1985), and the change in learning environment (Biggs & Moore, 1993).

The change in attitude mentioned in Chapter 1 Goodrum et al., (2001) attribute in part to relevance of the curriculum and the way science is taught:

> [w]hen students get to high school many students experience disappointment, because the science they are taught is neither relevant nor engaging and does not connect with their interests and experiences. (p.vii)

Some research has been done on the change of student perceptions during this turbulent transitional stage (Ferguson & Fraser, 1998). Two Australian research projects (Ferguson & Fraser, 1998; Speering, 1995) focussed on the change in students' attitude towards school science during the transition from Year 6 to Year 7 by exploring some of the factors contributing towards the developing and changing perceptions of students. Ferguson and Fraser (1998) reported on a longitudinal study of how gender and school size influenced changes in student perceptions during this transition period using the Questionnaire on Teacher Interaction (QTI). They found evidence to show that secondary school was less favourable than primary school because there was decreased teacher helpfulness, leadership and understanding. Secondary school was more favourable in terms of decreased friction and competition. Ferguson and Fraser also concentrated on students' perceptions of teachers' interpersonal styles, emphasising the nature of relations between teacher and students as significant.

Speering (1995) explores the perceptions and expectations of Year 6 and 7 students. Through a longitudinal study using interviews, observation, and attitude surveys, she found that students enter high school with an expectation of a high degree of practical hands-on activities during science. Students maintained enthusiasm where this approach was seen to be adopted, but became negative in classrooms where lecturing and note-taking predominated. Speering suggests that in order to curb the waning interest in science careers, science curriculum should "consider increasing the amount of practical problem-solving activities" (p.103), emphasising that it is the teacher who has the potential to provide a stimulating and hands-on subject that is relevant for students (Speering, 1995). Common to the findings of Ferguson and Fraser and Speering is the role that the teacher plays in determining the classroom environment in building positive attitudes towards science.

Motivation is considered a concern in the middle years of school. In a review of the scholarly literature pertaining to motivation in the middle years of school, Anderman and Maehr (1994) reported the generalisation that there is an apparent down turn in motivation, expressed through "negative attitudes and behavioural patterns, which appear to negate the benefits of learning in school" (p. 287). Anderman and Maehr cite Haldyna and Thomas (1979) who state that, in general, as children get older, their attitudes towards academic domains, such as mathematics, science and art, decrease progressively. This shift in motivation is both a function of pubertal change, where students have a heightened awareness of emerging adulthood, and also a function of environmental and contextual factors, specifically, moving to a different learning environment at secondary school (Anderman & Maehr, 1994).

The concern about reduced motivation of Year 7 students is not only the potential for learning to be limited, but that this is a time when attitudes towards the pursuit of science and career choices are formed (Anderman & Maehr, 1994; Speering, 1995). If a science course offered to a student fails to meet their expectations, Anderman and Maehr (1994) state that their attitude towards science for the future is potentially negatively biased. The transition into secondary science becomes an important year for establishing positive attitudes towards both science at school and the potential for science as a career. Students' expectations of secondary science must, therefore, be acknowledged.

## 3. An Appraisal of Science Education – The Educational Context

In order to build the context within which this transition operates, the current state of science education is presented. In recent years, research has focused on and responded to the continuing decrease in young people choosing science as a vocation (for example, Goodrum et al., 2001; Harwell, 2000). This reduced interest in science beyond the formative years becomes indicative of the current science education program in secondary school. Responding to these claims, in 2001 DETYA (Department of Education, Training and Youth Affairs) published a report by Goodrum, Hackling and Rennie, *The status and quality of teaching and learning science in Australian schools*. This report assessed and made recommendations for the future direction of science education in Australia based on the finding that the ideal picture of science education is far removed from what is actually occurring in schools. Their report emphasises the importance of making science accessible to all, rather than those who are likely to continue with science as a career, and encompasses the twenty year old target of attaining "scientific literacy"[11] (or "science literacy") for all students. This DETYA study describes scientific literacy as

> the capacity for persons to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well being. (p.15)

In 1990, Lederman responded to a similar direction in American science education, by focusing on the intrinsic link between students forming an adequate appreciation for and understanding of the nature of science, and the attainment of scientific literacy. This view is supported in the literature (Abell & Smith, 1994; Duschl, 1988). Abell and Smith (1994) assert that if the ultimate goal of science education is scientific literacy, then teaching of science must encompass both scientific knowledge and the nature of science. The teacher's conception of the nature of science and the way that this is presented to the students are considered paramount to students' success in becoming scientifically literate (Abell & Smith, 1994; Cobern, Gibson, & Underwood, 1999; Lederman, 1992, 1999).

Scientific literacy as a goal of educational reform is not without criticism. Tippins, Nichols and Kemp (1999) highlight that it has been assumed that scientific literacy is essential for all, embodied by the "science for all" slogan of science education reform in America. Tippins et al. (1999) critique the intrinsic link between the goals of "science for all" and "scientific literacy." They highlight the disparity of these terms, arguing that scientific literacy is based on meeting benchmarks and standards that represent "a single

[11] "Scientific literacy" was promoted as part of the "Science For All" report produced in America by the AAAS (American Association for the Advancement of Science) in 1989 as mentioned in Goodrum et al. 2001.

(though dynamic) set of knowledge, understandings, skills, and dispositions that all students should possess" (p.3). In comparison, "science for all" implies the goal of science as being accessible, relevant and interesting to students, requiring different science experiences for different students, depending on backgrounds, beliefs, values and interests. Their conclusion is not that either of these goals is inappropriate or unachievable but that all students deserve quality science education experiences and that achieving this requires a re-examination of the goals and assumptions underlying teachers' courses to ensure that science is made relevant and purposeful.

Cobern et al. (1999) assert that for scientific literacy to be successful for students, the science presented to science learners must find a "niche in the cognitive and cultural milieu of students" (p.54). Scientific literacy is achieved when students are able to see the interplay between their daily experiences and the scientific concepts presented at school (Cobern et al., 1999). In order to see the relevance, students have to "view the world" in a different way. For this reason, Cobern (1996) equates scientific literacy with learning science as a second language, rather than merely involving the processes of "language literacy" where students already speak the language that they are learning to read and write. Cobern (1996) equated "scientific literacy" with "scientific worldview" and "scientifically compatible worldview." A person's worldview "provides a person with presuppositions about what the world is really like and what constitutes valid and important knowledge about the world" (Cobern, 1996, p.584). When a person possesses a "scientific worldview," it means they see the world scientifically, a notion Cobern preferably calls "scientifically compatible worldview." Cobern contends that for scientific literacy to be achievable, students must have a view of the world that is scientifically compatible.

> As one becomes scientifically literate, that is, as one comes both to understand and value the concepts and methods of science, one comes to see the world differently – although the degree of difference varies with a person's initial background. (Cobern, 1996, p.586)

The impact of worldview on conceptual change has been researched within another focus of science education reform, where conceptual change is the measure (see for example, Gunstone & Watts, 1985; Pintrich, Marx, & Boyle, 1993; Yager & Tamir, 1993). Other research is concerned with what students see as essential elements of the Discourses (Gee, 1990, 1996) occurring within the science classroom that provide an engaging learning environment. Such research prefers to consider how to construct learning environments that provide the best opportunity to attain scientific literacy. Hanrahan (1999) sees literacy as "being willing as well as able to participate authentically in the social practice of a particular community" (p.699) where, if viewed this way "what students believe and how they feel will be seen as significant factors in the process of learning science, since it then becomes a process of induction into the beliefs and values of the scientific community" (p.699). Her research into the use of affirmational dialogue journal writing argues that "science literacy has...more to do with teachers and students engaging each other in ways which are personally meaningful and which promote not only better communication in the short term, but also better personal understanding of the interaction between humans and their environment in the long term" (p. 714). The attainment of scientific literacy becomes relevant to this study as it recognises that the way a student sees the world, their worldview, including what they believe and how they feel about science, has a bearing on how students can learn and become interested in the scientific concepts.

## 4. The Cultural Phenomenon – The Framework of the Study

Central to the theoretical frame of this study is the supposition that the social context of the classroom as a learning environment operates within a culture, that is, the classroom culture. The concept of culture is very broad, and has origins in anthropology, sociology, and philosophy (Duschl, 1988). In some research the concept of culture appears to be a given, especially in ethnographic studies, where the concept of culture is applied but undefined (for example, Oldfather, 1994). A general definition of culture is provided by Geertz (1973):

> [I]t denotes an historically transmitted pattern of meanings embodied in symbolic forms by means of which men [*sic*] communicate, perpetuate, and develop their knowledge about and attitudes towards life. (p.89)

In closer reference to the classroom, Collins and Green (1992) define culture as being a social situation distinguished by norms and expectations, roles and relationships, and rights and obligations. The following section attempts to define culture as it can be found in the classroom, first bound only by the gathering of its members as a "classroom culture," then considering the influence of external cultures on student learning through research into "lifeworlds" and "cultural border crossings." Two theoretical orientations that embody a cultural perspective will be considered here as representing the classroom context: academic tribes (Becher, 1989) and Discourses (Gee, 1990, 1996).

## 4.1. CLASSROOM CULTURE AND LIFEWORLDS

Over the past ten years or so a growing number of researchers have attempted to interpret the teaching and learning of science from the cultural perspective (Gitomer & Duschl, 1995; Moje, Collazo, Rosario, & Marx, 2001; Oldfather, 1994; Shapiro & Kirby, 1998; Vellom & Anderson, 1999). In research, some of the terms that embrace the cultural perspective include "school culture" (Phelan, Davidson, & Cao, 1991), "classroom culture"(Collins & Green, 1992; Oldfather, 1994), "learning environment" (Ferguson & Fraser, 1998; Fraser & Tobin, 1990; Hanrahan, 1998; Henderson, Fisher, & Fraser, 2000; Taylor, Fraser, & Fisher, 1997), "community of learners" (Brown, 1997; Varelas, Luster, & Wenzel, 1999), as well as the various terms used by Shapiro and Kirby (1998), "subculture of school science," "science culture" and "school science learning culture." Two perspectives of culture are considered that impact on the classroom: first, the construction of classroom cultures by the gathering of students and teacher to learn about some knowledge and, second, the external cultures of a student impacting on the classroom environment that take into account the realities of students' lifeworlds. Through addressing both of these cultures, an operational framework of culture as applied to this study was constructed.

Classroom as a culture is presented by Shapiro and Kirby (1998) as being a sub-culture of the larger cultures of both the school (where each subject represents a different subculture), and of the wider science culture (which teachers are attempting to reflect in school science). The latter subculture of science as represented in schools is what they have termed "school science learning culture" (p.224) and acts as the context within which they contend students learn the "particular subset of cultural knowledge we call science" (p.224).

Collins and Green (1992) found that the culture of a primary style classroom had been implicitly and explicitly defined through interaction between the students and the teacher to establish norms, values and expectations for the students and teacher.

An alternative perspective of culture influencing science learning is the influence of external cultures on how students approach learning science within the culture of the classroom. The various "lifeworlds" of students are germane, a sphere of research associated with cultural border crossings, where the various lifeworlds of the students are seen to influence student engagement with science learning (Aikenhead, 1996, 2001; Costa, 1995; Phelan et al., 1991). This sphere of research was championed by Phelan et al. (1991) who moved beyond the focus of isolating and studying the various lifeworlds of students to consider how students manage negotiation between these lifeworlds. They illustrated that meanings and understandings derived from the various lifeworlds influenced engagement in schools and learning[12]. This approach was adopted and extended by Costa (1995) who considered cultural border crossings from a school science perspective, likening them to different categories of negotiations that students exhibited.

Aikenhead and Jegede (1999) explored the cross cultural boundaries that students face when crossing from their lifeworlds into the science world. They suggest that cultural border crossings also occur between "micro-cultures" such as students moving to another subject (Aikenhead, 1996)[13]. The way students negotiate the borders between their various lifeworlds affects the degree and nature of acquisition of the science culture (Aikenhead & Jegede, 1999). For students who find the negotiation into learning science difficult, Aikenhead and Jegede (1999) suggest a light-hearted, flexible, playful environment for learning.

By acknowledging the various lifeworlds of students in my research I move beyond the constraints of the classroom culture as described by Collins and Green (1992) where the members construct the culture. Reconstruction of the culture that is "within" can be informed by the culture that is "out there" that in covert and overt ways invariably ventures within.

## 4.2. ACADEMIC TRIBES AND DISCOURSES

Another dimension of the social grouping is the idea of academic tribes, where those who belong to particular tribes exhibit particular tribal characteristics. Becher's (1989) theory

[12] "World" was defined by Phelan et al. (1991, p.225) as "cultural knowledge and behaviour found within the boundaries of students' families, peer groups, and schools" where there is the presumption that "each world contains values and beliefs, expectations, actions and emotional responses familiar to outsiders." "Boundaries and borders" are termed as "real or perceived lines or barriers between worlds."

[13] More recently, a further category of students has been added by Aikenhead in 2001.

of academic tribes depicts the grouping of different sections of the tertiary community as being centred around their particular discipline, the tribalistic nature of these communities becoming manifested through idols, defining artefacts, and language. Becher suggests this last characteristic is the greatest distinction. Disciplinary discourse highlights the cultural features that are characteristic of a discipline and its various related knowledge domains and is crucial to establishing cultural identity. But it also makes the discipline inaccessible to those who are unfamiliar with the discourse, symbols and specialised terms, as they are not easy for an outsider to imitate.

This idea of academic tribes pertains to groupings that are associated with an epistemology and the appropriate systems, behaviours and practices that accompany that epistemology, for example, school of science versus the school of arts. Although no research could be located that applied Becher's notion of academic tribes to the classroom, I contend that such tribal characteristics can be reflected in classroom situations, where students are directed by a teacher who has been taught according to a particular epistemology. Teachers have a body of knowledge that they wish to teach and adopt particular ways of unravelling this to the students. Having access to the school science tribe depends upon students being able to "speak the language," act as is required according to the norms set by the tribe, and to think in a particular way in order to prove their cultural identity.

Gee's (1990, 1996) notion of Discourse[14] represents a way of being in the world. In this respect Discourses

> integrate words, acts, values, beliefs, attitudes, and social identities, as well as gestures, glances, body positions, and clothes. A Discourse is a sort of identity kit which comes complete with the appropriate costume and instructions on how to act, talk and often write, so as to take on a particular social role that others will recognise. (Gee, 1996, p.127)

Such an "identity kit" is identifiable to those within and outside the Discourse, but those that have assumed the Discourse may not necessarily be able to say exactly why they are different. In order to become an insider one has to assume the identity kit of the Discourse, which requires taking on the role of the members of the group. "You learn the

[14] Discourse with a capital "D" refers to the way one becomes fully immersed into the cultural dimension of becoming literate, and is distinguishable from discourse, which refers to the way people communicate.

Discourse by becoming a member of the group: you start as a "beginner," watch what's done, go along with the group as if you know what you're doing when you don't, and eventually you can do it on your own, even with something of your own style" (Gee, 1990, p.xv). Gee's concept of Discourse pertains to social linguistics and literacy, and since Discourse is constituted by social practices, it is relevant to any social grouping where there is interaction between people. "All school activities...are bound to particular Discourses" (Gee, 1990, p.xvii) such that an individual can have a variety of Discourses. A person's Discourse can clash with the expected Discourse of specific situations (Gee, 1996). For example, the students in the science class operate within the Discourse of school science, as set by the school, the teacher, and the curriculum. The students are likely to also have their own Discourse of science, which is personal and probably strongly influenced by the home-based Discourse that entails the values and beliefs relating to science that are learned at home (Gee, 1996).

In the science classroom, students can operate according to particular Discourses, some of which may clash (such as that of home science and school science). Others are constructed within the classroom, such as the Discourse of learning science in a particular classroom, with a particular teacher, and with a particular group of peers. This Discourse is likely to have been influenced or monitored by the teacher, and negotiated between teacher and students. The students then operate within this Discourse.

## 5. Learning within the classroom culture – The Focus of the Study

Of particular interest to this study is how the learning environment in the classroom culture contributes to students' *engagement* with science learning, and how such engagement can be maintained. A number of studies have focused on maintaining students' interest and engagement with learning science (Campbell, Smith, Boulton-Lewis, Brownlee, Burnett, Carrington & Purdie, 2001; Hidi, 1990; Hidi, Renninger & Krapp, 1992; Krapp, Hidi & Renninger 1992; Prenzel, 1992; Renninger, 1992; Schick & Schwedes, 1999; Voss & Schauble, 1992). Pertinent are issues of motivation (Anderman & Maehr, 1994; Biggs & Moore, 1993; Eccles, 1983; Oldfather, 1994), attitudinal and cognitive responses to science (Baird, Gunstone, Penna, Fensham & White, 1990), and the way children learn (Wadsworth, 1984, on Piaget). Considered central to science learning throughout the years is the constructivist theory of Piaget, and the more recent shift towards social constructivism. Piagetian constructivism, the focus of instruction in the late eighties to early nineties, has progressively moved towards social constructivism (Bowers, 1995). An awareness of the social influence on learners constructing meaning in science becomes relevant for my study. Consequently, also considered central to the theoretical framework are Vygotsky's views that emphasise the interactive processes among learners within the social context of learning (Oldfather, 1994; Vygotsky, 1978).

### 5.1. LEARNING SCIENCE CONSTRUCTIVELY

This section first describes Piagetian constructivism then draws in the social constructivist perspective that acknowledges the social influence on learning. Piaget's theory of construction of knowledge (Wadsworth, 1984) is based on the supposition that learners actively construct their own interpretation of events given their prior experiences. This construction occurs in the "schemata," cognitive or mental structures that individuals adapt to organise their environment. Their nature is dynamic, getting more generalised and differentiated as the person ages, with new experiences being organised into existing schemata according to common characteristics. Schemata are "constructed" through the interpretation of events resulting in representations rather than exact copies of reality. With time, the schemata reflect reality more closely. The emphasis of Piaget's developmental theory is that "it is an active construction process, in which children, through their own activities, build increasingly differentiated and comprehensive cognitive structures" (Crain, 1980, quoted in Bowers, 1995, p.80). The process is not automatic but has the child acting on the stimuli in the surrounding environment to construct the world (Bowers, 1995).

Based on Piaget's theory, constructivists have the belief that students create their own reality, knowledge, beliefs, attitudes and meaning, thereby rejecting the idea that students enter the classroom as "empty vessels" devoid of prior experiences and knowledge. Learning is considered an "active process occurring within and influenced by the learner as much as by the instructor and the school" (Yager, 1995, p.37).

Learning science is especially reliant on the constructivist paradigm to draw on what students already know and to deal with the hurdle of "misconceptions" of scientific concepts (Fleer & Hardy, 1996). Constructivism is commonly associated with conceptual change and learning approach research (Aikenhead, 1996; Kelly, Chen, & Crawford, 1998; Yager & Tamir, 1993). For example, Yager (1995) presents the case of constructivism in terms of applicability to classroom situations, presenting a number of descriptions of teaching strategies from classroom research to illustrate constructivist practices.

O'Loughlin (1992) describes Piagetian construction of knowledge as "the process of constructing abstract, decentred representations within the mind" (p.799). O'Loughlin is of the opinion that learning constructively is not simply a mechanistic, individualistic process, occurring within the individual's interaction with stimuli in a decontextualised fashion, but asks the question "Is there room within constructivism for the kind of social communication and interaction that leads to collaborative meaning making?" (p.792). Central to O'Loughlin's critique of constructivism is the argument that coming to know requires consideration of the "historically and socially constituted self that engages in the process of knowing" (p.799), as construction of meaning is a "dialectical process that takes place in specific economic, social, cultural, and historical contexts" (p.799). In this dialectical interaction a person constructs critical representations of reality "so that one may become empowered to envisage and enact social transformation" (p.799). Weinstein (1983) extends Piaget's theory of cognitive development to encompass the construction of social as well as physical reality.

A number of studies adopt the sociocultural dimension of learning constructively, thereby not abandoning Piagetian constructivism but expanding its application to encompass the social complexities of the classroom. For example, Watts and Bentley (1987) and Noddings (1993) stress the importance of developing a caring supportive environment if students are going to engage in active, constructivist learning practices.

## 5.2. Interactive Processes Among Learners Within the Social Context of Learning

Relevant to this study is Vygotsky's theory of the process of internalisation, where an individual develops an internal reconstruction of an external operation (Vygotsky, 1978). This internalisation of the cultural forms of behaviour "involves the reconstruction of psychological activity on the basis of sign operations" (Vygotsky, 1978, p.56-57) where an interpersonal process is transformed into an intrapersonal one. This is a socially influenced process where an action, behaviour or sign is given meaning through interaction with the people around them. The development of speech is an example of a social form of behaviour, where a person realises and changes themselves in the varied contexts of culture and history. John-Steiner and Souberman in the Afterword (from Vygotsky, 1978) conclude that

> In the development of higher functions – that is, in the internalisation of the processes of knowing – the particulars of human social existence are reflected in human cognition: an individual has the capacity to externalise and share with other members of her social group her understanding of their shared experience (p.132).

In the classroom context, students are able to converge historically created and culturally elaborated dimensions of human life through social interaction, situating language and thought in a social setting. Reminiscent here is O'Loughlin's perspective of knowing being a sociocultural process that does not occur apart from the social context.

### *5.3. INTEREST AND MOTIVATION IN THE CLASSROOM CULTURE*

The processes of interest and motivation in learning provide insight into what is involved for students to be engaged. Research into student motivation and interest is prolific and is addressed in both psychological and educational circles (see for example Anderman & Maehr, 1994; Biggs & Moore, 1993; Campbell et al., 2001; Eccles, 1983; Hanrahan, 1998; Hidi, 1990; Oldfather, 1994; Pintrich et al., 1993; Pressick-Kilborn, in press; Renninger, Hidi & Krapp, 1992; Schick & Schwedes, 1999). Piaget's process of "equilibration" provides an explanation for understanding how engagement can be maintained. This process results in motivation to restructure knowledge in the cognitive structure when experiences are encountered that conflict with a person's prediction of events. This results in what Piaget called "cognitive conflict," considered to be the "major source of motivation with respect to intellectual development" (Wadsworth, 1984, p.19), and may be central to maintaining student engagement in science. Wadsworth proposes that Piaget's method of "critical exploration" is appropriate for ascertaining how students approach a problem and how they arrive at the answer, that is, the constructions (rules and generalisation) that students have regarding the content being taught[15]. Wadsworth suggests the use of questions designed to conflict with the reasoning underlying the constructions. Where the prediction proves false, there results "cognitive conflict."

[15] Here Wadsworth is putting Piaget's developmental theory into an educational perspective, although he acknowledges that Piaget's research was not necessarily intended for an educational setting.

Cognitive conflict can be induced by using children's "spontaneous interests" and elements of surprise where the outcomes are not expected: "The unknown and the unpredictable can generate both interest and cognitive conflict" (p. 192).

The first step in motivating students is to grab their *attention*. Voss and Schauble (1992) state that attention occurs when a person attends to a small portion of the stimuli around them. This is a selective process and is controlled by that which is salient to the person, specifically goals and interests. More intense attention is referred to by Voss and Schauble as "concentration," and "involves mental effort upon something relatively specific. Concentration is thus regarded as a facilitating factor in learning and performance" (Voss & Schauble, 1992, p.8). Echoed in Voss and Schauble's analysis of attention is Vygotsky's (1978) reference to Koffka's identification of "centre of gravity" (p.35). Mastery of attention involves creating structural centres in the perceived situation, as with children who create new structural centres with the "indicative function of words" (p.35). Piaget suggests that grabbing attention of an individual can be achieved by creating cognitive conflict that can result in interest and motivation (Wadsworth, 1984).

Such a conflict does not automatically result in an altered cognitive structure (Wadsworth, 1984). When faced with an experience that is counter to current understanding, sometimes the evidence presented is disregarded and the current beliefs are maintained. A classic example of this occurring in the science classroom was captured by Allan Marshall's experience of learning about the weight of air (Marshall, 1955). In his description, the teacher introduced the idea that air has weight, which to Marshall seemed incomprehensible. Marshall shared with the teacher that his father had told him that "the fuller you are with air the lighter you are and you couldn't sink in the river," which the teacher disregarded as foolish. With the use of a leather disk, the teacher attempted to demonstrated that air has some weight:

> He then wet the leather disc and pressed it on the desk and none of us could pull it off except Maggie Mulligan who ripped the guts out of it with one yank and proved air didn't weigh anything. (p.98)

Faced with an idea that conflicted with current understanding shaped by his father, the evidence before him, though seemingly conclusive to the teacher, was disregarded and the preconceptions were actually reinforced. This draws on Phelan et al.'s (1991) notion of crossing cultural boundaries between a student's lifeworld of home science into the lifeworld of school science. For Marshall the border was impassable. Instead of approaching the gap between current understanding and the new evidence as a problem to be solved (where cognitive conflict would be the result), the conflicting evidence was disregarded and there was no motivation to account for the difference.

# 6. The Interplay Between Experience and Perception – The Vehicle of Research

The vehicle of research is termed here as the interplay between experience and perception. Piaget, Vygotsky and Kolb are considered significant.

## *6.1. Perception*

Perception is not a passive process of recording of what is sensed, but a logical organisation of what is sensed that is already on its way to building the concept (Piaget, 1972). Piaget (1972) wrote that "it is no longer a case of showing that the concept does not derive simply from the corresponding perception, but making it apparent that perception itself is already organising itself in a way which provides the rough outline of the concept" (pp.57-58).

Similarly, Vygotsky's (1978) view of perception supports Piaget's claim of non-passivity. The world is not seen simply as a series of colours and shapes but as a world with sense and meaning. Vygotsky suggests that human perception consists of categorised rather than isolated perceptions. (For example, a clock hanging on the wall consists of numbers and black sticks, but once we learn that the parts form a clock, then in the future it is immediately perceived as such.)

One's perceptions of one's experiences are not exact copies of reality. In O'Loughlin's (1992) sociocultural model of meaning making, our perceptions are deemed to be constructs shaped by the historical and social context. New experiences are shaped and moulded, or even disregarded, by the existing constructs.

The perceptions of students' experiences are personal, depending on the holistic (O'Loughlin, 1992) nature of a person's way of knowing. Although each student operates within a bounded classroom culture, with the stimuli from the environment being somewhat similar, how each student perceives these experiences is of value. Eccles's

(1983) study into determinants of achievement-related behaviours in students learning maths found that

> students' interpretations of reality (i.e., attributions, self-concepts of abilities, and perceptions of the beliefs of parents and teachers) were more influential determinants of expectations, values, and course plans than were objective indicators of past reality (i.e., previous grades and actual teachers' behaviour). (p.137)

This suggests that a person's interpretation of events shapes their actions more powerfully than the events themselves. Communication or interaction between the teacher and students becomes necessary to inform the teacher about how learning in the classroom is being experienced and perceived by the students.

The value of ascertaining student perceptions to inform teaching practice is not new. Research into student perceptions became prominent in late 1970s and early 1980s focusing predominantly on students' perceptions of classroom phenomena, student success and failure, and classroom learning environments (as reviewed in Weinstein, 1983). Weinstein asserts that "investigations of children's understanding of classroom phenomena can be informative about the role of classroom context in influencing children's thinking about school" (p.288). Perceptions of classroom phenomena from researcher and teacher perspectives are expected to be unrepresentative of the way in which *students* see their classroom environment (Oldfather, 1994; Weinstein, 1983). Research comparing student, teacher and researcher perceptions of the same classroom environment has found that teachers consistently view the classroom climate more favourably than do students, whereas researchers perceived the classroom environment much less favourably than either teachers or students (Fraser, 1990). Using students' perspectives of their experiences is considered to be more effective in understanding students' motivation and achievement in learning (Oldfather, 1994; Weinstein, 1983). In addition, approaching the classroom or school environment in terms of shared perceptions of the students and teachers in that environment "has the dual advantage of characterising the setting through the eyes of the actual participants and capturing data that the observer could miss or consider unimportant" (Fraser, 1994, p.494).

Both qualitative and quantitative research into perception continues to be strongly represented in the literature with research focusing on, for example, student perceptions of science teaching (Palmer, 1999) and learning experiences (Prain & Hand, 1999), comparisons between preferred and actual learning and teaching environments as perceived by students and teachers (Harwell, 2000; Henderson et al., 2000; Rickards, Fisher, & Fraser, 1997), students' affective response to learning science (Kobala, 1995), associations between student attitude and elements of the classroom environment (Harwell, 2000; Lederman, 1999), and motivation (Oldfather, 1994; Slavin, 1983), as well as a growing body focusing on students' perceptions of the nature of science which is beyond the scope of this literature review, but includes authors such as Harwell (2000), Hogan (2000), Cobern (for example, Cobern and Loving, 2001) and Nass (1999). In Fraser's (1994) review of the use of student perceptions to research classroom environments, he has uncovered associations between student outcomes and student perceptions. Investigation of students' perceptions cannot only be informative of how students experience the classroom environment, but can also inform the teacher of how best to provide in the learning environment experiences that meet the students' needs for learning. Here the connection between perception and experience is implied.

## 6.2. EXPERIENCE

In the previous section the idea of finding out students' perceptions of their experiences was explored and found to be important for gaining the view of experiences that were not necessarily images of reality but subjective and constructed representations influenced by past experiences. Associated with the study of perceptions are the experiences that are being perceived. This section describes how the notion of "experience" is applied to this research. Van Manen's phenomenological stance provides a working definition of experience, while Kolb's experiential model of learning provides the central theoretical frame for how students learn by experience.

Van Manen (1990) refers to "lived experience" as it is investigated by phenomenologists. He borrows from Dilthey (1985) the definition of lived experience as being the immediate, pre-reflective consciousness of life. It is "a reflexive or self-given awareness which is, as awareness, unaware of itself" (van Manen, 1990, p.35). A lived experience can only be grasped on reflection, not in its immediate manifestation (van Manen, 1990). At the point at which an experience is experienced, it is non-thematic, that is, a mere consciousness that has no meanings attached. Through reflection the meanings are attached and the experience is thematised. Ascertaining lived experience is always going to be at the thematised level because the notion of lived experience is embedded in language (van Manen, 1990). A lived experience, therefore, does not necessarily reflect reality but is an adjusted reality that has been shaped by our reflecting on it (van Manen, 1990). This research recognises that accounts of students' experiences in science are transformations of those experiences and not "true" images of reality as the experience of the person is bounded and constrained by their language.

Kolb's (1984) model of experiential learning has its foundations in Piaget's cognitive development theory. Experiential learning is an holistic approach to learning that combines experience, perception, cognition and behaviour, and is based on the supposition that the learning students experience in the classroom is a result of the concrete experiences occurring around them, to them and enacted by them. Learning is considered to be a "process whereby knowledge is created through transformation of experience" (Kolb, 1993, p.155). The model of experiential learning is a recurring cycle that begins with a "concrete experience," followed by active reflection called "reflective observation," then "abstract conceptualisation" where the reflection is assimilated into a theory, followed by "active experimentation" where the hypotheses are tested in new situations (Kolb, 1993). Wight (1970) expresses the vitality of learning by experience:

> The assumption is that we seldom learn from experience unless we assess the experience, assigning our own meaning in terms of our own goals, aims, ambitions and expectations. From these processes come the insights, the discoveries, and understanding. The pieces fall into place, and the experience takes on added meaning in relation to other experiences. All this is then conceptualised, synthesised and integrated into the individual's system of constructs which he imposes on the world, through which he views, perceives, categorises, evaluates and seeks experience. (p.255)

Experiential learning invites learners to reflect on their experience and appropriate significance through such reflection.

Drawing together these theories pertaining to perception, experience and learning, experience is considered to form the basis of human learning, where the removed experience becomes internalised by intersecting with the existing cognitive structure from which the experience becomes personally meaningful. Of particular interest from the experiential learning model (Kolb & Fry, 1975) is the link between perception and experience. The experiential model considers perception as the result of organised and value added experience, where the experience has been shaped by the existing cognitive structure built from prior experiences, and is constructed through interaction with both the environment and society. This gives support to the claim that learning is a social accomplishment for each individual learner.

## 6.3. Research into the Experience of Classroom Culture Using Student Perceptions

Research grounded in both the students' experience and perception of the classroom culture is necessary to access this personally constructed perspective of how learning occurs, and what is most conducive to learning. This requires being immersed in the culture of the classroom, so that students' perceptions can be contextualised by the experiences of the science classroom. There has been a wide range of techniques and tools used in researching student perceptions, not all of them informed by the context of what is actually occurring in the classroom. For example, some research uses only quantitative tools without firsthand observation of the experiences from which the students draw, so the perceptions are not contextualised, or given meaning by the myriad of subjective experiences that occur in the classroom. Such tools include, for example, the Questionnaire on Teacher Interaction (QTI) (such as Fraser, 1994; Henderson et al., 2000; Rickards et al., 1997), the Constructivist Learning Environment Survey (CLES) (Taylor et al., 1997) and the Classroom Environment Scale (CES) developed in the early 1970s by Moos (Fraser, 1994).

Other studies access student perceptions by a combination of qualitative and quantitative methods, such as questionnaires constructed from either the teacher or researcher perspective followed by interviews (see for example, the investigation into students' perceptions of their experience of the social constructivist classroom conducted by Hand, Treagust, & Vance, 1997). Another approach to understanding students' perceptions was from Harwell's (2000) study of girls' perceptions of science learning, teaching, and the nature of science through the use of "creative interviewing," where a student/peer interview protocol was followed. In both of these studies, there was no contextualisation of the experiences being reported by the students through direct observation of the classroom.

There is a limited body of research focusing on student perceptions where the researcher has spent prolonged time in the classroom so that the perceptions provided by students can be contextualised. A study by Oldfather (1994) is one example where prolonged engagement in the classroom allowed the researcher to focus on "students' subjective experiences or their emic or 'insider' views of the classroom culture" (p.2), specifically perceptions that reveal their motivation for learning literacy. Other examples of such research include Pressick-Kilborn and Walker's (in press) use of a sociocultural approach through ethnography to conceptualise interest development; collaborative action research, such as a study of communities of learners by Varelas et al. (1999); and critical ethnographies with the purpose of understanding and transforming cultural practices, such as Barton (2001).

## 7. Summary

A perusal of the literature has shown that, during the time of transition into the secondary science setting, students are being pressured on many fronts, such as hormonal, physiological and environmental that can account for behavioural and attitudinal changes during this time. The environmental pressures are central to this study. Studies indicate that part of the problem relates to students' expectations of secondary science not being met, resulting in reduced motivation to be engaged in learning. The current move towards scientific literacy in science education reform responds to this apparent disparity between students' interests and what schools are offering. An exploration of what "scientific literacy" entails has uncovered both support and criticism of the move. The cultural dimension of the classroom becomes relevant when the research foci turn to the classroom as a learning environment. A review of selected research and cultural theory was considered in terms of how the notion of culture could be applied to the classroom. Two notions of classroom culture were uncovered, one that identifies the classroom and its members as an enclosed system that is constructed by its members, another that acknowledges students in a more holistic way by recognising the various cultures, or lifeworlds, that influences how students exist culturally in science. The notions of academic tribes and Discourses were defined for this research.

Learning within the classroom has been considered as a constructive process. Piaget's developmental theory of learning, constructivism, is seen particularly relevant for learning science, given the scope for misconceptions. The shift towards the socio-cultural dimension of learning constructively led into Vygotsky's theory of the process of internalisation, which sees learning in the classroom as occuring within a social setting. Construction of knowledge is seen to be a social accomplishment, deeply entrenched in the historical and cultural context. Considered fundamental to this process is the interaction between the environment and the learner, such as is achieved through experimental and hands-on manipulation (experiential learning). The classroom culture is seen to be socially constructed by interaction among teacher and students to explicitly and implicitly negotiate the cultural norms, resulting in an identifiable culture within which students operate.

A perusal of the literature has provided evidence and justification for using students' perceptions of their experiences of learning science as a vehicle for accessing the meanings of such experiences. Research into students' experience of science learning is wide and varied. Capturing the personal meaning of such experience is best achieved by approaching experience through the perspective of the students. Students' subjective experiences and perceptions take on new meaning when a researcher becomes immersed in the culture of the classroom. This sociocultural approach to understanding the meanings of students' experiences is not greatly represented in research, especially in science education. I contend that a grounded approach is suitable and effective for informing teaching practice of how the experience of the classroom and how the classroom environment in science influences students' engagement with learning. Little research appears to have been done on the changing perceptions of students during the transitional stage into secondary school (Fraser & Ferguson, 1998).

The following two chapters present my interpretations of how students from this class perceived their experience of learning (chapter 4) and the role the teacher played in this learning experience (chapter 5). As a prelude to these chapters I offer a "confessional tale" of the decisions I made in shaping and representing the interpretations in Appendix 16.

# Chapter 4. THE LIGHT OF SCIENCE

## 1. Introduction

The transition to secondary school brings with it new teachers, new requirements and responsibilities, and new experiences. The science subject adds its own newness – the science laboratory, new scientific knowledge, a new perspective on science, and a new culture of learning, where students encounter learning experiences that are likely to be distinct from any experienced so far. These characteristics also make secondary science distinct from other subjects in secondary school.

How do the things that are taught as science in secondary schools become learned by students? One of the aims of science education is to make known to the students the concepts and processes that define science and which science has discovered in order to explain the natural world. But learning science in schools should not be restricted to the content. The current science education reform emphasises "scientific literacy" for making science relevant to all, not just the few who intend to embark on a career in science (Goodrum et al., 2001). For learning to be achieved, recognition of first *how* learning occurs and is best achieved is required in order to provide meaningful and effective learning experiences. Even more effective for informing teaching practice of what is paramount for optimising student learning is when the evaluation of learning is achieved through the eyes of the students (Eccles, 1983; Fraser, 1990, 1994). For the students, science becomes *illuminated* through the learning of it, therefore, this chapter serves to describe the *light* of science, beginning with the journey towards the light where students identify the nature of the path which they are traversing.

In addressing the research questions, this chapter focuses on the students' lived experiences of learning (van Manen, 1990). Two focus questions have guided the analysis of student learning, within the framework of the first emergent research question:

*What is it about the experience of learning that keeps students engaged with learning science?*

1. *What do the students say about how learning is best achieved in science?*

*2. Since students have used the words interesting and fun in response to their learning experiences in science, what do the students mean by these terms and how does the use of these terms indicate opportunities for learning?*

These two questions are considered in two corresponding sections. The first section deals with what students see as being important for them to be able to learn in science and is entitled "The journey towards the light," signifying their walk in schools, having experienced six years of learning within schools. During this section it becomes clear that students often refer to "science as fun" and "science as interesting," so the following section attempts to uncover what these terms mean for the students and how they reflect the light of learning in science.

## 2. The Journey Towards the Light: Construction Through Interaction

There were three major themes that emerged from the interview and observation transcripts associated with how students perceived learning could be optimised:

- Interaction with the science
- Interaction with peers
- Interaction of the familiar with the unfamiliar

Each of the themes illuminates how students want to be able to *interact* with various facets of the school science culture to help them learn.

The framework of this section draws heavily on constructivist approaches to learning, where the students construct their interpretation of events using prior experiences (Wadsworth, 1984). Acknowledged is the process of lived experience (van Manen, 1990) of both the *physical* and *social environment* (O'Loughlin, 1992). This process is active, determined by the actions of the learner (Yager, 1995). The sociocultural emphasis is considered pertinent, based on Vygotskian (1978) approaches to learning and development where students interact with the physical and social environments.

The following exploration of each of these themes revolves around a "compilation of students' reflective responses" related to the theme and "reconstructions" of experiences from class observation transcripts that illustrate the elements of the theme. Other supportive comments from the interviews are interspersed within the explorations to give added meaning and extension to the ideas presented in the reflections and reconstructions. An audit trail for each compilation of student responses (Figures 2, 3; and Figure 7 in Chapter 5) is found as an appendix showing the student's name, the interview that each response was recorded, and contextualising comments where appropriate. Some phrases have been added or paraphrased from student's words to allow the reflections to flow and make sense. Be reminded that I have attempted to capture the variety of student perceptions relating to the theme rather than represent the "dominant" ones.

### 2.1. THEME ONE: INTERACTION WITH THE SCIENCE

REFLECTION: "BEING INVOLVED HELPS ME LEARN"

I like interesting things. I like to learn about it and yeah, I like doing things. I don't like watching and just taking things in, I like doing things cos, when we're just hearing about stuff, it doesn't appeal to me. I really like seeing what happens, things when they get mixed. It's a lot funner and more interesting actually doing it, cos like you can go up there and do something, and you can have a laugh.

It really helps me if I can experience it for myself, like doing the experiments, and Miss Baker would say "This is a tripod" and we'd say "Oh, OK." So she would help you, but you would still be interacting with the stuff, with the materials. But what I find boring in class is just doing pracs where half the time I don't learn anything. I learn more things from experiments cos I'm actually doing what they're trying to teach us. Maybe we learn better because we like, we do it ourselves, instead of like reading it and we have fun with it, and that makes us remember it more.

So, I like science because it's a bit more interactive, a bit more hands on. Like, in maths, you've got to be thinking all of the time. And with this you've got to be thinking most of the time, but it's not as hard and each step you can work it out for yourself. And they don't have to be a particular thing, just whatever you want it to be.

FIGURE 2: Reflection: "Being involved helps me learn." A compilation of some Year 7 student responses given during focus-group interviews relating to the hands-on, interactive elements of school science and their influence on learning. See Appendix 17 for audit trail.

The above compilation of reflections (Fig. 2) by students presents the perception that having the opportunity to interact with the experimental part of science helps them to learn.

The first paragraph draws out the idea that these students like to be able to interact with the components of the laboratory, and be actively involved rather than just watching a demonstration or hearing about the concepts when the teacher is talking. During the process of interacting there is the opportunity to make direct observations for themselves. Such interaction is seen to be fun ("funner") and interesting because there is freedom to move.

The second paragraph draws on a student's experience of being introduced to the components of the laboratory in first term. This student acknowledges the benefit of combining both the guidance and expertise of the teacher with interaction with the materials of the laboratory in order to enhance the learning experience. Counter to this involvement is the experience of the practical reports, "pracs," which were considered to be boring. Nancy, in particular, felt that at times the "pracs" did not help her learn anything, and that the experiments were where the learning occurred since "I'm actually doing what they're trying to teach us." This was especially the case when the "prac" required simply copying from the textbook. The last sentence of this paragraph gives one student's idea of how interacting with the science aids learning. Here the "fun" element emerges again, along with being able to "do it ourselves" where learning is not second hand from the textbook. These two combined factors, he feels "make us remember it more." Referring back to the first two sentences of the first paragraph in the reflection, the notion of interesting experiences being perceived as opportunities to learn is inferred. This suggests that being involved with the experimental dimension of science may increase interest and appears to be perceived by some students as having a positive impact on their learning.

Some students seem to like the interactive nature of school science and it makes them more positive towards learning science. The third paragraph draws a comparison between the interactive nature of science lessons, where there appears to be a more free and relaxed environment, and maths where there is the pressure of "thinking all of the time." The student also identifies the things she does in science as being more achievable for her, as it is "not as hard and each step you can work it out for yourself." In order to illustrate why the students are able to be more independent in what they do, the student draws on a characteristic of the pedagogy of the classroom that appeared to be very significant in creating this relaxed, low pressure environment. During lessons Miss Baker often stated to the students, "It doesn't matter whether you get the right answer, as long as you have a go" [OBS07]. This type of statement was often stated in relation to homework, where Miss Baker's emphasis, as explicated to the students in class, was be get the students into the routine of doing homework and working independently in order to attempt the work, not necessarily to always have the right answer. I found it quite amusing one time during an observation where a substitute teacher was brought in due to Miss Baker's absence. My additional observer, Sally, and I assisted the students with the questions that had been assigned from the textbook. Three boys up the back were being quite demanding, as they were having trouble with the questions and playing around. Following is an extract from the observation field-notes describing this interaction between these students and myself:

> When I tried to explain where to find the answer they asked me to tell them the answer. In the end I found it important that I just tell them to have a go and write what they think. They responded, mimicking Miss Baker, "Just have a go, it doesn't matter if you get the wrong answer!" [OBS22]

I found it interesting that they should respond in this way. It appeared that they were not really content with simply "having a go," but wanted the correct answer and wanted it pointed out. It would appear that, although there exists this relaxed environment where the pressure to get the right answer all of the time is not pronounced, the result, and sometimes to the exasperation of the students, is that students are forced to think for themselves and will not always be guided to the answer!

### 2.1.1. Discussion of Interacting with Science

Some students responded positively to the interactive nature of school science because "doing" something increases interest, and therefore maintains engagement. Further, some students were positive towards learning science because they considered the atmosphere associated with the interactive nature of the classroom culture to be less pressured and could be more achievable when compared to maths. Through interaction with the hands-on components of science, such as experiments and activities, some students were provided engaging opportunities to experience for themselves and personalise the concepts through tactile means of discovery.

These attractive interactive elements can dominate the students' experience of the classroom so that learning the principle can be side-lined, as was found by teachers after the introduction of the experimental model[16]. Because this study is not focusing on

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[16] This type of approach to learning was influenced by Bruner's experimental model of teaching science and maths that allows learners to discover scientific principles by manipulating and experimenting with concrete objects. Intrinsic motivation for learning does not always result as some students become more focused on the act of experimenting rather than on discovering the principle behind the experiment (Kolb & Fry, 1975; Wadsworth, 1984).

whether conceptual learning has occurred, it is difficult to determine whether these positive responses to science influenced student learning. Some literature suggests that little learning is actually gained through doing practical work. Gunstone and Champagne (1990) found that students' focus during laboratory work can be on completion of the task such that the learning became negated. Other researchers suggest spending less time following recipe style experiments and more time on discussion and reflection in order to promote conceptual change (Gunstone & Champagne, 1990). Kolb (1984) suggests that emphasizing for the students what the teacher's purpose of an experimental activity has both cognitive and affective benefits for students. The theory of experiential learning provides justification for including practical work in science, where students learn by experiencing the principles (Kolb, 1984), but the students must also know the purposes of the experiment so they are aware of where to place that attention. The interpretations of the findings presented here suggest that some students acknowledge interacting with the materials and equipment in experiments as being valuable for their learning. These findings are supported in other research, such as Ferguson and Fraser (1998), where students were found to be more positive about science when their Year 7 experience of science maintained a strong hands-on component. Some questions, however, remain relating to the origin of these positive perceptions of the hands-on element of science. How much of this positive outlook of science is related to expectations being met, where students expected high amounts of practical work, or to expectations not being met, where students did not expect many experiments since their primary school experience of science limited "real" experiments? Further, is this interaction simply an opportunity for students to have fun together and how does creating a fun learning environment make for optimised learning? What is clear from some student responses is that they "like" the interactive side of science. The relaxed work environment and reduced pressure to be "right" that seemed to typify the interactive side appeared to be effective for some but exasperated others. The act of experimenting was *perceived* by certain students as being where the learning occurred because they were working with the materials and seeing for themselves how things worked and how it was done. My discussions with students in the interviews gave them the opportunity to reflect on the value of these experimental components of the science curriculum. As a consequence of this reflective act I have come to realize through my own reflection on student perception and relevant literature that when experiments are carried out purposefully (where the teacher's purpose is made clear) and students are given time to discuss and reflect in light of what occurred, the experiments can be more meaningful and enjoyable for them.

## 2.2. *THEME TWO: INTERACTION WITH PEERS*

Unlike interaction with the science (the content and hands-on components) being unique to the science subject, the interaction among peers is perhaps common to the school experience. What is unique about this interaction is that in science there are greater and different opportunities for the students to group together as a result of the types of activities occurring in school science. Betty acknowledges this, saying:

> It's just different, science class is different in a way because we are doing different things than other subjects, but sitting with friends and things like that, and having a quiet chat while you're working. [INT1A]

There appears to be a different expectation in science to be able to interact more freely with those around them while working. Betty encapsulates the social nature of the classroom – "sitting with friends," and "having a chat." The following compilation of student reflections (Fig. 3) captures three aspects (one per paragraph) of how interaction with peers can influence student learning.

The first paragraph identifies the *solidarity* of the student tribe and how this influences student learning. Initially the student uses the question activity for the rocks unit as the vehicle to examine how there is a sense of empowerment when the class works together. There appears to be a oneness about the class, a tribal feeling where the similar levels of knowledge provide a common bond.

Other responses not represented in the reflection suggest that some students are aware of the different levels of knowledge among students. For example, Lorraine is fully aware that other people in the class are "smarter" and it is this possession of more knowledge that makes those students "good at science": "Some people are just naturally very smart. And so they know stuff' [INT3E]. Despite this acknowledgment of the different levels of knowledge or expertise, the responses in the reflection recognise how they see that each member of the tribe was recognised as having some knowledge. The contributions made by each individual were valued and the individual was recognised as acting as part of the whole. There is the acknowledgment also of students being able to learn from each other as "we can explain it the same way sometimes." This emphasises the importance of class discussion and allowing students to listen to each other's ideas. Allowing students to interact can improve learning in two ways: by learning from each other because students' words make sense to them sometimes due to the common ground, and by allowing students to build a secure tribe where there is a sense of belonging.

REFLECTION: "WE LEARN TOGETHER"

There was one time when we were doing rocks. Instead of Miss Baker writing out questions for *us*, we got into groups and wrote the questions ourselves, like, what *we* wanted to find out. Then these were put into a hat and we chose a question from the hat and we had to answer it for homework. So, we weren't just writing out what *we* wanted to find out, we were writing what everybody wanted to find out. This type of thing helps me learn because I know that we're all in the same boat. You know about the same amount as everyone else. Some person might know a bit, another person might know a bit about it, but it's different. You put it together. We all sort of share the same interests and we can explain it the same way sometimes. And like, with these questions, other people wanted to find something out and you wanted to find it out as well. But sometimes it's like, you didn't want to write it down cos you think "Oh, everybody will laugh at me," but then somebody else happens to write it down and you get it, and then you think, "Oh, thank God!" and it just makes it easier, it makes it not as uncomfortable.

But also, I've always enjoyed working in groups and partners. It's lots of fun and you don't feel alone on it. Like if you're doing an assessable task, like a prac by yourself, you feel more alone and it feels more like a test, and if you do it with a partner and you have fun, you enjoy it, and you like doing it. I think that if you're doing science by yourself it's not that bad, but when it's boring it becomes sort of like "We're going to science, blah!" It's like a chore and you have to do it. But if it's more enjoyable and you *are* learning - cos you don't want to go if you're just having fun, mucking around - but if you are learning and having fun and doing it in partners and doing what you want to be doing, it doesn't become like that. It's not like you don't do anything, cos we have to hand it in so it has to be done. But you have more fun doing it because you're not doing all the work, you have *participation.* And when you're learning in a group, it's like, learning together, where you're working on something and you're both learning at the same time. Like, if you don't know, you can just go, "Oh, can you explain this to me?" instead of asking the teacher all the time, like our teacher might get a bit, you know, "Oh, here we go!"

Also, if no one else in my group is confident about doing an experiment, I'm like, this is going to be really bad and I'm going to hurt myself and I sort of, don't want to do it. Like with the Bunsen burners, I think I saw everyone else doing it so I sort of had a go and found how easy it was so I didn't really get frightened of it. If there's a guinea pig first ...

FIGURE 3: Reflection: "We learn together." A compilation of some Year 7 student responses given during interviews relating to the social interactions of the science classroom and how they influence learning. See Appendix 18 for audit trail.

There is also the sense of students' fear of being excluded from the tribe. When forming the questions for the rock unit, the students express their reluctance to write something that might incriminate themselves or make them look foolish in front of their peers. There is relief when the threat is dissolved by the confirmed oneness with another member of the tribe when "somebody else happens to write it down and you get it", thereby confirming membership of the tribe and making existence within the tribe "easier" and "not as uncomfortable." In this example ridicule represents isolation from the group, whereas when there is a sense of solidarity and freedom from such ridicule "you don't feel alone." This threat of ridicule emerged a number of times during the interviews mainly when students were asked about what they did not like about science. The common response was associated with the threat of "getting the wrong answer" when asked a question during a class discussion, or responding with a "Huh?" when they were not listening. The fear that students will think "you're a dork" or laugh at them was sometimes motivation for some students to pay attention. Some students appeared to need to be *part of a group* where there is acceptance and freedom from ridicule.

Group work was highlighted by some students as being the most enjoyable experience of science, as explored in the second paragraph. Apart from the obvious technical advantages of working as a group, such as not needing to find out as much information and decreased work load, there appeared to be two other elements of group work that seemed to make this a positive experience for some students. The first relates to what is added to the learning experience: when working individually the motivation is getting the task completed for assessment, whereas working in groups adds enjoyment and increased satisfaction. For some students, most of the satisfaction was derived from the addition of "fun" through "participation;" students do not feel "alone." The second element is that there is collaboration of learning where students are able to use each other to learn from and learn with; an extension to the thinking capacity that is close by and perhaps more readily available than the teacher expert.

The potential down side of such interaction relates to these elements also. Lyle and Daniel were both very negative towards group work in their last interview, with Daniel saying that "If you put [assignment and groups] together it is dynamite, one person ends up doing all the work...usually yours truly." Lyle's response was a resounding "I absolutely hate group assignments!" [INT4B]. These two boys were considered by other students to have a strong science knowledge base, so for Lyle and Daniel, group assignments meant that their expertise was in great demand. This suggests that group work can be fun and productive when there is equal collaboration between the members of the group, but hazardous when there are unequal roles, making it a most *un*enjoyable experience.

Further in the second paragraph of the reflection, the fun side of working in groups is highlighted as "doing what you want to be doing" when in groups. While students acknowledge that working in groups or "partners" is fun, and that being in a group also prevents science from becoming boring, they acknowledge that fun on its own is not productive for learning. Students want the opportunity to be able to learn and not just have fun: "cos you don't want to go if you're just having fun, mucking around" and prefer to be able to have fun *and* learn something.

The third paragraph presents the effect of being part of a group during experiments. As suggested here, the members of the group impact on confidence and dealing with apprehension of the unfamiliar. The other members of the group in a way give the "go-ahead" to tackle something that is unfamiliar. Within the group there is comfort, just being surrounded by like minded and familiar people can provide support through example. Another student captures this: "If there's a guinea pig first..." Some other students expressed similar use of more confident students to deal with apprehensive situations. Kerry said that she felt apprehensive about doing dissections in Year 8 and stated: "I'll make sure Nicole's my partner... she's like the out going one. I'll get a boy" [INT4E]. Here the group does not necessarily foster confidence but security as other students provide a refuge for avoiding experiences that they expect to be unpleasant.

### 2.2.1. Discussion of Interacting with Peers

The different culture of the school science and expectation for interaction with peers make the interactions that occur in science different from interactions occurring in other subjects. A reliance on the social construction of learning predominated the perceptions of learning shared here. Interaction with peers can help build a secure tribe, where all students are valued and feel a sense of belonging due to the common ground based on similar levels of knowledge and experience. This is reminiscent of Becher's (1989) description of academic tribes. These students were able to identify themselves as members of the tribe, based on the having and sharing of knowledge. Some students preferred to be able to share and display this knowledge, but were aware that with such exposition comes the potential threat of ridicule, such as if they give the wrong answer during a class discussion. Fear of exclusion from the tribe becomes evident and can provide motivation to conform or can act to alienate students that feel unable to conform, such as where students do not understand. Discourses (Gee, 1990) within the classroom culture are also evident as defining students' way of learning in the cultural and social setting of the classroom. Students share information through appropriate discourses that are a product of the various lifeworlds of the individual where students share lived experiences. Some individual experiences add to the variety of accumulated shared knowledge, others are common to all and represent the experiences offered in the classroom. For example, students were concerned about articulating their questions about rocks in a way that did not expose something of themselves that may identify then as non-members of the Discourse, such as looking "dumb."

Working as a group was seen by some students as being positive for learning as it adds enjoyment to the task and provides opportunities for collaboration and an extension to the thinking capacity where help is readily available. The element of fun that group work offers is value-adding, and helps to prevent science from becoming a "chore." Working in groups during experiments was considered to improve enjoyment by offering support when dealing with unfamiliar situations or negate learning when members of the group had unequal roles due to an imbalance of knowledge and expertise.

Students' reliance on the social construction of knowledge emphasises how important it is to allow students to interact in their social setting of the classroom. Slavin (1983) found similarly that when students work in groups the quality of the work is not necessarily improved, but that there is greater motivation to complete the task. In Haberman's (Wadsworth, 1984) description of "good teaching," he states that group work offers students the opportunity to be exposed to "cultural and intellectual heterogeneity" (p.294). He claims that "[g]rouping can either limit or enhance students' self-concept and self-esteem and thus has a powerful effect on future learning." (p. 294). Providing environments where students can be exposed to the variety of knowledges, personalities, skills, and expertise that are present in the classroom can contribute to learning. Even though some students are resistant to working in these collaborative settings, participation in a whole class setting, such as through class discussions, can provide opportunities to develop a learning environment as long as incrimination is reduced by providing a relaxed environment where all students' contributions are valued.

## *2.3. Theme Three: Interaction of the Familiar with the Unfamiliar*

I have drawn on three student experiences to illustrate how interacting students' existing knowledge with the new knowledge was valuable for student learning. The first is represented in this reconstruction of the teacher demonstrating the particle model to students (Fig. 4). Betty is struggling to comprehend what is really happening with the mixture of potassium permanganate and water particles. Potassium permanganate is unfamiliar to her and in order to understand how the particles of two liquids behave when mixed together, she recalls a familiar experience of mixing cordial with water at home that she recognises as behaving in the same way.

| RECONSTRUCTION: "IN ORDER TO UNDERSTAND I MUST BE ABLE TO THINK ABOUT WHAT I KNOW" |
|---|
| Miss Baker takes out the potassium permanganate crystals and walks around to show the students what they look like. "This is a solid," she says. "Now look what happens here when I put them into a beaker of water." Miss Baker plops some of the crystals in and the water immediately turns a purply-red colour. Nancy calls out, "Why does it go red?" Miss Baker reflects the question back at the class with "What's happening to it?" Betty says "It moves along the shape of the water and takes the shape of the glass." While the discussion continues, the purple colour sinks to the bottom of the beaker. Miss Baker puts a spoon in and swirls the water, and some students say "Wow, cool!" Betty pronounces, "It looks like a tornado." The teacher then asks three students to come up the front and draw their ideas of how the particles in a gas, liquid and solid behave. Betty has been asked to draw the particles in the purple liquid. Betty begins to draw the beaker and asks the teacher "Is this right?" Then she stops, turns around again and says "Can I use cordial? That's easier. I know what happens in cordial because I mix that with water at home." |

FIGURE 4: Reconstruction: "In order to understand I must be able to think about what I know." A reconstruction of Betty's attempts to understand the particle model of liquids, where she relies on familiar experience (cordial in water) to understand an unfamiliar experience (potassium dissolved in water). Reconstructed from observational field-notes [OBS07].

The second experience relates to Maree's reliance on the tangible experience of her uncle acting as a geologist to make personal her understanding of science. In the second interview Maree considers how in science she likes to "discover things", and with probing she explores this notion by referring to her uncle and the work that he does as a geologist.

> Maree: … I like discovering things in science.
>
> Linda: OK. When you say discovering what do you mean by that.
>
> Maree: Well, an experiment and things. Like looking at rocks and geology and stuff.
>
> Linda: Well, you'll enjoy the next unit then won't you.
>
> Maree: Yeah.
>
> Fay, Betty: (repeating Maree) Yeah.
>
> Maree: My uncles a geologist and he gives us all his rocks that he doesn't want. They're cool to look at.
>
> …
>
> Linda: Tell us something you've learned or discovered.
>
> …
>
> Maree: … one thing that I learned is Miss Baker showed us all different types of scientists on a slide show and we saw it on the TV and we saw like, geologists, and things and what they do. [INT2A]

Discovering in science, for Maree, means doing similar things to what scientists do, the scientist being her uncle. Maree's uncle acts as a concrete and familiar embodiment of how a scientist looks and acts, "what they do," within a branch of science, "Geology." Maree grasped onto that image as something familiar to her and she was able to build her perception from that familiarity. When explaining what she had learned, Maree recalled a slide show of scientists from the first lesson and referred to the geologist as an example, again highlighting her tendency to recall familiar experiences and knowledge.

The third experience emerged during an interview with Lyle where we discussed how Miss Baker was considered a scientist in part because she had experimented with flies. When it was pointed out that *he* had experimented with dirty water, so did that make him a scientist, he stated, "There's not much scientific about dirty water!" [INT3B]. The familiarity of common materials, in this case the dirty water, is not seen as scientific, whereas the unfamiliar and perhaps more bizarre act of "experimenting on flies" is perceived as more scientific.

Taken together, these three experiences can be used to make comment in two ways on how Betty, Maree and Lyle use the familiar and the unfamiliar: (a) in order to understand the scientific concept students attempt to relate the unfamiliar concept to something familiar to them, and (b) the unfamiliar components of the laboratory warrant interest. In actually experiencing the concept in a science lesson, it could be contended that some students would prefer to use the elements of the laboratory, the unfamiliar, such as potassium permanganate crystals dissolving in water, or experimenting on flies. There is less interest developed in watching the familiar as they have seen it before. Would there have been as many Wow!s if cordial had been mixed by the teacher in order to represent this scientific concept?

According to the students, the primary experience used common materials that were designed to evoke "curiosity," things that were familiar to the students to represent the scientific concepts, whereas secondary science offers specialist scientific equipment, the unfamiliar, where the elusive part of science is finally becoming known for the students. Nicole stated this perception: "… I didn't do science at my primary school, not like real science, just like curiosity… not with Bunsen burners and stuff like that..." [INT4C]. Having been introduced to the unfamiliar scientific equipment Nicole feels that they will now be doing real science.

### 2.3.1. Discussion of Interacting Current and New Knowledges

The unfamiliar elements of the science environment appear to act as a catalyst for capturing student attention. This captivating capacity was seen to be strong for Betty, Maree and Lyle who were experiencing secondary science for the first time, given their expectations of secondary school science and longing to encounter the elements of the laboratory. These students have found it important to be able to interact with the unfamiliar elements of science in motivating them to learn. The opportunity to think about the familiar concepts or experiences that they have at home or at school was important also to give meaning to the unfamiliar things that they encounter. Constructivist processes are enacted here, where new experiences are given meaning by the existing constructs (O'Loughlin, 1992). Allowing students to participate in class discussion has been seen to allow such construction to be effective, as was stated in the previous section where students appreciated being able to contribute their ideas to the class. It is this process of contributing freely and assembling everybody's ideas (that incidentally, are also most likely familiar to them since there is that common ground between the students), that allow the students to give their experiences meaning.

It becomes clear that the constructing of meaning moves beyond the constraints of Piagetian personal constructivism to encompass socio-cultural constructivism (Crotty, 1998) where both the social and physical environment act on the construction of meaning. Students interact with science as presented in various ways: by the teacher through instruction, by students in discussion, and by their own lifeworlds outside of the science classroom, as was evident with Betty's cordial analogy, and Maree's reliance on the image of her uncle for conceptualising science. Through these interactions, students discover for themselves their own reflection of the content of science. Science is experienced by each individual through a personally and socially constructed lens (van Manen, 1990) where previous experience determines how new experiences are lived (van Manen, 1990). I am aware that the students experience learning differently. The perceptions presented by the students in interviews were snapshots of these lens-filtered lived experiences.

Common in this section were the terms "fun" and "interesting" in students' reflections of their experiences in science. The following section attempts to draw out the meanings that students attached to these terms.

## 3. The Depiction of Science as "Fun" and "Interesting"

So far, many of the quotes that describe students' experience of learning are scattered with the words "fun" and "interesting", especially in regard to group work. These words represent common elements of the discourse of teenagers. Finding the meaning of these words can enable teachers to have a better understanding of what students want their experience at school to be like. When a student says, "I think experiments are fun," they are equating their understanding of experiments with their meaning of "fun". The problem arises when the teacher has a different meaning attached to the same words and they, too, say that science is going to be "fun". The teacher's understanding of fun may mean enjoyable for learning, whereas fun for the student in the back row might be laughing with friends and not have anything to do with learning whatsoever. This variation in meaning for the same term is described by Gee (van Manen, 1990) as the "exclusion principle" (p.73), and denotes how exclusion from and inclusion into a Discourse is determined by the sharing of meanings. The potential for this is compounded further since this type of emotive language becomes moulded by life experience, so is dependent on the person and the experiences that have led to the construction of its meaning (van Manen, 1990). I felt that it was important to explore what students meant when they referred to science as "fun" and "interesting" in order to establish whether the use of these words indicated something about learning in science. This line of inquiry developed during the first interview where Nicole pointed out that, for her, some experiences can be more interesting and others could be considered more fun.

Given the potential for different experiences to be labelled as fun or interesting, the following is a reconstruction of the first lesson that identifies examples of fun and interesting experiences (Fig. 5). The various meanings of these terms as divulged by the students during interviews are then presented and explored.

One of the perceptions predominating this reconstruction is that science is "interesting" and "fun." The reconstruction provides examples of the type of experiences that may be deemed fun and/or interesting. The perceptions of science as fun and interesting are a result of the experiences that students have in science, and as such, come to be indicative of school science. The experience of the first lesson has had such an effect on some students that, even in Term 4, students still recall the Chemical Demonstration as being a high point for the year. Elements of this important experience could be distinguished as being either fun or interesting. For example, the more subtle reactions were not considered fun as they were less animated, so were considered interesting, but not fun. In comparison, the explosive demonstrations that were high in action were classified as being fun, producing responses such as laughter, movement, satisfaction and a longing to experience it again.

RECONSTRUCTION: "THE FIRST LESSON"

I walk into the science room, not really sure what is going to happen. I didn't really enjoy science in primary school. It was kind of boring because we already knew half the stuff. We only just sat there and learnt off a text book and it wasn't fun. I am worried that I won't know how to do the experiments, I don't know much about science. I don't really want to be here, I actually wanted to go to sick bay, but I didn't.

The teacher asks us about what science we've done in primary school. It is interesting hearing about what other people have done and finding out what they know. The teacher says that science is going to be Fun.

Then the teacher shows us some scientists on a PowerPoint presentation. This is very interesting, finding out about different famous scientists. She says that we are all scientists, but I can't imagine myself as a scientist. They invent new things and they know a lot about chemicals and that's all they work on. They work on their own and know what to do and they use big words. I don't want to be one of them when I leave school.

And then we go over to the lab. We get to put on lab coats. Everybody looks funny, but this is great, really fun. A man comes in and shows us some experiments where he mixes chemicals together. He shows us some with different chemicals changing colours: he puts two clears together and it changed to like a purple. These are a bit boring, but they are still interesting. Then he does some that have sparks going everywhere and one where this foamy stuff pops out. It looks really good. We don't see it very often. I've never seen an experiment, besides on TV. And everyone just goes Wow! And big expressions on their faces and you can just see that it is really fun and, when it's time to go it's like But I want to see more!

This is what science is all about. We have the lab coat, we get to use special science equipment and play with chemicals. Now I feel that I will really be doing science. I think I am going to enjoy science now because of the experiments because it's fun, yeah, really interesting. Now when I walk into the science room, I think that something fun is always going to happen. There's so many different things you could actually do.

FIGURE 5: Reconstruction: "The first science lesson" capturing the types of experiences that students considered "fun" and "interesting." Reconstructed from interview responses [INT1/INT2] and observational field-notes [OBS01].

This use of the terms "interesting" and "fun" presents positive images of science, and they potentially represent different aspects of the science experience. Some students have also described something fun as being interesting: "How can you have something that's fun but not interesting?" was one student's comment. Perhaps the difference between these two types of experiences has more to do with the absence of fun in the more subtle colour changing experiment, rather than the more animated experiments just being fun.

Following is an exploration of what students mean by the terms "science is fun" and "science is interesting." The various meanings of these terms have been derived from interviews and are described in Tables 2 and 3, along with a brief description of how each contributes to learning.

### 3.1. "SCIENCE IS INTERESTING"

Before identifying the meanings associated with this term, I have found it valuable to identify how students' interests changed throughout the year in order to emphasise that, although students' interests are not tantalised continually, students can still perceive enjoyment of the whole.

Students' journey though the year presented them with different experiences, some of which they considered interesting, were seen to strongly influence their perceptions of science and were productive for their learning. Others were seen to do little to influence learning due to the lack of interest they provoked. Nola's journey through the year highlights how her engagement depended on her experiences:

> At the start of the year ... it was a lot more exciting because we have all the real stuff, like Bunsen burners and stuff. Whereas at primary school it was like pegs and stuff. We used pegs all the time and toilet rolls. And then, probably at the end of first [term] ...I didn't really like doing the MicroWorlds thing, so I sort of felt like I had the wrong impression at the start of the year, like we weren't always going to ... use the equipment and that. And then after we'd done, like at the start of the electricity thing, yeah, I found that really interesting and I became interested again. And then, just at the start of this term, I sort of felt like sometimes I didn't want to come because I knew what we were doing. Other times I felt like I wanted to come because it could have been something really good or, I suppose I like being surprised with what we were doing, not just carrying on with the same thing all the time. And then now, I'm really glad that we've done all these things because I've learned so much more than I have like through primary school, so I feel like I've actually learned something that's been worthwhile. [INT4C]

Nola recognises that science was exciting in the beginning because the unfamiliar was becoming known while interacting with the elusive elements of science that were absent in primary school, "real stuff, like Bunsen burners." During this time, interest was high. As the year progressed, her interest levels shifted depending on the experience. Her reflections culminate in a summary of her year, where she is able to acknowledge confidently how her accumulated experiences have been productive for her learning compared to her primary science experience.

The up and down progression of interest experienced by Nola was described by Lyle and Daniel as being like the pattern produced by an electro-cardio-gram (ECG), where some experiences were considered to be high in interest, others were rated way down on the interest scale [INT4B]. Coupling Lyle and Daniel's "ECG model of interest" with Nola's experience of varied interest levels, it could be suggested that, even though interest has not been maintained all year, as long as there was a certain level of interest injected, then a series of experiences may be considered productive and positive for learning. Here, interest is entrenched in the learning experience – learning is a result of interest.

With this in mind, an analysis of what "interesting" means has given rise to three types of interesting experiences and two requirements that were common to each type, as listed in Table 2.

TABLE 2. *Types and Requirements of "Interesting" Experiences as Defined by Year 7 Students During Focus-Group Interviews*

| TYPES | REQUIREMENTS |
|---|---|
| **Unexpected**<br>Where they don't expect the answer or response | **Not repeatable**<br>Something new, experienced only once, otherwise it is not considered interesting as you already "know" it |
| **Unknown or unfamiliar**<br>Something "weird" or different, or where students don't know how to get the answer, or they are in search of evidence to support the hypothesis stated by an informed source, such as the teacher or other students | **Attention grabbing**<br>To be interested in something it has to grab your attention first, it has to be appealing |
| **Challenge**<br>Where the outcome is not obvious and they have to work it out, problem solving is required to answer the questions that arise | |

An interesting experience was typified in three ways: it could be deemed as unexpected; it encompassed the element of the unknown or it was different or weird; or it presented a challenge to them, and problem solving was required to find the answer. Each type of interest expressed different responses to an experience, although they are all very much interrelated in that they all suggest an encounter with a new stimulus, which prompts the student to ask questions and seek answers, even just mentally. The difference, perhaps, is the dominance of the type of interest, that is, the predominance of the unexpectedness, unfamiliarity and challenge in the experience.

For example, the unexpectedness of a result, not knowing what to do, and being surprised by the result was a component of students working out how to separate mixtures. For example, Betty felt watching mixtures being separated was interesting because she had no idea what steps to take, and she asked herself the question "How am I going to do that?"

> Betty: ... the dirty water, it was interesting ... I thought, oh my gosh how are we going to get water and get the dirt out of it and I got so confused and didn't know what to do and people came up with other ideas and I thought Oh, so that's how you do it! Wow, that's a good idea and you wonder how people make it up or.. It's interesting. [INT2A]

On doing it she was surprised by the results. The unexpectedness provoked interest, and stimulated the learning process. Further evidenced here is how interaction with other students enabled her to answer the questions and learn from the experience: "people came up with other ideas." It was not that Betty was able to answer the questions herself, but that observing the actions of her peers enabled her interest to be maintained for completing the task. Just seeing her peers have ideas was of interest to her.

The requirements of interesting experiences defined in Table 2 acted as conditions for each type of experience to be called interesting. The first requirements states that the experience must grab their attention and be appealing in order for it to be considered interesting. This suggests that there needs to be some existing construct for the experience to interact with in order for the attention to be focused (see Voss & Schauble, 1992; Vygotsky, 1978).

The second requirement of interest that students expressed was that the experience is not repeatable. Something ceased to be interesting if they had already done it or they already knew it. Once the answers become known, the intrinsic motivation to continue to be engaged becomes lost. This suggests that interest, in fact, may actually inhibit the learning process, as suggested by (Wadsworth, 1984): "Individuals are known to suspend learning when they believe the learning has been accomplished" (p.442). Betty encapsulates this non-repeatable notion of interest:

> Betty: Because once you know it, and you've done it, it was interesting at the time...

You know it, you've done it; it is a progressional process where interesting experiences need to be built on rather than repeated. Knowing what is going to happen leaves no surprise, challenge or unknowns, so some students perceived they have no unresolved questions to pursue – there remains no "cognitive conflict" (Wadsworth, 1984) for them.

Students do learn from interesting experiences. It may be the fact that a result was not expected that actually impressed the experience on a student and this might help them to remember the results or process. The interest that is depicted here by students suggests that students find themselves wanting to know more about it and begin to ask themselves these questions, such as when Betty wondered how she might go about the separating mixtures experiment. Cognitive conflict becomes influential as a gap appears between the current level of understanding and the new experience and students are prompted to find out how to bridge the gap (Wadsworth, 1984).

Prenzel (1992) defines interest as "the selective persistence of engagements," also as a "personal disposition or value orientation" (p.73). If something is of interest, it is especially valuable to that person. This value does not appear to be representative of Betty's insistence on interesting experience being non-repeatable, where her interest is conditional, limited, and maintained for as long as the elements of the experience capture her attention. The discrepancy can be explained by Krapp et al. (1992) and Hidi (1990), who characterise interest as "Individual Interest" and "Situational Interest," both variations on the person-environment relation.

> Individual interests are always specific to individuals. Generally, researchers liken them to dispositions that develop over time. Individual interests are considered to be relatively stable and are usually associated with increased knowledge, positive emotions, and increased reference value. Situational interests, on the other hand, are generated by certain stimulus characteristics (eg., life themes, novelty) and tend to be shared among individuals. Because this type of interest may be evoked suddenly by something in the environment, it often has only a short-term effect and marginal influence on the subject's knowledge and reference system. It may, however, have a more permanent effect and serve as the basis for the emergence of individual interests. (Krapp et al., 1992, p. 6)

Hidi et al. (1992) explains that the two forms of interest generally do not exist on their own, but that both are likely to interact and influence each other's development. In this research, when students say that fun is needed for continued interest, this suggests that the interest that develops is an impermanent situational interest where the stimulus of the environment, such as hands-on activities, are considered interesting experiences. Nicole, on the other hand, stated in the first round of interviews that something is interesting when she is "comfortable with it," which could be an example of an individual interest. Her interest is independent of the environmental stimuli of the science room but influences what she becomes attentive to in the environment. At this point when an experience develops into an individual interest, Renninger (2000) argues that there has occurred an "intersection of cognitive and affective functioning" (quoted in Pressick-Kilborn and Waters, in press).

Both cognitive and affective functions become operative when interest is evoked. In the literature, however, interest is often limited to an affective response, such as where Baird et al. (1990) label interest as the affective component of challenge. These authors envisage challenge as comprising two main components – a cognitive/metacognitive *demand* component and an affective *interest* (and *enjoyment*) component. The results of the current study suggest that the use of the word "interesting" by students is not just affective, where they say they enjoy science because it is fun and interesting. "Interesting" appears to also have a cognitive component, where the students are prompted to begin to question. The idea that the cognitive action is separated from the interest, as suggested by Baird et al., does not seem to be represented in this study. Interest as perceived by the students appears to be of two types: the interest that is the affective part of fun, represented for example when students say they need fun for their interest to be maintained; and the interest that embodies the demand component of challenge, which is the cognitive/metacognitive response to the situation, such as where students are prompted to question. This connection to cognitive response is emphasised by Hidi (1990) who asserts that "the concept of interest should be recognised as an integral part of cognition" (549), as interest is considered "central in determining how we select and persist in processing certain types of information in preference to others" (p.549). In the current study, some students perceived that their use of the word "interesting" described experiences that prompted them to question and were intrinsically embedded in the cognitive process of learning.

### *3.2. "Science is Fun"*

As outlined in Table 3, the research shows that an experience was deemed "fun" when there was no pressure to perform or get the right answer, as was considered the case in maths: "you've got to be thinking all of the time. And with [science] … it's not as hard and each step, you can work it out for yourself… and they don't have to be a particular thing, just whatever you want it to be" [INT2A] (less pressure). When the experience is "big," it could be considered fun, such as sparkling chemical reactions. Also when experiences were hands-on and students could move out of their chairs: "When we get involved in it and we like can go up there and do something, that makes it funner, cos like you can have a laugh, and when you're just sitting down and writing off the board, that gets pretty boring" [INT2B] (demonstrative). You get to be yourself (sense of freedom), for example Kerry believed that "usually fun is something doing it, like making experiments, playing on the playground, just things like that..." [INT2C]. Association with friends contributes to a fun experience where "you enjoy things with your friends" [INT1A] (social interaction). Students felt that for something to be fun, it may mean that they tended to want to do it again as expressed by Lyle, who said, "if you want to do it again, I think you could consider that fun" [INT2D], although this is not unconditional (repeatable to an extent).

TABLE 3. *Characteristics of "Fun" as Defined by Year 7 Students in Focus-Group Interviews*

| CHARACTERISTICS | DESCRIPTION |
|---|---|
| **Less pressure** | Where they do not feel threatened in any way, such as reduced pressure to get the right answer and such embarrassment |
| **Demonstrative** | Action-packed, big responses, involves movement such as games, and even just getting out of their chair, hands-on |
| **Sense of freedom, more relaxed** | Being relaxed and being able to do your own thing, but also not as in the idea of being free to be happy or giggling all the time. |
| **Social interaction** | Being able to interact with your friends, such as laughing and talking |
| **Repeatable to an extent** | You will want to do it again, within limits |

The relationship between fun and learning was considered from two perspectives: fun as "play" that has no bearing on learning, and fun as motivation for maintaining engagement with learning. The first perspective relates to how working in groups infused an element of fun. It was found that students wanted to have the opportunity to learn and not "just have fun," implying that if an experience is *just* fun, then there is no educational value.

Nicole: It's not really science if it's just fun. It has to be interesting as well. [INT4C]

A similar association between the "just" in "just fun" was found by Griffin's (2001) study into students' perceptions of learning in science centres, where she considers perceived associations between play and learning. It was found that "just having fun" was associated with "just playing," but not learning (p.8). Griffin acknowledges that there is a wide range of research into how play contributes to learning; "playfulness, in a learning context, de-emphasises the need to be perfect and thus, increases ... self-esteem" (Boyer, 1998, cited in Griffin, 2001, p.9). Many teachers and students still do not consider "play" as appropriate for school learning (Griffin, 2001).

The question is: Does fun have value for learning? The fun element was considered by some students as imperative for maintaining their interest in science. This represents the second perspective of how fun is related to learning. Here, when asked what the teacher could do to increase learning, Sam responds:

> Keep it fun, and not like start to make it real boring so that we don't want to learn anything. So that we're not just sitting there doing nothing. Like, keep us to *do* something. Cos if we're just sitting there waiting for other people to finish it gets a bit boring, nothing to do. [INT2B]

For interest to be maintained there needs to be the element of fun. Sam emphasises the active and "doing" component of science as the source of motivation. It appears that he *needs* the element of fun to keep him interested. This suggests that fun is separate from interest: it is like a fuel to interest, it is a *type* of experience that results in particular behaviour, attitude and emotion. Further research is required that considers fun as a type of activity that can have variable impacts on learning depending on the context, quantity, and emphasis. I had great difficulty trying to work out exactly *what* fun is and how having fun influences learning.

Some students expressed the view that a person needs to be *interested* in something for it to be considered *fun*. If this is the case, an analysis of such a "fun" experience appears to suggest that there must have been some interest in the experience for it to be labelled as fun but that this *interest* may not be the type that prompts them to ask questions or leads to obvious learning. Exposure to something "fun" requires the person to perceive the experience, to focus their attention, to judge whether it is fun or not, and then determine appropriate responses. This is not a superficial response to an experience, but requires cognitive action.

Much of the research into the relationship between "fun" and learning has concentrated on fun as being an emotive or affective response, usually associated with the hands-on side of science. Campbell et al.'s (Munby, Cunningham, & Lock, 2000) study of surface and deep approaches to learning showed that "fun" interactive learning activities decreased boredom, which resulted in limited learning for students with surface approaches. In a study by Munby and others (2000) into the professional knowledge of teachers, the teacher under investigation indicated that she equated "science as fun" with "science as being hands-on oriented" and chose to incorporate into the classroom a high amount of such experiences in order for students to understand the "facts" (Haberman, 1991). These two studies support how students of the current study found interacting with the hands-on elements of science as being fun, presenting the value of such activities for learning in varying degrees. Neither study attempts to explain what it is about the notion of "fun" that makes it positive or ineffective for learning.

This study has shown that students *want* to have fun; teachers and this school *want* to make learning fun. But why? What is so attractive about fun? I contend that finding out what it is about the notion of fun that motivates students to learn is required to inform teachers, especially since "fun" is so entrenched in the discourse, aims and wants of students. The students stated that fun means they are able to be more relaxed as they can do what they want, it is commonly associated with doing something where the students are actively involved without pressure to perform, and that the experience is so enjoyable that it has enough *something* for them to want to do it again. Perhaps the question is what is the *something*? Perhaps the something is an individual interest, a need or desire to operate or exist in an environment that is free of pressure, to be self-directed, and interact with like-minded people in a positive environment that affirms self-concept and self-esteem (Haberman, 1991).

### 3.2.1. Discussion of interest and fun

The meanings of "fun" and "interesting" which were commonly associated with science were found to indicate that, for learning to be enhanced, the fun element is imperative for interest to be maintained. On its own, fun does little for learning, but where fun is combined with experiences that are interesting, then there is engagement, excitement and productive learning. An injection of fun seems to keep students interested; in other words, students are motivated to be engaged. There is a danger that such fun experiences may be reduced to "seductive details" (O'Loughlin, 1992; Vygotsky, 1978), p.558) that intensify the unimportant ideas of the experience. Such seductive details may be easily recalled, but the interest they create may not result in the recollection of other important details (Hidi, 1990). With such misguided attention coupled with the potentially side-tracked effect of hands-on work mentioned earlier, there is danger that students become more focused on the fun side of science and rely on fun to keep them interested. In a way they are being pulled along by the temptation of fun to lead them to learning. What needs to happen for interest to become intrinsic is for the student to be able to, in a sense, learn to "walk on their own", and be more *directed* by the events that occur in science lessons, rather than *rely* on them to keep them motivated for learning.

## 4. Summary

Students' journey toward the light in science began the moment they entered the laboratory. The very thing that makes science different from other subjects is what positively impacts on their learning. In other words, the interaction with the things of science (experiments, equipment, knowledge) that are not encountered within any other subject have been perceived by students as what keeps them engaged with learning science and helps learning to be meaningful. The culture of the laboratory, where interactive activities were perceived as being relaxed and generally free of pressure, provided opportunities for interacting with peers. Students also acknowledged that through this social interaction, learning is effected, hinging on the notion that learning is a social accomplishment (O'Loughlin, 1992; Vygotsky, 1978). Pertinent here were students' perceptions that within the classroom there exists a solidarity based on student familiarity and common ground of similar knowledge. Also, group work for assignments acted as a motivational mechanism where the task becomes enhanced by social interaction within the group. Here the fun element is emphasised, where interacting with peers is considered fun and this keeps students motivated to work, as was supported by Slavin (1983), unless there was an imbalance in expertise where *un*enjoyment was perceived to be the result. Where students were able to interact during experiments, the familiarity and varied expertise provided confidence to embark on the unfamiliar, or alternatively, to offer a way out of unwanted experience, such as dissections. A third element of the classroom culture of science that was identified by students as contributing to learning was having the opportunity to bring existing, familiar ways of understanding into interaction with the new, unfamiliar experiences, in order to increase, improve or change understanding. This is strongly entrenched in constructivist ways of learning and building understanding. Not only did students appear to require the opportunity to think about what they already know in light of the new information, there appeared to be greater merit in using unfamiliar or unknown materials to provide attraction. The unfamiliar is enticing, but the familiar enables the unfamiliar to be understood. Such enticement is reflected in the meanings students attached to their evaluation of science as being "fun" and "interesting".

It was found that students' levels of interest were determined by their lived experience of the classroom and represented by the "ECG model of interest." It was found that both "interest" and "fun" were required for learning to be effective and motivated. Interesting experiences were those that provoked cognitive conflict, resulting in students asking questions to resolve the gap in knowledge. There were found to be three types of interesting experiences, depending on the dominant characteristic of the experience: those that are unexpected, those where something unfamiliar or unknown emerges, and experiences that are characterised by challenge. For each of the three types, there are two common requirements: interesting experiences are generally not repeatable because the result is already known, and cognitive conflict is no longer present. The experience also has to focus their attention and be appealing to the individual, that is, be of value to the person.

The notions of "individual" and "situational" interests could be identified where interest was seen to be conditional, such as where students were only interested in an experience for as long as it held their attention (not of the fun experience itself). The infusion of fun becomes indicative of situational interests where students often stated that a teacher needs to keep science fun for them to stay interested in learning. This phenomenon of fun increased motivation to be engaged in science, as was indicated in how the social interaction in group work made completing tasks more fun for some students. The role that fun has in a person's cognitive response to an experience appears to be poorly represented in the literature. The contention was made that, since fun is so strongly represented in student and some teacher discourse, an understanding of how fun impacts on the cognitive action is needed in order to inform teachers of how to provide learning experiences that maintain student interest. I suggest that the inherent characteristic of fun is individual interest, where a person creates for themselves an experience or environment that is satisfying, where they can do their own thing, and interact with like minded peers and feel included.

Returning to the research questions, this chapter has focused on students' experiences, their perceptions and how these perceptions have changed as they move from primary science and through their first year of secondary science, and can be summarised in the following way:

*Experience:* I experience learning in science, which includes learning about science, learning about myself and others, and learning what is most effective for working and learning within the culture of the science classroom.

*Perceptions:* My perceptions of learning in science are twofold: I learn by interacting with my environment and my social setting, and learning is best when experiences are fun and interesting.

*Change:* I have found that my learning is influenced by my level of interest, which changed during the year depending on the topic.

The classroom culture embodies the students and their attempts to learn about science, but a description of learning would be incomplete without considering the role that the teacher plays in student learning. The next chapter draws on the pictures of interaction and motivational power of interest and fun presented in this chapter to consider how the pedagogy of the teacher influences students' wanting and being able to learn.

# Chapter 5. THE PEDAGOGY OF SCIENCE

## 1. Introduction

Students are aware of the ways they perceive themselves learning in science, and have identified particular mechanisms or phenomena that keep them wanting and being able to learn. The teacher has emerged from the findings as being strongly represented in students' perceptions of their learning. In what ways, then, can the teacher provide this learning environment that is interesting, infused with fun in order to maintain the interest, where students can interact with the science, their peers and give meaning to the new unfamiliar concepts that science education intends to impart, with the ultimate aim of allowing students to gain an understanding of what science is all about?

This chapter deals with how components of the teacher's pedagogy appeared to influence the development or change in student perceptions and expectations of science. This exploration emerged from an extension to the question, "What can the teacher do to maximise learning in science?" Within the framework of the original research questions, the following focussing questions have guided the analysis of the observation and interview transcripts:

*What role does the teacher's pedagogy play in building a learning environment conducive to student learning of science?*

> *1. What do the students say about what the teacher can do to improve learning?*
>
> *2. What do the students say about the way the teacher teaches and how this impacts on what they expect and think of science?*

These questions are considered concurrently, so that the maximising of learning is related to the way the teacher teaches: her pedagogy. Through analysis it became evident that students were identifying two aspects of teaching that had been experienced. Students commonly drew on the pedagogy of Miss Baker, other science teachers and all teachers they had encountered during their schooling years. During a preliminary analysis I labelled the two aspects as "Instructional Pedagogy," which related to the methods the teacher used to get the content across and included teaching strategies, and "Relational

Pedagogy," which pertained to how the teacher nurtured a relationship with the students. Even though these were identified, it also became evident that students recognised the innate relationship between these two aspects of the teacher. During observations I was sensitive to both these aspects of the teacher, and how Miss Baker's interactions with the students fostered a caring, responsive environment focused on providing students with a stimulating, challenging and fun experience of science.

Unlike the preceding chapter where the theoretical framework was less influential in the analysis, I felt it necessary to peruse pedagogy based theory and research literature to ascertain whether the theoretical notion of pedagogy was representative of the pedagogy identified by the preliminary analysis. Two particular spheres of pedagogical research provided the theoretical basis for the two types of pedagogy represented here: van Manen's (1999) relational emphasis, and Shulman's (1986, 1987) pedagogical content knowledge that focuses on instructing for understanding.

Van Manen (1999) highlighted the relational dimension of pedagogy and how pedagogy is ultimately and foremost "the study and practice of actively distinguishing what is appropriate from what is less appropriate for young people" (p.25). In terms of the classroom, pedagogy can be considered as the way we are "attentive to the manner that students experience their lives in the classroom" (p.26). Van Manen is adamant that every action carried out or not carried out by teachers has significance for students "[b]ecause as teachers we stand in relations of influence to our students" (p.19). It is through relating with the students that we influence them in the way they view teaching, learning and themselves. His exploration of how students experience the interactive or relational dimension of teaching was influential in the analysis and formation of the "Relational Pedagogy" represented in the current study.

Shulman (1986, 1987) introduced the notion of *pedagogical content knowledge* (PCK) where of greater concern than simply having the knowledge is *how* the content is delivered in a way that is sensitive to the needs, and requirements of the audience. Students have already shown that learning is enhanced when they are able to place the unfamiliar knowledge into an existing framework of the familiar. For this to be effective, (Carr, Barker, Bell, Biddulph, Jones & Kirkwood, 1994) advocate teacher use of analogies that provide *for* the students examples of the familiar to assist in constructing meaning from the unfamiliar. The teacher is seen as playing a pivotal role in identifying for the students that familiar experiences will help to understand the unfamiliar. In order for this to be effective, the teacher must be able to respond to the needs of the audience and know which experiences will be most appropriate.

> Explanatory legitimacy in the classroom depends upon the students' interest and prior knowledge, the subject level, the teacher's knowledge and the science content. (Treagust and Harriosn, 1999, p.32)

*Content knowledge* is defined by Shulman (1986) as having understanding of the content that is appropriate for teaching. Teachers understand that something is so and "why it is so, on what grounds its warrants can be asserted, and under what circumstances our belief in its justification can be weakened and even denied" (Shulman, 1986, p. 9). PCK adds to the dimension of subject matter the knowledge for teaching it to students, and refers to the "ways of representing and formulating the subject that make it comprehensible to others" (p. 10). The presumption of PCK is that students do not walk into the classroom as "blank slates" (p. 10), but bring with them previous conceptions, and sometimes "misconceptions" about the knowledge under instruction. Accessing these previous conceptions becomes paramount (Carr et al., 1994). For this research, PCK forms the basis of the "Instructional Pedagogy" described here, where students identify how teachers use various teaching methods to allow them to talk and think about what they already know, and to transfer teacher content knowledge in an understandable way.

Within the framework of these dimensions of pedagogy ("PCK" and "relations of influence"), the following chapter first explores what the students say about how the teacher presents the curriculum and what the teacher can do to maximise interest and learning. This is followed by how students perceive teachers' efforts to relate and interact with them impacts on their learning environment and the culture of school science. The final section conjoins these two aspects of teaching, to show that both relational and instructional dimensions of teaching were valuable for these year students.

## 2. Instructional Pedagogy

Commonly discussed in interviews was the actual way the teacher taught. This aspect of the teacher I called "instructional pedagogy" as these ideas reflected how the students were instructed in the science content. Students' recognition of how the teacher taught did not encompass simply a list of the activities used by the teacher, but included also how the teacher actually made her knowledge become known to the students. This could be characterised as the teacher's pedagogical content knowledge, as presented by Shulman (1986, 1987).

Students' perceptions of the instructional side of teaching were identified in the interview transcripts, organised within themes, and then mapped to show how these themes related to each other. The following diagram (Fig. 6) conceptualises how students perceived and expected the teacher's instructional pedagogy to contribute to the culture of learning science and includes the teacher as controller of the learning environment who makes learning attractive and makes learning understandable. This section considers these three aspects of the teacher's instructional pedagogy in light of student reflections and observational field-notes that I considered to be representative of each of the three themes.

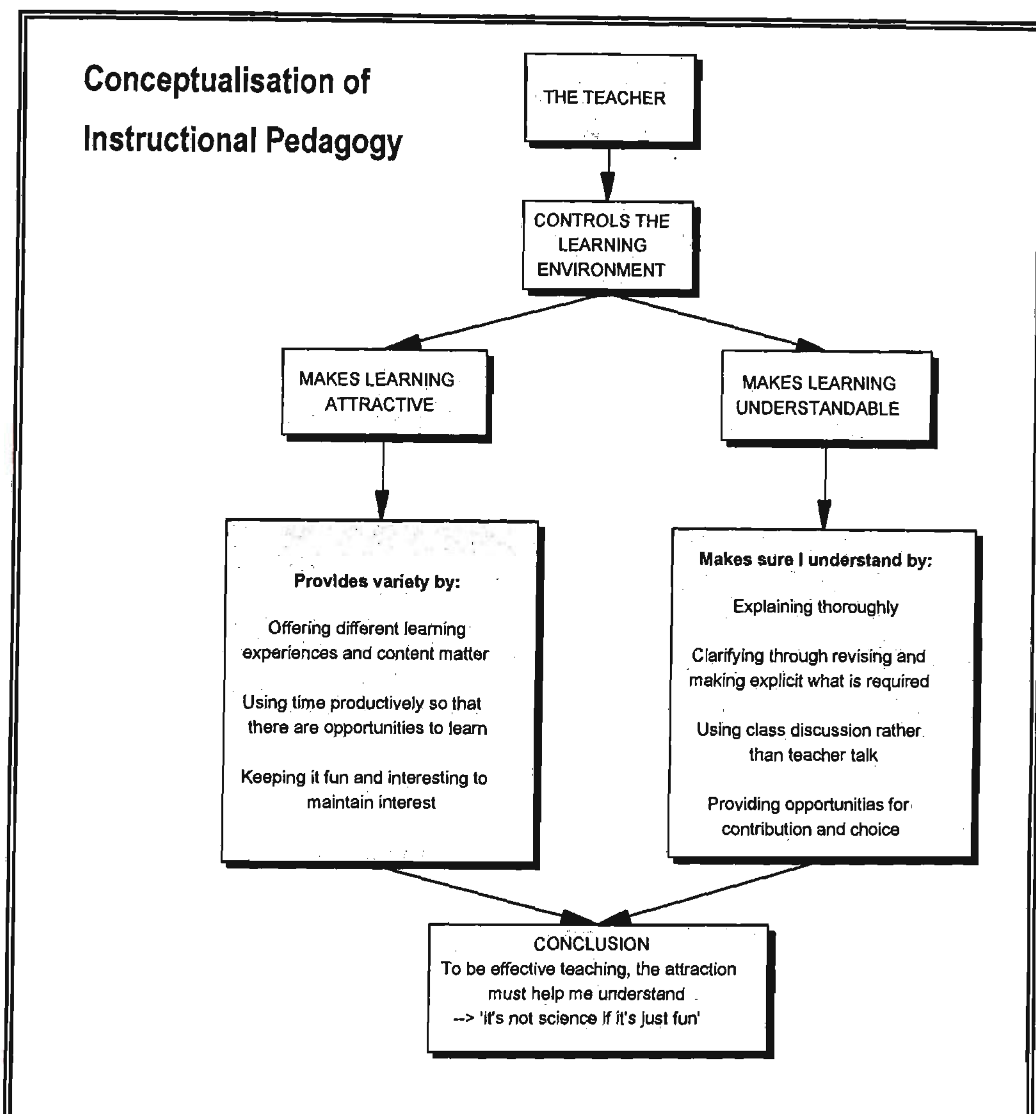


FIGURE 6: Conceptualisation of how the three themes or aspects of instructional pedagogy influence students' wanting to and ability to learning, as perceived by some Year 7 students.

## 2.1. ESTABLISHING THE TEACHER AS DIRECTOR OF LEARNING

Common throughout the interviews, students frequently acknowledged the teacher as the person in control of the learning environment. For Lorraine, the teacher is the one who determines whether science is enjoyable:

> To learn, I think to help us to learn it has to be something that appeals to us ... Because it really depends, if you enjoy science or not, on the teacher you have in primary school, cos my teacher was really boring, she never let us do anything, she just talked, talking and so that wasn't interesting for us. But I think science in secondary school is better cos you actually get to do more things... [INT2E]

Enjoyment of science is determined by what the teacher does, how the teacher presents the curriculum, and the activities that the teacher planned.

Lyle comments on the content presented in science as being determined by the teacher. For Lyle, chemistry is seen to be the epitome of doing science and he is looking forward to doing Year 8 due to the increased chemistry focus. He hopes that there is no "boring chemistry," meaning boring things "in the subject" (school science) rather than the actual chemistry (the chemistry concepts) being boring. This suggests that, rather than the actual science as a body of knowledge being boring, it is more the way it is taught or the activities planned by the teacher that can influence whether science is considered "boring" or not [INT4B].

In discussions of the benefit of Science Centres for learning, Fay and Betty profess that, although they are eager to go on a school excursion to one of these places they acknowledge that the students may not necessarily use the opportunity in the way the "teachers had planned, cos they sort of count on us to read the facts. Cos we'll just go off and do all the stuff and not actually learn" [INT2A]. The students are aware that teachers *plan* their learning opportunities, but also that it is the choice of the students to profit from them.

Nancy noted the control of the teacher in determining what is to be learnt. In an attempt to make explicit her ideas on how repeating parts of the curriculum would impact on her learning, she had the expectation that "You might learn more in it" because "the teacher might not tell you as much then, she might tell you in Year 10 about it" [INT2E]. The teacher is seen as determining the type, depth, and timing of content through their schooling life.

These examples show how the teacher is seen by some of the students as having a major influence on their science experience. In the following excerpt from term 4, Fay, Betty and Maree explore their expectations for next year when Miss Baker will be their science teacher. These students expect that Miss Baker will take into account students' achievements this year when she teaches the class next year.

> Fay: She is, great stuff. She'll … be more impressed, impressed, she'll know, if she's happy with what we've done this year she'll move on. If there's something we need to clarify, she'll go over it and then if we can move on, we'll go somewhere else.
>
> Linda: What would happen if you had a different teacher perhaps?
>
> Fay: She'd tell them.
>
> Linda: She'd tell them?
>
> Fay: About us, she'd write a record about us.
>
> Betty: She'd get all the records, cos all the records like the pracs and everything that we've done she'd sort of know what we're up to but like she'd maybe say So you've done this and done this and done this, and sort of carry on and then she'd get the niff of what we're on.
>
> Maree: I think that if we have her again and we do something that we've done something this year and we don't get it right, she'd be kind of disappointed, cos she's already taught it to us.
>
> Linda: Does that worry you.
>
> Maree, Fay: No.
>
> Betty: It bothers me. I don't want to get a low mark in science because I want to get a high mark. I've learnt so much this year. [INT4A]

The students expected Miss Baker to consider what was done in Year 7 and if there were areas that the students struggled with then she would recap and strengthen these before going on to something new. (This perhaps says something about Miss Baker's tendency to ensure understanding before going on, as discussed later.) There is also an acknowledgment of the teacher being affected by the students, "she'd be kind of disappointed" because she expected them to "get it right…cos she's already taught it to us." The repercussions of the teacher being affected in this way are strong for Betty and associated with the teacher being in control of assessment and the desire to have her efforts of learning noticed by the teacher. This type of response from the teacher implies a relationship between her and the students. The teacher builds an awareness of how best to encourage, prompt, and entice each student on to a greater sense of achievement through learning.

These examples show that students perceive that the learning experiences are ultimately directed by the teacher. This is perhaps an inevitable perception of students. Many students desperately seek direction and to be "told the answer" in order to complete the task, as demonstrated by the boys during the substitute-teacher lesson. The teacher knows the answers, the teacher controls what is being done, and even if there is collaboration between the teacher and students in defining what the students will do, as was a common practice for Miss Baker, the teacher makes the final decision. What is more important than establishing whether there is control is how the control is established and used. There appear to be two major qualities that students acknowledge about a teacher: they must be able to make learning attractive for the students, but at the same time provide opportunities to be able to learn.

### 2.2. *Makes Learning Attractive*

The preceding chapter identifies two particular aspects of the classroom environment that influence the engagement of students, first being able to interact with the science, their peers, and make connection between the existing and new knowledge, and secondly that the students recognised how the elements of fun and interest impacted on their learning. Students have identified the need for variety in what they do. It is this variety that makes learning attractive for the students: it makes them "want" to learn. The following reflection (Fig. 7) identifies how variety adds to the quality of the learning experience.

> VARIETY IS THE "SPICE OF LEARNING"
>
> I like learning about the cells and stuff because you learn about something different each lesson and like, first you made clag and then you did a prac and then you learn the parts of the cell and how it works and something different about it each lesson. So it wasn't the same thing over and over again. It's interesting.
>
> The stuff we did on electricity I found that interesting because Miss Baker did different stuff in it, like the circuit stuff with the piece of string and we were electrons going around the atom wire. We got smarties every time we got to the people who were the batteries, and that was interesting. It was different. And it makes you pay more attention because it's different stuff, the stuff that we actually do.
>
> Not like the MicroWorlds assignment. Like, I hate it when you're walking to class and you know what you're going to be doing for the entire session, and I know that I'm not really going to have to think that much. And that's how it was with MicroWorlds. And even though it did take a really long time to get all the pages set up and stuff, it sort of dragged on for ages, so you didn't really get much of a variety. Staying on the one subject for too long is just boring!
>
> And the Demos that Mr S did at the start of the year, it was fun watching him, but it will get boring, because of all the things that we've seen, like Miss Baker needs to keep changing things that we do so that we don't do the same thing twice.

FIGURE 7: Reflection: "Variety is the 'Spice of Learning'" A compilation of some Year 7 student responses given during focus-group interviews relating to the value of adding variety into the curriculum for maintaining student engagement with learning science. See Appendix 19 for audit trail.

Through these students' reflections on what the teacher does to keep them engaged, it became clear to me how important variety in the learning experience was for some students. The responses in Figure 7 suggest that these students tended to respond well to variety within the curriculum because of the opportunities for different learning experiences. Novel or unfamiliar activities catch the eye of this student resulting in her "paying more attention."

For some students the MicroWorlds[17] assignment was much less enjoyable because it lacked this variety. Knowing what was ahead, especially when it was the same thing for two weeks, lacked this attention quality and had the effect of making the lessons seem to "drag on." Most students interviewed were positive about the actual experiments of separating mixtures but felt that they did not learn anything by using MicroWorlds. For some, the learning became lost amidst the struggle to understand and use the programming language in order to present their findings and the value of the activity for learning was degraded for some students. It must also be noted that some of the students were very positive about the assignment, as it added its own variety by allowing them to do something different with their results, "instead of just doing it in Word."

Limited variety can result in boredom, which can be equated to an absence of fun and possibly interest. This is inferred by the student in the third paragraph who is responding to the question "what can the teacher do to get you to learn?" In the last paragraph the suggestion is made that "Miss Baker needs to keep changing things" so that they do not become saturated with the same knowledge over an extended period of time. Sam expects teachers to keep the curriculum varied as he progresses through school to maintain student interest: "They wouldn't want to teach us the same things. Still want to keep it fun, keep doing experiments and stuff, and not … [make] us copy stuff off the board" [INT4D].

[17] MicroWorlds is a programming environment designed with simple language for students. The assignment involved students presenting scientific data in MicroWorlds format. Students collected data from a separating mixtures experiment based on a scenario where a fictional character, "Dr Van Goof," is stranded on a desert island and needs water for various purposes.

The growing body of experiences appears to influence students' responses. Highlighted here, perhaps, is the difficulty for teachers to maintain students' interest, where repetition can play a dichotomous role: one positive, where understanding is constructed through repetition and revision so that students have time to fully comprehend the content; and a negative role that detracts from the experience as there results no cognitive conflict. The key perhaps is not necessarily finding a balance between the two, but emphasising the positive and reducing the negative by focusing on different aspects of the content in order to provoke cognitive conflict through critical exploration.

Maintaining variety in the curriculum has a positive impact on students aligning themselves to learning and has the potential to positively influence a student's school experience. Variety for its own sake or without direction and explicit connectedness to the curriculum can have a negative influence on a student, as it demeans the value of the experience and can be confusing. In order to make learning attractive, variety and a clear use of time were considered important for maintaining engagement in science.

### 2.3. MAKES LEARNING UNDERSTANDABLE

The other aspect of the teacher's instruction is how the teacher aids students' understanding of the content of science. There were five methods, or teaching strategies that students identified as characterising the teacher's *ways* of teaching: explaining, clarification (reinforcement), discussion, contribution (brainstorming), and choice. These have been summarised in Table 4 with supportive evidence from the student response in interviews.

For each method, a reconstruction of a critical incident (scenario) from classroom observations typifies the discourses and characteristics of each method of teaching. An extended account of each of the scenarios can be found in Appendix 20. This section discusses each method in light of what the students say and the representative scenario.

TABLE 4: *Methods that the Teacher Uses that Help Student to Understand the Content of Science, a Component of the Teacher's Instructional Pedagogy* (A representative scenario reconstructed from observation field-notes and student responses provide evidence for the characterisation of each method can be found in Appendix 20.)

| **Method** | **What the students say** | **Scenario from class** |
|---|---|---|
| Explanation | *It's good cos she explains everything well, more than other people do. [INT4E]* | Explanation of how to use a microscope, focussing here on the purpose and use of the mirror. What is significant is how the teacher uses questioning to get the students to make the explanation in their own words, and then summarises. |
| Clarification | *Over and over again for those who don't understand [INT2C]* | Revision at the beginning of a lesson of the experiments and activities on ammeters, voltmeters, and series and parallel circuits done in the previous lesson, as well as clarification of what electricity is, all in readiness for preparing a practical report. |
| Discussion | *Class discussions are OK when we are included [INT2E]* | A discussion follows a scenario read from the text book where a phone card has been wiped after sitting on the stereo. Students participate freely in a discussion about what has occurred. Students listen to each other, responding to and building up the ideas that emerge. |
| Contribution | *It's good how she doesn't just write the things up but gets other people to tell [INT4E]* | Students draw their versions of a cell projected on the TV screen, then Miss Baker draws the cell as a scientific drawing. The students compare the diagrams and build up a list of rules for drawing in science. |
| Choice | *They could let people decide [INT3C]* | Being faced with not being able to go to Science Works, the teacher responds to the students by allowing them to choose what they do for the last science lesson of the year. |

### 2.3.1. Explanation

The first of the methods identified by the students relates to the teacher's efforts to *explain* the content. The scenario of the teacher explaining the purpose and use of the microscope mirror shows how the teacher directs the thoughts of the students by the use of questioning, rather than providing the details herself. Another element of the teacher's style represented here is her treatment of an incorrect answer. Betty suggests that the mirror directs the image of the specimen up through the lenses. Rather than saying "No, that's not right", Miss Baker incorporates the elements of the students' response into the explanation and refocusses it so that the ideas presented by the student are not incorrect, but made right: "These are the magnifying lenses, so those make the object look bigger, so *you're right, it does go up through there, but what about this bit here, what is the mirror actually doing?*" These correct elements then become part of the summary explanation at the end of the scenario. This was a typical discourse of the classroom, and is evident in most of the scenarios presented here where the teacher is attempting to draw certain information from the students: *What do you think? What happens if? So if it's that, then what if, or what does?* She then ends with a brief summary that draws together students' ideas.

### 2.3.2. Clarification

The students valued the teacher's efforts to *clarify* what had already been said. Such clarification appeared to serve a number of purposes, including allowing the students to realign themselves at the beginning of each class with what had occurred in the previous lesson, to reinforce protocol such as homework responsibilities, and in confirming student understanding of concepts and instructions.

This tendency of clarification related closely to the way the teacher used explanations. Clarification commonly occurred during explanations where the teacher confirmed students' understanding. Kerry stated that the teacher "explains things more than other people do. She makes sure you understand before she goes on" [INT4E]. Explanation with clarification of understanding appears to be considered optimal for this student in helping her feel confident about what she is learning.

Repeating previous lessons and concepts through revision at the beginning of each lesson was a common practice for Miss Baker. There was mixed reaction from the students to this revision as to whether this was done adequately or too much. Nicole called for more "going over" what was done in the previous lesson, while *at the same time* felt that there was *too much* revision at the beginning of some lessons, making science boring at times. The scenario referred to in Table 4 is an example of how the teacher referred to activities performed in the previous lesson and clarification of "electricity" in readiness for preparing the practical report. The scenario emphasises how little students retain from one lesson to the next, and how important it is to not presume that students will bring with them their thoughts and learnings from the previous lesson. Having revisited what was covered in the previous lesson, Miss Baker focuses the students on the fundamental concept of electricity: "Who can remember what electricity is?" and directs it at Fred. Fred's answer is a little vague so Miss Baker prompts him to think further. Out of this prompting came an alternative conception that electrons and atoms are basically the same, just one is more basic than the other. Miss Baker asks for further "clarification" and other students help to put the pieces together. Miss Baker summarises what electricity is after students have shared their understandings, again using student ideas, and then directs the students onto the next task.

Miss Baker's attempt to clarify understanding was not a simple transmission of previously constructed meanings, but allowed students to engage with the process of revision through questioning and probing students to identify and deal with alternative conceptions.

### 2.3.3. Discussion

The role that Miss Baker assumes in a discussion is mainly as facilitator by the use of open questions to allow the students to share their ideas, then directive questions to focus and summarise the ideas presented by the students. Class discussion was seen by students as being more effective for sharing knowledge and a more attractive alternative compared to the teacher simply "telling" them, as the members of the class are "more involved." What is unique about a discussion compared to the other methods used by the teacher is how the students listen to each other as they respond and build on each other's ideas. The purpose of a discussion is to allow the students to share what they know about something and not to necessarily arrive at a pre-determined answer. The spread of ideas has greater prevalence. Discussions were often used as a means of brainstorming, especially at the beginning of a unit to elicit students' current level of understanding and to expose preconceptions, but not always so. In the scenario referred to in Table 4, with very little input from Miss Baker, seven students (plus others who were not picked up by the tape recorder) provided an introduction to what magnets can do and how they are used in everyday life.

### 2.3.4. Contribution

Students acknowledged the tendency of Miss Baker to use students' ideas, *contribution*, through these discussions. Some students were appreciative of being able to contribute what they know in order to build up a concept, as was played out in the scenario referred to in the previous paragraph, and not have the teacher dictate what is going to be learned:

> Kerry: Yeah, it's good how she doesn't just write the things up, ... like get other people to tell. She's good...[INT4E]

An example of the teacher using the students' ideas as the content to be learned is how the teacher devised the list of rules for scientific drawing. It began with something "fun" and "different" – getting some students to draw their picture of a brain cell pictured on the television – and then followed with Miss Baker taking the lead by drawing her own version. The teacher then prompted students to identify the differences using open, focusing and directive questions in order to build up the nine rules. These rules became the content that defined the following activity. They also set the standard for scientific drawing for the future. Similar to the teacher's method of explaining the purpose of the mirror, this activity explains what to remember when doing diagrams. What is produced from the discourse is a conglomeration and meaningful recognition of student ideas that define the activity and the practice of science for the future.

### 2.3.5. Choice

One student alluded to the desire to be able to choose what they do, and from the observations, there was an apparent tendency for Miss Baker to give students some *choice* over what they do and how they might go about it.

The scenario shows how the students were given choice over how they wish to spend their last science lesson for the year. Allowing choice was often a response to the students' desires. This provision of choice sometimes took the shape of alternatives, where the final choice within set parameters was given to the students, and as such the teacher maintained ultimate control. For example, choices could be:

- "You can do either this or this but whatever is not done now needs to be done for homework."
- "You can do anything you want on the assignment as long as the criteria are met."
- "You can try any approach you like to get the mixtures separated given you are safe and we have the equipment."

The presence of constraints and provisos is evident in each of the three examples. Safety precautions must be heeded when allowing students to "discover" and explore during experiments. Within such constraints, Miss Baker made efforts to ensure that *some* choice over what they do and how they organise their time provides opportunities for the students to develop a sense of independence. Student choice occurred in relation to: completing work during class or for homework; selecting the learning experiences they wanted to have, for example, the method for separating mixtures; and, as represented in the scenario, the way the students spent their time designated as play time or flexible time. Although this last choice does not necessarily impact on their learning, it can serve to give students a sense of ownership over a part of the school experience.

### 2.4. Discussion of Instructional Pedagogy

Given students' perceptions of the teacher's instructional pedagogy, it could be concluded that an aim of instructional pedagogy is to provide students with an optimal learning environment where (a) the curriculum is offered in an attractive way by adding variety in order to maintain interest, and (b) there are opportunities for learning through methods that acknowledge students' desire to understand and contribute to their own learning. Students acknowledge that the teacher uses a number of methods in order to help them understand, and have testified that adding variety is vital for maintaining their interest. Such pedagogy emanates from the position of the teacher, who controls the learning environment by directing learning experiences, the curriculum and the way the curriculum is delivered.

For this to occur, however, there needs to be a caring, supportive environment for engaging in active, constructivist learning practices (Noddings, 1993; Watts & Bentley, 1987), as is discussed in the next section.

## 3. Relational Pedagogy

Van Manen (van Manen, 1999) emphasises the relational influence teachers have on their students and that it is important to listen to how students *experience* the interactive dimension of teaching. He has found that teaching is often seen by students in terms of style, personality and qualities such as fairness, patience, commitment, and kindness. When students in this study were asked what they felt as being important characteristics for a teacher, snapshots of both the teacher's style (which is perhaps more represented in the previous section) and how they related with the students emerged. Students made comparisons between or drew on experience with teachers other than Miss Baker to articulate what they perceived as valuable qualities that impacted on their learning.

Students and teachers are in a constant state of interaction, where teachers always have some influence on students, whether it is the teacher's intent or not (van Manen, 1999). Fraser (1994) asserts that the teacher and the environment affect each other. Through this interaction, the teacher and the students expose something of themselves, whether intended or not. What is also fundamental is that "students tend to experience instructional relations as personal relations" (van Manen, 1999, p.23), suggesting that instructional pedagogy cannot be isolated from the relational pedagogy.

Through analysis, six "characteristics of relation" emerged pertaining to how students felt a teacher *should* be: enthusiastic, friendly, non-threatening, encouraging, understandable, and attentive. These are presented here as the "Relational Pedagogy" of the teacher, and

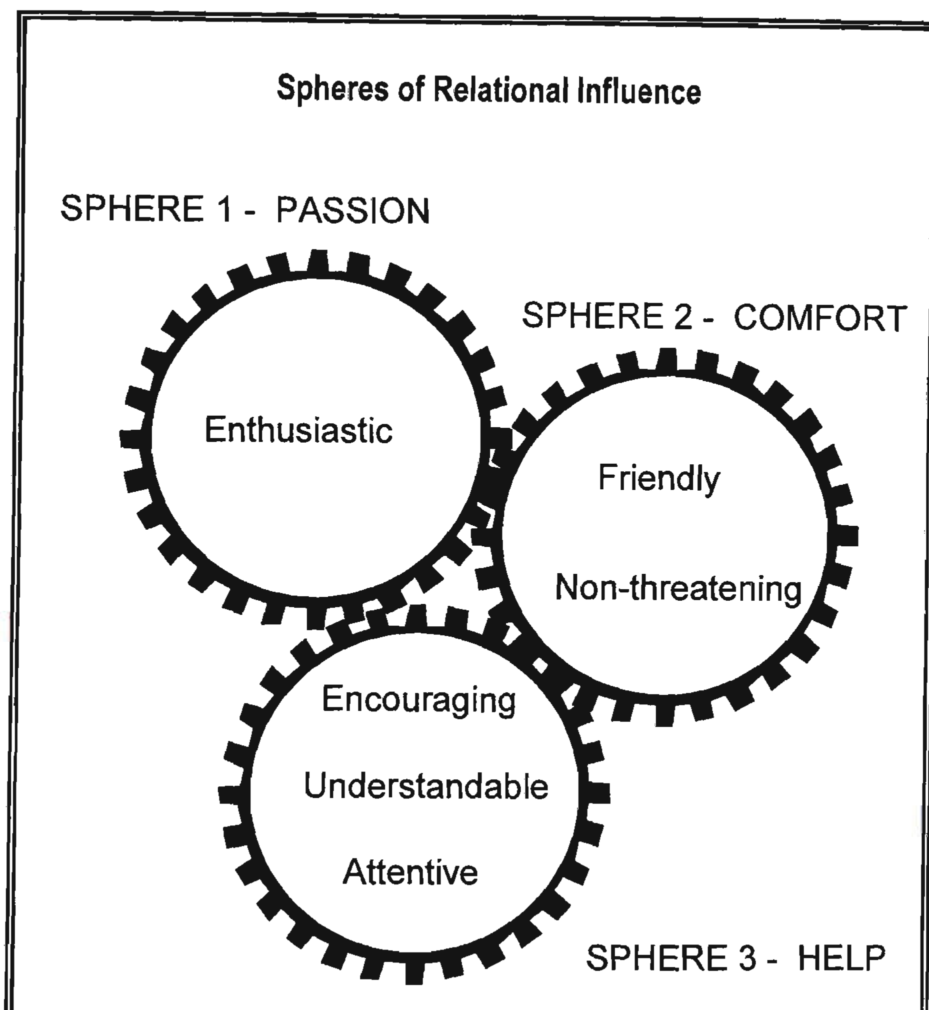


FIGURE 8. "Spheres of relational influence." Year 7 students' reflections of teachers' relational pedagogy are identified as occurring within six categories, then organised within three spheres of relational influence: help, comfort and passion.

represent what students identified as teachers' interpersonal interaction with them. The diagram in Figure 8 represents three cogs, or "spheres of relational influence," inspired by van Manen's (1999) "relations of influence" (p.19): passion, comfort and help.

These "spheres of relational influence" are distinct, consisting of the "characteristics of relation." They are also interrelated as represented by the clockwork mechanism, where if one is activated they are all activated. This representation acts as a summary of the characteristics that different students perceived as being important for a teacher to possess in order to create a secure and productive learning environment.

Barnett and Hodson (2001) assert that two teachers exhibiting the same characteristics and style of teaching may not necessarily have the same level of success in teaching. Therefore, the categories and spheres of relational influence that are accumulated here are pertinent only for those students interviewed.

### 3.1. SPHERE 1: PASSION

In the first sphere of relational influence, students acknowledge that Miss Baker is *passionate* about both teaching and science. Students referred to this as "enthusiasm," which was considered to be essential for students in keeping them interested and enthusiastic. Enthusiasm represents a sense of care, that the teacher cares about what she does and wants to share that with the students: "Cos she's enthusiastic about it and she like enjoys doing it and so she tries" [INT3E].

In discussion with Miss Baker after one lesson, she expressed to me that this particular class "just takes it out of me." She elaborated, saying that it's not that they're hard to handle, but that she feels she has to be "up" all the time – energetic, smiling, cheery. She felt that other classes did not require this sort of energy. This raises the question, was this a response to the needs of the Year 7 class or was it influenced by my presence? Either way, students appear to have recognised the benefit of her enthusiasm.

In comparison, when asked whether they know of any teachers that do not represent such enthusiasm in class, one student felt that a couple of substitute teachers have not been enthusiastic about being there. This appears to be representative of what is expected of substitute teachers at this school, that this is time set aside as time for preparation and correction, so there is an expectation that little effort needs to go into teaching during these substitute classes. This perhaps speaks more about the expectations of substitute teaching rather than an incrimination for the actual teacher.

### 3.2. *Sphere 2: Comfort*

The second sphere of influence incorporates the *friendly* and *non-threatening* characteristics of the teacher in providing a comfortable environment. Students like to have a *friendly* teacher, one that will talk with them: "Can have a chat to you about not particularly school all the time, they can talk about other stuff... in science and out of science" [INT4D]. The teacher shows that they see the student as a worthwhile individual, and that they can enjoy being "friends" with the student. Friendliness contributes to them being able to enjoy a subject. A non-friendly teacher is considered to be more threatening, thereby subsuming the preferred "non-threatening" element of the teacher: "I reckon you've got to have a friendly teacher if you want to enjoy it because you don't want to be sitting there and have someone growl at you or something" [INT2A].

The sense of humour was a common element of the better teacher: "they have to be able to have a joke" [INT4D] and, specifically about Miss Baker with the non-threatening element, "She's pretty good, cos you can have a joke with her and stuff and she doesn't get mad at you" [INT4D].

A friendly teacher ultimately leads to a feeling of comfort for some students. The following response came from a student who was questioned whether she was happy to have Miss Baker as her science teacher next year, or would she prefer to have a different teacher: "No way, no way. I'm sort of more comfortable with a teacher that, well not coaxes but you're sort of friends with instead of another teacher" [INT4C]. The student finds comfort in having this feeling of familiarity about a teacher, somebody they are friends with. This response highlights also the concerns pertaining to transition from primary to secondary school, where students come from a supportive environment with few teachers, to a school culture that has less support, and different teachers for each subject providing less consistent classroom cultures. Nola commented about how difficult this transition was for her:

> Nola: Like in our primary school you always had the one teacher for most subjects and when you get here you have a different teacher for every subject so, it's kind of confusing at the start, like maybe they should have, like in primary school, when you get up into the higher years you should start to get used to it, they should do something so you can get used to it ... easier. [INT4C]

Having found the transition confusing, Nola recommends allowing students to have a greater length of time to get used to the transition into a school that requires contact with different teachers for each subject. The familiarity and consistency emerges as an issue during this time, as was found in research by Ferguson and Fraser (1998) and Speering (1995) into students' transition into secondary school.

The *non-threatening* teacher provides students with a safe environment within which they can learn. As would be expected, students do not like teachers who "growl" at them or "get mad or yell". When asked whether he has seen a teacher "go troppo", Sam said, "Yeah, I think everybody has, mainly in the common room" [INT4D]. None within the classroom could be recalled. Management of student behaviour has the potential to expose threatening behaviour (van Manen, 1999), so handling those "testing" times by the teacher places the teacher's "true" self on display. Miss Baker commented in discussions with me that she felt that this class required very little "management" as such. The following compilation of speech acts from the classroom observation field-notes relates Miss Baker's non-threatening character when dealing with a class that it is unsettled:

> Why aren't people listening, I'm wondering about that
> ...
> We will just wait till you are all listening.
> Who's not listening?
> I'm just thinking about the time we are wasting...
> Sorry Joan, you're being rude. I think you need to apologise to Ken for being rude.
> ...
> Do you think that is a good thing?
> Well, I don't understand why you are doing it
> if you know that it is not a good thing.
> ...
> I'm not sure you're doing the right thing here.
> If you're not I'll ask you to move. So when I come back around I'll come and check.
> OK?
> Right. I'd like you to move please.
> Good on you. That's heaps better.
> Can you see that you're working better now?
> ...
> I know you're talking about it, but put your hand up because
> I want to hear what you have to say.
> What's happening?
> I'm not used to this, you're usually very very good.
> I'm not impressed with your talking. Could you just answer me one question?
> Why are you talking?
> I really want an answer.
> (Looking, waiting ... then smiling)
> If you listen, we can go.

Seven characteristics emerge from this compilation exemplifying Miss Baker's tone when managing a disruptive class or individuals:

1. the teacher's act of confusion in response to the students not doing what they know they should be doing,
2. her demand for politeness and respect for all people,
3. clarity in expectation and setting the limits and consequences, then following through with the consequences but also acknowledging good work,
4. explicating her interest in students, so ensuring that all students can be heard by insisting on hands up,
5. holding students accountable for their actions or lack of respect for others,
6. kindness through smiling, and
7. incentive – where good works are to be rewarded.

Students' responses and classroom observation have portrayed Miss Baker as being fair, tactful and thought-provoking, logical and controlled, rather than domineering, demanding and unfair. Situations are dealt with constructively so as to reduce damaging her relationship with the students.

In summary, students acknowledge the value of a teacher who is friendly and non-threatening as they provide comfort within a safe environment. Oldfather (1994) found that empathic understanding of and response to children's thinking and feeling form the basis for creating nurturing classroom environments that maintain and enhance caring.

### 3.3. Sphere 3: Help

The third sphere relates to students feeling like they are getting "help," or support, from their teachers.

> Sam: [The most important thing about a teacher is] that they understand how you like, what you're like and they do, and they help you and talk to you and stuff. [INT4D]

This issue of knowing that a teacher is willing to give help was common amongst the interviewees and related to the teacher's ability to *encourage*, be *attentive* to their needs, and help them to understand and were only achievable if the actual teacher is *understandable*.

Students respond to a teacher that *encourages* them, both personally and with their work. This encouragement helped students with feeling confident about their work and about themselves as people, thereby also being closely linked to the comfort sphere.

A teacher that listens and is *attentive* to the needs of the students is responsive, acts fairly and acknowledges all students. This puts a relational dimension onto students preferring class discussions, and being able to contribute to and have some choice of what they learn. To bring students to a point of understanding requires instilling confidence in the student through encouragement and being attentive to what the student needs in order to be able to understand. This is an acknowledgment of the individual and requires being able to read, respond to, and relate to an individual, so being able to elucidate what will make the matter of concern have meaning. More importantly for the students, the teacher must be able to present their way of thinking in a way that students can understand.

In the literature, this issue of "help" often comes under the guise of "teacher support" (see for example, (Campbell et al., 2001)) or "supportive learning environment" (Fraser, 1990, 1994) and has been found to be pivotal in building learning environments that are conducive to learning (Fraser, 1990, 1994).

This acknowledgment of the individual in helping them understand and the teacher being understandable is where the two types of pedagogy meet, and is further illustrated in the following section.

## 4. Where the Two Unite – "Good Teaching"

As was shown in the previous section, students prefer a pedagogy that makes learning attractive and understandable. To do this it is important to have a repertoire of teaching strategies. The students recognise also that "good teaching" requires a relationship to be built up that is based on enthusiasm for the subject, providing an environment and relationship that is comfortable through friendly and non-threatening interaction, and by being able to offer help in an encouraging way that is attentive to the needs of the students. This pedagogy contributes to the culture of learning in the classroom.

The following two experiences illustrate what can happen when the relational and instructional pedagogies first, do not conjoin, and then secondly, how powerful it can be when they do.

## 4.1. NOLA'S EXPERIENCE OF SCIENCE TEACHERS

In the following reflection (Fig. 9), Nola is aware initially of her primary teacher's limited content knowledge. Other students have similarly acknowledged the content knowledge of teachers. Nola identified her science teacher as a specialist, but pointed out that she felt that the teacher learned it from a book as the unit progressed. Limited content knowledge made her less of an expert, and definitely did not qualify for the status of "scientist."

| DRAWING ON THE PAST TO TAKE STOCK OF THE PRESENT |
|---|
| Yeah, I think it was good that he could show us what to do [in the first lesson], because I always thought that science was really boring and you did stuff that, like you had lots of abbreviations for stuff that was really simple. [INT1C] |
| [In Primary school] we had this huge thick book and it was over two weeks that you did an activity. And like at one stage we did an experiment of how you can make vegetables grow without actually planting them, the seeds. I don't think we looked at that enough to know what was going on. Like mine was all mouldy and half of the things weren't finished, so we'd start something and wouldn't finish it. And we did some building stuff, like with lego, then making it work. Yeah I didn't really find it that interesting at all. [INT1C] |
| She wasn't actually *our* teacher, like we didn't learn from her all the time so maybe she could have got a bit more involved with us, cos we had a class six teacher and we were usually with her, except when we had music and science. So I think maybe our science teacher could have, like talked to us a bit more and like about school things, because we didn't really know her well enough to know what she wanted. So you got a bit confused so that's why half the things didn't work. Not many people liked the teacher as a person. I don't know. Well, as a teacher, she was a nice person. But you couldn't really understand her as a teacher. [INT1C] |
| [At secondary school there is] more writing out, you get it explained, and I can understand that better. And well, you get to see all the actual science equipment, what they use and that, instead of simple little things. [INT1C] |
| I suppose my ideas of what a scientist is comes from primary school [where] we didn't have a teacher that specialised in science, so even though she taught it I still wouldn't call her a scientist because she sort of learned it from a book as we went along, so she did it as we went as well. So it sort of wasn't really coming from someone who knows. Whereas now, I'd call Miss Baker a scientist because she knows what she's talking about and she's been taught by somebody else... [INT4C] |

FIGURE 9: Reflection: "Drawing on the past to take stock of the present." Nola's reflection of how the teacher's pedagogy in primary school and secondary school science influenced her wanting to learn and enjoyment of science. Taken from interview transcripts of term one and four.

Nola appears more concerned with how available the teacher makes what limited knowledge they have for the students rather than whether the teacher knows everything. Daniel says that he likes a teacher that knows what they are doing and recalls Miss Baker saying she doesn't know much about electricity, but Daniel acknowledges that she does know something, and "that's not nothing!" [INT3D]. This is the pedagogical content knowledge as described by Shulman (van Manen, 1999), where the teacher is able to consider the students' need for understanding when explaining the content. This is exemplified by Nola when she compares her primary and secondary experience of science teachers and feels that in secondary science there is "more writing out, you get it explained, and I can understand that better."

The teacher appeared to have a superficial relationship with Nola and was not able to explain the concepts or instructions in the way that was effective for her. The teacher was not able to judge what the students needed in order to take them to the point of understanding. This is where the instructional and relational pedagogies interact. Of course, there may have been other pressures involved, such as time constraints as could have been the case when they ran out of time when growing the seeds, restricting time for providing clear and personalised instruction. As van Manen emphasises, students' accounts of their teachers must be considered as interpretations of how they experience the teacher and may not necessarily be true accounts of events (van Manen, 1999). For Nola, the ability of the teacher to relate to the students was the determinant. Without that relationship, there was limited understanding *between* the student and the teacher, resulting in reduced understanding *for* the student.

Compare this primary experience of science teaching to what Nola says about the relational development between her and the teacher in secondary science. The teacher is seen to be able to explain things, provide more opportunity to make concrete records of her experiences by writing things down and time to reflect on her experiences which allows her to understand. Nola's learning is enhanced by a teacher with enough content knowledge to draw on, but most importantly enough pedagogical content knowledge influenced by a relational understanding where the teacher understands the needs of the students in order to teach the content appropriately, with time to reflect, so that it is understandable.

### 4.2. A Case in Point: Bottle Rockets

The following is a reconstruction of how the Bottle Rockets incident unfolded. It was constructed from the observational transcripts [OBS13] in order to highlight how listening to the students informed Miss Baker of how to engage students in science by allowing the relational pedagogy to influence and direct her instructional pedagogy. The final sentence of the reconstruction uses Miss Baker's passing comment to me as she reflected verbally on this event experience.

> Students have been doing Thinking Skills for three weeks now, during which time the use of variables as part of the scientific method has been impressed upon the students. During a discussion of a graph from the previous lesson, Lyle calls out to Miss Baker, "How long are we doing 'Thinking Skills' for?"
>
> The teacher turns around to him, looks, and asks, "Why?"
>
> "It's boring," replies Lyle.
>
> "I like Thinking Skills," Fay interjects.
>
> The teacher maintains her gaze on Lyle and asks, "Give me a reason."
>
> Lyle simply responds, "We have to write too much."
>
> "But we need to write to remember what we've done." Miss Baker pauses and then asks, "Don't you like the experiments that we're doing?" Some of the students in the class respond negatively, others are more positive. In response to the negativity, the teacher asks how they suggest the experiments could be changed. Lyle shrugs and says, "I don't know."
>
> Fred however, calls out eagerly, "Blow things up!"
>
> Miss Baker tells the students, "Why don't you go home tonight and have a think about what experiments we can do instead."
>
> Lorraine puts her hand up and suggests something like Deane Hutton's rocket experiment that they saw the previous week as part of Science Week. The teacher pauses with her hand on her chin, looking at the students, then down at the floor. Then she smiles and asks, "What are the variables?"
>
> The students call out enthusiastically elements of the rocket experiment they witnessed as potential variables, which the teacher equally as enthusiastic then records on the board: bike pump, bottle of water, fins as cardboard or plastic, rubber tubing, cork.
>
> Lorraine, who has been contributing to the discussion, asks, "Are we going to be doing this?"
>
> Miss Baker, who is writing madly at this point, says, "I don't see why not. We are looking at variables and this fits in. Which variables are we going to test?"
>
> Nicole suggests water volume. The teacher asks, "Well, what will be our volumes then?"
>
> "Size of bottle?" suggests Nola.
>
> The students then discuss the sizes they could use. During this discussion, all students are watching intently. They either contribute by calling out suggestions or talk excitedly amongst themselves. As a class, they decide on small (650 ml), medium (1.25ml) and large (2L).
>
> Lorraine, a boarder, has an idea of where the bottles can come from. "You can buy Coke from the Boarding House."
>
> "Am *I* buying this stuff," the teacher replies playfully. "No, way! This is *your* experiment!"
>
> Preparations for the Bottle Rocket experiments continue, as students and Miss Baker work out the constraints of doing such experiments, exactly what variables they would be looking at, the number of bottles they will need, what needs to be done if or when some problems arise, efforts to ensure other variables are not introduced but kept controlled, such as the size of the bottle's hole and bottle's shape, and the assignment of who is doing what.

As Miss Baker takes the students through the necessary preparations, she thinks to herself, "Isn't this great. It fits in so well. They have no idea they are doing science!"

In the previous 23 lessons, Miss Baker has developed an environment where students have been encouraged to share their reflections on what they are doing. Miss Baker was also their house teacher[18], so through science and her other contact with students she has built a rapport with them based on enthusiastic, comforting interaction where help is readily available. The students know that the teacher listens to them and will do her best to give them an interesting experience of science. So, when Lyle offers his opposition to the current topic, he knows that it is likely his objections will not go unnoticed. When Miss Baker hears of the students' dislike of the work (although, this is not representative of all students, as expressed by Fay), she acknowledges that she has heard them by asking the question, "Why?" She keep the lines of communication between herself and the students open by asking them "Don't you like the experiments that we're doing?" By doing this, the teacher shows that she has stepped back from the director role and makes herself and the program vulnerable to criticism, but in a welcoming and inviting way in order to show that the opinion and response of the students are important.

This illustration shows how the instructional pedagogy (the choice of teaching strategy used to help students understand the curriculum) is directly influenced by the relational pedagogy (the teacher's efforts to relate to the students), where this relating is based on presenting science enthusiastically. Miss Baker presents herself as a person that is non-threatening so they can express what they think, as long as they can justify their thoughts. In order to help them, she shows that she is willing to be attentive to their needs and respond with a course of action that makes her understandable to the students.

## 5. Discussion of Instructional and Relational Pedagogy

Fraser (1994) has found that "student outcomes might be improved by creating classroom environments found empirically conducive to learning" (p.506). Student perceptions from

[18] In the Middle School (years seven and eight), students are organised within a housing system where a class of students are in the same house. Miss Baker is this class's house teacher, so she meets with them during "house" (25 minutes in the morning) and during "study" (25 minutes after lunch) everyday.

the current study have shown that when the two dimensions of pedagogy are present the result can be the provision of learning experiences that are understandable, interesting and fun, and socially constructed. This is under the direction of a teacher that shows that she cares that the students both understand the content and maintain a positive self-concept about themselves.

In discussing the various roles of the teacher, Hand et al., (1997) asserted that, ultimately, the "teacher's role is to mediate the learning of students" (p.49), where the focus of the teacher should be on getting the learner to a point of understanding rather than on covering the curriculum. "As a mediator, the teacher must ensure that students are given opportunities for quality learning experiences to provide a solid base for learning with understanding" (p.49). Responding to the learning needs of students requires the teacher to learn the best way of representing the material to effect understanding. The teacher could be regarded as a "student/learner" (p.49) to reflect this dimension of teacher response. Tippins et al., (1994) explain the importance of teachers allowing students to compare their new understanding against the extant knowledge by testing the viability of knowledge claims. They assert that it is the teacher's role to consider how to provide opportunities for such testing to occur. Similarly with my study, the students were aware of the teacher's role to provide a learning environment that helped them to understand the science content. Students were seen to prefer a teacher that made available interesting and relevant experiences to promote engagement with learning science; allowed them to test the unfamiliar experience against their existing framework of the familiar through discussions; provided opportunities to reflect on current understanding during revision, where students were able to contribute what they knew; and provided a classroom environment that encouraged and responded to student interests by allowing some choice over their school experience.

Common throughout this thesis has been students' preference to being able to contribute to their learning, especially when it involves interaction with their peers in some way, such as class discussions and group work. Other empirical studies support this response, showing that students appreciate the opportunity to use their own ideas and knowledge, and through such social interaction students feel more valued (Hand et al., 1997). Tobin, Tippins and Gallard (1994) state that

> Group discussions can play a significant role in students' learning by providing time for interaction with peers to answer student-generated questions, clarify

> understandings of specific science content, identify and resolve differences in understanding, raise new questions, design investigations, and solve problems. (p.49)

Promoting an atmosphere of social interaction can enable students to negotiate differences of opinion and seek consensus and further foster students' ability to voice their opinion, even on moral issues. These social contexts of teaching and learning "provide the impetus for a vision of science teaching and learning that is grounded in the search for meaningful experiences" (Tobin et al., 1994, p.49). In a study by Varelas et al. (1999) the teacher successfully developed a learning community with a social-organisational dimension where students felt safe to contribute and voice their thinking and ideas, where there was cross-dialogue between students during lively, respectful discussion, where the teacher revoiced ideas to add value, and the students were given opportunity to think and share ideas orally and in writing.

The perceptions of the students in the current study are consistent with those of other studies into student perceptions of teaching. Some examples may be Palmer's (1999) investigation of "best" science teachers, and Tobin and Fraser's (reported in Fraser & Tobin, 1990) study of "exemplary" teachers. In his evaluation of teaching practice, Haberman (1991) ascribes the term "good teaching" to "the process of building environments, providing experiences, and then eliciting responses that can be reflected on" (p.294). "Good teaching" means "drawing out" rather than "stuffing in" and is identifiable more by the actions of the students than by the actions of the teacher. This can be compared to "pedagogy of poverty," which is restricted to a basic menu of teacher acts aimed at maintaining control. Haberman describes a number of actions that the students are involved in that can collectively constitute evidence of good teaching, such as contextualising facts so that students see the big picture, by encouraging student-directed planning where students make real choices about their learning experiences, getting students actively involved, exposure to the cultural and intellectual heterogeneity of the student mass where students can learn from each other, and questioning existing understandings where a student is able to "compare, analyse, synthesise, evaluate, generalise, and specify in the process of developing thinking skills" (p.294). These actions of students highlighted by Haberman are represented in the accounts of learning and teaching provided by the students of the current study. It is interesting that Haberman does not appear to explicitly discuss the interpersonal dimension of pedagogy. Hanrahan (1998), on the other hand, asserts that interpersonal factors such as the extent to which students feel affirmed by the teacher and perceive support for autonomy in thinking can increase or decrease emotional constraints on reflection of current and prior learning. Deep engagement in learning is dependent on the emotional aspects involved, such as feelings of self-worth and autonomy (Hanrahan, 1998). She argues that the interpersonal factors should be addressed concurrently with "more obvious institutional constraints" (p.738) when considering student participation in decision making about curriculum matters.

Perhaps where the current study is different is that these various characteristics of "best," "good" or "exemplary" teachers identified in other studies represent parts of each of the relational and instructional pedagogies, although the relational is perhaps less identified. I acknowledge that both are part of the same teaching act, but at the same time, I have found it important to dichotomise the pedagogy so as to highlight that, for these students entering secondary school and secondary science, how the teacher relates to them on a personal level has as much effect on student learning as does the depth of their pedagogical content knowledge. To my mind "good," "exemplary" and "best" teachers are aware of how their relations with students, whether intended or not, affect self-esteem and self-concept during their instructional dealings with students.

## 6. Summary

The teacher is seen by some students as having a major influence on the experiences that they have in school science. The way the teacher teaches and relates with the students is pronounced by students as impacting on their learning and the formation of the culture of the classroom, where passion, comfort and the availability of help contribute to how students respond to the various ways that the teacher teaches. The responses presented here identify the following as being valuable for learning: clear explanations, attempts of clarification to monitor student understanding, class discussions that valued students' contributions in socially constructing knowledge, and allowing some choice over their learning experiences to result in a sense of independence, time management and student autonomy with the content. The students consider as essential ingredients for an effective learning culture a teaching repertoire that caters for the students' learning needs, and the development of a supportive relationship.

Having been exposed to a wide variety of teachers for the past eight years, I expected the students to be able to identify what it is about the way teachers teach that helps them to learn, especially drawing on their experience of Miss Baker who has introduced the new experience of learning science. Their experience, perceptions and change in meaning of perceptions about the pedagogy of science can be summarised in the following way:

*Experience:* The teacher strongly influences my enjoyment of a subject, so has a big impact on my perception of science.

*Perception:* The teacher influences my learning in these ways: by defining the curriculum and my learning experiences, and by relating to me, both with the goal of helping me understand.

*Change:* I build up my perceptions of the teacher by experiencing them, both how they teach and how their teaching is influenced by how they relate to me as a person.

# Chapter 6. REFLECTIONS, CHALLENGES, AND POSSIBILITIES

Consistent with my commitment to reflexivity throughout the research process, my position at the end of the research is one of reflecting on my interpretive re-constructions of students' words and accounts of their lived experiences. I do not profess to have captured "*the* truth" about how these students see their learning experience, especially given that the interviewees only represented half of the students with a predominance of the female voice. While not claiming to provide definitive answers to the questions guiding the research, through prolonged engagement at the scene of experiences and by hearing the words of the students I am confident that I have captured the essence of what these students see as constituting a learning environment that promotes their engagement with learning. Reflecting on their experiences during this transition period with the "thoughtful attention of another person" (Knights, 1985, p.90) appeared to help students become aware of specific perceptions, meanings, or behaviours of their own or of habits they had of seeing, thinking or acting. By being prompted to reflect on their lived experiences students have been able to articulate the meanings that these experiences have had for them by making explicit what had been implicit and unquestioned previously (Woods, 1996). At the same time, by being immersed in the culture of the classroom over the course of the year and being able to take an outsider's look at the insider's world, I have been able to be reflective of my own teaching practice, particularly the importance of being attentive to the lived experiences of students in understanding how they want to learn and what best helps them learn.

This chapter begins by addressing the research questions as a methodological framework within which the focusing questions were constructed then addressed through the final analytical stages. Reflections on the findings of the emergent research questions follow, although, in the tradition of ethnographic inquiry, these "findings" were more of a construction than a discovery (van Manen, 1990). The words of the transcript texts were in dialogue with my own lived experiences of the classroom, my relations with the students and teacher, my previous learning and teaching experiences, but especially with my interpretive frame constructed by the emergent patterns and lines of inquiry. In attempting to make meaning from students' words, I acknowledge that I have been involved in an ongoing process of inquiry that began even before my own experiences as a Year 7 science teacher. Given that my purpose of embarking on the research was to gain insight into the relationship between student engagement with learning and the culture of the classroom, my search for understanding continues beyond the research into my own teaching practice still to come.

Three research questions provided the starting point and the methodological frame for the study:

*Research Question One*

> *What experiences do a group of Year 7 students have during science lessons?*

These are the "lived" experiences (van Manen, 1990) of students to which, in recognising them as being experienced, the students attach meaning. It was this meaning that I accessed. A variety of experiences were uncovered through discussions with students in interviews, but the experience selected to be reported by this thesis is that of learning science. Reflecting on their current and past learning and teachers allowed students to construct an image of learning and how the teacher impacted their learning process.

*Research Question Two*

> *How do their expectations and perceptions of science change throughout the year?*

Students were able to present their perceptions and expectations of science four times throughout the year through the focus group interviews. They were able to identify changes to their perceptions and expectations contextualised within their current feelings at the time of the interview and through reflecting on their past experiences.

*Research Question Three*

> *How may the meaning of the experiences during science lessons be seen to be contributing to changes in these expectations and perceptions?*

By being attentive to the meanings of their experiences and the evolution of their perceptions and expectations, I was able to gain some valuable insights into how they perceived and what they expected from their science learning experience.

I approached the research questions from two angles that brought into view the experience of learning in the classroom, specifically, what it is about the learning experience that keeps these students engaged with science learning, and the part that the teacher plays in this learning experience. These formed the two emergent research questions.

*Emergent Research Question One:*

> *What is it about the experience of learning that keeps students engaged with learning science?*

My interpretations discussed in Chapter 4 have shown that the experience here is learning in a sociocultural classroom that provides students with opportunity to interact with both the physical and social environments. As engaged learners who appeared to be focused on learning, students were seen to be interacting with the physical environment of the laboratory and the scientific concepts, with their peers, and by giving meaning to the unfamiliar knowledge by interacting it with the frame of the familiar knowledge. As descriptors of science, the words "interesting" and "fun" were identified by students as indicating opportunities for learning in varying degrees: interest presented both a cognitive and affective response to experiences characterised by a prompting to ask questions, thereby initiating the learning process. I found understanding the role of "fun" in learning more difficult. Many of the students stated that they needed fun to have their interest maintained, and a strong part of this was related to the socialness and physicality of fun, especially being able to interact with their peers and be personally involved in the hands-on side of science.

The science room can be described as a potentially engaging place as long as students are able to construct their knowledge in a social environment and by interacting with the physical environment.

*Emergent Research Question Two:*

> *What role does the teacher's pedagogy play in building a learning environment conducive to student learning of science?*

The students perceive that the provision of such a classroom culture as stated above is primarily in the control of the teacher. Some students do take some responsibility for their own learning but the teacher is seen to make the final decisions about what and how knowledge is to be learned. The teacher was seen to influence students' ability and wanting to learn in two interrelated ways: the methods used to get students to a point of understanding, described by this research as "instructional pedagogy," and the way she related to the students at an interpersonal level, her "relational pedagogy."

Students were clear about how they saw the teacher[19] contributing to their learning, as illustrated in my interpretation of "instructional pedagogy." The teacher is recognised as being in control of the learning environment in two ways. They make learning attractive by providing variety and infusing the learning experience with fun and interesting experiences. They also they make learning understandable by explaining, clarifying through revision and making requirements explicit, allowing students to discuss matters with their peers, valuing their contributions, and giving some choice of what to experience with the result of student autonomy with their learning.

As was stated in Chapter 5, the relational side of the teacher's role was also profoundly represented in students' responses. Three spheres of relational influence in the spirit of van Manen's (1999) "relations of influence" conceptualised how students gave preference to teachers that were *passionate*, and provided a *comfortable* and *helpful* (or supportive) classroom environment.

## Good Teaching

Rather than these two dimensions being two distinct actions of the teacher, the Bottle Rockets episode illustrates that they are part of the same teaching act, and is representative of Miss Baker's concern to provide the students with experiences that will help them understand and maintain interest. The teacher exhibits the two dimensions of teaching with the one teaching act in an attempt to create a classroom environment that responds to the learning and personal needs of students in order to effect understanding. This is what I have labelled "good teaching", and is similar to the notions of "good teaching" from Haberman (1991), "best teachers" described by Palmer (1999), and Fraser

[19] The description is not restricted to Miss Baker as students were encouraged to draw on past as well as present teachers.

and Tobin's (1990) search for "exemplary teachers." What appears to be understated in these other accounts of teaching is recognition of the two dimensions of the one teaching act. My intention was to highlight that the relational dimension of teaching was as important to some of these students in getting them to the point of understanding as was the depth of the teacher's pedagogical content knowledge (Shulman, 1986, 1987). I am particularly disposed to van Manen's (as cited in Oldfather, 1994) view of pedagogy as referring to the way people are "attentive to the manner that students experience their lives in classrooms" (p.26). Creating caring classroom environments where students opinions are heard and valued involves teachers having an empathic understanding of and response to children's thinking and feeling (Oldfather, 1994). The value of listening to students in order to understand how they want to be engaged becomes clear. "Learning in science," says Hanrahan (1999), "may be facilitated by paying attention to students' needs to be treated with dignity ... and be heard and answered in their difficulties" (p.714). Hanrahan argues that students need to feel empowered before they will be motivated to construct their own understanding of science, to feel that they have the permission to take risks when exposing their naïve concepts. Students in this study were interested in having the opportunity to both share their ideas and to listen to ideas of others, even though there was the constant pressure to not look silly in front of their peers. Perhaps what contributed to the willingness and desire for students to contribute was that Miss Baker often provided students explicit permission to present their naïve concepts during class discussions, where they were able to contribute what they considered relevant and valuable snapshots of their realities, and which allowed them in this social setting to intersect the unfamiliar with the familiar.

## A Sociocultural Model of Teaching and Learning

Even though I was informed by the sociocultural perspective, I was surprised by the students' reliance on the social nature of the classroom, as reflected in the reflections and reconstructions. The interpretations of student perceptions were based on their words, and what spoke most strongly to me was the preference of these students to be able to interact with and be stimulated by each other in a social classroom.

My interpretations of student perceptions of how they learn and the role that the teacher plays in their learning have uncovered a preference of a sociocultural model of learning and teaching. I have found that students wish to operate in a social classroom that provides opportunity for them to interact with their peers both physically and cognitively, such as during experiments and through class discussion, group work, and while they work, in order to make their experience of learning more enjoyable and more meaningful. In the literature, although not a new idea, there is mounting attention being given to the effects of sociocultural approaches to learning and teaching (for example, Hand et al., 1997; Hanrahan, 1998; Pressick-Kilborn & Walker, in press; Varelas et al., 1999). O'Loughlin (1992) presents such a model in terms of social constructivism. The students' existing interpretive frameworks that are socially, historically and experientially situated are constructions of knowledge that result from a dialectical interaction between the learner's subjectivity and their "sociocultural situatedness" (p.810). Learning, Hanrahan (1999) writes, "is a much more sociocultural process involving the interpersonal relationship between teachers and students and as such is likely to be enhanced by genuine dialogue" (p.714) between students and teachers. Other research has found that a classroom focussed on socially constructing meaning does not necessarily result in more effective understanding. Varelas et al. (1999) found that in a classroom that achieved relative success in building a "social-organisational dimension" to a community of learners[20] did not attain accompanied success at the "intellectual-thematic level." Students did not achieve understanding as a group consensus of meaning in some areas. Other studies have found a social approach to learning and teaching successful in conceptual change (such as Hand et al., 1997). Adopting the approach that students of the current study are promoting as one that they believe maintains their engagement and enjoyment in science must be considered with care so that what is on offer suits both the teacher and the learning styles of the students. This highlights the important of teachers to be attentive to the social and historical backgrounds of the students. Loughran and Northfield (1996) suggest that these individual contexts of students need to be managed sensitively. Here again arises the importance of listening to students, requiring meaningful and purposeful dialogue between teacher and students as, for example, was offered and found to be successful through Hanrahan's (1999) affirmational dialogue journal writing.

[20] that would participate in classrooms respectfully, make the content relevant to their lives, and keep them interested and motivated,

Hand et al., (1997) assert that within social constructivist classrooms we begin to understand how students can become involved in the culture of science. Their study found that learning in this environment can improve students' attitude towards science and confidence in participating in discussions of science. What students believe and how they feel about their learning has significance in them being able to understand and make personally relevant the content of science whereby scientific literacy can be achieved (Hanrahan, 1999).

## Reflections on the Research Process

Although many of my questions have been answered, many more remain after the final analysis. In relation to the notion of "fun," what is the *something* that makes "fun" so attractive to teenagers? What value does the infusion of fun into the curriculum have, especially in higher grades? How does fun relate to the building of learning environments that are positive for student outcomes? How much of the positive outlook that these students had of science was related to the meeting of their expectations?

The interpretations reported here are only a selection of what my time in the field proffered. Much more could be said that would provide valuable insight into student perceptions of their realities, such as how they see the nature of science, the importance of school science and professional science, and different levels of collaboration that students use depending on the situation, need and availability of sources of assistance, especially in relation to computer use. These are some of the lines of inquiries that would warrant further study.

The qualitative study discussed in this thesis was conducted in the context of one classroom as a single case study. This enabled me to focus on the processes and meanings of students' complex experiences. The strength of ethnographic inquiry lies in the depth and richness of data that is gathered to gain insight into student learning. Given my attention to the single case, the extent to which these interpretations "can be applied to a new situation must be based on a judicious comparison between the two contexts" (Hanrahan, 1998, p.750). In order to provide a basis for comparability, further research into the issues arising during this transition into the secondary setting is needed in a variety of other contexts, such as other science classrooms, schools with differing middle-school structures to deal with transition concerns, different socio-economic contexts, with students of varied cultural backgrounds, in classrooms with different styles of learning and teaching, and with a researcher of a different theoretical background.

Researching the classroom using ethnographic methods required me to capture something of the lives, learning and teaching of the participants where I made the decisions about what was relevant for observing, recording, analysing and reporting. I became aware of the power relations existing between myself and the co-participants. Hanrahan (1998) suggests collaborative action research as an alternative methodology in order to promote the active learning of teachers (and students) rather than reducing them to "passive recipients of the results of someone else's learning" (p.751). She suggests that more collaboration between the researcher and the students and teacher with the way the research is interpreted may be more meaningful to and advance the learning of all directly and indirectly involved.

Finally, in reflecting on the research, its process and the student learning, I offer some words from the beginning of my journey when I considered my perspective as a learner of life:

> And what I see is not just what is in front of my eyes, because we don't always see everything that is in front of us, but I see what is easy to see because it is already there, as a shadow waiting in my head, waiting to have its object connect with it and illuminate the sight.

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# APPENDIX 1 "Confessional tale" of my sensitivities while in the field resulting from my interaction with research and theory

Intensive search of the literature followed later in the project, particularly in second and fourth term. As the research proceeded and particular lines of inquiry emerged my sensitivities changed leading to exploration of particular fields of research, such as research on the nature of science (Abell & Smith, 1994; Cobern & Loving, 2001; Costa, 1995; Hogan, 2000; Jimenez-Aleixandre et al., 2000), and worldview (Cobern, 1996), where I became interested in eliciting from the students their perceptions of the nature of science, phrased for the students as "what science is all about." An alternative method of eliciting students' perceptions of the nature of science, and particularly the experiences and influences on these perceptions, was found in Cobern's heuristic exploration of students' conceptualisation of nature (Martin, Kass, & Brouwer, 1990; Roth & McGinn, 1998; Trumbull, Bonney, Bascom, & Cabral, 2000) and presented to the students in the third round of interviews (term 3). Responses from this heuristic line of questioning contributed to the development of a theme reconstructing students' perceptions of the nature of science, resulting in a chapter written prior to and preceding chapters four and five presented in this thesis. This chapter dealt with investigating how students built their perceptions of the nature of science, but was later excluded from the thesis. Its removal was both pragmatic and directive, allowing more latitude for the development of the remaining chapters, thereby placing the focus of the report on learning and pedagogy. However, I believe that it is important to mention the emergence and analysis of the excluded chapter as the development of the following chapters was partly influenced by the represented data.

Hovering throughout the data collection phase was the cultural perspective as addressed by the literature, particularly the cultural influences on students learning science, such as further research on students' "lifeworlds," worldviews as mentioned earlier, and later in third term drawing in the idea of "authenticity" of school science experiences (Martin et al., 1990; Roth & McGinn, 1998; Trumbull et al., 2000). Continuing the construction of the term "culture" and how it fitted in to the conceptualisation of my research, an alternative to the notion of "culture" was presented through Gee's (Hanrahan, 1999) use of the term "Discourse" to explain the social and environmental influence on students developing literacy, particularly relevant for science in terms of students achieving "scientific literacy" (Hidi, 1990; Hidi, Renninger & Krapp, 1992; Krapp et al., 1992; Prenzel, 1992; Renninger, 1992; Voss & Schauble, 1992).

Another report that attracted my attention prior to entering the field related to group work, specifically phenomena occurring between groups of learners in classrooms. Windschitl (2001) highlighted for me the value in observing not only how students relate to each other and learn from each other within the group, but also how different groups may interact and influence the learning of students in other groups. Therefore, I was sensitive from the beginning to the ways in which students interacted and used each other as a resource for learning.

Through interaction with the students' lives in interviews and during science lessons it became clear early in the research (during first term) that the meanings of their experiences were strongly bound in the language that they used. After allowing the students to analyse the meanings of their words in the second round of interviews, specifically the terms "interesting" and "fun," categorical analyses were compared and informed by the literature pertinent to students' affective response to school science (Hidi, 1990; Hidi et al., 1992; Krapp et al., 1992; Prenzel, 1992; Renninger, 1992; Voss & Schauble, 1992). While such literature had little bearing on the way in which students' meanings of these terms were categorised, it became important later for clarification (particularly (Baird et al., 1990)) and providing alternative perspectives (Fleer & Hardy, 1996).

The constructivist approach and ways of dealing with misconceptions (Cochran, 1997; Haberman, 1991; Henderson et al., 2000; Rickards et al., 1997; Songer, Lee, & Kam, 2002; van Manen, 1999) were foremost in my mind during most of the data collection. I was therefore sensitive to the teacher's elicitation and use of students' ideas during science lessons.

Throughout the year I was particularly sensitive to the way in which the teacher interacted with the students both as observed during the observations and as represented in student reflections in interviews. It was not until after a preliminary analysis that I considered the sphere of the literature relating to pedagogy. The emerging character of the teacher's pedagogy represented by students' perceptions about how she influenced their learning and engagement enabled a guided exploration of the literature pertaining to pedagogy

(Aikenhead & Jegede, 1999). Such literature responded to and informed the in-depth categorical analysis by giving initial clarity of the various meanings of the term "pedagogy."

During observations and interviews I was sensitive to students' varied responses to science, especially those students who exhibited the use of "school games" (Aikenhead & Jegede, 1999). Where appropriate, I made attempts to probe into the home lives of students through questioning whether they do science at home and receive encouragement from parents, although a thorough exploration of their lives out of school science was beyond the scope of the research. Such a restricted focus was employed by Oldfather (2001) in her exploration of students' perception of literacy learning, where she explicitly stated at the beginning that she was not looking at the students' lives outside of the classroom.

In summary, my sensitivities to the phenomena occurring in the classroom were influenced by literature selectively and sporadically throughout the study. My resistance to embarking on a thorough literature search prior to entering the field allowed the data to assemble its own jigsaw through a cyclical interaction between the data and the literature rather than being guided predominantly by a picture constructed by the literature prior to entering the field. Consequently, the data analyses were less informed by reported theory and more saturated with the "feel" of the data. This has resulted in a more representative construction of how the students of this study perceived learning and pedagogy than had my sensitivities been directed strongly by literature.

## APPENDIX 2 Artefacts Proforma

| | |
|---|---|
| **Document Number** | |
| **Date received** | |

### CONTEXT

| | |
|---|---|
| **Setting** | |
| **Actors** | |
| **Event** | |
| **Process** | |

### DETAILS

***Name or description of document:***

***Significance or importance of document***

***Brief summary of contents:***

## APPENDIX 3 Summary of "Thick Description"

| | |
|---|---|
| Observations | Term 1 = 9<br>Term 2 = 10<br>Term 3 = 11<br>Term 4 = 8<br>**38** lessons observed out of 65 lessons for the year |
| Focus-group Interviews | Term 1 over weeks 3-6: 4 interview sessions, 10 students interviewed<br>Term 2 over weeks 1-3: 5 interview sessions, 11 students interviewed<br>Term 3 over weeks 1-3: 5 interview sessions, 10 students interviewed<br>Term 4 over weeks 7-8: 5 interview sessions, 11 students interviewed<br>**19** interview sessions |
| Fieldnotes | Term 1 = 1<br>Term 4 = 1 not typed |
| Informal discussions | Term 1 = 2<br>Term 2 = 1<br>Term 3 = 1 |
| Informal interviews | Term 1 = 1 Teacher<br>Term 3 = 2 Head of Science (not typed); Vice principal |
| Artefacts | Term 1 = 9<br>Term 2 = 7<br>Term 3 = 5<br>Term 4 = 3 |

## APPENDIX 4 Example of Reflexivity in Journal

*REFLECTIONS following OBS04 team teaching session (week 4, 4th observation):*

"... During the teaching I became aware of how a student's behaviour can dictate how well a student is noticed. This is important to consider when observing a class as the observer will automatically have a higher sensitivity to those students that make themselves stand out. There were a number of students that seemed more obvious to me as the teacher. Perhaps they would stand out more to the teacher as the teacher is responsible for meeting the needs of all the students in the class and their attention can be drawn towards certain types of behaviour. As the observer, it is easier to make sure those less obtrusive students are considered in the observation record.

Rather than the types of students standing out, I should concentrate on the types of behaviour that is more prominent to the teacher. This of course will differ between the teachers, depending on level of sensitivity to all students, relationship with the students and teaching style. I did not know the students very well. I know the names of the student that perhaps get themselves involved more as Miss Baker has referred to them more. This sensitivity sets the context for these descriptions."

(Types of behaviours described: "the bright students," "the goers," "the difficult learners," "the disruptive student.")

From "the disruptive student:"

"... These students stand out in the class where my perceptions are limited. Consequently, students that exhibit these types of behaviour dominate my observations, especially the 'activities' that are recorded. These contrast to the students I do not notice, the quiet students that don't get involved in class discussions, so are not picked up by the tape recorder; the students whose names I do not know, they are restricted to a code during observations according to their seating arrangement..."

# APPENDIX 5 Notes on Conducting Observations

**Preparation and Procedure**[21]

**PREPARATION**
1. Take Primary Record
2. Take Field journal
3. Make sure tape recorder has batteries, tape.
4. Stationery: pens, extra paper, plastic pocket for handouts, teacher outlines.
5. Inform Miss Baker of additional observer (where necessary).
6. Note experiences around the yard, corridors, staff room etc to be recorded into Field Journal.

**DURING**
1. Sit near groups that are concentrated on. Possibly move to different places in the room to focus on different groups.
2. Introduce new observer.
3. Collect handouts, documents, examples of children's work
4. Note posters on the wall, displays.
5. Tape lesson, from before entering to after exiting the room.
6. Recording observation (Primary Record)
   a. use "low-inference vocabulary"
   b. see below for procedure for making and recording observations.
7. Ask groups and individuals for permission to observe and/or tape them for a short time – actually approach them and ask, if any objections then move on to next group. Suitable for group work, prac work.

**AFTER**
1. Conduct "member-checks" – get Miss Baker to read typed record of one lesson, with reflections, invite comments.(Occasional)
2. Type observations with a description and justification of approach taken.
3. Where the lesson has been taped, separating typed transcripts and observations should include a coding[22] system so that they can be referred to in the reflections.
4. Record observations into Field Journal.

**Making and Recording Observations (Primary Record)**
1. Diagram of room layout – movement of people, describe areas of room.
2. Context notes – start of lesson, context of this lesson, eg. where in unit, what had happened in previous lesson, events preceding/following lesson eg camps/special events/sport/visitors/incidents during lunch/recess, comments from teacher before class.
3. Thick record – Components and Qualities of "Thick Description":
   a. Speech acts, body movements, body postures – from notes & tape-recordings.
   b. Low inference language.
   c. Record time frequently
   d. [OC] Observer Comments noted – speculations of meaning
   e. Under line speech acts, if not recording
   f. Type up with a coding system.
4. Make specific note of:

[21] Constructed in part prior to entering the field, but updated where the need arose. Also given to the additional observer to assist in her observation of the class.
[22] Only the first, second and fourth observations had separate typed transcripts for the taped version and the observed version. Most converged the two so that the taping informed the observation notes.

g. Friendship groups: how members act (body language, how they talk and what they say) when together/alone; allocation of tasks, change of friendship groups throughout the lesson
h. Interaction between friendship groups
i. Level of work done – range of abilities, student responses to different activities, teacher responses to student work, amount of effort spent reiterating task for groups/class/individuals, amount of prompting required by certain students
j. Responses of groups to parts of the lesson – introduction, theory, prac, use of equipment, clean up, conclusion, other activities, homework, questions (level of knowledge/comprehension)
k. Responses to mention of science initiatives – monitor these responses and pay particular attention to who shows interest, see if their interest changes with time
l. Response to encouragement/reprimanding of teacher

5. May want to change approach-
    - Students focus – individual students for short time eg five minutes
    - Overall – individual agendas (students, teacher, researcher); mood, movement
    - Teacher focus – who/where she directs her attention, how students interact with her
    - Group focus – friendship groups, working groups: Why are they in these groups (physical constraints, teacher directed, student choice – why have they chosen to sit together or interact)

## OBSERVATION PROFORMA

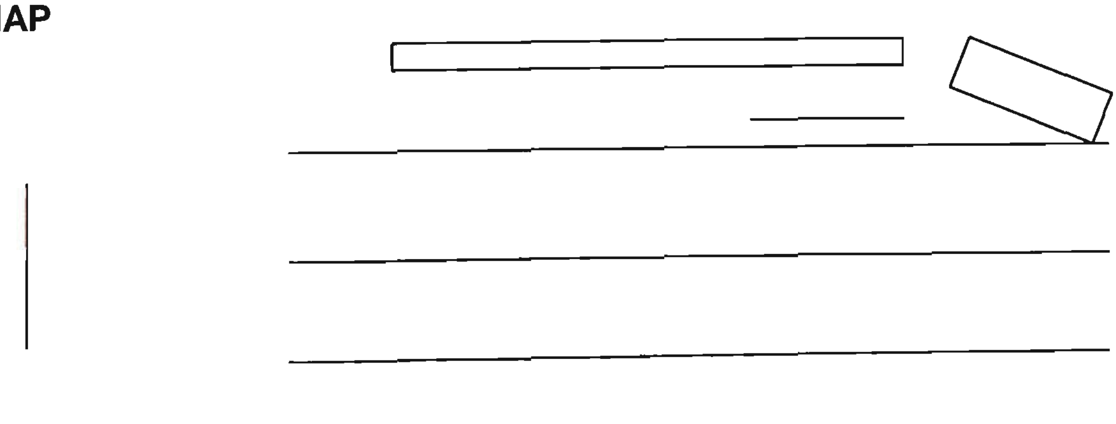
| | |
|---|---|
| OBS Code | |
| Date | |
| Period | |
| Time | |
| Room | |
| Taped | |
| Comments | |

**CONTEXT**

**OBSERVATION METHOD**

**OVERVIEW OF CONTENT**

**MAP**



## OBSERVATIONS

| Time | [1] Name: |
|---|---|
| | |

## APPENDIX 6 Informed Consent: "Plain Language Statement"

The purpose of this investigation is to see what experiences a group of Year 7 students have during science and what they think about the science subject. This will include monitoring whether these experiences change during the year and whether such changes influence the students' expectations and perceptions of the subject.

This information will be obtained primarily through "watching" student experiences during their science lessons – observing student responses to the teacher, peers, activities and use of equipment, whether the students get involved in science-based activities outside of class time and gauging what the students think about the content of the lesson.

I will compile these experiences in an attempt to reconstruct what went on in the science lesson, from which I will gain some insight into which experiences are important in influencing what students expect and think about science. In addition, the science teacher and students will be asked at various times throughout the year to participate in interviews.

An initial interview at the beginning of term 1 will concentrate on:

1. How important they think the science subject is;
2. How much "science" they have done at primary school and at home;
3. What they expect to happen during science lessons;
4. Whether they think they will enjoy it; and
5. What they think their teacher will be like.

Interviews at the beginning of terms 2 and 3:

1. How important they think the science subject is;
2. How much of the science covered so far they have already done at school or at home;
3. What they expect to happen during science lessons for the remainder of the year;
4. Whether they enjoy science (Yes/No) and what about science they do and do not like; and
5. What types of activities help them to learn about science.

Interviews at the end of the year:

1. How important they think the science subject is;
2. How much of the science covered so far they have already done at school or at home;
3. What they expect to happen during science next year;
4. Whether they think they will enjoy science next year and what it will take for them for enjoy science next year; and
5. What types of activities help them to learn about science.

I will observe the class twice a week for term 1, then once a week for the rest of the year. Interviews will be carried out during class time/outside of class time.

Students who do not wish to be interviewed or observed will not be obliged to do so and alternative arrangements will be made during classes that will be under observation. I will be available to any student, teacher or parent to discuss the project. Any student who has given consent to be included in the study may withdraw consent and discontinue participation in the study at any time.

This project aims to help teachers identify which experiences may improve students' enjoyment of science and, therefore, improve student learning.

## APPENDIX 7 Interview proforma

| | |
|---|---|
| **Interview Session** | |
| **Focus Group** | |
| **Student names** | |
| **Day and Date** | |
| **Time** | |
| **Room** | |
| **Comments** | |

**Context**

**Transcript**

[1] L:

## APPENDIX 8 Interview Schedule Term 1

1. How important they think the science subject is;
2. How much "science" they have done at primary school and at home;
3. What they expect to happen during science lessons;
4. Whether they think they will enjoy it; and
5. What helps them learn: how the teacher can help, types of activities.

[ ] What do you enjoy at school? Why?

good at them, enjoy writing, blowing things up, getting out of chair, sitting with your friends, links with hobbies..

[ ] So what do you think of science?
[ ] How important do you think studying science is, and does this means that the science classes you have at school are this important too? Why?
[ ] What do your friends think about science? Do you sit with them?
[ ] When you enter the science room, do you think you need to start acting a different way? – talk differently, sit differently, sit with new people?

[ ] Tell me about what you believe a scientist is.
[ ] Do you know anybody who is a scientist?
[ ] What did you do at school in the classroom, camps, excursion?
[ ] What sort of things do you do at home that is about science – on the TV, computer programs, Internet, books?

[ ] What sorts of things do you think you will be learning about in science this year?
[ ] What do you expect to happen during science lessons this year – so, what types of activities will you be doing?
[ ] What sorts of things do you enjoy doing the most in science – what is going to be fun? Why?

Do they make you learn better?
Are you good at them?
Your friends like doing them too?

[ ] What sorts of things don't you enjoy doing in science - pracwork, discussions, fieldwork, homework? Why?

Make you feel uncomfortable
Boring, would rather be doing something else, yucky

[ ] What can the teacher do to help you think and learn about science?
[ ] What can the teacher do to make your science experience fun?

## APPENDIX 9 Interview Schedule Term 2

1. How important they think the science subject is;
2. How much of the science covered so far they have already done at primary school and at home;
3. What they expect to happen during science lessons for the remainder of the year;
4. Whether they enjoy science (Yes/No) and what about science they do and do not like; and
5. What helps them learn: how the teacher can help, types of activities.

| What do you enjoy at school? Why? |
|---|

good at them, enjoy writing, blowing things up, getting out of chair, sitting with your friends, links with hobbies.

**IDEAS ABOUT REAL vs SCHOOL SCIENCE**

[ ] What is science?

[ ] Do you think there is a difference between the science you do at school and the science that scientists do outside of school? In what ways?

[ ] What do you think Miss Brown thinks of science? What gives you that impression?

**CONTACT WITH SCIENCE INSIDE AND OUTSIDE OF SCHOOL ENVIRONMENT**

[ ] What have you done in science so far this year?
[ ] What sort of things do you do at home that is about science – on the TV, computer programs, Internet, books? *Do you do anything outside of school that you would call science?*

**PERCEPTIONS OF SCIENCE: VALUE, INTERESTING vs FUN**

[ ] What do you think of science?

[ ] How important do you think studying science is, and does this means that the science classes you have at school are this important too? Why?

[ ] What do your friends think about science? Do you sit with them?

[ ] When you enter the science room, do you think you need to start acting a different way? – talk differently, sit differently, sit with new people?

[ ] What do the terms "interesting" and "fun" mean? What in science is (a) interesting, (b) fun?

[ ] What sorts of things *do* you enjoy doing the most in science? Why?

Do they make you learn better?

Are you good at them?

Your friends like doing them too?

[ ] What sorts of things *don't* you enjoy doing in science - pracwork, discussions, fieldwork, homework? Why?

Make you feel uncomfortable

Boring, would rather be doing something else, yucky

[ ] Have your feelings about science changed from *before you started Yr 7* and the *start of the year*?

## LEARNING SCIENCE

[ ] Think of a time when you have really learnt something in or outside of school. What happened to get you to the point of *wanting* to learn about it? Was it the teacher/topic/activity/your choice?

[ ] What (makes you)/(would make you) *want* to learn about science?

[ ] What can the teacher do to help you think and learn about science?

[ ] How can the teacher make it more (a) interesting, (b) fun?

## EXPECTATIONS OF SCIENCE

[ ] What sorts of things do you think you will be learning about in science this year?

[ ] What do you expect to happen during science lessons this year – so, what types of activities will you be doing?

# APPENDIX 10 Interview Schedule Term 3

## Nature of Science (getting away from enjoyment value)

1. (What is the nature of science?) What is **science** all about? What does **scientific** mean? Eg. prac
2. Why is it important to find out about science stuff? What sorts of things do you like to find out and why?
3. What does it mean to be **doing** science? What would it take for you to call yourself a **scientist**?
4. Do you want a career in science? What would it mean if you wanted to be a scientist – what field, type, and **expectations** of this career? What do you want to do when you **leave school**?
5. What does it mean to be **good** at science? Are you good at science? Is being good at science linked with whether you want to be a scientist?
6. How students perceptions of the Nature of Science has formed – **Where did you first experience this idea of science?** Where and how did it begin to develop, what has influenced it, how might this have compared to your perceptions of the Nature of Science pre and post the transition between primary and secondary school. **Primary and secondary idea of science.**
7. At which point does the **idea of science** (Nature of Science) enter the classroom?
8. Ways in that the students have and could experience the Nature of Science – teacher, school, home.

## Importance of science (real vs school; applied and education)

**Real science and school science:**

1. How might the two be able to meet so that you are able to experience this real science? Poss.?
2. Is school science based on getting students involved in real science?
3. How may the teacher be able to link the two and how may this affect students' perception of science?
4. What do you think is the most important thing you can ever do in **science** – important, valuable, useful; fun, exciting, entertaining? What is the most important thing you can do at **school**?
5. In what ways do you think **school science and general science has added to your life** – both in and out of school, now and what you expect for the rest of your life?
6. What are some other factors that influence what you think about science? Eg. Teacher, school, parents, entertaining, would your ideas of science be the same with a boring teacher?

## The teaching and learning (T as person and scientist)

1. What can you tell me about the Teacher? How did you find this out?
2. How do you expect T to behave – as a scientist or as a teacher? Would you consider her a scientist, if so, what are the **characteristics** that make her a scientist?

## Response to the curriculum (enjoyment value)

1. If you had a choice in science, what would you **do** and **know** in science – topics, activities? Why? What I do and don't want to know. How I want to find it out.

2. What have you thought of the **experiences** (list) you've had so far in science? – repeated? Too long? **Other questions.**
3. Explore **"entertainment"** value – how this relates to how the perceptions of science are formed.
4. What does it mean to enjoy something – what about it is enjoyable, how does it make you feel? Is it like being entertained? **Relate enjoyment/entertainment of science to science perception?**
5. Is there a difference between the **boys and girls** in the class – their response to science?

## Culture of school and home

1. Difference between the science culture and the cultures of other KLA's.
2. What happens at home that is science related – what do parents think about science, is it encouraged (comparisons between home and school science cultures)

## Major experiences

What the students thought of them,
How it compared to classroom science
What it taught them about science,
How it contributed to their perception of science.

**Extra-curricular:**
Deane Hutton
Science Week Activities
Science Competition

**Classroom:**
MicroWorlds program assignment – computers
Thinking Science – group work, small experiments, worksheets
Bottle rocket – planning, making, experimenting, evaluating, retesting
Geology – rocks, student directed
Lightning - video

**Alternative Question: "What is Nature?"**

**Focus:** To get students to talk about what they know about "Nature" from which I can establish their understanding and incorporation of science into their constructs of nature. At this stage, these students have done nature as a topic only in primary school, not so far in Year 7. This will be done in term 4. I hope to conduct a similar exploration of their understandings late in term 4 as a comparison – before and after.
From Cobern, et al. (1999) – "understand conceptualisations of Nature and the place science finds in those conceptualisations." The question is given as a series of questions along the lines of the following, with other probing questions to prompt, clarify or expand responses.

**Guiding questions:**

1. Can one *know* about nature? (can you)
2. If so, what *sorts of things* can one know about Nature and *how* do these things become known? (what and how)
3. *Who* finds out these things that can be known about Nature? (who)
4. *Why* do they (or does anyone) seek to know things about Nature? (why)

# APPENDIX 11 Interview Schedule Term 4

**"Looking Back, Looking Forward"**

The purpose of this round of interviews is to explore whether they have perceived any change in how they think about science – reflective opportunity for them to think about the year and what it has done for them in building up their ideas on science. In essence, how their experience of science has been seen to have influenced their conceptualisation of science, and what especially these experiences are.

***Broad Questions:***

How important they think the science subject is;
How much of the science covered so far they have already done at school or at home;
What they expect to happen during science next year;
Whether they think they will enjoy science next year and what it will take for them to enjoy science next year; and
What helps them learn: how the teacher can help, types of activities.

***Prompt cards:***

Derived from the major themes or ideas that evolved from previous interviews and observations, things that I felt impacted or reflected what the students had been saying about science during the year. These will hopefully focus students on the ideas that I want to explore and perhaps provide indirect parameters within which I want their thoughts to develop.

| | | | |
|---|---|---|---|
| 1 | **School science** | 12 | We do lots in science |
| 2 | **Science outside of school** | 13 | We do science for a reason |
| 3 | **Scientists** | 14 | Experiments |
| 4 | **Doing Science** | 15 | Groups |
| 5 | **What science is all about** | 16 | Pracs |
| 6 | Interesting | 17 | Assignments |
| 7 | Fun | 18 | Teacher |
| 8 | Boring | 19 | Activities |
| 9 | Science is the same as other subjects | **20** | **Next Year** |
| 10 | Science is different to other subjects | **21** | **The future** |
| 11 | We learn in science | **22** | **Other stuff** |
| | | **23** | **Primary and Secondary School** |

Building up your ideas of science. For all responses, get them to proffer examples or evidence to show where their ideas have come from. Set them up in these groupings on the table, perhaps ask for any changes in their groupings, depending on the feel of the interview.
**1,2,3,4,5 – dimensions of science and what it means to do science, NOS, what scientists do** Building the general science culture, within which school is or may be seen to be part of.
**6,7,8,9,10,11,12,13,14,,15,16,17,18,19 – School Science culture (14-19 = teacher-defined experiences).** Represent images of the microcosm, sub-culture or tribe of the larger science culture
**20,21,22,23 – expectations, change from past and looking forward** What they see for the coming years and where science fits into that.

## *INTRODUCTION*

Think back to your last days of Grade 6, your anticipation of going to secondary school. You have told me of some of your experience in primary school and compared it to your first few

weeks of science in the first round of interviews. We then explored what you thought about school science compared to real science. We looked at how school science is fun and interesting and what it means to be fun and interesting, as well as when it is not fun and interesting. In the next lot of interviews I got you to tell me about what Nature is and you were able to explore it in your own way, which in many cases included the idea that science is part of it, or that it is a part of science. You explored what it means to be doing science, and what scientists do and what makes somebody a scientist.
Think back now over this year, how you settled into school, how you got to know each other and the teachers, the things that you have experienced in the classroom and outside of the classroom. Cast your mind over the topics you have done in science, the things that you've enjoyed and not enjoyed, how your ideas, attitudes and skills have changed, what you couldn't do and what you can do now, what you wanted to know, what you didn't know and what you do know now.
What I would like to do today is to think about whether you have seen any change in how you think about science. I would like you to think about how your experiences of science (at school, home, walking down the street, on the TV) have helped you build up your ideas of science. So firstly, what has stuck out to you, and then how it has built up your ideas about science in general, not just school science.
Next I would like you to think about what you expect and hope to happen from now, both next year and in the future and where these expectations and hopes have come from. Then think about where science fits into your future.
These cards are snapshots of some of the things we've looked at this year. (Use explanations above of the groupings.)

***SPECIFIC QUESTIONS***

**PERCEPTIONS:**

*Culture of school science – how it is built up/its components, how it is done, importance, what it produces*
*Culture of science in all its dimensions – nature of science, its components, how it is done, importance, what it produces*

**GENERAL**

[ ] How have your ideas about science changed/what influenced this change, including
what science is all about,
what it means to be doing science,
what it means to be a scientist?

**SCHOOL SCIENCE**

[ ] What is the ideal picture of school science, has science this year been all that you thought it would be?
[ ] What do you think have been the main influences on forming your ideas about what school science is?

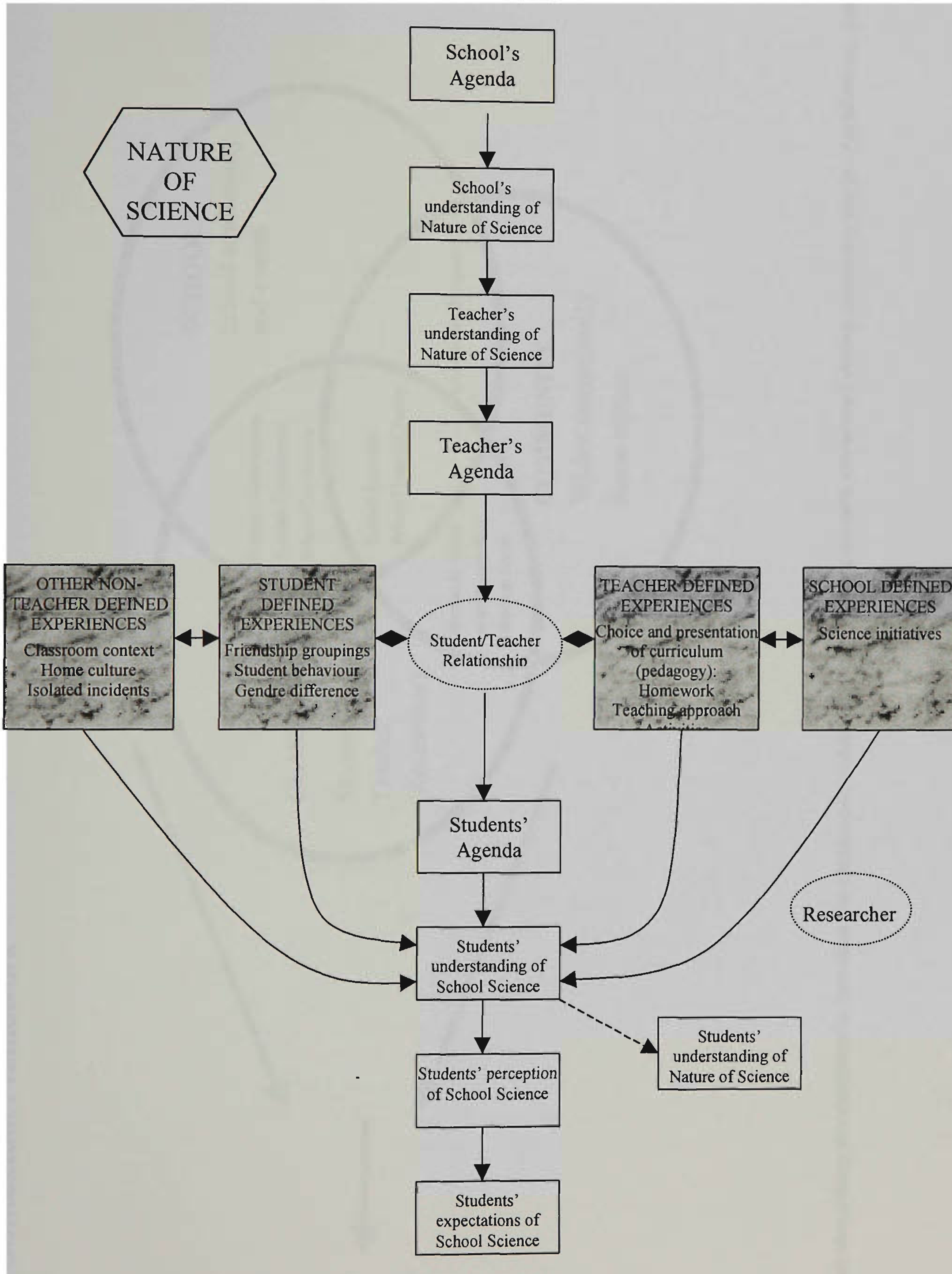
**REAL SCIENCE**

[ ] Is this out of school world of science relevant to school science at all? How does/could /should it enter the science class? What would school science be like if you got to do more of what scientists do?
[ ] Where did you get these ideas about what happens in the world of science outside of school? and how out of school science is seen to be

**EXPECTATIONS:**

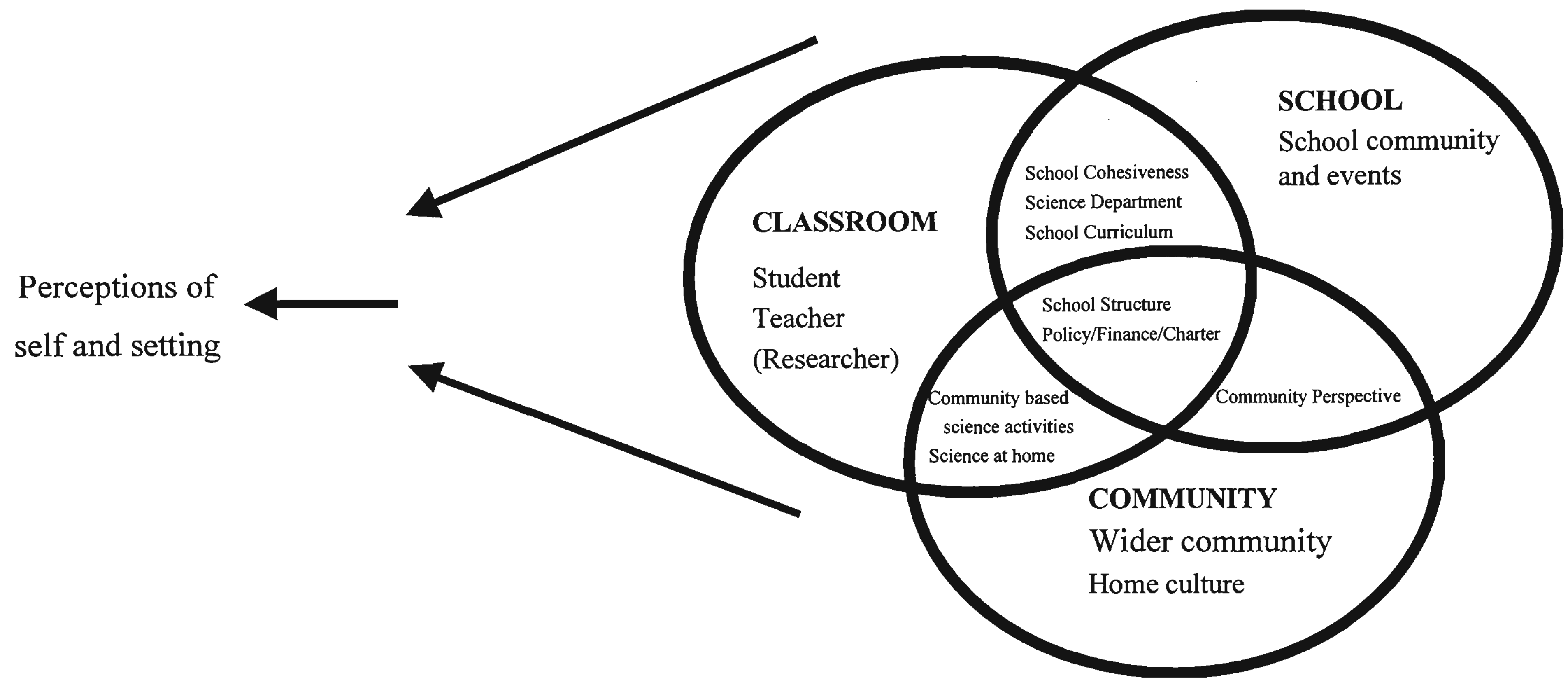
[ ] Have your expectations of science changed?
[ ] What do you expect for science next year? What makes you think that? (eg, role of who the teacher is, since they know that T will be their teacher next year, what)
[ ] How do you expect science to fit into your future?

## APPENDIX 12 Conceptual Framework




Conceptual Framework constructed after week seven during preliminary analysis.

## APPENDIX 13 Contextual Framework




***Contextual Framework describing the relationship between the classroom, school and community contexts, developed during Discovery stage of preliminary analysis. (In progress)***

## APPENDIX 14 Starter List of Codes

| CATEGORIES with definition | CODE |
|---|---|
| **Agenda** | AG |
| School's agenda – Agenda of the College | AGC |
| Teacher's agenda | AGT |
| Student's agenda | AGS |
| **Nature of Science** | NS |
| Nature of science | NS |
| School's understanding | NSC |
| Teacher's understanding | NST |
| Student's understanding | NSS |
| **School Science** | SS |
| Teacher and school science | SST |
| Student's perception of – level of fun vs interest | SSSP (topic) |
| Student's expectation of | SSSE |
| **Relationships (interactions)** | R |
| Student/Teacher | RST |
| Student/Student | RSS |
| Researcher/Student | RSR |
| Researcher/Teacher | RTR |
| **Researcher** | RE |
| Reflexivity | REF |
| Impact on teacher | RET |
| Impact on student | RES |
| Impact on research | RER |
| **Context** | C |
| School structure | CCS |
| School policy/finance/charter | CP |
| School curriculum | CC |
| Science department | CS |
| Classroom | CCL |
| Community perspective | CCO |
| School cohesiveness | CSC |
| **Perceptions of self and setting** | P |
| Perception of roles | PR |
| Perception of self | PS |
| **Student defined experiences** | ES |
| Work level – response to activities | ESW |
| Friendship groupings, | ESF |
| student behaviour, | ESB |
| gender difference, | ESG |
| peer influence | ESP |
| Feelings towards curriculum | ESC |
| Response to classroom discussion/episodes | ESD |
| Response to pracs/activities (other than work) | |

| | |
|---|---|
| **Teacher defined experiences** | ET |
| Choice and presentation of the curriculum, activities | ETC |
| Homework | ETH |
| teaching approach (PEDAGOGY) – questioning etc | ETP |
| management techniques | ETM |
| **School defined experiences** | EC |
| non-science | ECN |
| science initiatives | ECI |
| other curriculum areas | ECC |
| **Other Non-teacher defined experiences** | EO |
| Home culture | EOH |
| isolated incidents | EOI |
| **Methodology** | ME |
| Methodology | ME |
| Observations | MEO |

| | |
|---|---|
| **Episode**<br>(where T and stt are engaged, suggesting student learning)<br>Key characteristics of episode | (E)<br>Classification:<br>CASTE:<br>1 – Discussion<br>2 – Activity from discussion<br>3 – T directed activity<br>RATING:<br>1 – Student Involvement<br>2 – Apparent Learning<br>3 – Impact on perception of science |

# APPENDIX 15 Final Coding List

| Line of inquiry | Categories | Code |
|---|---|---|
| Science Tribe | Science as different<br>Safety Aspect<br>Group Working/Relaxed (Friendship groups and other group stuff)<br>Action (hands on) | SAFETY<br>GROUP/RELAXED<br><br>HANDS-ON |
| | Examples of students showing obvious signs of learning or engaged | LEARNING<br>RESPONSE (direct sign of response (eg.Oh cool!) |
| | Examples of the variety of activities and approaches to delivering the curriculum used by T | ETP<br>q questioning<br>c brainstorm<br>demo demo<br>disc discussion<br>e experiment<br>r exp report (prac)<br>a activity<br>aref in reference to past act<br>st student defined or initiated<br>p play<br>t task/assignments<br>h homework<br>v video<br>comp computer use<br>text textbook usage |
| | Exposure to the lab, any mention of the lab envt, hands-on | LAB |
| | Language – fun vs int | FUN or INTERESTG |
| | Transition issues – prim → sec | TRANSITION |
| | Pedagogy – the way Miss Baker encourages learning | PED<br>MT (management) |
| | Other interactions between stt AND OR t | INTERACT/stt |
| | | INTERACT/teach |
| | | INTRA – GROUP<br>INTER – GROUP |
| Scientific World | Defining or characterising science | SCIENCE |
| | | |
| Scientists | Defining or characterising scientists | SCIENTIST |
| | | |
| | Episodes | E |
| | Reflexivity | REF |
| | Risk | RISK |
| OTHER | Surroundings, eg chairs, walls, school procedures | CONTEXT |
| | Other experiences | EXPERIENCE (describe) |
| | Individuals – characters, preferences, learning styles | IND – with names or as groups |

# APPENDIX 16 Confessional Tale of my "Crisis in Representation"

Throughout the research I attempted to make sense of the emerging ideas and themes in a number of ways. What elements of the culture to focus on, what to represent and how to present it were decided as the research unfolded. What follows is a "confessional tale" of the decisions I made in shaping chapters 4 and 5 of this thesis.

I feel I should begin with a summarized account of what my experiences, values and biases were as I embarked on the research. In March I reflected on my teaching experience prior to embarking on the research and how I thought this might influence what I was sensitive to during observations. I addressed the following issues that I felt may explain why certain experiences were emerging through the research: how close to get to the students and how much of my personal life to share, how to deal with homework, concerns of letting students see me as less than an expert especially in areas where I have limited content knowledge, and my sensitivities to the management techniques other teachers employed. These areas were all centred on the teacher's perspective and it highlighted for me how my focus during classroom observations, especially in the early stages of the research, was largely on getting acquainted with the teaching practices of this teacher and the influence she had in constructing the classroom environment. I found that once some lines of inquiry emerged after the first round of interviews, my sensitivities in these areas shifted.

The first round of interviews were conducted a few weeks into the first term, and were analysed as described in chapter 1. The emergent conceptual framework (Appendix 12) and the analysis of these interviews enabled me to develop lines of inquiry. It was during the formation of this framework that the idea of the "science tribe" emerged. I had also had discussions with my supervisors about school science being seen metaphorically as a "science tribe" that could be distinguished from other subjects by its cultural dress (lab coat and safety glasses) and activity (experimenting with "real" scientific equipment). In these earlier stages of the research when lines of inquiry were still developing I approached my analysis of the classroom in a more "holistic" way as I was influenced by various methodological references that stressed the importance of capturing every aspect of the classroom during observations. Following construction of the conceptual framework I began thinking about how experiences, perceptions and expectations, and introduction to this potential "science tribe" appeared to influence how students constructed their understanding of the importance of school science and the nature of science in general. Using my analysis of the first round of interviews and my intuitive feel for the observational data, I conceptualized these ideas in various models. The first is a student model that identified issues relating to the initial transition period that these students appeared to be going through as they moved from primary to secondary school science, and deals with the question "Why are we doing this?" A second is a teacher model that is basically the reverse of the first and attempts to deal with the question "What are we teaching science for?" This analysis drew in my understanding of the constructivist approach. For example, in the teacher model, I began considering how students' prior experiences and understandings of science could be used in planning the experiences. In the student model, I questioned whether students constructed their understanding of the nature of science by drawing on their prior school science and home science experiences. This raised a further question of whether the nature of science was possibly embedded in the nature of school science. The following interviews in Term 2 and 3 attempted to find out more about students' thoughts on school science, the nature of science and the difference between school science and professional or "real" science. I drew on various researchers to inform the process, especially the heuristic methods of Cobern (2000; and with Gibson & Underwood, 1999)(as identified in Appendix 1). Although this particular line of inquiry is not fully represented in this thesis, there were elements that I found to be instrumental in understanding how students interacted with the components of the lab during experiments and demonstrations, and how they constructed new understanding through interacting prior knowledge with the new science knowledge.

The science class as a "science tribe" became the focus of my analytical reflections after Term 2 interviews. I noticed various ways that the students in the interviews perceived school science. I devised terms to represent these: *The trademark of science* (what makes school science different to other subjects at school, and draws on the safety aspect, group working mentality and the interactive components, such as experimenting and moving around the classroom); *The light of science* (how students see their learning occurring); *The scope of science* (the types of topics and concepts covered and activities that are done); and *The exposure of science* (the experience of the science lab for the first time). These areas were described and conceptualized using student responses.

Term 2 interviews focused further on ascertaining the meaning of particular words that I had identified as being used by students to describe the science experience during the first interview: "interesting" and "fun."

In June I devised a system of recording events, "episodes," that I felt were of interest to the students. Episodes were seen to be key experiences where some or all of the students (and sometimes Miss Baker) appeared to be obviously engaged. These episodes were in the form of class discussions, student-directed or prompted transmission of concepts, and activities evolving from student direction. These episodes appeared to encourage student-directed learning. They illustrate how Miss Baker listened to the students in terms of "what" and "how" they wanted to learn. The episodes were tabulated, noting the key components that characterized them and any reference that students made to them in subsequent observations or interviews. I also rated the episodes according to their form, for example, class discussion, and I attempted to ascertain what apparent effect they had on the students, either conceptually or emotively, using student behaviour and/or responses to them in interviews. I was aware of the subjectivity of this classification, but it provided a mechanism for highlighting potential important experiences that I could draw on in attempting to reconstruct aspects of the culture.

During Term 3 as I analysed some of the data for my conference paper, I noticed that three themes were becoming progressively more pronounced in my reflective and analytical thoughts and writings: students' perceptions of the nature of science, the science tribe and their use of particular language. These were developed as my three lines of inquiry. The final interview for the year attempted to gain students' ideas on these three areas. The coding of the observational data in the in-depth analysis subsequently focused on these areas, and was influenced by the conceptual framework from Term 1 and the ideas captured by the "episode" classification system.

When it came to making decisions on what to represent from the data and how to represent it, I struggled to see how I could present all of these areas in enough detail. Three areas of student perception were selected to focus on during fourth term, drawing in various aspects of the "science tribe": the nature of science and the comparison between real and school science (stemming in part from the Trademark), learning in science (drawing in elements of the Light and Trademark), and the pedagogy of science (drawing on the Scope and Light where it related to the teaching). As I pored over the data I chose to focus firstly on students' perceptions of the nature of science and school science, as this had been partly examined for a conference paper. (This section has since been removed from the thesis as mentioned earlier.) I then focused on how students perceived their learning and the role that the teacher played in this, drawing on my constructed images of the "science tribe."

The interpretations that follow are the culmination of a very long analytical process. My intention to "hear" what the students had to say about their experiences prompted me to represent student perceptions by using *their* words in a series of reflections and reconstructions rather than as abstract writings.

## APPENDIX 17 Context of excerpts contained in Figure 2. Reflection: "Being involved helps me learn"

| INT | STUDENT RESPONSES | COMMENT |
|---|---|---|
| | *Paragraph 1 – Like to be able to interact with lab components*<br>**I like interesting things. I like to learn about it and yeah, I like doing things. I don't like watching and just taking things in, I like doing things cos, when we're just hearing about stuff, it doesn't appeal to me. I really like seeing what happens, things when they get mixed. It's a lot funner and more interesting actually doing it, cos like you can go up there and do something, and you can have a laugh.** | All students interviewed enjoyed the idea of doing the experiments and being introduced to lab |
| 1C | [103]Nola: **I like interesting things. I like to learn about it and yeah, I like doing things. I don't like watching and just taking things in, I like doing things.** | Doing is more interesting than watching |
| 2E | [97]Nancy: Well, when my, it depends, like I'm really interested in the computer thing and the experiments, and solids and liquids and gases, but sometimes **when we're just learning about stuff it doesn't appeal to me.** | Students had completed units on science skills, particle model and had used MicroWorlds computer program. |
| 1C | [82]Nola: Well, maybe like, if we don't do much experimenting in the first seem, in the first half of the year, maybe she could mix up the stuff we do so it's not all on the one topic all the time (Lyle agrees), so your brains not like overloading with stuff to remember and stuff, so maybe whack in a few experiments where there wasn't meant to be one. **I really like seeing what happens, things when they get mixed** and stuff | Question was "What can the teacher do to keep you interested?" |
| 4C | [67]Nicole: I like actually doing something instead of just writing like what you're meant to be doing. I know that writing is sort of a big part of science but, **it's a lot funner and more interesting actually doing it.** | |
| 2B | [34]Sam: When we get involved in it and we like **can go up there and do something**, that makes it funner, cos **like you can have a laugh**, and when you're just sitting down and writing off the board, that gets pretty boring. | Question: "What helps you learn in science?" |
| | *Paragraph 2 – Experiencing it for themselves*<br>*It really helps me if I can* **experience it for myself, like doing the experiments, and** *Miss Baker* **would say "This is a tripod" and we'd say "Oh, OK." So she would help you, but you would still be interacting with the stuff, with the materials.** *But* **what I find boring in class is just doing pracs where half the time I don't learn anything. I learn more things from experiments cos I'm actually doing what they're trying to teach us. Maybe *we learn better* because we like, we do it ourselves, instead of like reading it and we have fun with it, and that makes us remember it more.** | |
| 2A | [30]Fay: Miss Baker. I mean **experiencing it for ourselves, like** kind of **doing the experiments and she'd say 'This is a tripod' and we'd say "oh, Ok". So she would help you, but you would still be interacting with the stuff, with the materials.** | Question: "What can help you learn in science?" The teacher guides the interaction |
| 4E | [209]Nancy: Plus, um, like the discussing, discussion questions made me understand it all, but with our last one just copying it out of the book she made us. Yeah that was easy, but I didn't think I learned anything from it.<br>[210]Kerry: That's true, I don't think I learned anything. | Practical reports seen to be of less of learning experience and more interesting than actually carrying our the experiment, especially when simply copying from book. |
| 4E | [334]Nancy: ... And **what I find boring in the class is about just doing pracs, where half the time I don't learn anything. I learn more things from experiments cos I'm actually doing what** | |

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| | **they're trying to teach us**, and I find it boring when the teacher is just talking about it when she's up at the board. | |
| 4C | [67]Nicole: I like actually doing something instead of just writing like what you're meant to be doing. I know that writing is sort of a big part of science but, it's a lot funner and more interesting actually doing it. | |
| 2B | [174]Sam: No, like when you do the experiments. Cos like mix the things together, I'd rather doing that than the pracs.<br>[175]Linda: What's a prac?<br>[176]Sam; It's like writing down your aims, your conclusions, your method and your materials. That part of the experiments. | |
| 1A | [41]Nicole: We've learned things, like we had to find out about what pyrex glass is, like you learn things and you're working with them so you really learn them.<br>[42]Fay: You're working in groups, so you're not alone. | Students had to investigate what pyrex glass is for homework, then use pyrex glassware during class |
| 2B | [100]Sam: **Maybe it's because we like, we did it ourselves, instead of like reading it and we had fun with it and that made us remember it more.** | Question: "How do the experiments improve learning?" |
| *Paragraph 3 – More interactive and relaxed environment with less pressure to think* | | |
| *So,* **I like science because it's a bit more interactive, a bit more hands on. Like, in maths, you've got to be thinking all of the time. And with this you've got to be thinking most of the time, but it's not as hard and each step you can work it out for yourself. And they don't have to be a particular thing, just whatever you want it to be.** | | |
| 2D | [82]Lyle: Oh, why? Well, I like the Bunsen burners. Um, yeah I **also like it because it's a bit more interactive, a bit more hands on.** | Introduces the word "interactive" |
| 2A | [97]Maree: Well, it's **like**, kind of **maths you've got to be thinking all of the time. And with this you've got to be thinking most of the time but like it's not as hard and each step, you can work it out for yourself. And** work things out yourself and **they don't have to be a particular thing, just whatever you want it to be.** | Students in this int. group had just discussed maths being hard with lots of tests, so the emphasis in maths appears to be getting the right answer. Compare this to Miss Baker's tendency to emphasise attempting of work more important than getting correct answer. |

"INT" column refers to the interview, coded with the interview session of 1-4 (referring to the school Term) and the interview focus group (e.g. 1C means interview session 1 in Term 1 with focus group C). "Student Responses" column shows extracts from interview transcript. [#] shows the paragraph number of that student response from original interview transcript. "Comments" column attempts to contextualise the student response where appropriate to indicate what I consider to be relevant classroom activities; or to share my thinking from earlier stages of the analysis. Paragraphs from Figure 2 are included: words taken from student responses are in bold, with joining words (that help to link the words and identify the leading question where appropriate) are shown in italics. Student responses: student's words that are directly used in the corresponding paragraph are shown in bold.

Responses from the first, second and fourth interviews have been extracted. The possible link between the interactive side of science and students' positive perceptions of science was foremost in my mind from the beginning of the research. During the first interview when the experiments were described as being fun and interesting I became interested in finding out whether students perceived the interactive side of science as being engaging and improving learning. The value of these activities became a focus of my questioning during the year.

## APPENDIX 18 Context of excerpts contained in Figure 3. Reflection: “We learn together”

| INT | STUDENT RESPONSES | COMMENT |
|---|---|---|
| | *Paragraph 1 – influence of the solidarity of student tribe on learning*<br>*There was one time when we were doing rocks. Instead of Miss Baker writing out questions for us, we got into groups and wrote the questions ourselves, like, what we wanted to find out. Then these were* ***put into a hat and*** *we chose a* ***question from the hat and we had to answer it for homework.*** **So, we weren’t just writing out what *we* wanted to find out, we were writing what everybody wanted to find out.** *This type of thing helps me learn* **because *I* know that we’re all in the same boat. You know about the same amount as everyone else. Some person might know a bit, another person might know a bit about it, but it’s different. You put it together. We all sort of share the same interests and we can explain it the same way sometimes. And like, with these questions, other people wanted to find something out and you wanted to find it out as well. But sometimes it’s like, you didn’t want to write it down cos you think “Oh, everybody will laugh at me,” but then somebody else happens to write it down and you get it, and then you think, “Oh, thank God!” and it just makes it easier, it makes it not as uncomfortable.** | |
| 3C | [101]Linda: What do you think is a very helpful thing for you to find things out?<br>[102]Fay: Games about questions.<br>[103]Nicole: Say if you were studying plants or something, you could go find the plant and write down some notes on it, what it looks like, what it does if you can find out about it, or you can just go on the Internet and cheat in a way.<br>*[104]Fay: We’ve done it before. We all put in a couple of questions each and we had to find out about them. And that’s how we can find things out. Instead of writing out a question we do for ourself and Ms T writing out a question for us, we do it between us all and it’s not as boring.* **We’re not just writing out what we want to find out, we’re writing what everybody wants to find out.**<br>[105]Linda: So you’re using the other people the classroom there yeah? And how do you think that might help your learning?<br>[106]Fay: **Because we know we’re all in the same boat.** Like, they **want to find something out and if you want to find it out as well. It just makes it easier, it makes it not as uncomfortable.**<br>[107]Nicole: We share the same interests and we can explain it the same way sometimes.<br>[108]Kerry: **You know about the same amount as everyone else.**<br>[109]Nicole: **Some person might know a bit, another person might know a bit about it, but it’s different. You put it together** …<br>[110]Fay: **And then you think Oh, thank God. You didn’t want to write it down Oh nobody else, Oh, everybody will laugh at me, but then somebody else happens to write it down and you get it,** you feel so much more comfortable…<br>[111]Nicole: That’s happened to me before. | Italics in response drew on a classroom activity where the teacher asked students to write their own questions about rocks and research them for homework, as described in paragraph 1 of this reflection. I have paraphrased this experience using Fay’s reference to it in order to introduce the various responses that emerged relating to this activity. |

*Paragraph 2 – Group work as enjoyable and assisting learning*

**But also, I've always enjoyed working in groups and partners. It's lots of fun and you don't feel alone on it. Like if you're doing an assessable task, like a prac by yourself, you feel more alone and it feels more like a test, and if you do it with a partner and you have fun, you enjoy it, and you like doing it. I think that if you're doing science by yourself it's not that bad, but when it's boring it becomes sort of like "We're going to science, blah!" It's like a chore and you have to do it. But if it's more enjoyable and you *are* learning - cos you don't want to go if you're just having fun, mucking around - but if you are learning and having fun and doing it in partners and doing what you want to be doing, it doesn't become like that. It's not like you don't do anything, cos we have to hand it in so it has to be done. But you have more fun doing it because you're not doing all the work, you have *participation*. And when you're learning in a group, it's like, learning together, where you're working on something and you're both learning at the same time. Like, if you don't know, you can just go, "Oh, can you explain this to me?" instead of asking the teacher all the time, like our teacher might get a bit, you know, "Oh, here we go!"**

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| 4A | [92]Fay: So I have to suggest something to do. **I've always enjoyed working in groups and partners and um, it's lots of fun and you don't feel alone on it, like if you're doing an assessable task, like a prac by yourself, you feel more alone and it feels more like a test, and if you do it with a partner and you have fun, you enjoy it, and you like** doing it.<br>[95]Maree: Can I add to that? I think it's more fun in partners as well because, um, in partners you think of it more as something fun, but when you're by yourself it's like boring, you don't want to do it.<br>[96]L: So where does learning come into that do you think then?<br>[97]Maree: Well, **it's not like you don't do anything,** but mostly someone will want like, force the other person to do it and stuff, but<br>[98]L: Just wait. Betty is lifting up the Boring card.<br>[99]Maree: Well **we have to hand it in, so it has to be done, but you have more fun because you're not just doing all the work, you have participation.**<br>[100]Fay: **I think that if you're doing science by yourself it's not that bad, but when it's boring it becomes sort of like 'We're going to science, blah' It's like a chore and you have to do it. But if it's more enjoyable and you <u>are</u> learning, cos you don't want to go if you're just having fun, mucking around. If you are learning and having fun and doing it in partners and doing what you want to be doing, it doesn't become like that.** | Students have been working on a group assignment "Sell a cell" where students design an advertisement for a body cell. Students got to choose their own groups. Group work up until this point had largely been associated with conducting experiments and was mainly mentioned by students in relation to working or interacting with peers within an interactive, hands-on classroom environment, as seen in the previous theme. This may explain why such firm ideas about working in groups and its impact on learning had not emerged in the interviews till then. My interpretations of these ideas could not member checked due to the lateness of their emergence. (This was the final interview session.) The students, however, draw on similar themes to describe this experience, such as fun and the potential to interact with peers. I had also been sensitive to the way students interact with each other and had focused on inter- and intra-group interactions in previous observations, such as during experiments, and how they relied on each other as they worked on their MicroWorlds projects. |
| 4A | [105]L: How would learning in a group be better?<br>[106]Betty: Because **when you're learning in a group, it's like, learning together**<br>[107]L: Learning together, what does that mean?<br>[108]Betty: Like, **you're working together on something and you're both learning at the same time.**<br>[109]L: How is that a, are you both in tune and you know exactly what's going on in the other person's head?<br>[110]Betty: Yeah, **and if you don't know, you can just go, 'Oh, can you explain this to me?' instead of asking the teacher all the time, like our teacher might get a bit you know, oh, here we go** | |
| 4A | [112]Maree: This is going back a bit. I've been like forward to kind of to science days cos we're in a group<br>[114]Maree: Cos we're in a group. (Others say YEAH!!) And it's really fun what we're doing. | |
| 4E | [106]Kerry: Work more in groups actually. It's a lot more fun. You don't have to get as much information for the prac. | Question probing how to make the "boring" parts of science more interesting "How would you have liked those |

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| | | experiments to be done? So would you perhaps have liked more control over them, would you have liked the teacher to have helped you more, worked more in groups or work on your own a bit more?" |
| OB35 | [30]Betty says to Tracey 'This is going to be the best assignment we've done in ages!!' [OC Because they are working in pairs?'] [31]Fay says to Maree as they leave the room, 'Maree, let's do a really interesting one, OK.' [OC As if they'd do a boring one! It also suggest that they have to know something about the cell to be able to know whether it is interesting or not. Should direct my obs for the library why they chose particular cells?] | Two girls' response to the idea of doing a group assignment. |
| *Paragraph 3 – Working in groups adds confidence* *Also*, **if no one else in my group is confident about doing an experiment, I'm like, this is going to be really bad and I'm going to hurt myself and I sort of, don't want to do it.** *Like with the Bunsen burners,* **I think I saw everyone else doing it so I sort of had a go and found how easy it was so I didn't really get frightened of it. If there's a guinea pig who does it first ...** | | |
| 1C | [96]Nola: Sometimes I am, Like **if no one else in my group is really confident about doing it I'm like, I'm like, this is going to be really bad and I'm going to hurt myself and I sort of like, don't want to do it.**<br>[97]L: So how did you go with the *Bunsen burners* then?<br>[98]Nola: Well, **I think I saw everyone else was doing it so I sort of had a go and found how easy it was so I didn't really get frightened of it.**<br>[99]Lyle: **If there's a guinea pig who does it first...** | Response to question: "Is there anything you don't enjoy in science or don't want to do in science?...So are you actually worried that you might get hurt?" |

"INT" column refers to the interview, coded with the interview session of 1-4 (referring to the school Term) and the interview focus group (e.g. 1C means interview session 1 in Term 1 with focus group C). OBS35 refers to classroom observation number 35. "Student Responses" column shows extracts from interview transcript. [#] shows the paragraph number of that student response from original interview transcript. "Comments" column attempts to contextualise the student response where appropriate to indicate what I consider to be relevant classroom activities; or to share my thinking from earlier stages of the analysis. Paragraphs from Figure 3 are included: words taken from student responses are in bold, with joining words (that help to link the words and identify the leading question where appropriate) are shown in italics. Student responses: student's words that are directly used in the corresponding paragraph are shown in bold.

# APPENDIX 19 Context of excerpts contained in Figure 7. Reflection: "Variety is the 'Spice of Learning'"

| INT | STUDENT RESPONSES | COMMENT |
|---|---|---|
| *Paragraph 1 and 2 – I like having different experiences*<br>**I like learning about the cells and stuff because you learn about something different each lesson and like, first you made clag and then you did a prac and then you learn the parts of the cell and how it works and something different about it each lesson. So it wasn't the same thing over and over again. It's interesting.** | | |
| 4C | [66]Nola: **I like learning about the cells and stuff because you learn about something different each lesson and like, first you made clag and then you did a prac and then you learn the parts of the cell and how it works and something different about it each lesson. So it wasn't the same thing over and over again.** | In Term 4 students were learning about different types of cells and cell components. They made a Jelly cell and used the microscopes to look at cells |
| 4C | [128]Nicole: Well, we're not like sticking on the same cells every day or every lesson when we have science. We're moving on to different ones, yeah moving onto their feature. **It's interesting.** | |
| ***Paragraph 3 – Unique experiences catch my attention***<br>**The stuff** *we did on* **electricity** *I found that* **interesting because Miss Baker did different stuff in it, like the circuit stuff with the piece of string and we were electrons going around the atom wire.** *We* **got smarties every time we got to the people who were the batteries, and that was interesting. It was different.** *And* **it makes you pay more attention because it's different stuff, the stuff** *that* **we actually do.** | | |
| 3E | [193]Lorraine: Um, it's all been pretty important, the stuff we learn. *The stuff about electricity is pretty interesting.*<br>[194]Linda: Interesting? Why do you say interesting?<br>[195]Lorraine: **Because Miss Baker does different stuff in it, like the circuit stuff** today, were you here today? (no) We had like a **piece of string and we were the electrons going around the atom wire. Got Smarties every time we got to the people who were the batteries, and that was interesting. It was different.**<br>[196]Linda: Because it was different, is that why it was interesting?<br>[197]Lorraine: Yep.<br>[198]Linda: Did you learn much?<br>[199]Lorraine: Yep. How they use up all their energy when they get to the globe which, when they sit on the chair, they go around and they lose more energy when they sit on the other chair, which was the other globe. And then they come to the battery and they get more energy again and it goes round and round. And then we had two circuits. So we had one going round the outside, one going round the inside.<br>[207]Lorraine: It just **makes you pay more attention because it's different stuff.**<br>[208]Linda: Different stuff, you mean the way she's doing it or the actual information she's giving you?<br>[209]Lorraine: Yeah. Like **the stuff we actually do** with it that's different. | This circuit activity was done three times during this unit to illustrate various elements of the action of electrons in a circuit. I was in the class during two of these instances. |
| *Paragraph 3 – Lack of variety makes it boring*<br>*Not like the MicroWorlds assignment. Like, I hate it when you're walking to class and you* **know what you're going to be doing for the entire session, and I know that I'm not really going to have to think that much. And that's how it was with MicroWorlds.** *And* **even though it did take a really long time to get all the pages set up and stuff, it sort of dragged on for ages, so you didn't really get much of a variety.** *Staying on the one subject for too long is just boring!* | | |
| 2D | [185]Daniel: Sort of in science at the moment you don't really have to think as much because we **know what we're going to be doing for the entire session,** *but so you don't really have to think that much.* | "MicroWorlds" is the same as the "Dr Van Goof" assignment. It had two parts: experimenting with separating |

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| | | mixtures, then presenting results in MicroWorlds. Daniel and Nola are diligent students that appear to be very successful academically. |
| 4C | [19] Nola: Yeah, I didn't really like doing the MicroWorlds thing, so I sort of felt like I had the wrong impression at the start of the year | |
| 4C | [32]Nicole: Dr Van Goof. When we had to click all the buttons, and then you have to go to a certain page. I didn't get that so I didn't end up doing it, and I got lots of marks taken off for that, but it wasn't explained to me, even though I asked for it. | Not knowing how to do the task appears to be associated with not valuing the task |
| 4C | [57]Linda: Alright, getting back to what you thought science would be like, what I would like you to do is think about what your ideal picture of school science might be like. So if you two could design your year 7 curriculum, how would you make, what would you do in science, so what would science be like?<br>[58]Nicole: Um, just experiments, I dunno.<br>[59]Nola: I'd probably make it like, one lesson you'd do experiments the next lesson you'd do a prac on it maybe, and then next lesson you'd learn something new. Like, something new about the topic that you're doing. And then go on.<br>[60]Nicole: And not stay on the one subject for too long.<br>[61]Linda: Can you think a an example where you stayed on the same thing for too long.<br>[62]Nola and Nicole: Dr Van Goof.<br>[63]Nola: **Even though it did take a really long time to get all the pages set up and stuff, but it still sort of dragged on for ages. So you didn't really get much of a variety.** | For Nicole and Nola, the MicroWorlds assignment dragged on and they found it unproductive for learning. |
| 2C | [172] Nicole: Differences between solids, liquids and gases, condensation um.<br>[173] Linda: Yes, but what's something that really really, has been impressed upon you, that you have really learned?<br>[174] Nicole: Probably the Dr Van Goof experiments, separating salt from salty water, dirt from dirty water, etc, etc. I've learned those experiments off by heart. It interested me...<br>[175] Linda: Why do you think?<br>[176] Nicole: I suppose because I understand it. And in primary school I hardly understood anything (both girls laughing). | Nicole had been enjoying and was interested in the particle experiments for the "Dr Van Goof" assignment as she "understood" them. Compare this to her later impression of the task in INT4C after she was required to use MicroWorlds to present her findings. Perhaps indicates association between feelings of competency and satisfaction of task. |
| 2C<br>2E<br><br><br><br>2E | [101]Kerry: Well, I think it's fun how we do all the experiments and how we're doing Dr Van Goof. (Linda: You're enjoying that?) Yeah.<br>[40]Lorraine: It's sort of, interesting is in a way different to fun, cos if something's interesting it mightn't be fun, it might not be fun. Like the news is interesting, but it might not be fun. Whereas, like Dr Van Goof was more fun than interesting. It depends on the person too.<br>[36]Nancy: Yeah. Like the Dr Van Goof project that everyone liked. So that was interesting. | Examples of Dr Van Goof as a positive experience. |
| 4B | [313] Lyle: Well, I enjoyed the Van Goof assignment but, because I was very experienced with the MicroWorlds language, I wish I wasn't though. And, it's just, going around and helping people, | |
| 4D | [121]Caleb: No. I sort of liked using the MicroWorlds ... | |
| OBS 36 | [19] I walk around the class for a while... I sit next to Vanessa to talk with her about having computers at school ...She said that she liked doing the MicroWorlds assignment but that she got a lot of help from Lyle. | |

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| *Paragraph 3 – Change in activity keeps me interested* <br> ***And* the Demos that Mr S did at the start of the year, it was fun watching him, but it will get boring, because of all the things that we've seen, like Miss Baker *needs to* keep changing things that we do so that we don't do the same thing twice.** | | |
| 1B | [115] Linda: What else do you think she can do? (pause) <br> [116] Sam: She can make it fun so we want to learn. <br> [117] Linda: OK.(pause)Good...Actually, you said that she can make it fun. What do you mean by fun? <br> [118] Sam: Like, make it so that we can do stuff, like what *Mr S was doing his experiments.* <br> [119] Linda: Did you enjoy that? <br> [120] Sam: Yeah. **It was fun watching him, but it will get boring, because of all the things that we've seen, like, Miss Baker keep changing the things that we do so that we don't do the same thing twice.** | Response to what the teacher can do to increase learning. Sam refers to experiments in first lesson by Mr S. |

"INT" column refers to the interview, coded with the interview session of 1-4 (referring to the school Term) and the interview focus group (e.g. 1C means interview session 1 in Term 1 with focus group C). OBS36 refers to Classroom observation number 36. "Student Responses" column shows extracts from interview transcript. [#] shows the paragraph number of that student response from original interview transcript. "Comments" column attempts to contextualise the student response where appropriate to indicate what I consider to be relevant classroom activities; or to share my thinking from earlier stages of the analysis. Paragraphs from Figure 7 are included: words taken from student responses are in bold, with joining words (that help to link the words and identify the leading question where appropriate) are shown in italics. Student responses: student's words that are directly used in the corresponding paragraph are shown in bold.

# APPENDIX 20 Scenarios of Instructional Methods

## Explanation

This is the first time students have been able to use a microscope. Miss Baker takes the students through each of the features that they have already labelled on a sheet for homework and gets the students to think about what each feature might do. She has got down to the mirror. In her normal fashion she asks the students, "What about the mirror, what's the mirror for Betty?" Betty responds, "To reflect the object so it goes up, and when you look through this (indicating the lens) it makes it bigger." Miss Baker thinks for a second. "OK," she says, "these are the magnifying lenses, so those make the object look bigger, so you're right, it does go up through here, but what about this bit here, what is this mirror actually doing there?" Daniel calls out, "It makes the light go around, or up through the lenses." "OK," says Miss Baker again. "If we want to reflect the light, where is the light coming from?" Sam looks around him and then calls out "The room." "But look at mine," responds the teacher. "Where's my light coming from?" Lyle indicates his globe. The teacher points out the box of microscope lamps sitting on the bench and says, "The mirror's turnable, so you can make sure that you've got the maximum amount of light going through, up through the specimen on your slide, like Betty said, and into your eyepiece." [OBS31]

## Clarification

Miss Baker: Alright everybody. Who can remember what we did last time?
Lorraine: Talked about atoms.
Miss Baker: Not up here, we were down there last time.
Sam: Oh, we did that thing with the choc beans (lollies).
Miss Baker: Yeah. We did that up here too didn't we? So the atoms with the choc beans. What else did we do? Caleb, do you know what we did? We did a few experiments. Can you remember what they were? Can't remember? Bob?
Bob: We were using the ampmeter and the volt thingy.
Miss Baker: Yeah the ammeter and the voltmeter. And what else were we doing? Daniel?
Daniel: Series and parallel circuits.
Miss Baker: And we were doing series circuits and parallel circuits. Anything else do you think Maree?...Who can remember what electricity is? Fred?
Fred: It flows atoms and electrons.
Miss Baker: Flows atoms and electrons? Would you like to refine that a bit for us?
Fred: Well, electrons are atoms.
Miss Baker: Are the word atom and electrons exactly the same, or how do they fit together?
Fred: Well, aren't they a different name for, well, one's more basic than the other one.
Miss Baker: Is it?
Fred: Yeah. I think so.
Miss Baker: I think you're on the right track there Fred, you're basically on the right track. We just need a little more confirmation of what's going on.
Fay: It's a flow of protons and not electrons.
Miss Baker: Is it?
Fay: Or the other way around, I can't remember.
Roydon: Right, in a wire, there's positive electrons and a negative electrons.
Miss Baker: Positive electrons!
Roydon: Oh, protons. And the positive are really big and they attract the negative. The negatives are really small ones and they move along to the bigger are protons.
Miss Baker: Right. So the definition of electricity would be the flow of
Roydon: Negatives.
Miss Baker: Electrons. And how does an atom differ from an electron? Maree, do you know?
Maree: They're, the protons don't move, do they?

Miss Baker: Mm hmm. They're kind of stuck aren't they.
Maree: And then the electrons they attract to the big proton.
Fay: I don't get why the electrons don't go to positives in the middle there.
Miss Baker: Because this (the battery positive) is much much stronger. Say if you had one magnet that was quite weak and next to it you had another magnet that was quite strong and you put a nail in between the two mains, which way would it go to do you think? The big or the little.
Students: Big.
Miss Baker: So that's like the big plus. And that one's not so big... So, if you remember we did all of these things... and we did two experiments. And if you could take out your text book please and turn to the first experiment that we did.... [OBS25]

## Discussion

Fay: (reading from the textbook) "You leave your phone card sitting on the stereo for a long period of time. When you try to use it you find that the money has totally disappeared. And since no members of your family have been making secret calls, what do you think has happened to your card?"
Miss Baker: What do you think?
Ken: It's been near a magnet and it's drawn all the credit out of it.
Miss Baker: You think that?
Ken: Yeah, cos if it's been near a floppy disk -
Joan: Yeah, I think that too.
Miss Baker: So, it's been near a magnet and drawn all the credit out. How does the magnet draw the credit out?
(A number of students yell out answers?) Daniel. When you're listening. I'm glad to see we've got lots of hand up cos I want to hear what you have to say. Daniel.
Daniel: (talks about binary code and floppy disks).... Part of the floppy disk is magnetic and when you put something on it it writes it in binary code, like positives and negatives and stuff and it...and it puts the little bits in the right spot and then when you put a magnet over it it puts, it just reorganises everything so that it doesn't recognise it any more.
Lorraine: It mucks it up.
Miss Baker: That's good Daniel.
Betty: Ok. I know what the phone card is. It's like when a magnet touches metal it goes up, well it's sort of like, the card has a bit of metal in it and like it sort of drags it all out.
Miss Baker: Right. Mitchell.
Mitchell: Well, the same thing happens with a mobile phone.
Miss Baker: It draws the credit out of a mobile phone?
Mitchell: No, no, not, I had my SIM card, the magnetic strip at the back, near my phone and you're not supposed to.
Miss Baker: Yep, Ohh, the mobile phone draws the amount of money out of the card.
(some students respond to this idea.)
Fred: It normally does that, when you make phone calls, no, no, the key card, when you make calls.
Miss Baker: Oh, that's interesting. I didn't know that. Joan and Jackie. My eyes are going "What are you doing?" (pause) Please listen. Lorraine.
Lorraine: Because, are these the cards you put in and pull out straight away? They have a copper thingy in it to tell how much money you've got on. And um, the magnets in the machine thingy draw it out.
Joan: When Dad wants to erase floppy disks he just runs a magnet over it.
Miss Baker: Does he? That's quick isn't it! I didn't know it had anything to do with that. [OBS20]

## Contribution

There is a brain cell projected on the TV at the front using the microscope projector. Miss Baker asks who would like to come and draw the projection of the brain cell: Betty, Sam and Mitchell

immediately put up their hands enthusiastically, partly jumping out of their seats.
Betty, Sam and Mitchell walk up to the board and draw their pictures with help from others: "Draw a long line Betty!" "Mitchell's looks like a big ant!" Kieran and Jason get up next to have a go.
Miss Baker says to the students: "I've been drawing for a long time, drawing scientific drawings." She says that she is going to draw her scientific drawing of the brain cell and she asks the students to write down the things that she does that is different to how the students drew it. Students take out their books and begin to chat and make jokes about how the students drew the diagrams compared to the teacher's rendition, which has labels and a heading. Students sit quietly, some writing, some just sitting and looking. Betty clicks her pen. When Miss Baker has finished she stands back and asks the students to comment on the differences between the drawings. As they do, she writes a heading on the board: "RULES FOR DRAWING SCIENTIFIC DIAGRAMS." "OK," she says, "What rules do you think there might be for when we draw things in science?" As the teacher focuses the students on various aspects of the drawings, the students suggest 8 rules, which are recorded on the board. Students note these down. The teacher refocusses the slide on a different cell which the students are then asked to draw according to the rules. As they do so, Miss Baker walks around the class, commenting on the students' efforts. "Good," she says to Nicole and Nancy, "Both of those are really good." She reaches Betty, looks at her drawing and says simply, "A bit sketchy." Betty groans and sits back in her chair. Then Miss Baker whips around on the spot and says "We didn't write that one did we." She walks to the board and writes:

(9) Don't sketch. [OBS32]

## Choice

"I'm sorry," says Miss Baker, "but we are not able to go to Science Works." "But why?" Lorraine asks, sitting up in her chair. Miss Baker looks around at all the disappointed faces to whom the trip had been promised. She explains that the science department of the school doesn't have enough money. Another student calls out, "But we can pay ourselves." Miss Baker smiles, but explains about the school's excursion policy of the school that prohibits excursions that cannot be paid for by the department. The students and Miss Brown discuss the matter further. Miss Baker understands that the students are disappointed about not going and makes a decision. "Well, next lesson is our last lesson and I was going to see if you wanted to get out into the garden. But is there anything else you would like to do that wouldn't cost any money?" The students immediately sit up in their sits and begin calling out suggestions: video, pool, go for a walk. For the next five minutes together they negotiate and vote on what would be their final moments of Year 7 Science. [OBS37]