

CHAPTER 3

LITERATURE REVIEW

In this chapter, I cite from the literature, studies dealing with the attitudes of primary teachers towards science and science teaching. Content knowledge and self-efficacy, as cognitive and psychological factors, respectively, are then discussed. I emphasise the value of methods courses as empirical research fields with examples from the literature. Community and identity and the work of Etienne Wenger (1998) are revisited. Reference is made to research findings on the development of science identity from a variety of sources and a variety of research methods as I clarify my stand on the issues raised.

3.1 Introduction

3.1.1 Attitudes of primary teachers towards science and science teaching

Most of the primary student teachers that I have observed are generally good teachers, being empathetic with young children and able to find new and creative ways to make concepts accessible. However, these primary student teachers tend to shy away from the sciences, particularly when their teaching skills are being assessed. This observation is not new, as it has been well known for decades that the sciences are not highly favoured among primary teachers [Westerback (1982); Ginns and Foster (1983); Barrow (1987); Czerniak and Shriver (1994), Watters and Ginns (1997) and Spector and Strong (2001)]. In other words, many primary teachers hold a negative science identity. A reason for this negative identity could be lack of content knowledge or perceived lack of content knowledge in the sciences. It is to certain science content knowledge that I now turn.

3.2 Science Content Knowledge

The reasons for science educators' interest in learners' conceptual understanding of science as well as their alternative concepts are not hard to find. Science is about natural phenomena - and, which is all too often overlooked, science is about human effort and action to describe, understand and explain natural phenomena. For this reason, student teachers' understanding of certain natural phenomena was investigated. The reason for testing students' ideas is that what we know about scientific phenomena influences our science identity. Selected areas in which student teachers experience difficulty are selected as part of the course content for each year.

3.2.1 Alternative Concepts

For some years it has been obvious to educators that learners bring to school, sundry ideas about natural phenomena that they have constructed in order to make sense of their surroundings (Driver 1982). Frequently, the explanations children or learners construct are not in tune with generally accepted scientific explanations. Research has indeed demonstrated that many primary student teachers (and their pupils) hold ideas about science concepts which are at odds with accepted science theories (Driver, 1982; Atwood

and Atwood 1996, 1997; Ginns and Watters 1995; Summers and Kruger 1994). In the case of science teachers, faulty conceptual understanding is very likely to constrain efforts to teach small children about natural phenomena. Accordingly, several concepts were selected for further investigation. The concepts (listed below) were selected on the following criteria:

- appearance in the **Revised National Curriculum Statement**, with particular reference to the intermediate phase
- having been a subject of research elsewhere giving one a point of comparison and also the use of tried and tested instruments
- having been identified in pilot studies as a potential issue of concern

Accordingly, the concepts selected for the study are as follows:

Photosynthesis / Green Plants Produce Their own Food / Plant Nutrition; Scientific Understanding of the Word 'Animal'; Magnetic Properties of Substances; Causes of the Seasons; Change of State.

3.2.1.1 Photosynthesis / Green Plants Produce their own Food / Plant Nutrition

Photosynthesis has long been acknowledged a difficult topic to teach and to understand. The following brief explanation of the process attempts to shed light on some of the intricacies of the process.

Chlorophyll-containing plants are truly autotrophic organisms. They build body mass from carbon dioxide and water, the chlorophyll molecule playing a role in the transfer of energy from the sun. Photosynthesis has long been acknowledged a difficult topic to teach and to understand. The conceptual demands of the topic of plant nutrition are not inconsiderable. Arnold (1980) sums up the demands made by the abstract and complex concept of photosynthesis by pointing out that pupils are expected to understand that:

'an element, carbon, (which is solid in pure form) is present in carbon dioxide (which is a colourless gas in the air) and that this gas is conveyed by a pigment (chlorophyll) in a green plant into a sugar (a solid, but here invisibly in solution) when hydrogen (a gas) from water (a liquid) is added using light energy which is consequently converted to chemical energy'.

It is not surprising, therefore that learners appear to find it difficult to understand that the biomass of a tree, for instance, originates in carbon dioxide and water. We can understand why learners have not mastered the required concepts (Simpson and Arnold 1982) and why they find it much more plausible to believe that plants obtain food by

'sucking' it, via roots, from the soil. Indeed, many researchers have identified just this idea (Bell 1985; Eisen and Stavy 1988; Haslam and Treagust [1987]; Amir and Tamir [1994]; Ozay and Oztas [2003]). As well as the common alternative concept mentioned above, researchers (e.g. Capa, Yildirim and Ozden [2001]; Marmaroti and Galanopolou [2006]) identified other areas of conceptual difficulty, including:

- ideas that plants are heterotrophic
- confusion between photosynthesis and respiration
- uncertainties about the function of chlorophyll
- uncertainties about the role of carbon dioxide
- uncertainties about the role of sunlight
- confusion about light and heat as energy sources for photosynthesis
- incomplete concepts about energy
- the idea that plants always need light to grow
- ideas that plants have multiple modes of nutrition
- difficulties with scientific terms like gas

Barker's (1985) study revealed many instances where students failed to distinguish correctly between the material and non-material components of photosynthesis. For instance some learners regard gas as a non-substance, and suggest that sunlight energy changes into food. Understanding of the meaning of the word 'food' appears to have contributed to the general confusion and lack of understanding about photosynthesis. Possibly as a result of everyday speech and unscientific terminology, some learners appear to consider carbon dioxide, water, proteins, sugar, starch, mineral salts and plant fertiliser all as 'plant food'.

As indicated above, the concept of photosynthesis has been well-researched and documented over the years. Educators are aware of the difficulties encountered by learners who meet photosynthesis for the first time. Possibly for this reason, much time and effort has been spent by researchers on designing teaching and learning materials. Research has been conducted on some of these packages, in turn

3.2.1.2 Scientific understanding of the word 'animal'

The scientific concept of 'animal' encompasses several other concepts. Research by educationists such as Bell (1985), Bell and Barker (1982), Kattmann (2001), Trowbridge and Mintzes (1988) suggest a general tendency among learners (and the public) to equate the word 'animal' with the word 'mammal'. Research suggests that learners seem unclear

as to the idea of sets and subsets or the notion of levels or ranks of biological classification.

The work of Kattmann (*ibid*) suggests that learners may prefer to classify animals along habitat and locomotion lines. Learners may be responding intuitively to the notion of 'grouping' when they use non-biological classification schemes. Trowbridge *et al.* (*ibid*) suggest that many alternate animal classification systems remain intact in the minds of learners for several years.

3.2.1.4 *Magnetic Properties of Substances*

Magnetism is a property exhibited by very few materials. These materials (said to be magnetic) are attracted by magnets. A magnet exerts a force on these magnetic materials even when the magnet is not in contact with the material. Magnetic forces act in all directions around the magnet.

Misconceptions regarding magnetism and magnetic materials have been reported by Gagliari (1981); Barrow (1987b), (2000); Finley (1986); Ashbrook, (2005); Finkelstein (2005). According to Hapkiewicz (1992) misconceptions about magnetism include the following:

- All metals are attracted to a magnet
- All silver coloured items are attracted to a magnet.
- All magnets are made of iron.
- Larger magnets are stronger than smaller magnets.
- The magnetic and geographic poles of the earth are located at the same place.
- The magnetic pole of the earth in the northern hemisphere is a north pole, and the pole in the southern hemisphere is a south pole.
- Only magnets produce magnetic fields.
- A magnetic field is a pattern of lines (not a field of force) that surrounds a magnet.
- In a magnet, the magnetic field lines exist only outside the magnet.

For the purposes of the present study, the alternative conception focus is largely restricted to the first two conceptions i.e. '*all metals are attracted to a magnet and all silver coloured items are attracted to a magnet*'.

3.2.1.4 *The Causes of the Seasons*

Accepted scientific understanding about the reasons for the seasons is related to the tilt of the Earth on its axis as it orbits the sun. However, other, alternative ideas about why we experience seasonal change still exist and persist. The most common idea seems to

involve the distance between the Earth and the sun, which encompasses the idea that we are closer to the sun during summer and further from the sun during winter. As evidenced by the video recording of graduates' and faculty's ideas about the causes of the seasons, entitled 'A Private Universe', many well-educated persons hold alternative concepts about annual changes in the weather.

Joan Lindgren (2003: 21) comments that this particular video recording:-

'... (M)ore than any other message or reading that I can offer, engages students in the ideas regarding alternative conceptions.' Lindgren goes on to describe her approach to the topic, which uses *i.a.* a discrepant event strategy to help student teachers confront their erroneous ideas. Atwood and Atwood (1997) found that almost all of the 51 pre service primary science students participating in their study revealed alternative views about seasonal change. Bakas and Micropoulos (2003) describe similar findings among secondary school students in Greece. Kikas (2004) and Summers and Mant (2005) also worked with pre service teachers and seasons. Further research into South African learners' and teachers' ideas would not go amiss.

3.2.1.5 Change of State

The particle model of matter explains that all matter is composed of submicroscopic 'bits' of something. Scientists may call these 'bits' atoms, molecules, ions; and it is generally accepted that these 'bits' or particles are in a state of constant motion. The speed of motion alters with energy changes, but the particle size does not change. However, the size of the spaces between particles does change, for example as particles acquire more energy and move further apart as the substance as a *whole* occupies more space⁵⁸.

The item selected for the present research focuses on **condensation**. Bar and Travis (1991), using the same question as that in the present questionnaire, found that Israeli children, aged 11 to 14 years, experienced conceptual difficulty when required to account for the change of vapour to liquid. Similar findings have been reported by Novick and Nussbaum (1978), Glasson, Teates and Roychoudhury (1988), Osborne and Cosgrove (1983), Nussbaum (1985) and Thorne (1990).

3.2.2 Self Efficacy and Outcome Expectancy

Bandura's (1977) self efficacy construct has been introduced in the previous chapter. I have also indicated that the notion will be used in a similar way to that of 'confidence'.

⁵⁸ In other words, matter expands when heated . . .

Therefore, for example, if a teacher has low self-efficacy in his / her knowledge of science and ability to teach science, he / she may be said to show a lack of confidence in his / her science knowledge and ability. During this research, the notion of self-efficacy will be used to help understand certain behaviors of the student teachers as they engage in the practices of science teaching.

Riggs and Enochs (1990) developed and validated an instrument to measure science teacher efficacy beliefs i.e. the Science Teacher Efficacy Belief Instrument (STEBI). Later in 1990, the instrument was adapted for use with pre service primary teachers, and is referred to as the STEBI - B (Enochs and Riggs 1990). A minor modification of this instrument, which has been used in this thesis, I have named the STEBI – B (BT⁵⁹). This research intends to

- determine the science teaching self-efficacy belief of selected cohorts of student teachers
- investigate and record changes in science teacher identity of the student teachers as they engage with learning and teaching natural sciences

Several reasons, separately and in combination, may be responsible for low self-efficacy. A number of researchers have taken the notion further and have investigated self-efficacy in conjunction with a variety of science education issues. These include *teacher beliefs and behaviours* (Czerniak and Shriver, 1994); *pupil control or discipline* (Enochs, Scharmann and Riggs, 1995); *factors impacting on self-efficacy* (Morrell and Carroll (2003); *beginning teacher experiences* (Mulholland and Wallace, 2001); *durability of improved self-efficacy* (Palmer, 2006); (Mulholland and Wallace, 2001); *science conceptual understanding* (Bleicher, 2006); *science and mathematics methods course evaluation* (Brand and Wilkins 2007). Indeed the STEBI B instrument itself has been the focus of re-examination by Cantrell (2003) and Bleicher (2004) among others. This research will refer to self-efficacy or confidence changes (if any) during primary science methods courses as students' learning-to-become facilitate identity repositioning.

3.3 Methods Courses

Methods courses are useful and convenient sites for research into teacher education because the learning activities embodied in such courses are (or should be) very similar to the best activities of practicing teachers⁶⁰. It is during the methods courses described in chapter one of this thesis that students get opportunities to demonstrate their teaching

⁵⁹ BT refers to Barbara Thorne.

⁶⁰ These activities would include scaffolding, interaction and mediation as discussed in the previous chapter.

abilities in many ways. Methods courses, therefore, are sites of practice. Butzow and Davis (1975); Dobey and Schafer (1984); Summers and Kruger (1994); Adams and Griffard (2001); Akerson (2005) and others have conducted research into methods courses for a variety of purposes. Several instances follow.

Attempts to improve student teachers' attitudes to and concept knowledge in science have been reported by Roychoudhury, Tippins and Nichol (1994) in terms of *feminist* pedagogy which aims to reduce apprehension about science among girls; Guillaume (1995) on the *processes* by which student teachers come to learn about teaching science. Ginns and Watters (1995) monitored student teachers' *attitude* changes during a number of science courses, one of which was a methods course. Several other researchers [Koballa and French (1995), Abell and Bryan (1997), Huinker and Madison (1997), Meichtry (1999), Smith and Gess-Newsome (2004)] also point to the primary science methods courses as a potentially powerful site for conceptual and attitude change among student teachers.

A compulsory natural sciences course (at the University of the Witwatersrand) is, for many students, the only time in four years of post-secondary study that they encounter any science content, let alone science teaching methods. The methods courses, therefore, provided an appropriate research field for this study.

3.4 Community, Learning and Identity

3.4.1 Community

The work of Lave and Wenger (1990) and Wenger (1998) has provided insights into learning within a community of practice. A community of practice may be understood as a group of people formed around a common enterprise. Wenger (1998:73) identifies three dimensions along which a community of practice is defined. These are

- *mutual engagement* during which participants work together in diverse ways, sometimes harmoniously and sometimes not.
- *joint enterprise* where participants are involved in a dynamic rhythm of negotiation and renegotiation of meaning.
- *shared⁶¹ repertoire* where the group develops common understanding of words, terms, signs and symbols, 'in-jokes', specific historical events

This reciprocity does not suggest that all people within a community of practice engage with the practice to the same extent or, indeed, in the same way. In other words, not all participants engage fully or identify fully with the practice. In this way, within a single

⁶¹ It should be noted that these underlined terms have similar meanings which embody 'togetherness'.

community of practice, a wide range of forms of participation (or non-participation) are enacted and a wide range of identities are authored. The issue of non-participation has been outlined in the previous chapter and will be taken up further at a later point.

3.4.2 Learning

Learning by participation in a practice is apparent in contexts described by Lave and Wenger (1990) which involve types of apprenticeship such as novice tailors. In a related way, the same concept can be used to explain the activities of members in several other communities, one of which is the 'learning to teach about science' community which I describe in this thesis.

In many spheres of life, people join communities as peripheral newcomers, with the intention of learning about the practice in question - the word practice is well used here, for the newcomers practice what it is that they wish to learn to do. This intention to learn presupposes their eventually becoming full participants in the practice, moving centripetally towards the core as they become more competent, or as they learn. Wenger's (1998) seminal work on communities of practice provides essential insights into identity, which, according to him, is an essential component of learning because learning something changes who we are, or in other words, changes our identity. For Wenger (*ibid*), identity involves learning as [being and] becoming. Therefore if we return to the South African Norms and Standards Document for Educators mentioned in chapter one, teachers are expected to

- *be or become* mediators of learning
- *be or become* interpreters of learning programmes
- *be or become* designers of materials
- *be or become* leaders, administrators and managers
- *be or become* lifelong learners
- *be or become* Learning Area or Phase specialists⁶²

As student teachers are taught about and possibly learn about science, their knowledge base changes and their identities also change. It should be noted at this point that learning (about science for example) is *not always* a necessary consequence of having been taught (about science) [Lave and Wenger 1990]. Nevertheless, according to Wenger's social theory, learning is inevitable, because if we fail to learn one thing, we learn something else.

⁶² It is to be understood that this demanding type of 'being and becoming' should take place over time and not overnight.

Experience suggests that the student teachers with whom I come into contact illustrate four basic science teacher trajectories:

- a beginning and a continuation, both characterised by little interest in teaching science
- a beginning and a continuation, both characterised by great interest in teaching science
- a beginning and a continuation, the beginning characterised by little interest in teaching science and the continuation characterised by greater interest in teaching science
- a beginning and a continuation, the beginning characterised by some interest in teaching science and the continuation characterised by little interest in teaching science.

It is what happens between the beginning and the 'end'⁶³, as it were, that is less obvious to the onlooker and which is to be investigated here. In other words, 'How are science teacher identities influenced and developed?' With what science identity do they enter the methods course and what science identity do they construct during the methods course? Certainly, much of the literature suggests that race, class and gender are prominent role-players in the scenario. They are not, however, the only factors of influence, as will be illustrated later in this Literature Review and in the findings of this research.

The notion of positional identity - which is to be understood as the space where we are positioned i.e. at the intersection of various subjectivities (race, gender, class and religion) – has been used by Felicia Moore (2008) who argues that we exhibit and enact multiple identity markers or positionings. In this way, intersections vary for different people and we are positioned at different points along a continuum. I shall illustrate how some of the student teachers participating in this research were positioned, not entirely passively, according to (*i.a.*) gender, race and religion.

3.4.3 Identity

In this review, I focus mainly on research into science identities and science teacher identities, although I mention some research into identities in general as well. In various contexts and by various means, researchers have examined the identities, science identities and science teacher identities of diverse groups of people. Because of the wide range of research into identity, my review of the identity literature may seem somewhat

⁶³ The 'end', in this case, refers to the point at which this research ceases, not the end of the student's career.

fragmented. However, I have attempted to group the research areas into coherent clusters when reporting on the literature pertaining to different groups of participants⁶⁴. Nevertheless, it should be noted that issues of class, race / ethnicity / culture and gender overlap and merge, making an attempt to group these latter issues appear quite clumsy.

Tucker-Raymond, Varelas, Pappas, Korzh, and Wentland (2007: 561) define identities as multi modal narratives and assert that because identities are built up over time, '*as interlocuters we can help construct experiences and possibilities for identity*'. Teachers and teacher educators, therefore, have some responsibility for the construction of these possibilities. Tucker-Raymond *et al.* (ibid) assert that from an early age a scientist identity is a distinct possibility for some children but an unlikely scenario for others. Such seems to be the case with many of the primary student teachers participating in this research.

Varelas, House and Wenzel (2005) raise the notion of conflicting 'multiple identities' among science teachers and Enyedy, Goldberg and Welsh (2006) also stress the complex nature of identity as they report on the experiences and identity challenges faced by two very different teachers as they implement a new curriculum. Faced with the challenges of a new curriculum or with different teaching methods, both pre service and in service science teachers in South Africa have experienced difficult identity reformations.

Emphasising the possibility for changing identities, Holland *et al.* (1998: 281) remark that 'remembered stories, recreations of one's story – can be used purposively to redirect one away from negative experiences in science to interpose new actions and to cast oneself as a new actor in a new social play.' This comment resonates with Bandura's notion of 'mastery experiences' or, if the 'remembered story' belongs to another, 'vicarious experiences'. In either case, however, the difficulty of mastering an identity shift should not be underestimated.

3.4.3.1 Identities at School

It was mentioned in chapter one that many of the student teachers at the university are first generation degree hopefuls. Such a position brings some responsibility and also some tension. Many of their less fortunate school friends and relatives are envious of the student's future lifestyle possibilities and make their feelings clear. The students themselves also feel ambivalent about leaving home and family behind to embark on something heretofore unheard of – a university education. These tensions may well cause identity predicaments of varying severity. On this very topic, paying attention to both

⁶⁴ These groups refer to people at school and university studying science as a discipline, as well people studying science teaching at preservice and in service levels.

narrative autobiography and social structure, Myra Hird (1998), investigated the experiences of several secondary school working class girls as they aspire to a university education. In so doing, these students see themselves as both similar to and different from their peers. It is almost as though they shift reluctantly from their histories into new territories (figured worlds) which are not entirely welcoming. They are well aware of the ease with which middle class girls gain acceptance to that figured world. Similarly, they become somewhat distanced from their families and from the traditional values and cultural practices of those families. Their identities are thus discontinuous and ambiguous.

Hird (1998:517) emphasises both inner and outer diversity in terms of individual self-identity, pointing to the influences of gender, social class and ethnicity in identity construction. She goes on to explain [we] “... *are produced through shifting relations of power*”. That is to say that learning and identity are located in social organisations as well as in individuals. This point has also been made repeatedly by Wenger (1998) in his book. Influences, whether individual or communal, act in different ways. Some of these ways emerge in the narratives of the student teachers discussed in later chapters.

From a different perspective, Gilbert and Yerrick (2001) report on a group of working-class scholars from whom little is expected by their school and their teachers. Partly or superficially buying in to the negative stereotype image and identity of black (or ‘minority’⁶⁵) students, they formed a subculture of low achievers, adept at negotiating minimum schoolwork demands. Working class – and/or low-achieving - white and Latino students experienced identity disjuncture when included in the subculture. I hear echoes of reproduction theories such as those offered by Willis and Corrigan (1978) when I read that being a ‘good’ student is tantamount to being a cultural or class traitor.

Nasir and Saxe (2003) and Maulucci (2008) emphasise the tensions between ‘own culture / language’ and ‘academic identities, suggesting that for many, they are mutually exclusive. Working class identity and academic success are certainly mutually exclusive in the minds of some educators described by Rubin (2007). She describes how, in a certain American school, a sense of self developed around urban⁶⁶ youth who were subjected to constant humiliation in terms of their own race, class, gender (and ethnicity and language). I, too, have observed a science teacher who found it amusing to call his Asian pupils ‘samoosa’.⁶⁷ Significantly, in Rubin’s (*ibid*) study pupils were also subjected to atomistic

⁶⁵ I am aware that ‘minority’ is a highly contested term (Atwater, 2000) but am using it rather than a clumsy ‘American not of European descent’. Of course in South Africa the word ‘minority’ carries a different connotation – usually meaning ‘white’.

⁶⁶ ‘Urban’, in this case also carries a specific connotation, akin to what we understand in South Africa as ‘inner-city’ high density living, decaying apartment blocks and ‘latchkey kids’.

⁶⁷ A samoosa is a traditional Asian food item.

and rote-based teaching methods as though these pedagogies were adequate for those 'doomed to failure'.⁶⁸

Taking the argument further, Yerrick *et al.* (2008: 18) make the point that under such circumstances, students leave school and / or bring to further education a series of 'sterile learning experiences'. Such is the case with many, if not most, students entering tertiary education. For those students wishing to become qualified teachers, the situation is doubly difficult because they need to 'unlearn' many of their own study methods in addition to learning to teach other people in ways which are foreign to them. Confusion and resentment often accompany this new learning trajectory.

At this point, I wish to return to a point made earlier about the inadequacy of focusing on pure cognition or 'what the student knows' or does not know without reference to other factors. Many students know or do not know a number of facts, but the circumstances under which the knowledge was gained or not gained remains opaque. The situation is particularly fraught if one is inclined to disregard those who do not seem to be 'in the know'. Their life stories are crucial. Rubin (2007: 20), following this argument, urges educationists to use 'three overlapping socio-cultural concepts to reframe the question of urban school failure; situated learning, identity and figured worlds'.

3.4.3.2 *Science Identity*

The literature pertaining to identity raises a number of issues for science teacher educators – indeed for science educators in general. In recent years a social theory of learning (taking cognisance of identity) as a unit of analysis has been taken up by science education theorists such as Helms (1998), Olitsky, (2007) and Varelas, House and Wenzel (2005) among others.

Girls have not always been included in what matters in science. Taking seriously the notion that girls are somewhat disadvantaged in science classes⁶⁹, Brickhouse, Lowery, and Schultz (2000) questioned how different girls moved beyond expectations and authored their school science identities. The girls' histories include one being a particularly good student, another internalising the science teacher's view of her as a 'good science student', and significantly, a third assisting her father with his 'masculine' repair chores around the home. The authors suggest that, for these girls, their engagement with science

⁶⁸ Here I return to a comment I made in the previous chapter of this thesis. 'In considering the written science histories of the student teacher participants, I speculate that *no scaffolding, no participative discussion, no social interaction during science learning could lead to alienation and a non science identity.*'

⁶⁹ There exists a wealth of literature on this issue which is beyond the present scope but see, for example, Roychoudhury, A., Tippins, D. and Nichols, S. (1993) An Exploratory Attempt toward a Feminist Pedagogy for Science Education. *Action in Teacher Education* 15 (4) pp 36 – 46

was shaped by their views of what sorts of girl they were and possibly still are. These thoughts hark back to the significant narrators proposed by Sfard and Prusak (2005) and to the notions of identifiers proposed by Holmes (2002).

Referring to his research findings, Letts (1998) (1999) makes the point that both boys and girls experience science teaching and learning in a gendered manner. 'Being like a girl' comes to mean the same as not engaging fully with science activities⁷⁰ or 'being bad at science'. Letts (1999:19) goes on to suggest that should science teachers work more actively toward eliminating science stereotypes, 'school science could perhaps one day function as a critical counter discourse to hegemonic masculinity.'

Extending beyond the gender issue and pertinent to at least one case study reported in this thesis, Carlone and Johnson (2007) describe various science trajectories followed by 'women of colour'. They quote an experience of a Native American female university student who, observing a cultural taboo, was unwilling to kill animals during a life sciences exercise and received little understanding from her professors. Significantly, the student herself claimed that a racial component was also involved⁷¹. Making Letts' point in a different way, Carlone *et al.* (2007: 1210) claim that there should be 'room for individual agency and cultural production at the university level' despite structural constraints.

3.4.3.3 *Science Identity and Language*

In chapter one, I remarked on some of the difficulties experienced by student teachers who are English second language speakers. Dhingra (2008: 124), from a personal point of view, asserts that language is a crucial cultural factor under certain conditions. Referring to her own experiences as 'the other', she comments that individuals author their identities under circumstances frequently not of their choosing. She claims that the 'critical factor around which learning revolves is the provision (or absence) of access to participation in meaningful science – related activity'. Participation is hindered if mediating tools, like language, are not readily available. Levels of participation (or not) in any practice have profound effects on the trajectories and possibilities of individuals.

Brown, Reveles and Kelly (2005) use the construct of discursive identity in the context of scientific literacy as a way to understand student learning in science. Observations in a fifth grade classroom provided insights into the ways the children appropriate scientific discourse (terminology like 'herbivore'). The researchers underline the ways in which identities are constructed through language. In classrooms (in this case science

⁷⁰ In this instance, the victim was tormented for not wanting to touch a cockroach.

⁷¹ I would argue that gender dynamics are at work here, too.

classrooms) speakers select genres of discourse with the knowledge that others will interpret the discourse, affirming the speaker's right to belong to the cultural group.

It is important to note that decoding the discourse in this case (Brown *et al.* 2005) appears to take on at least as great a significance as understanding the concepts (e.g. of herbivore) involved. It is also significant that, in this explication of identity construction, primacy is not given to *talk about* the identified, but rather *talk by* the identified about scientific concepts using accepted vocabulary. Consider again the difficulties experienced by an English second language speaker when learning the language of science *in English*.

As Maulucci (2008:38) has pointed out, 'Language acquisition and appropriation in science are nested in issues of cultural reproduction and domination, raising important questions about the hegemony of science and science language'. Olitsky (2006) concurs, reporting on her work with African American girls where several pupils, referring to scientific discourse, suggest that teachers make science difficult to understand by deliberate obfuscation. In similar vein, using data from teacher interviews, Moore (2007: 320) illustrates how language as discourse and the language of science function as gatekeeper, keeping some people out of 'mainstream' science.

3.4.3.4 *Some success*

Hopefully, research suggests optimistic outcomes as well. Working as participant-observers, when examining schoolchildren's interaction with science, Tan and Barton (2008a) worked from an identities-in-practice standpoint. They describe how, during a year of supportive, highly scaffolded science teaching, the disruptive identity of a Latina girl from a low income family was changed with strong teacher support to cooperative participation. These authors (2008a: 50) emphasise the plurality of identities-in-practice arguing that identity and community are neither static nor immutable. They go on to point out that '*a student may develop a repertoire of identities-in-practice*' any of which may be tried at a given time. This concept resonates with Gee's (2001) identity components and with Wenger's (1998) notion of (overlapping) communities of practice.

In a different study, the same authors, Tan and Barton (2008b: 584), describe a different kind of 'metamorphosis' or trajectory of yet another girl in a science class. Her science identity was transformed over time from marginal to peripheral. Her trajectory was punctuated by support from both teacher and peers, highlighting the importance of a community of practice. With time her ideas were validated and helped transform the community. In this way, doors were opened to a 'new and figured world'.

Olitsky (2006) reports on her work in an American magnet school with a science focus. She describes how four African American or mixed-race girls exercise their own agency to (re)define themselves at school and to resist an imposed identity. The families of these girls are generally not well educated and there is awareness among them of a consequently limited social and economic standing. Significantly, one particular pupil, despite not wishing to specialise in science, exercises her own agency in debate to persuade others that she is indeed worthy of a robust science education.

3.4.3.6 *A brief return to community*

The findings reported in the previous section (3.4.3.5 Some success) resonate with remarks made by Barab and Kirschner (2001:5) who present an overview of several papers which offer alternatives to traditional science educational research commenting that 'knowing is a process distributed across the knower, the environment in which the knowing occurs and the activity in which the learner is participating.' Extending this comment, I would argue that learning; participation and identity formation are also distributed across knower, known and environment. An appropriate environment for knowing, learning and identity formation is a community of practice as described above. Such a community may be considered a dynamically interacting system where one learns by the type of participation which encourages learning and also contributes to the learning environment.

While acknowledging the concerns of Boud and Middleton (2003) who caution that communities of practice do not always form naturally, some research findings reported above may suggest that school classrooms could well be considered communities of practice of a particular kind. Communities, of course, can also be deliberately constructed as Morrell (2003) recounts. Using Wenger's terminology, she describes a summer research seminar as the context for illustrating the concept of legitimate peripheral participation by a group of teachers. As the seminar progressed, participating teachers moved towards the center of a community of practice as they learned new research skills and teaching practice. It is to teaching and particularly the teaching of science that I now turn.

3.5 **Teacher identity and science teacher Identity**

Two major issues emerge when discussing science teaching (Luehmann 2007). These are *knowledge of science* and *science inquiry teaching*. Science knowledge in certain areas has already been addressed in this Literature Review. As mentioned in chapter one of this thesis, the latest science curriculum of the country aims for skill⁷² and attitude⁷³

⁷² Several process skills are stated, including inquiry.

development, as well as knowledge construction in the natural sciences. Therefore a competent science teacher is expected to encourage an inquiry approach (among other ways of thinking) in his / her science teaching.

Luehmann (ibid) suggests further that creating learning activities in inquiry mode is a practice which follows a firmly held conviction or theory which must be part of the teacher / author's identity. For those students of science education who have experienced a rote-learning education, constructing this new, confident, identity is a challenge indeed. According to Plevyak (2007) and to Smart (2008) science teacher educators are in a good position to help students meet this challenge. Inquiry-based pedagogies embodied in methods courses could provide student teachers with valuable examples as a starting point. Ideally, they will, as Forbes and Davis (2008) have found, appropriate the role of curriculum developer for themselves. In Wenger's terms, they should move from peripheral to central participation. In this way they would contribute to the community of practice and also construct a different, richer science identity.

Focusing on science pedagogy, Eick and Reed (2002) investigated the construction of secondary science teacher identity with respect to orientation towards inquiry teaching. They make the valid observation that when the student's past science history is at odds with inquiry approaches, s/he finds difficulty reconciling the desired identity with what is known and has been experienced. A new teacher's role identity is formed from past experiences, role models, personal histories, personal beliefs, values, fantasised views and other incidents. An inquiry science teacher identity is not something readily assumed, like a borrowed jacket.

The preceding remarks are not to suggest that identity should be understood as static and immutable. Identities are dynamic, in a state of flux and are subject to influences from a variety of sources. With changing circumstances, science teacher identities are subject to conflict as reported by Volkmann and Anderson (1998), Varelas, House and Wenzel (2005) and Enyedy, Goldberg and Welsh (2006). As these authors above point out, even qualified teachers face a number of dilemmas with respect to their identities. Of particular note is the integration of various roles expected of teachers and how adjustments are made by constant compromise until an appropriate identity⁷⁴ is articulated.

⁷³ These include appreciation of natural phenomena, respect for life, wise use of natural resources, and respect for cultural diversity.

⁷⁴ or *modus vivendi*

'Appropriate at the time' or 'appropriate for the occasion' are noteworthy aspects of identity, particularly that of a primary teacher, because many of these teachers are responsible for several school subjects imposing or bearing different identities. Drake, Spillane and Hufferd-Ackles (2001) make just this point when reporting on the 'storied identities' of primary teachers. Their research findings demonstrate that while 'literacy stories' of the teachers were encouraging, having commonalities with everyday life, 'mathematics stories were 'dominated by disappointing and discouraging experiences' (*Ibid* 2001: 2). What could be said of science? Not only subjects, but settings too, influence identity. Flores (2006) describes the changing identities of a cohort of student teachers over two years. School types, colleagues, unfamiliar rural and urban environments all were seen to influence teacher identity as the novice teachers retreated from idealism into the 'real world'.

Unsurprisingly, both pre service and novice teachers experience quite some difficulty developing their own teacher identities having been subjected to several influences such as that of their own school teachers, different university lecturers, different supervising tutors and different supervising teachers (Helms 1996, Jackson 2001, Jang 2004). Student teachers whom I have tutored on teaching experience complain that 'every lecturer is different and we have to jump from one style to another.' One can empathise with such a dilemma, but I suggest that the inexperienced student teacher feels the constraint acutely because s/he has not constructed a coherent teacher identity just yet.

While mentoring is an important scaffold for inexperienced teachers, opportunity should also be provided for the development of specific teacher identities. Teaching is an intensely personal experience and the way one conducts one teaching, the explanations, jokes and shared repertoire between a teacher and his/her pupils all contribute to identity. A teaching identity is incomplete, discontinuous if the practice relies too heavily on another's expression of self.

3.6 Views of scientists, science teachers and others

Drawings have been used for some decades to determine aspects of a person's development, understanding or opinions. Therefore, I have used drawings by pupils and student teachers as research tools and as indicators of opinion in the present. More details will be provided in the following chapter but for the present, research findings into drawings about scientists and teachers will be reviewed below.

3.6.1 Scientists

Chambers' (1983) 'Draw a Scientist Test' (DAST) was among the first such exercise which laid emphasis on views about science and scientists. Results of his research suggest that a stereotypical image of 'scientist' was quite firmly fixed in the minds of the learners by about Grade 5. In addition, the author identified a number of common stereotypical indicators such as spectacles, facial hair and laboratory coat among the sketches of scientists drawn by children. This work was met with interest among the scientific community and sparked a wealth of reports and debates about the views of science and scientists held by students of various ages.

For instance, Schibeci and Sorensen (1983) conducted similar research to that of Chambers (ibid) among learners in two schools in Western Australia, and found similar stereotypical views among their participants. Barman's (1996; 1999) findings among North American and Canadian students are comparable to those already mentioned. Extending the applicability of the DAST, Finson, Beaver and Cramond (1995) developed and trialled a new checklist for the test. The checklist (DAST-C) was used in a controlled study among 47 junior high students in the United States. Pre and post test drawings by the 'treatment' participants were very different, suggesting that the stereotype in the minds of the students was not indelibly fixed but could be altered. Further investigating the applicability of the DAST-C, Finson (2003) tested the instrument against images of scientists held by different 'racial' groups in 3 states of America.

In other parts of the world, other researchers have used the DAST, DAST-C and modifications thereof in various contexts. In 1991, in Australia, Hill and Wheeler adapted the DAST by including an interview-about-instances component to the test. They found their extended version of the test useful in discovering nuances of understanding and suggest that participants may know more than is at first apparent. She (1995) also used a modified version of the instrument to investigate young Taiwanese students' images of scientists and found that many images held by students correspond to images which appear in the prescribed textbook/s.

The DAST has been used not only in different countries and cultures but latterly, also with post-secondary students. In Israel, Rubin, Bar and Cohen (2003) used the DAST together with other instruments to investigate the images of scientists and science among student teachers from different cultures (i.e. Hebrew- and Arabic-speaking). Findings suggest that different images are held by members of the two cultures. Many of the people drawn by Arabic-speaking students were clothed in Arabic traditional garb and the Hebrew-speaking

students illustrated their cultural traditions in their drawings. These findings suggest that the cultural identities of the students themselves influenced their drawings.

The current research required students of several backgrounds and cultures to draw diagrams of *themselves* as teachers and some differences were noted. Thomas, Henley and Snell (2006) explored the similarities and differences between the drawings of college-aged students and those of school children reported in previous research. Although their findings also illustrated the common stereotype in many cases, the authors suggest that some differences in drawings, which are not captured by the DAST, do exist.

Latterly, possibly due to various television programs portraying scientists in a more positive and glamorous light, Jones and Bangert (2006) found that some students drew scientists which did not conform to the stereotypical view. Of concern, however, is that students in higher grade levels drew more stereotypical scientists than did students in lower grades. These findings suggest that science schooling may entrench the stereotype in some way.

From some of the findings reported, it can be inferred that, despite their usefulness, the DAST and DAST-C should be utilised with caution and that there is scope for methodological refinement. Losh, Wilke and Pop (2008) made just this point when discussing their research among 206 school children in the United States. Nevertheless, they do acknowledge that scientists have an 'image problem' among children. Other research cited above (Rubin *et al.* 2003; Thomas *et al.* 2006) suggests that scientists may also have a negative image among certain undergraduates. The focus of this paper is on the images of *science teachers* held by undergraduate or pre service primary teachers and it seems that in many cases, science teachers too, suffer from an image problem.

3.6.2 Science Teachers

For their research with pre service teachers, Thomas and Pedersen (1998) modified the DAST-C to produce the Draw a Science Teacher Test Checklist (DASTT-C). Their findings suggest that like that of the scientist, images of the science teacher are stereotypical. Like Finson *et al.* (1995) these researchers used a pre-test – post-test research design, the intervention being a science methods course. The majority of pre-course drawings revealed teachers using didactic methods with post-course drawings showing teachers using a range of more learner-centred methods. The authors remark that it is 'very interesting to compare pre- and post-pictures of individual students' (*Ibid* 1995:6).

Images of authoritarian science teachers and teacher-centred lessons have been reported by Pedersen and Thomas (1999) Thomas, Pedersen and Finson (2000), Thomas, Pedersen and Finson (2001) in the United States. During these studies, the Draw a Science Teacher Test Checklist (DASTT-C) was trialed, validated and modified. Later versions of the DASTT include a narrative component which requires students to explain (in writing) what the teachers and learners in the drawings are doing. Further afield, in Turkey, Yilmaz, Turkmen, Pedersen and Huyugzel Cavas (2007) used a version of the DASTT-C to investigate the images of science teaching held by pre service teachers. Their findings resonate with those reported by researchers elsewhere. In 2010, James Minogue reported on similar research which yielded statistical significant shifts in participants' mental models of science teaching and learning before and after a methods course. In his research, he used a coding scheme very similar to the one I used when analysing students' drawings.

Modifying the DASTT somewhat, Carnes (2003) used drawings as a springboard to initiate dialogue with a number of student teachers. He warns that the drawings of science teachers by student teachers (possibly also others) are not always consistent with their own experiences. This comment supports the notion that the DASTT can be used together with other techniques to obtain rich detail about images of science teaching. For this reason, I included the DASTT among several other data gathering techniques.

3.6.3 Other Teachers

Weber and Mitchell (1996) investigated the 'gradual and life-long nature of socialisation into teaching' by examining drawings of various pre service teachers, finding signs of ambivalence, conflict and inner struggle in the drawings and explanations of the student teachers. Building on this work, Coughlin and Seldin (2001: 191) found evidence of 'evolving images . . . of complex classroom cultures'. Utley and Showalter (2007:6) developed a Draw a Mathematics Teacher Test (DAMTT) by adapting the DASTT. This was administered to 84 pre service primary teachers enrolled in mathematics methods courses. Findings revealed that almost two thirds of the drawings were illustrative of teacher-centred pedagogy and the authors suggest that 'students do not readily change their identity from student to teacher.' Very similar findings are reported in this thesis as are some surprising changes.

Identities of teachers are part of their learning histories and their futures. Histories and possibilities, however, do not occur in isolation but are constituted in time and place by broader social contexts.

3.7 Summary.

In this chapter, I have referred to both theoretical and empirical literature sources which have helped to broaden my understanding of the concept of identity construction. Content knowledge (of certain phenomena) and self efficacy of individuals have been taken into account. I have included references to research findings dealing with both content knowledge and self efficacy because these aspects play a role in identity formation although they do not account for the entire picture.

Following the point made in the previous paragraph, and searching for further insights into identity formation, I cite a number of research findings which report various identity constructions of teachers and students, by teachers and students. In much of the research referred to, science and science teacher identities are foregrounded. Certain research findings support the contention that negative identities about oneself by another can hold sway. Conversely, a body of literature suggests that negative identities can be reformed under certain favourable conditions.

Much of the literature mentioned above also suggests that identities are not uncomplicated nor are they static. I have taken the view that identities are subject to a number of influences, both internal and external, both constructive and destructive and that identities are in a state of flux. The concept of science teacher identity, therefore, is brought into focus with particular reference to social, cultural and historical influences as reported in the literature.