

EMPLOYING METACOGNITIVE PROCEDURES IN NATURAL SCIENCE TEACHING

BY

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DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

.....

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.....

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ABSTRACT

Education, both in South Africa and internationally, experiences a number of challenges with regards to the need for improved teaching and learning. South African education is in a state of transformation to address the country's educational needs. In science education specifically, there is a heightened necessity to develop teaching that will respond to distinctive educational needs in the sciences. Many of the educational issues, presented in current literature, are mirrored in my Natural Sciences classroom. Given the benefits of enhanced metacognition for effective learning, this study aimed to investigate the use of metacognitive instruction procedures to improve my Natural Sciences teaching practice. Consequently, it also aimed to explore the influence that this may have on the metacognitive development of my Grade 9 Natural Sciences learners. This research study was based on a social constructivist perspective that views learning as a unique, internalized construction of knowledge from a social interaction, such as teaching.

This study was embedded within a paradigm of praxis, with a qualitative action research cycle forming the research methodology and design respectively. Purposeful sampling was used to select nine of my Grade 9 Natural Sciences learners to act as informants for the Grade 9 class. Data was collected in the form of learner reflections, an open-ended questionnaire, a focus-group interview, and a research journal. Furthermore, the data was analysed, using a theoretically founded coding scheme, to identify and interpret significant themes and/or trends.

The research findings indicated that the employed metacognitively orientated teaching procedures enhanced my Grade 9 Natural Sciences learners' metacognition. Their metacognitive awareness and reflection abilities improved, as well as their knowledge and regulation of cognition. The teaching techniques also demonstrated the potential to facilitate the development of my learners' conscious thinking, self-discipline, responsibility and active participation in learning - all characteristics envisaged for the ideal South Africa learner. In addition to this, the research process demonstrated the ability to enhance my Natural Sciences teaching practice and the information gained from this study will be used to inform my future teaching practice. I now realise the value of incorporating metacognitive teaching procedures into my lessons, as well as the importance of reflecting on my teaching process and

considering the uniqueness of each learner in my class. Additionally, teacher training institutes and educational policy makers may benefit from the information gained from this study, for improving teaching practice. Apart from this, findings attained from this study have the potential to inform future cycles of this action research process or alternatively to be used for other research within the field.

Keywords: Metacognition, Social Constructivism, Action Research, Natural Sciences, Grade 9 Learners

OPSOMMING

Onderwys, beide in Suid-Afrika en internasionaal, ervaar 'n aantal uitdagings rakende die behoefte aan verbeterde onderrig en leer. Die Suid-Afrikaanse onderwysstelsel is tans in 'n staat van transformasie om die land se opvoedkundige behoeftes aan te spreek. In die wetenskap-onderwys spesifiek, is daar 'n toenemende noodsaaklikheid om onderrig te ontwikkel wat die unieke onderwysbehoefte in die wetenskappe kan aanspreek. Baie van die opvoedkundige kwessies soos in huidige literatuur uitgelig, is ook in my Natuurwetenskappe-klaskamer teenwoordig. Gegee die bewese voordele van verbeterde metakognisie vir effektiewe leer, het hierdie navorsingstudie gepoog om die gebruik van metakognitiewe onderrigprosedures vir die verbetering van my Natuurwetenskappe-onderrigpraktyk te ondersoek. Die studie was ook daarop gemik om die invloed van metakognitiewe onderrigprosedures op die metakognitiewe ontwikkeling van my Graad 9 Natuurwetenskappe-leerders, na te vors. Hierdie navorsingstudie is gebaseer op 'n sosiaal-konstruktivistiese leerperspektief wat leer sien as 'n unieke, geïnternaliseerde konstruksie van kennis binne 'n sosiale interaksie, soos onderrig.

Hierdie studie is binne 'n paradigma van 'praxis' ingebed, met aksienavorsing as navorsingsontwerp en daar is van 'n kwalitatiewe navorsingsmetodologie gebruik gemaak. Doelgerigte steekproefneming is gebruik om nege van my Graad 9 Natuurwetenskappe-leerders te kies om as informante vir die graad 9-klas op te tree. Data is in die vorm van leerders se refleksies, 'n oop-einde vraelys, 'n fokusgroep-onderhoud, en 'n navorsingsjoernaal ingesamel. Verder is die data met behulp van 'n teoretiese koderingskema geanaliseer wat belangrike temas en/of tendense identifiseer en interpreteer.

Die navorsing het aangedui dat die metakognitiewe onderrigprosedures wat gebruik is, my Graad 9 Natuurwetenskappe leerders se metakognisie versterk het. Hulle metakognitiewe bewustheid en reflektiewe vermoëns het verbeter, sowel as hulle kennis en regulering van kognisie. Die onderrigtegnieke het ook die potensiaal getoon om die ontwikkeling van my leerders se bewuste denke, self-dissipline, verantwoordelikheid en aktiewe deelname in die leerproses te fasiliteer. Hierdie eienskappe is van dié wat vir die ideale Suid-Afrikaanse leerder beoog word. Benewens hierdie aspekte het die navorsing ook my Natuurwetenskappe-onderrigpraktyk verbeter en die navorsingsbevindinge sal in die toekoms gebruik word om my onderwyspraktyk toe te lig. Ek besef nou die waarde daarvan om metakognitiewe

onderrigprosedures in my lesse te inkorporeer, sowel as die belang van refleksie oor my onderrigproses en om die uniekheid van elke leerder in my klas in ag te neem. Onderwysopleidingsinstellings en opvoedkundige beleidmakers mag uit hierdie navorsing voordeel trek rakende die verbetering van onderwyspraktyk. Afgesien van die bogenoemde, het die navorsingsbevindinge ook die potensiaal om toekomstige siklusse van aksienavorsing toe te lig en om binne verdere navorsing in die veld gebruik te word.

Sleutelwoorde: Metakognisie, Sosiaal-konstruktivisme, Aksienavorsing, Natuurwetenskappe Graad 9-leerders.

DEDICATION

For Leah Ann Marie Bolton

(Born 19 February 2011)

My niece and godchild

Your miraculous journey into this world corresponds, through time and space, with my own rite of passage in the naissane of this thesis. The countless hours of diligently carving this work, which has necessitated my tireless, focused attention, has impinged on the many cherished moments that I wished to share with you this year. Yet the synchronicity of our respective "births" in 2011 is significant and cements our deep and precious bond.
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CHAPTER 1

CONTEXT AND RATIONALE FOR THE STUDY

1.1 INTRODUCTION

This research study has the aim of exploring how I (the researcher) can develop my own teaching practice, with the incorporation of metacognitive teaching procedures, in order to enhance my Grade 9 Natural Sciences learners' metacognition. The study will function on the established assumption that the incorporation of metacognitive teaching procedures can improve learners' metacognition and learning (Cilliers, 2009; Desoete, 2007; Desoete, 2008; Schraw, 2002; Veenman, Van Hout-Wolters & Afflerbach, 2006; Woolfolk, 2010; Yore & Treagust, 2006). The study will therefore explore the changes in my learners' metacognition and learning, brought about by the incorporation of metacognitive teaching procedures into my Grade 9 Natural Sciences instruction. Through this process, I hope to inform and advance my teaching practice.

This first chapter will provide a framework for the aforementioned research study and will attempt to outline an introduction to it; by explaining the significance of the study, in terms of current circumstances. The chapter will present the problem, inform the research, as well as explore the aims and research questions that evolve. The research design and methodology will be articulated, and the chapter will conclude with a clarification of significant concepts and a presentation of the remaining structure of the research study.

1.1.1 Motivation for the study

Changes in South African governance have brought with it changes in the focus of education (Department of Education, 2002a; Galyam & Le Grange, 2005; Malcolm & Alant, 2004; Rossouw, 2009). The National Curriculum Statement and inclusive education policies have redirected learning to focus on preparing and supporting all learners to be proactive and effective citizens, as well as life-long learners, with the overarching aim of creating a society of well-informed, knowledgeable citizens (Department of Education, 2002a; Dignath & Büttner, 2008; Coles, 1993; Galyam & Le Grange, 2005; Linn, 1986; Malcolm & Alant,

2004; Olson & Loucks-Horsley, 2000; Rossouw, 2009). In preparation for this "knowledge society" (Ball & Wells, 2006, p. 191), individuals are required to: work effectively in teams; actively solve problems; connect relating information meaningfully; make sensible judgements on information gained; and be flexible and adaptive to a rapidly changing environment (Malcolm & Alant, 2004; Yore & Treagust, 2006). These changes and ideals have brought about much educational curricula reformation, with a particular focus on moving away from didactic, direct transmission style teaching (Ball & Wells, 2006; Hawkins, 1994). Transmission teaching was never promoted in the intended curriculum for science teaching, as it encouraged rote and uncritical learning. Rather, a strong emphasis on inquiry based teaching was encouraged, despite not always being implemented in practice (Department of Education, 2002a; Department of Education, 2002b, Ellis, 2001). The restructuring of the curricula aims to emphasise interactive, learner-centred mediation, where the learner takes charge of his/her own learning and develops a critical approach to learning. The ultimate goal, of the 'new' curricula, is for learners to develop the ability to transfer knowledge, information and skills beyond classroom walls, to become independent thinkers and effective citizens (Ball & Wells, 2006; Connerly, 2006; Costa & Kallick, 2000; Department of Education, 2002a; Galyam & Le Grange, 2005; Gourgey, 2002; Hester, 1994; Malcolm & Alant, 2004; Rusbult, s.a.; Schraw, Crippen & Harlley, 2006; Watson, 2000; Williams & Sternberg, 1993).

Global changes in educational focus, such as those mentioned above, have also brought about changes in the focus of educational theory. This is partly due to the need to promote teaching that develops learners, who are equipped to function effectively in society (Ball & Wells, 2006, p. 191; Malcolm & Alant, 2004; Yore & Treagust, 2006). Changes in educational theories have had educational researchers and practitioners spending decades studying how people think and learn, what influences learning, and how teaching effects learning (Malcolm & Alant, 2004; Woolfolk, 2007). From this, a number of conceptualisations of learning exist, but one seems most appropriate for the purpose of this research study as it encapsulates social constructivism, the theoretical framework underpinning the study. From this perspective, learning is more than the simple reception and processing of information - it is the "active and personal construction of knowledge" (Woolfolk, 2007, p. 344).

Daniels (2007, p. 315) on the other hand makes the assertion that effective teaching should "promote general mental development as well as the acquisition of special abilities and

knowledge". He views part of good teaching as helping learners to develop the capacity to reflect on their own thinking. "Changes in thinking" is what Woolfolk (2007, p. 22) refers to as cognitive development, a central aspect encompassed by good teaching and learning. This allows one to easily recognise that thinking and reflection play a central role in effective teaching and learning.

Over the past few decades, particular focus has been placed on the importance of metacognition as a significant variable for mediating the thinking required in good learning and teaching, as mentioned in the previous paragraph (Desoete, 2007; Gourgey, 2002; Hessels, Hessels-Schlatter, Bosson, & Balli, 2009; Joseph, 2010; Lin, 2001; Thomas, 2006a; Yore & Treagust, 2006). Metacognition is a complex concept, which is most broadly understood as "cognition about cognition" (Woolfolk, 2010, p. 270) or "awareness and control over one's thinking" (Hartman, 2002a, p. 34). As a higher-order cognitive skill, metacognition is used in various ways to regulate thinking and learning (Blagg, 1991; Cilliers, 2009; Desoete, 2007; Desoete, 2008; Schraw, 2002; Veenman *et al.*, 2006; Woolfolk, 2010). Several respected educational researchers recognise metacognition as a "valuable skill [...] for the advancement of learning" (Ball & Wells, 2006, p. 193) and "a most powerful predictor of learning" (Veenman, *et al.*, 2006, p. 3). This emphasises the need to include metacognition into teaching; so as to enhance the desired thinking skills, to create effective learners, who can contribute to, and function in, a thriving knowledge society (Yore & Treagust, 2006). Research supports this need for enhancing metacognition in educational set-ups (Thomas, Anderson & Nashon, 2008; Yore & Treagust, 2006), as it has revealed that many learners experience limited metacognitive abilities (Connerly, 2006; Lipman, 1993; Manning & Glasnir, 1996). Hence, the relevance of this research inquiry.

Educating learners to become effective 'thinking' citizens does not only entail enhancing their metacognition. Another component of the educational reform, mentioned above, focuses on the need to enhance science and technology both internationally and in South Africa (Yore & Treagust, 2006). Science is a subject field of particular importance, both nationally and internationally, as there is a general necessity to expand success in science to meet global needs (Guo, 2007). International organisations, such as UNESCO, OECD and the EU, place a particular focus on science and technology in education, as they are of the opinion that these subjects have a significant function in developing citizens, who are culturally sensitive and democratically orientated in modern societies (Sjøberg & Schreiner, 2010; Yore & Treagust,

2006). This links with reformations of the South African government and the ideals to develop effective citizens, presented in the initial part of this chapter. The importance of effective science education is therefore inherent in this argument, and forms one pillar of the reasoning behind this research inquiry. Adding to this, the relevance of improving science education is evident in the need to develop citizens, who specialise in fields of science and technology (Sjøberg & Schreiner, 2010; Yore & Treagust, 2006). Further fuelling this dispute, about the need to improve science education, is research that shows science education in South Africa to be facing a crisis (Mwangi-Zake, 2001). This crisis is evident in that science is one of the learning fields, where a majority of children struggle to achieve. South Africa is ranked high on the list of countries where this crisis is particularly pertinent (Department of Education, 2008; Giest & Lompscher, 2003; Guo, 2007; McCarthy & Bernstein, 2011; Naidoo & Lewin, 1998; Sjøberg & Schreiner, 2010; Viljoen, 2010). This, along with the arguments outlined above, supports the need for effective science education both in South Africa, and internationally, and therefore also motivates the relevance of this research inquiry.

In South Africa, science is incorporated as a compulsory learning area for part of a learner's school career (up until Grade 9 level or the equivalent thereof), not only to convey certain scientific knowledge, but also to establish respect for science as a part of one's culture. In addition to this, science as a subject can act as an important determinant in future educational choices, while simultaneously instilling interest and values that have the potential to be of benefit to developing citizens (Sjøberg & Schreiner, 2010; Yore & Treagust, 2006). It is after the Grade 9 year that learners must choose whether they will continue with scientific learning areas. This choice is usually based on the career path that a learner intends to follow (Sjøberg & Schreiner, 2010). With reference to career choice in South Africa, and worldwide, there is a need for more individuals to specialise in scientific career fields (Department of Education, 2008; Ellis, 2001; Sjøberg & Schreiner, 2010), and this highlights the importance of inculcating, not only the inquiry based mind of scientists at the relevant school age/stage, but also the interest and desire to continue with tertiary education in science, and eventually with careers centralised in the field of science. This forms part of the rationale for this research inquiry, suggesting that if learners are taught to engage effectively with science at a Grade 9 level, through enhancing their metacognition in the subject, they may be more inclined to embrace the sciences in their future (Sjøberg & Schreiner, 2010; Yore & Treagust, 2006).

1.1.2 Linking science and metacognition

In the context of this study, one needs to question the rationale for connecting the need for developing science education and the need for enhancing metacognition. To address this question, I refer to Thomas' (2006a, p. 2) argument that the positive effects of metacognition on learning make it worthy of "increased attention in the field of science education", clearly revealing the need for metacognition in science teaching and learning (Yore & Treagust, 2006). International research, on science education, over the past decade, has been inclined to focus on curriculum change and ways to improve learning using multiple instructional strategies (Schraw *et al.*, 2006; Thomas, 2006a). South African science education research, however, has focused on addressing multiculturalism in science, policy transformation, assessment, teacher training, and textbooks, with a continuous need for research to inform science teaching and learning (Malcolm & Alant, 2004). South Africa specifically requires research to aid learning and teaching methods in the area of cognitive sciences (Ellis, 2001), since part of the international research on science teaching and learning has drawn our attention to the need for meaningful active learning, with metacognitive strategies from both teachers and learners (Hartman, 2002b; Yore & Treagust, 2006).

Research shows that there is a lot more to effective science teaching than many teachers realize or make use of (Fisher, 1990; Yore & Treagust, 2006). Literature indicates that, despite many advances in metacognitive research and theory, with some emphasis on metacognitive elements in science education, insufficient attention has been given to metacognition, and learning in general. There seems to be a gap in bridging this information in such a way that it is accessible to teachers to apply practically within their classroom environment (Fisher, 1990; Hawkins, 1994; Manning & Glasner, 1996; Roth & Garnier, 2007; Watson, 2000; Yore & Treagust, 2006). As a result many teachers are not aware of the most effective ways to mediate the development of their learners' metacognitive thinking skills (Azevedo 2009; Ellis, 2001; Schraw *et al.*, 2006; Sagor, 1999).

The argument traced above portrays some of the current challenges that face education in South Africa. While there is a need for localised research to inform science teaching, there is also a need for research findings that can be practically implemented in the classroom to enhance learners' metacognition.

Within my own teaching context, the problems I experience clearly mirror the national and international concerns and experiences revealed above. Research on science teaching and learning has emphasised the importance of active learning, which involves metacognition, as one of the ways to conquer the challenges that science education presents (Hartman, 2002c; Ellis, 2001; Thomas, 2006a). These challenges that contribute to poor performance in science education range from a need for more effective teaching that promotes more interactive learning, to a need for learners to be more interested and motivated in science education. Other challenges include the need for learners to develop more effective and critical thinking skills in science so that their knowledge and skills can be better transferred to everyday situations. There is also a need for more individuals to enter careers in the science fields, and therefore, science education needs to be better promoted at school level (McCarthy & Bernstein, 2011; Sjøberg & Schreiner, 2010).

I therefore present the next section to take the above argument one level further, by stating the problems which have led to the development of this research inquiry. The summarised review of literature presented above aims to support the rationale for the study, and this will be discussed in detail in Chapter 2.

1.2 PROBLEM STATEMENT

The general themes that emerge from the literature reviewed in the previous section; aim to reveal the need for the improvement of learners' metacognitive skills (Joseph, 2010; Van der Walt & Maree, 2007). This need is particularly relevant in science education, and more specifically in developing countries, like South Africa, where performance in science education and interest in science-orientated careers is particularly poor (Adendorff, 2007; Department of Education, 2008; Naidoo & Lewin, 1998; Schraw *et al.*, 2006; Sjøberg & Schreiner, 2010; Viljoen, 2010). There appears to be a need for national and international research that provides in depth analysis of how to adapt and apply teaching strategies in order to improve metacognition (Hessels *et al.*, 2009; Joseph, 2010; Van der Walt & Maree, 2007), with an increased need for this, especially in science education (Malcolm & Alant, 2004; Yore & Treagust, 2006).

The challenge of enhancing metacognition in science education is echoed in my Natural Sciences classroom. As a Natural Science teacher, I have come to recognise that many of the learners that I teach seem to lack awareness of their thinking and the ability to effectively

regulate their learning (metacognition). This problem is brought to my attention in a number of ways. For example, when exploring how some learners answer questions in class, tests and exams; many are too quick and guess the answer before applying a conscious effort to think about what they have learnt. This, among other indicators, implies that they have not been taught to 'think' about the 'problem' that is posed to them. It also reveals a common inability to transfer their knowledge and skills across situations. In addition to this, learners often complain of not being able to finish assessment tasks in the allotted time. On exploring this further with them, it seems that the problem lies with either their limited ability to set appropriate goals; or to manage their time effectively to get through all the work; or to employ the most effective skills to complete the task at hand; or to focus on the relevant information. These problems are often exacerbated by a large majority of learners' limited monitoring and regulation of their own progress. Other metacognitive deficits are seen through some learners' difficulties in organising and categorising concepts in meaningful ways, as well as their failure to seek the appropriate guidance or resources to help them. When conducting scientific investigations for instance, many learners simply complete their rote-learned structure and answer questions based on this, without having actively engaged with the investigation. They therefore experience problems hypothesising and determining variables that may influence the investigation, and as a result, often put statements on paper without having provided a well thought out response. Research has shown that the problems, I have mentioned here, are not unique to my situation (Hartman, 2002c; Ellis, 2001; Manning & Glasner, 1996). Internationally, there seems to be a general deficit in learners' awareness and ability to exercise cognitive control over their own learning, throughout different subject areas (Connerly, 2006; Lipman, 1993), making apparent the need for enhanced mindfulness or metacognition in many learners.

Being an advocate for effective teaching and learning (further discussed in Section 1.3.2), the problems mentioned above have fostered my deep concern about the quality of education. These problems have also prompted my realisation of the need to improve my teaching to facilitate the development of appropriate learning skills, with a specific concern for enhancing metacognition. In light of this, as both a teacher and researcher, I aim, through the process of this research study, to improve my own teaching practice, thereby helping my learners to enhance their metacognition. It is my hope that this will allow them to take ownership and control of their learning, and become self-regulating citizens. The indirect goal is therefore to enable my learners to eventually become 'ideal' South Africans, who are

responsible and effective citizens, and also lifelong learners (Department of Education, 2002a).

One of the main objectives of this study is therefore to track how the metacognitive modifications in my teaching bring about changes in the quality of my learners' metacognition and Natural Sciences learning. In essence, by interpreting and reflecting on this process, I hope to inform my teaching in such a way that it may enhance my learners' metacognition so that their learning, in general, and specifically in science, may improve. Throughout the study, these aims will be viewed, and decisions will be formulated, from the underlying assumptions of social constructivism, which will be discussed in detail in Section 1.3.1 and Section 2.2.

The primary research question this study therefore aims to answer is:

How will the incorporation of metacognitive instruction improve my Natural Sciences teaching practice?

With the sub-question:

How will my Natural Sciences learners' metacognition develop through my adapted teaching procedures?

1.3 RESEARCH PLAN

In order to answer these research questions successfully, there needs to be a research plan in place. Denzin and Lincoln (2005) highlight five phases of the research inquiry process. The following section endeavours to provide a systematic outline of the research plan for this investigation. As the theoretical framework selected for a study plays such an important role, guiding almost every aspect of the research, it will be discussed as the first phase of the research process (Agherdien, Henning & van der Westhuizen, 2011; Merriam, 2006). During the second phase of the research process, I will introduce myself as a teacher and the researcher in this study, explaining my role within the research process as teacher and researcher (teacher-researcher) (Denzin & Lincoln, 2005). The third phase will refer to the research design chosen for the study, and the fourth phase aims to indicate the chosen methodology and methods of data collection. The fifth phase of the inquiry will explain the processes of data analysis and presentation, concluding with a discussion of the findings (Denzin and Lincoln, 2005). In this chapter, a detailed account of the first two phases is

provided, while the other three phases are explained in greater depth in Chapters 3 and 4, and are therefore only briefly mentioned here.

1.3.1 Phase 1: Guiding the Inquiry: the theoretical framework

A theoretical framework acts as the underlying foundation, informing every part of a research study, and should therefore provide an essential link between all parts. It is also likely to play a role in determining and/or shaping the research question/s (Agherdien *et al.*, 2011; Merriam, 2006), which form the crux, upon which the rest of the inquiry is based. Towards the end of Section 1.2, I alluded to social constructivism as the perspective through which this study will be formulated (Woolfolk, 2007). I will specifically apply a Vygotskian take on social constructivism as my theoretical orientation and, therefore, all concepts will be reviewed through this theoretical lens (Woolfolk, 2007). The paragraphs that follow aim to provide an abridged description of social constructivism, highlighting the most essential elements of the theory that pertain to this study. A more detailed account will be provided in Section 2.2.

Vygotsky's social constructivism is characterised by a number of key features. There are, however, four aspects that are considered to be the central components of his theory (Stetsenko, 1999; Veresov, 2009) and they will therefore be essential factors in this research study. These components include: *social interaction*, *mediation* and *cultural tools*, as well as the *Zone of Proximal Development (ZPD)*.

In the explanation of these essential components, and their relation to teaching and learning, it is important to note that, from a Vygotskian social constructivist viewpoint, the relationship between learning and development (in which learning 'pulls' development) is understood as proceeding from the outside towards the inside (Del Río & Álvarez, 2007; Stetsenko, 1999). Linking my study to these four essential features of social constructivism; this essentially means that, in order for learning to take place, a particular *social interaction* must transpire. Learning, and therefore development, occurs from a socio-cultural (interpsychological) level to the individual (intrapsychological) level (Stetsenko, 1999). *Mediation* essentially facilitates this process through the use of different *cultural tools* (Kozulin, 2003). There are different types of mediation and cultural tools, some of which are discussed in Section 2.2. For effective learning to occur, Vygotsky's theory emphasises the importance for instruction (interpsychological interaction) to be directed at a level that is neither too difficult, nor too

easy, for the learner. In short, this level is known as the *Zone of Proximal Development* (ZPD). Detailed attention is provided to each of these important aspects of social constructivism in Section 2.2.

In summary, Vygotsky's theory of social constructivism accentuates the interactive nature of learning, as well as the importance of society in learning (Fox & Riconscente, 2008; Guterman, 2003; Watson, 2000; Woolfolk, 2007). Social constructivists therefore see the active role a learner plays, as well as socialisation, to be crucial to the learning process. Vygotsky's theory also emphasises the importance of tasks being "sufficiently challenging", but still remaining within the learner's capability, namely, within the ZPD (Watson, 2000, p. 136). His theory claims that, for effective learning to occur, the most important psychological developments to be fostered by teachers are "reflection" and "control of [...] thinking", with the aims of generalising knowledge beyond an initial context, such as the classroom (Watson, 2000, p. 136). Carr (1998) claims that in order to foster better reflective judgement, constructivist principles should be incorporated. In fact, Woods (in Watson, 2000) also views social constructivism as the most appropriate learning theory to enable metacognitive breakthroughs (explained further in Section 2.6.2); all of which highlight the suitability of the chosen theoretical framework for this study.

This section has aimed to provide a basic description of the theoretical orientation chosen for the research, and has also attempted to explain my agreement with Wood's previously mentioned statement, namely that social constructivism is the most appropriate learning theory to enable metacognitive breakthroughs. For these reasons, a social constructivist perspective permeates this research study, and the applicability of Vygotsky's theoretical underpinnings will be emphasised throughout subsequent chapters. The next section acts as an introduction to me, and it also aims to explain my role as teacher-researcher.

1.3.2 Phase 2: Introduction of the researcher

1.3.2.1 My lived experiences

It is not uncommon for me, as a teacher, to question my teaching abilities when I assess some of my learners' tests, assignments or projects. Despite the assumptions I may have about the quality of work I expect to see from a particular student, I often notice that there has been little thought put into the work. I cannot understand why it is that this learner has not thought about planning her project in a more efficient way, or why she has not answered a question

correctly, when we had completed many similar examples in class? Why is it that this is the way with only some learners and not others? Why is it that some learners take control of their learning and act mindfully, whilst others do not? What is missing? Is it something that I am doing wrong in my teaching? Is it something that I need to help develop in my learners? What can I do differently to improve my learners' learning abilities?

As a high school Natural Sciences teacher, I have often reflected on questions such as those mentioned above. This has finally brought me to the point where I feel compelled to investigate why these incidents occur, and what I can do to improve my methods of instruction in such a way so that this 'missing element' can be grasped. I have included the above insert to enlighten the reader about how the research questions of this study originated, as well as to share my stance in connection to these questions.

1.3.2.2 *Who am I?*

In the current stage of my life I see myself as playing a number of roles. As is well known, any teacher, by association, has a multitude of roles and seldom just teaches (Department of Education, 2002a; Malcolm & Alant, 2004). Most teachers act as mediators, specialists, leaders, administrators, and support providers, among other roles (Department of Education, 2002a), which will be discussed in Section 2.5.2. However, apart from being a high school Natural Sciences teacher, with all the embedded roles, I am also in the process of completing my Masters degree in Educational Psychology. In my private life I am also a daughter, a sister, a friend, an aunt, and most fundamentally, a human being. For the purpose of this thesis (a requirement for the completion of my Masters degree), I must take on the dual role of both teacher and researcher, but I cannot ignore any of the other different roles that constitute who I am. Instead, I need to embrace them all and acknowledge the subjective nature that they bestow upon me in terms of my epistemological views. According to Nieuwenhuis (2007), one cannot disregard the subjectivity of one's own happenings. It is my humaneness, subjective experience and knowledge that will influence my understanding of that which I research (Nieuwenhuis, 2007).

From a social constructivist positioning, my personal, social, cultural and historical experiences have shaped my thinking, and therefore influenced the way that I perceive the world (Thrift & Amundson, 2005). According to Denzin and Lincoln (2005), no research is value-free, and the researcher simply has to tackle the ethics and politics of research.

Henning, Van Rensburg and Smit (2004, in Oswald, 2010, p. 17) explain validity, in research, to be based on working with "precision, care and accountability", as well as communicating openly throughout the research process.

To attain this 'openness', I introduced myself in the section above, by providing an excerpt of my lived experiences as a teacher. These experiences, along with my views on advocating for good teaching and learning, have guided the development of this research inquiry, and they, along with a consideration for disciplinary, psychological and pedagogical perspectives, will continue to guide the research process (Yore & Treagust, 2006). In addition to this, one of my roles as a future educational psychologist will be to provide support and training to teachers (Health Professions Council of South Africa, 2007b). This is a role I feel very strongly about and, therefore, with the findings and experience I gain through conducting this study, I hope to be able to pass on my knowledge and experience to other teachers in the future. With this active and practical approach to improve my teaching practice in order to enhance my learners' metacognition, it seems appropriate to explore the paradigm of this research inquiry next, namely the paradigm of praxis.

1.3.3 A paradigm of praxis

The above discloses some of my views on teaching and learning, as well as my concern for improving both; revealing a small part of my 'worldview' or paradigm for this research (Hills & Mullett, 2000). The paradigm of praxis or action (Ball & Wells, 2006) provides an important bridge between that which is learnt in theory, and that which is put into practice (Hills & Mullett, 2000). With the aim of attending to the research question, in this research study, I will attempt to take what I have learnt in theory, put it into practice in my classroom, and then study the outcomes of this process. This active procedure seems most appropriate for accommodating the research needed to find practical ways to implement metacognition into Natural Sciences classrooms (Yore & Treagust, 2006).

In addition to this, I concur with Smith (1999) and Bernstein (1983), who believe that reflecting on the action process (praxis) is important, and it seems most appropriate, with the thinking and reflection required of metacognition. Hence the suitability of the action research design for this study in which I will personally form both an instrument of research, in that I conduct the research myself, as well as a partial focus of research, where I am studying my own practice. As such, my own thinking and practices will undergo analysis, implying that I

will constantly be required to think through my own practice as both a teacher and a researcher (Ainscow, Booth & Dyson, 2004; Baumfield, Hall & Wall, 2008; Berg, 2009). Not only does self-reflectivity add to the credibility of research, it also improves the quality of the action research process (Sagor, 2005). As indicated in Section 1.3.2, being explicit about my social and cultural positioning in relation to the context of the study as well as the learners who participate in it, will allow me to "demonstrate metacognitive awareness that heightens the intellectual rigor of the project" (Alsup, 2004, in Oswald, 2010, p. 17).

This brings me to the third phase of this research inquiry, namely, the research design. Details of Phase 3 will be provided in Chapter 3, but in order to continue with this outline to the research, the most fundamental aspects will be mentioned here in brief. Bearing in mind all that has been mentioned up until this point, the following section aims to reveal part of the reasoning behind the choices made for my research design.

1.3.4 Phase 3: Research design

To meet the outlined objectives, yet remain within the limited range of this fifty-percent Master's thesis, it has been decided that the best course of action will be to conduct my research as a pilot study. The inquiry will therefore aim to act as a "small-scale trial run" of all the aspects of a future research project (Strydom, 2005, p 206). A pilot study is defined as the process of testing the research design for prospective research (Strydom, 2005). It acts as a "dress rehearsal" for a bigger research inquiry, with the aim of determining whether the methodology, sampling, instruments and methods of analysis are appropriate and sufficient for the main inquiry (Strydom, 2005, p 206). Therefore, the target group of participants may be small, as probability does not tend to play a major role. The sample group, as well as the entire study, must however take into account all heterogeneous factors of the target population (Strydom, 2005). Pilot studies are becoming an increasingly standard practice in research today as they aim to improve the success and effectiveness of research inquiries (Strydom, 2005).

As such, the design of the research study will take on that of a small investigation, which includes one cycle of an action research process. Some reasoning behind this choice will be explored throughout this section, but specific details are provided in Chapter 3. Part of the rationale for choosing action research as the design for this study is that there is said to be a strong link between contemporary social sciences and action research (Hopkins, 2002).

Reason and Bradbury (2008) confirm that the growth of action research is concurrent with the emergence of social constructivism, which shows how action research links to the theoretical framework of this inquiry.

Linking to what was previously mentioned, action research is said to be orientated towards creating a change through reflection by continuously refining one's thinking when reflecting on a problem and ways of solving it (Baumfield *et al.*, 2008; Fraenkel, & Wallen, 2008; Gay, 1987; Hopkins, 2002; Mouton, 2001; Riding, Fowell & Levy, 1995; Thomas, 2009). With a central commitment to change and action, through reflection, action research provides a flexible structure that involves moving forward and building on what is discovered in research (O'Hanlon, 2003; Riding *et al.*, 1995; Rossouw, 2009; Thomas, 2009; Walker, 1998). The typical cyclical nature of action research determines that this study begins with the selection of a research problem, namely: Step 1, which will be presented in the form of the research questions. Step 2 will involve examining the problem and gathering information, which will be reflected in the literature review (Chapter 2). Step 3 will involve developing an action plan (Chapter 3), which will then be implemented in Step 4. Step 5 will incorporate the reflection on the process and decisions will be made on how to proceed (Chapter 4 and 5) (Riding *et al.*, 1995). The reflection and cyclical nature of action research will best accommodate the aims for this study, namely to improve my teaching practice by continuously reflecting, adapting, and building on it, in order to bring about a change in my learners' metacognitive abilities.

Most of the research carried out internationally on metacognition, has occurred in laboratories or clinics; in unnatural settings (Lin, 2001). Within these research settings, there is little or no validity in connecting the findings to classroom practice, as there is little similarity between the characteristics of the different settings. It has been noted that teachers often get frustrated when the erroneous assumption is made that teaching strategies, developed in a simulated classroom-research setting can be simply relocated to the classroom (Hawkins, 1994; Manning & Glasner, 1996; Patton, 2002). Action research is said to be one way in which research and classroom practice can merge (Hopkins, 2002). In support of this, I borrow various conclusions from Palincsar, Magnusson, Collins and Cutter (2001, in King-Sears, 2008) which all imply that teachers, who used metacognitive teaching practices within science classes for students with a variety of learning needs, promoted increased achievement for average learners, below average learners, and learners with learning difficulties. Rossouw

(2009) claims that South African teachers, who are facing educational reform, which is targeted at developing well-adapted citizens, should act as reflective practitioners and research their own teaching through action research, in order to improve their teaching. It is for these reasons; along with others mentioned throughout this chapter, that action research is the chosen design for this particular research.

Adding to these motivations, action research tends to have a narrow focus and therefore has no intention to provide findings to generalise beyond the specific research setting (Fraenkel, & Wallen, 2008; Patton, 2002). This particular study has the primary aim of improving my personal teaching practice through one cycle of an action research process. As a pilot study, the findings will be used to conduct an inquiry process, of which the results and conclusions will then be available for future action research cycles to take the research further.

Action research has proven to be very useful for implementing new ideas and practices in both schools and classrooms (Baumfield *et al.*, 2008; Berg, 2009; Mouton, 2001). For the purpose of this study, a research design, using a combination of school-based (also known as classroom action research), and "practical action research" (Berg, 2009, p. 259), will form the research methodology. These 'types' of action research are most applicable because they tend to involve the use of "qualitative interpretive modes of inquiry and data collection by teachers [...], making judgements about how to improve their own practices" (Kemmis & McTaggart, 2005, p. 561). Together, they involve the researcher reflecting on his/her own teaching practice, using research-based teaching, and implementing changes needed for improvement (Adendorff, 2007; Berg, 2009; Fraenkel, & Wallen, 2008; Galyam & Le Grange, 2005; Joseph, 2010; McMillan & Schumacher, 2001).

Having chosen, what seems to be the most appropriate research design, a methodology needs to be selected to enlighten which processes and research procedures will be employed to best accommodate this action research inquiry.

1.3.5 Research methodology

From the groundings of Vygotskian social constructivist perspective on learning and teaching (Karpov, 2003; Kozulin, 2003), this study aims to embody an in-depth, interactive inquiry with an emergent and flexible design (McMillan & Schumacher, 2001; Oswald, 2010). Apart from this, the study has the intention of tapping into the subjective experiences of the learners involved (McMillan & Schumacher, 2001; Oswald, 2010), with the intention of finding out

how my adapted teaching methods influence their metacognitive abilities. There is no intention for the findings of this pilot study to be generalised beyond the context (McMillan & Schumacher, 2001). These aspects are all characteristic of a qualitative research methodology, which will therefore act as the chosen methodology for the study and will be discussed in more detail in Section 3.4.

1.3.6 My action research intervention plan

Once an appropriate methodology and research design have been selected to target the research problems, a flexible plan needs to be put in place to address the research questions. Developing this action plan amounts to Step 3 of the action research process mentioned above.

The action plan for this study will act as a flexible intervention strategy, in which I will attempt to adapt my Natural Sciences teaching practice, so as to enhance my learners' metacognition, whilst continuously reflecting on the process. The plan involves a series of metacognitively enhanced Natural Sciences lessons, occurring over a 5 week period, which are intended to help develop the learners' metacognition. These lessons will follow the usual school curriculum, but will incorporate a number of metacognitive teaching procedures. The procedures include: *creating an appropriate metacognitive classroom environment* (Lin, 2001), *modelling* (Hartman, 2002a; Hartman, 2002b), *metacognition, scaffolding* (Donald, Lazarus & Lolwana, 2010; Gourgey, 2002; Guterman, 2003; Hartman, 2002b; Watson, 2000), *teaching for transfer* (Woolfolk, 2010), *teaching summarising skills* (Mills; 2009; Woolfolk, 2010), *explaining graphic organisers* (Hartman, 2002a; Woolfolk, 2010), *think-aloud techniques* (Hartman, 2002a; Sagor, 1999), *co-operative learning* (Donald *et al.*, 2010; Hartman, 2002b; Shamir; Mevarech & Gida, 2009; Watson, 2000), *teacher and self-questioning* (Bondy, 1987, in Sagor 1999; Hartman, 2002b; Palinscar, 1988, in Sagor, 1999; Short & Weissberg-Benchell, 1989, in Sagor, 1999), *and various self-regulation techniques* (Kistner, Rakoczy, Otto, Dignath-van Ewijk, Büttner, Klieme, 2010; Lin, 2001). Each of these strategies is explained in detail in Section 3.5, and the intervention plan is presented in the form of a flexible schedule (Addendum G).

After a research design, methodology and an intervention plan are all in place, certain qualitative research methods will be employed to carry out the plan. I now briefly refer to the different methods that will be employed in the research inquiry.

1.3.7 Phase 4: Research methods

1.3.7.1 Research context

The selection of the research setting, as implied by Holliday (2007), involves ensuring that it meets certain criteria, such as: providing a variety of relevant data; having opulence in the sense of heterogeneity; being of manageable size for the researcher; and providing the opportunity for the researcher to assume the necessary role/s. With the primary goal of this research being to look at improving my teaching practice, by employing different metacognitive teaching procedures into my Natural Sciences teaching, it only seems logical to use my own teaching environment as the context for the research. Therefore, this inquiry will take place in the all-girls government high school, where I currently teach, situated in the Winelands region of Western Cape Province, one of the nine provinces of South Africa.

I chose to work with my Grade 9 Natural Sciences class as the target population for this study. Holliday's (2007) criteria for selecting a research setting, mentioned above, have played a role in this decision, as well as the fact that there is a general need to improve science education and many learners' metacognition (mentioned in previous sections). Other reasons for this being the selected target population are mentioned in Chapter 3 but, essentially, at a Grade 9 level, there are many benefits for employing such a study to enhance metacognition in science education. For example, this research setting and population group are most appropriate as it is at a Grade 9 level that learners need to make the decision as to whether to continue with scientific learning areas in future grades, and after school (Department of Education, 2002a). This offers an opportune time to engage with learners so that they can experience the positive effects of science, which will hopefully encourage them to pursue careers in the science field (Sjøberg & Schreiner, 2010). In addition to this, the context and sample population of this study are particularly relevant, as it has been said that the capacity for effective metacognition develops during an individual's adolescent (high school) years (Fox & Riconscente, 2008; Goos, Galbraith & Renshaw, 2002; Hartman, 2002a; Manning & Glasner, 1996), making a high school setting most appropriate.

1.3.7.2 Selection of 'informants'

Needing to address ethical issues and consideration of the individuals involved in the study, it was decided that, in order for all of my Grade 9 learners to benefit from the potential opportunity to enhance their metacognition, the data collection would occur in two phases.

During the first phase, in which my adapted teaching strategies are implemented, my entire Natural Sciences Grade 9 class will have the opportunity to form part of the lessons (with their informed assent) and reflect on their development. In the second phase of data collection, a sample population will be selected from the class group, to act as informants for the research process.

Using criterion-based, purposeful sampling, a sample of nine learners (a third of the class) will be selected from the target population (my Grade 9 Natural Sciences class) to act as informants to the research process. To mirror the heterogeneity of this target population, the criteria that will be used to select the sample, include the learners' academic achievements, as well as their cultural-language grouping, so that the diversity of the class will also be reflected in the sample. The purpose of this selection is to include individuals in the sample that are able to give rich information to the study (Patton, 2002). I have decided to borrow the term 'informants' from ethnographic research to describe my participants (Delamont, 2002, in Oswald, 2010) as it seems well suited for this particular study. It highlights the agency of the learners as participants who will help to *inform* my research (Oswald, 2010).

The selected informants will be asked to participate in the study on a purely voluntary basis (McMillan & Schumacher, 2001), with the assurance that their identity will remain protected and that they can at any stage withdraw from the study. The learners and their parents will be informed of these ethical considerations, and other relevant information, before assenting (learners) and consenting (parents/guardians) to participate (Allan, 2008; Health Professions Council of South Africa, 2007a). The details of this selection and sampling process will be discussed in detail in Section 3.6.2.

1.3.7.3 Method of data collection

When the time comes for data collection in the research process, the intervention plan will be ready to implement, but as the researcher, I will need to know what is happening as I conduct the research. I will also need to know whether my research goals are being accomplished and how the different parts of the research plan are contributing to the accomplishments (or lack thereof) (Sagor, 2005). In order to facilitate the above, I will need to select methods for collecting adequate data, to inform the research process, but also take into account the research design and methodology, as well as my role as teacher-researcher (Borgia & Schuler, 1996, in Adendorff, 2007).

The main aim of this research inquiry is for me to adapt and analyse my teaching in such a way that I may improve it. For this reason, I will need to critically reflect on my teaching process, as well as use the other aim of this study, as an indicator of the process. This other aim of this research requires me to determine how my learners' metacognition is developing and how they internalise the different metacognitive teaching strategies that I employ. In other words, it is through the change in the learners' metacognition that I will gain an idea of the effectiveness of my adapted teaching procedures. However, with metacognition being an internalised higher order cognitive skill (Woolfolk, 2010), it makes it a difficult entity to observe (Hofer & Sinatra, 2010; Yore & Treagust, 2006). Therefore, I will need to collect data in such a way that I can directly and indirectly gain an idea of what they have internalised in terms of metacognition. (Internalisation and externalisation are looked at in more detail in Section 3.6.3). The methods of data collection will therefore need to look at how the informants think about their thinking, and this will be done in the form of learner reflections (Baumfield *et al.*, 2008; Connerly, 2006; Shamir *et al.*, 2009), an open-ended questionnaire (McMillan & Schumacher, 2001), and a focus-group interview (McMillan & Schumacher, 2001). In order to further validate the data about my teaching, I will also keep a research journal in which I can reflect on all interactions, observations and significant events that occur throughout the research process. These four data collection methods are described in detail in Section 3.6.3.

1.3.8 Phase 5: Method of data interpretation

Data, collected with the methods mentioned above, will be captured and interpreted throughout the data collection process. This will form a necessary part of my continuous self-reflection and will add to the reflections I make in my research journal. All the data will be explored in such a way that themes are identified (Berg, 2009; Sagor, 2005) with the intention to look at the data to find any patterns, which may provide information to answer the research questions. This may require the use of a coding scheme (Azevedo, 2009; O'Hanlon, 2003). Categorisation during the data analysing process will need to remain tentative because continuous input of new data may require flexible interpretations (O'Hanlon, 2003). A final reflection will be made on the entire research process in which a holistic interpretation will be provided (Holliday, 2007). This will help to address the research questions, as well as draw conclusions about the entire process and make suggestions for future research. The reflection on this cycle, of the action research process,

will then form the basis for the next cycle of action, which, along with conclusions and recommendations, will be presented in Chapters 4 and 5.

1.4 ETHICAL CONSIDERATIONS

Wassenaar (2006) brings to the forefront four ethical principles that should be applied in order for any research to be ethical. These principles include: avoiding harm or negative influences for those involved (nonmaleficence); increasing the benefits of the research for those involved (beneficence); autonomy and respect for the dignity of those involved; justice in the sense that all parties must be treated fairly and equally. Throughout the research process, I will need to ensure that these ethical standards are upheld. Details as to how these principles form part of the research process will be discussed in Section 3.9.

1.5 CLARIFICATION OF CONCEPTS

Before outlining the remainder of this research study, there are a few significant concepts that need to be clarified.

1.5.1 Natural Sciences

Natural Sciences is a learning area (subject) that forms part of the *National Curriculum Statement Grades R - 12* (NCS) in South African education. The different elements of the Natural Sciences Curriculum aim to provide a broad introduction for learners, to the specialisation areas of the sciences in the Further Education and Training (FET) phase, including Life Sciences and Physical Sciences. Natural Sciences is a learning area which is incorporated into the curriculum from the Foundation phase (Grades R to 3), to the Intermediate Phase (Grades 4 to 6) and continues to be compulsory for Senior Phase learners (Grades 7, 8, and 9) (Department of Education, 2002a). Learners may then choose to continue with either or both of the science subjects (Life Sciences and Physical Sciences) beyond Grade 9 (Barker, Cohen, Doubell, Mgoqi, Mkhwanazi & Mzolo, 2006; Department of Education, 2002a). The choice of learning areas (subjects) when progressing into Grade 10 is usually a decision based on career interest, and learners tend to decide on learning areas to continue with to Grade 12, based on the requirements they need for particular career fields and/or tertiary education programs (Bholanath, 2004). Natural Sciences therefore serves the purpose of enabling learners to interact with, and make sense of, the world in scientific

concepts, as well as prepare those learners who will continue with either (or both) of the sciences in the FET phase (Grades 10, 11 and 12), and after school (Department of Education, 2002a).

The Natural Sciences Curriculum is made up of four 'Knowledge Areas', which are used to organise the Physical Sciences, Life Sciences and Earth Sciences (Geography) elements of the subject. These Knowledge Areas include: Life and Living; Matter and Materials; Energy and Change; and Earth and Beyond. Despite being listed as such, these Knowledge Areas are not meant to be dealt with independently. Rather, the themes within each Knowledge Area are linked to form the broad subject Natural Sciences and are intended to be used interdependently in lessons (Barker *et al.*, 2006; Department of Education, 2002a).

There are three general Learning Outcomes (LOs) incorporated into the Grade 9 Natural Sciences curriculum. These include: LO 1: Scientific Investigations; LO 2: Constructing Science Knowledge; LO 3: Science, Society and the Environment (Department of Education, 2002a).

Within each of these three outcomes, there are numerous cognitive and practical skills that need to be developed (Department of Education, 2002a). These are discussed in more detail in Section 2.4.

1.5.2 Grade 9 learner

In the South African school system, high school ranges from Grade 8 (Senior Phase) to Grade 12 (FET Phase). At the end of Grade 9, learners can decide whether to continue to Grade 12, or attend a college or training institution, or leave the school system entirely (Department of Education, 2002a).

In Grade 9, most learners are in their adolescent years. Smith, Cowie and Blades (2003), as well as Meyer (2005) understand adolescence as a transition between childhood and adulthood. This is marked by biological changes discernible by the onset of puberty (Meyer, 2005). There are numerous developmental tasks during adolescence, such as developing a self-identity, gaining autonomy from parents, gender role identification, and internalising values and morals (Meyer, 2005). Development in many areas (physically, emotionally, socially), including development on a cognitive level, tends to be rapid during adolescence. Vygotsky's theory on childhood development emphasises that children learn in relation to the

construction of meaning associated with their social interactions in their environment, which in turn, influences their development (Mahn, 2003). He sees the holistic child developing in stages that are centred on critical periods, in which meaning is constructed. These critical periods are characterised by "abrupt and major shifts and displacements, changes, and discontinuities in the child's personality" (Mahn, 2003, p. 122). Vygotsky argues that changes in the mental structures and functions form the essence of development, and when these are mastered, development progresses to the subsequent level (Mahn, 2003).

According to Vygotsky, adolescence (from about 13 years old) represents a period where a new form of mental functioning develops through "higher formations that are the foundation of the whole conscious existence of man" (Mahn, 2003, p. 132). In adolescence, it is the first time that an individual begins to master the process of forming concepts (a new and higher form of intellectual activity). These changes bring about other significant effects such as an effect on the adolescent's perception and impulsive shift to think in concepts. Subsequent changes in verbal thinking ability allow them to make more "systematic, ordered, categorical" pictures of reality, unlike younger children who often do not understand the interconnectedness between systems (Mahn, 2003, p. 133).

In addition to this, adolescents start to understand the complexity of 'self' through reflection and introspection. This leads to the awareness of one's own internal mental processes, contributing to the basic change in an adolescent's perception and internalisation of social experiences. This occurs in conjunction with an adolescent's consciousness of his/her potential to control his/her thoughts and actions, which enables him/her to conceptualise activities and their consequences, and therefore plan them, in ways that younger children cannot. Essentially, the adolescent phase is characterised by self-awareness and the full development of consciousness, both of which are central to metacognition (Mahn, 2003). This implies that it is at this age that metacognition can really begin to develop effectively.

As adolescents, any Grade 9 learner is most likely experiencing the changes mentioned above. Besides for the developmental tasks associated with each critical period, another important task for a Grade 9 learner, as mentioned above, is that of making the choice which subjects to continue with into the FET phase (up until the end of Grade 12) of schooling, based on his/her orientation towards certain careers and the relevant tertiary institution programme requirements (Bholanath, 2004). This consequential decision only emphasises the

importance of the Grade 9 year for preparing learners accordingly within each Learning Area, so that they can make informed choices with regards to their subjects for Grade 10.

1.5.3 Metacognition

Metacognition is understood to be a higher-order cognitive skill which is used "to monitor and regulate cognitive processes" such as thinking, learning, reasoning, comprehension and problem solving (Woolfolk, 2010, p. 270). In general, metacognition involves an awareness of the various factors involved in the learning situation. It involves knowing about one's prior knowledge, being aware of which prior knowledge is necessary for the learning situation at hand, and how to use this prior knowledge effectively (Guterman, 2003; Manning & Glasner, 1996).

According to Hartman (2002b), there are two types of metacognition, *strategic knowledge* (also known as knowledge of cognition) and *executive management strategies* (also known as regulation of cognition). Strategic knowledge involves the application of *declarative knowledge* which involves knowing what to do when performing a task. This involves understanding oneself as learner, what factors influence your own learning and memory, as well as the skills, strategies and resources needed to perform a task. *Procedural knowledge* is about knowing how to use these strategies (identified with *declarative knowledge*), and *self-regulatory knowledge* involves knowing 'when' and 'why' to apply the skills, procedures and strategies (Woolfolk, 2010; Yore & Treagust, 2006).

Executive management strategies on the other hand aim to regulate thinking and learning, and they involve three essential skills which allow one to do so. These are *planning*, *monitoring*, and *evaluating*. *Planning* involves making decisions as to "how much time to give to a task, which strategies to use, how to start, what resources to gather, what order to follow, what to skim and what to give intense attention to, and so on" (Woolfolk, 2010, p. 270). *Monitoring* involves checking one's progress along the way, whether one is maintaining short-term and long-term goals, and determining whether one is still 'on track' for the task. *Evaluating* is about appraising the processes used, and the outcomes of one's thinking and learning (Gourgey, 2002; Hartman, 2002b; Hessels *et al.*, 2009; Woolfolk, 2010; Yore & Treagust, 2006).

For the purpose of this study, metacognition is viewed from a social constructivist perspective. Research has shown that metacognition can be taught (Joseph, 2010), and

therefore one needs to look at the mediation needed to incorporate metacognition into a learner's zone of proximal development (Blanton, Moorman & Trathen, 1998).

This section offers a small summary of the major aspects of metacognition, so that the reader has a basic understanding of the concept on reading the remainder of the thesis. More detail will be provided about the concept of metacognition in Section 2.6.

1.6 STRUCTURE OF THE PRESENTATION

Following the above layout, the structure of the remainder of the thesis, and presentation thereof, will be discussed in short.

Chapter 1 attempts to provide an outline for the research process; the research study is introduced and the relevance of it is explained and contextualised. It also includes Phase 1 of the study, in which the theoretical framework of the inquiry is presented, and Phase 2, an introduction to the researcher, is also included. The problem statement, research aims, and research questions are presented and the research design, methodology and relevant concepts are briefly discussed with details provided later in Chapter 3.

In Chapter 2, a review of the literature that pertains to metacognition, teaching and learning, as well as science education, will be explored.

Chapter 3 will aim to provide a detailed exploration of Phase 3 of the inquiry, which includes the research design and methodology of the study. The action plan for the research intervention is discussed in detail in this chapter. Phase 4 is also presented in Chapter 3 and it incorporates a detailed explanation of the research context, selection of the informants and methods of data collection. Issues of validity and reliability, as well as the ethical considerations relevant for the study, will also be included in Chapter 3, as is Phase 5, the method of data interpretation.

In Chapter 4, the implementation of the action plan of the study, as well as the findings, will be presented. The process will be recorded, interpreted and discussed in detail.

Chapter 5 will include a conclusion to the study. Limitations and strengths of the study will be referred to, and recommendations for future research will be made.

1.7 SUMMARY OF CHAPTER

This first chapter provided an explanation of the motivation for the study, and it also presented the problem statement, aims of the research, and the research questions. The research design and methodology were discussed, and the methods of data collection and analysis were briefly explained. Some key concepts were clarified, and the chapter came to a close with an outline for the structure and presentation of the remainder of the thesis. In the next chapter relevant literature, relating to metacognition, science and education will be reviewed to highlight elements that are of significance to this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

"The literature study is important not only for the clear formulation of the problem, but also for executing the planning and actual implementation of the investigation."

(Cilliers, 1973, in Strydom, 2005, p. 207)

This chapter has the purpose of providing a review of literature that is relevant to this research inquiry. With the above quotation in mind, it intends to further support the problem statement, the aim of the study and the rationale for the study, each of which were briefly discussed in Chapter 1. A literature review endeavours to provide a source for guiding the planning and execution of the rest of a research study (Henning *et al.*, 2004; Mouton, 2001). The literature that is reviewed and discussed in this chapter, presents a central focus on metacognition in teaching and learning in South African Natural Sciences education. A literature review not only helps to contextualise a study, it can also help to identify a "niche to be occupied by a particular research study" (Henning *et al.*, 2004 in Oswald, 2010, p. 28).

In this research, the social constructivist theory has been chosen as the theoretical framework for the study. As introduced in Chapter 1, the social constructivist theory assumes that knowledge and meaning are created through a person's social interaction and social experiences (Kozulin, 2003). This chapter begins with a detailed account of Vygotskian social constructivism, building onto the brief description provided in Section 1.3.1.

In addition to this, the chapter aims to synthesise available literature into a conceptual framework that highlights the importance of employing metacognitive procedures into Natural Sciences teaching to enhance learners' metacognition. Therefore, following the detailed description of social constructivism, the chapter focuses on general education in South Africa, and then it also aims to present a more focused discussion of the Natural Sciences learning area. The characteristics of effective learning and teaching are highlighted and the chapter ends with an in-depth explanation of metacognition and its relevant components.

2.2 A SOCIAL CONSTRUCTIVIST APPROACH TO TEACHING AND LEARNING

In order to grasp the complexity of social constructivism as the all encompassing theoretical framework for this study, it is essential to take a few steps back and first conceptualise the fundamental characteristics of *constructivism* itself. Constructivism is regarded as a theoretical perspective of considerable importance in both psychological and educational fields (Donald *et al.*, 2010; Giest & Lompscher, 2003). It is a time-honoured theory which, at its core, emphasises "the active and subjective processes involved in understanding" (Watson, 2000, p. 135). Constructivists view knowledge as something which is actively, and continuously, constructed and reconstructed by individuals, groups and societies, as they reach higher levels of understanding. Knowledge, for example, is therefore not something that is passively received - it is actively constructed (Donald *et al.*, 2010).

Constructivism forms the underlying principle for many studies in the educational and psychological fields. It is regarded as having added many benefits to facilitate the understanding of students' learning processes, and even to science classroom practice (Giest & Lompscher, 2003). One of the offshoots of constructivism is known as social constructivism. Lev Vygotsky (1978), a well known social constructivist, was an early 20th century Russian psychologist, who understood humans as shaping and being shaped by social, historical and cultural contexts (Van Der Veer, 2007). Vygotsky emphasized the importance of these contexts in the construction of knowledge and meaning (Donald *et al.*, 2010). This formed part of the development of Vygotsky's popular social-cultural theory (Kozulin, 2003), which in turn forms part of the social constructivist theoretical orientation.

Although Vygotsky's theories originated over 60 years ago, they have been revised and adapted, and today, they capture the imagination of psychologists and educators all over the world (Daniels, Cole & Wertsch, 2007; Kozulin, 2003; Watson, 2000). Vygotsky's theories have laid the foundations for potentially ground-breaking conceptualisations of the relationship between learning and development. He claims that there is an interdependent relationship between learning and development, with learning viewed as having a leading role in defining and shaping development (Stetsenko, 1999). It is the understanding of this interconnected dynamic process that is crucial in the design of educational practices that enhance all children's learning potential (Stetsenko, 1999).

Linking to what was mentioned in Section 1.3.1 about learning 'pulling' development in a process that moves from an inter-mental interaction to an intra-mental interaction, Vygotsky believes that each cognitive function appears twice in development. Initially, it occurs as an actual interaction between people, and a second time as an inner internalised form of this function, which then becomes an essential characteristic within a person's mind (Kozulin, 2003). This process is illustrated in Figure 2.1.

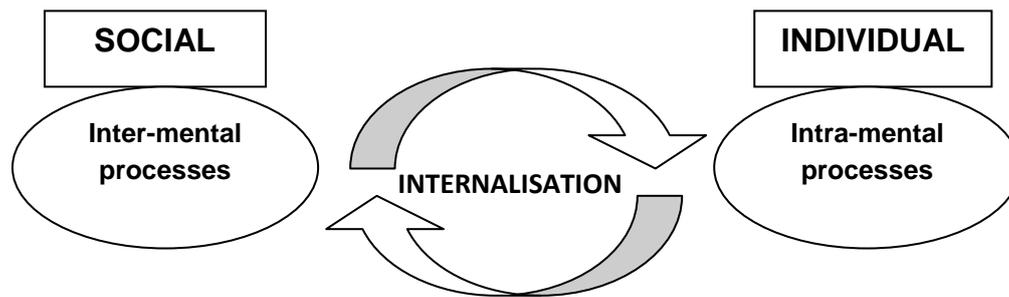


Figure 2.1: Process of learning and development

The question still remains, however, as to how, when and where this process of internalisation takes place? Internalisation (as indicated in Figure 2.1) explains the 'transformation' of mental processes from the social level to the individual level. It is the social relation itself that becomes an internal, individual human function. This was Vygotsky's view on internalisation:

[...] every higher mental function, before becoming internal mental function was external because it was social before it became an internal, strictly mental function; it was formerly a social relation of two people.

(Veresov, 2009, p. 273)

This is not to say that every social relation between two or more people becomes a higher mental function. Vygotsky uses the word "category" in his description of those social relations that have the capacity to be internalised as mental functions on an individual level. The meaning he attaches to "category" in this context is that of a "dramatic event", involving a "collision of characters" (Veresov, 2009, p. 273). In laymen's terms, a social relation needs to be characterised as an event that is dramatic enough to be internalised. In this situation, a dramatic event refers to "an emotionally coloured and experiencing collision, the contradiction between two people" (Veresov, 2009, p. 273). It is believed that a social relation, that has the magnitude of such a dramatic event, can lead to reflection (or self

reflection) and/or radical changes in the individual's mind, which in turn can lead to internalisation and the development of mental functioning (Veresov, 2009).

The preceding paragraph alludes to the characteristics of the social event that can become internalised in the construction of an individual's learning and development, but we still lack an explanation as to what exactly constitutes this so-called 'social event'. As mentioned before, Vygotsky understood a child to be active, but he also accentuated that he/she is mediated from the outside in (Donald *et al.*, 2010). Bruner, another influential constructivist, added to this that "[...] one finds no internal push to growth without a corresponding external pull" (Donald *et al.*, 2010, p. 81). This highlights the importance of mediation, another central aspect of Vygotsky's social constructivist perspective (Wertsch, 2007). The 'social event' from which internalisation occurs is sometimes understood as a form of effective mediation.

Mediation is understood in different ways (Kozulin, 2003; Wertsch, 2007) and for the purpose of this research study, Kozulin's (2003, p. 19) distinction between "human mediators" and "symbolic mediators" becomes important. Human mediation, as defined by Vygotsky's (1978) theory, refers to social interaction between a child and an adult or 'more educated peer' (a term that will be defined later in this section), bringing about cognitive development. Mediation therefore facilitates the transition of knowledge from being an interpersonal function to an intrapersonal function (Kozulin, 2003). Within the educational context of this study, it is relevant to refer to examples of teacher mediation as a form of human mediation. Activities such as modelling, contingency management (praise and critique), feedback and cognitive structuring (metacognitive strategies for the organisation of one's learning work) are some forms of teacher mediation (Kozulin, 2003). Rogoff (in Kozulin, 2003) distinguishes between different aspects of mediation, namely: apprenticeship, guided participation and appropriation. Apprenticeship provides a model of community activity that mediates socio-cultural patterns to others, whereas guided participation refers to the interpersonal aspect of a joint social activity. Appropriation, on the other hand, covers the changes that occur within the individual as a result of his/her involvement in the social/mediated activity (Kozulin, 2003).

The above refers to human mediators, but symbolic mediators, on the other hand, represent the 'tools' that may be employed in the mediation process (Kozulin, 2003). These tools can range from the primitive use of fingers, as tools for counting, to the higher order symbolic

mediators including language, different signs, symbols, writing, counting systems, formulae, works of art, schemes, diagrams, maps and graphic organisers (Kozulin, 2003). These tools are created by human society, and they are acquired by children in the course of interpersonal communication with adults and more knowledgeable peers (Karpov, 2003). According to Vygotsky, a child's cognitive learning and development is dependent on their ability to master symbolic mediators, as well as appropriation and internalisation to form inner psychological tools (Kozulin, 2003). Figure 2.2 provides a visual representation of this mediation process.

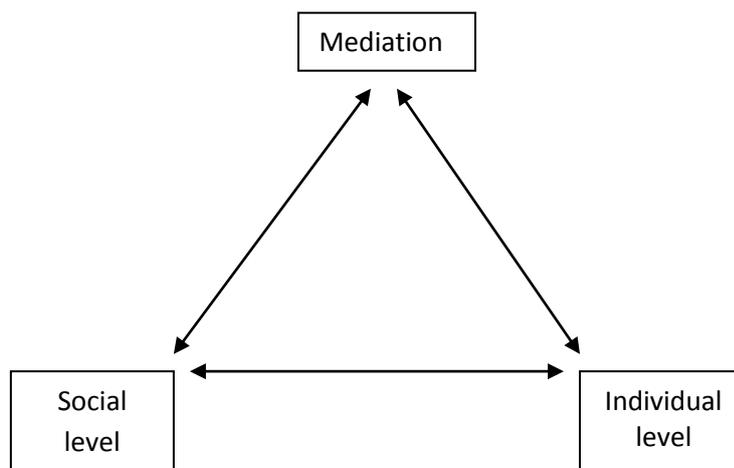


Figure 2.2: The mediation process (adapted from Blanton *et al.*, 1998).

Research has however shown that symbolic tools may be useless without their meaning as cognitive tools being properly mediated through effective human mediation. In other words, symbolic tools would be ineffective if their use is not explained to the person using them (Kozulin, 2003). This highlights the important role of the teacher in the mediation process. A generally accepted rule is that the acquisition of psychological tools must always take on the character of deliberate action. Essentially, there must be intentionality behind the teacher-mediator's actions; otherwise the 'tools' may not be appropriated by learners in effective ways (Kozulin, 2003). The metacognitive mediation tools used in this research inquiry are explained in detail in Section 3.5.

Vygotsky saw school instruction as a very important means for mediated learning (Karpov, 2003). He added that "[...] the only good kind of instruction is that which marches ahead of development and leads it; it must be aimed not so much at the ripe as at the ripening fruit" (Karpov, 2003, p. 65). This leads one to question, where exactly should teaching instruction

be 'aimed' at in order to bring about effective learning? Many a committed teacher has asked him-/herself the question: What kind of instruction is best for a particular learner? (Chaiklin, 2003). To this teaching problem, Vygotsky provides a solution in the form of the *Zone of Proximal Development* (ZPD). The ZPD is essentially:

[...] the distance between the actual developmental level, as determined by independent problem solving, and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

(Del Río & Álvarez, 2007, p. 278)

The ZPD is the region between instruction and the level of a child's learning development that should be focused on. The underlying assumption of this concept is: "what a child is able to do in collaboration today he will be able to do independently tomorrow" (Chaiklin, 2003, p. 40). A commonly understood conception of the ZPD accepts an interaction on a task between a 'more competent person and a less competent person' in such a way that the less competent person becomes independently proficient in a task that was initially accomplished in collaboration (Chaiklin, 2003; Daniels, 2007; Goos *et al.*, 2002; Manning & Glasner, 1996; Woolfolk, 2007).

Some understand the ZPD as characterising mental development 'prospectively', and the actual developmental level as characterising mental development 'retrospectively' (Veresov, 2009, p. 287). The ZPD is said to account for the movement between the interpsychological and the intrapsychological planes. The mechanism for activity in the ZPD is *internalisation and externalisation*. External activities involve those which cause a transformation on an internal cognitive process level. Internalisation corresponds with the organisation and regulation of external social processes, as previously explained (Blanton *et al.*, 1998).

Vygotsky's theory of self-regulation links internalisation and the ZPD in another way. For an individual to become an independent, self-regulating learner, assisted instruction (mediation) needs to be within the learner's ZPD. This is so that it can become an internalised repertoire of self-instruction, which can be performed easily without external mediation (Manning & Glasner, 1996). For this reason, very often a form of 'inner speech' or self-talk is necessary for internalisation to occur (Ball & Wells, 2006).

The most common interpretation of the ZPD sees three aspects as a central emphasis, namely: the *generality assumption*, *assistance assumption* and *potential assumption*. The generality assumption implies that the ZPD is applicable to learning all kinds of subject matter and that any individual is able to complete a number of tasks individually, but he or she could perform a greater number of tasks, or solve more difficult tasks, in collaboration. The assistance assumption indicates that learning is dependent on interventions by a more competent other such as an adult or teacher, also known as a more educated peer. The potential assumption emphasises the 'property' of the learner that permits the best and easiest learning. This could include the learner's potential and/or readiness to learn (Chaiklin, 2003).

The ZPD was initially introduced as a part of a general analysis of childhood development. Vygotsky's model of childhood development offers an explanatory model that considers the *whole child* (interacting with society) as an integral person. His model views development as a being divided into periods, with each period having a 'leading activity' that is the main source of development within that period (Chaiklin, 2003, p. 47). This 'leading activity' offers a way to identify the particular relations in the social situation of development, that are likely to contribute to the advancement of the functions, that lead to the "structural reorganisation of a child's psychological functions" (Chaiklin, 2003, p. 47). As has been mentioned in previous paragraphs, a child is not a passive recipient of an objective environment, rather, he/she is selective about what is perceived and interesting, creating that 'dramatic event' which leads to learning. That which is perceived as interesting to a child will change with the different age periods of the child's development, reflecting the psychological functions for that age (Chaiklin, 2003).

For each age period, there are certain psychological functions that are maturing in relation to the central new-formation. This will lead to the restructuring of the existing psychological functions and incorporation of these new functions, ultimately leading to the transition to the next age period. This 'objective zone' represents the psychological functions that need to be formed during a given period, in order for a transition to the next age period to occur (Chaiklin, 2003). The ZPD therefore describes a structural relation between the number and extent of maturing relations (subjective zone) and the functions needed for the next age period (objective zone), or the developments that will lead to progression to the next period. The objective zone is the same for all children, but each child's position in relation to this objective zone may differ. The assistance (or mediation) at each stage needs to be meaningful

to the individual child in order for learning (or development to the next period) to occur. In order to be meaningful, the mediation needs to correspond to the maturing functions needed for transition to the next age period (Chaiklin, 2003). Mediation, which aids teaching instruction, is said to be most effective when it is directed at a certain point within the ZPD (Veresov, 2009).

The above has explained how Vygotsky highlighted the crucial role that other people, such as parents, peers and teachers, play in a child's early and later learning. Vygotsky viewed learning as an entity constructed through social interaction, whereby understanding is enhanced by providing assistance, that is appropriate for the child's unique needs - emphasising the importance of his/her potential (Watson, 2000). This social interaction is commonly seen in the form of school instruction or teaching (Karpov, 2003). The question remains as to what should teacher instruction *include*, so that it is 'aimed' correctly at a learner's ZPD? For Vygotsky, content teaching and learning can be associated with two different conceptual processes, namely: the formation of *spontaneous empirical concepts* and *scientific concepts* (Ball & Wells, 2006).

Spontaneous concepts are considered to be the result of everyday experience "in absence of systematic instruction" (Karpov, 2003, p. 65). These everyday concepts are often acquired unconsciously, and usually do not add to a learner's cognitive development, as they are generally based on already existing cognitive mechanisms (Chaiklin, 2003). These concepts tend to be quite rigid, and are usually limited to the context in which they are situated (Blanton *et al*, 1998). Therefore, these spontaneous concepts of learning simply add "empirically rich experience" (Chaiklin, 2003, p. 32).

Vygotsky was more concerned with the importance of leading children beyond these empirically rich spontaneous concepts, as these concepts are often unsystematic and contradictory. In order to facilitate this development towards systematic reasoning, Vygotsky's theories support the incorporation of scholarly conceptualisation in the form of content learning, for example. This is understood as the formulation of the *scientific concepts*. These concepts are higher mental functions (Ball & Wells, 2006) and "represent the generalisation of the experience of humankind that is fixed in science, understood in the broader sense of the term to include both natural and social sciences as well as the humanities" (Karpov, 2003, p. 66). Scientific concepts, in this sense of the term, are therefore not specifically linked to Natural Sciences as a subject. Learners are taught scientific

concepts through the process of systematic instruction, allowing them to acquire these concepts consciously and according to a certain system (Karpov, 2003). Scientific concepts are systematically organised bodies of knowledge that are flexible and can be generalised to other contexts (Blanton *et al.*, 1998). A learner is consciously aware of these concepts and therefore, once they have been acquired they transform learners' everyday knowledge by facilitating the transformation of spontaneous concepts into conscious and structured concepts, raising them to a higher level. This implies that the acquisition of scientific concepts creates the ZPD for future spontaneous concepts (Karpov, 2003).

What is also important about the acquisition of these scientific concepts is that they begin to mediate a learner's thinking and problem solving, providing him/her with the opportunity to develop 'reflective consciousness' (Karpov, 2003, p. 66), which is part of metacognition. This allows a learner's thinking to become much more independent of their personal experience, operating on a level of 'formal-logical thought' (Karpov, 2003, p. 66), which is ultimately metacognitive thought. It is for these reasons that the instruction of scientific concepts plays a critical role in a child's mental, and therefore metacognitive, development (Karpov, 2003). These ideas, presented within Vygotsky's social constructivist theory, offer a good theoretical basis for analysis of what the content and process of school instruction should include in order to meet educational goals (Karpov, 2003).

With social constructivism forming the perspective, through which teaching and learning are understood in this study, it is now appropriate to look at education in South Africa, specifically to provide the reader with a contextualised understanding of the positioning of this research.

2.3 SOUTH AFRICAN EDUCATION

With educational reform adopting a driving force in South Africa, there have been a multitude of changes in the focus of curriculum requirements (Department of Education, 2002a; Galyam & Le Grange, 2005; Malcolm & Alant, 2004; Rossouw, 2009), with a particular focus on improving certain aspects of both teaching and learning (Department of Education, 2002a; Dignath & Buttner, 2008; Ramnarain, 2011). This has brought about much evaluation and analysis of the roles and responsibilities of both learners and teachers, with a significant focus on moving away from autocratic didactic instruction, which offers one-way communication and promotes rote, uncritical learning (Department of Education, 2002a;

Ellis, 2001; Hawkins, 1994; Ramnarain, 2011). The Constitution of the Republic of South Africa (Act 108 of 1996) provides the foundations for curriculum transformation and development in South Africa (Department of Education, 2002a). At the forefront of the Constitution are certain aims, such as restoring divisions of the past by establishing a community based on "democratic values, social justice and fundamental human rights" (Department of Education, 2002a, p.1). In addition to this, another aim is to improve the quality of life for every individual and build a united and democratic society, while instilling skills of lifelong learning and effective thinking (Department of Education, 2002a; Ellis, 2001). South African education is considered to be essential in attaining these goals, and the National Curriculum Statement (NCS) aims to facilitate every learner's attainment of his/her full potential. This aim of the curriculum corresponds with Vygotsky's concept of the ZPD in that both the aforementioned encourage a teacher (or more knowledgeable other) to facilitate a learner's development to reach his/her potential. There is a new curriculum, known as the Curriculum and Assessment Policy Statement (CAPS), to be implemented into the South African education system in the near future. However, as not all the details were available for inclusion in this thesis, it was therefore decided to focus on the current South African Revised National Curriculum Statement (RNCS) (Department of Basic Education, 2010).

Outcomes-based education (OBE), which currently forms the implementation methodology of the South African education curriculum, essentially strives to enable all learners to achieve their ultimate potential and ability (Department of Education, 2002a; Malcolm & Alant, 2004). It does so by explicitly stating certain outcomes to be achieved, in the hope of encouraging a "learner-centred and activity-based approach" to education (Department of Education, 2002a, p. 1). The Revised National Curriculum Statement (RNCS) has constructed a number of critical and developmental outcomes for Grades R - 9, based on the Constitution and democratic principles. These outcomes include the learners' ability to: identify and solve problems and make decisions using critical and creative thinking; work effectively with others, as members of a team, group, organisation and/or community; organise and manage themselves and their activities responsibly and effectively; collect, analyse, organise and critically evaluate information; communicate effectively using visual, symbolic and/or language skills in various modes; use science and technology effectively and critically showing responsibility towards the environment and the health of others; demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation; reflect on and explore a variety of

strategies to learn more effectively; participate as responsible citizens in the life of local, national, and global communities; be culturally and aesthetically sensitive across a range of social contexts; explore education and career opportunities; and develop entrepreneurial opportunities (Department of Education, 2002a). These teaching and learning outcomes essentially refer directly and indirectly to the development of metacognition (Van der Walt & Maree, 2007).

With these outcomes in mind, the shift in emphasis in the curriculum now focuses on encouraging interactive, learner-centred, mediation in which a learner takes ownership of his/her own learning whilst developing a critical approach to learning. The ultimate goal of these 'adapted' curricula is for learners to develop the ability to transfer knowledge, information and skills beyond the classroom walls (Connerly, 2006; Costa & Kallick, 2000; Department of Education, 2002a; Galyam & Le Grange, 2005; Gourgey, 2002; Hester, 1994; Rusbult, s.a.; Schraw *et al.*, 2006; Watson, 2000; Williams & Sternberg, 1993).

It is important to mention that, unfortunately, the fundamental principles and intentions of what was considered to be an effective outcomes-based education process have, for a variety of reasons, not been effectively implemented in South Africa (Chisholm, 2003; Donald *et al.*, 2010; Malcolm & Alant, 2004). Malcolm and Alant's (2004) review of research in South Africa reveals that the delivery of new policies and aspects of OBE were impeded by the need for other more basic developments in education. They say these included the desperate need for classrooms and schools to be built, the need to get rid of racism in schools, the need to re-educate teachers and create new and effective administration positions, while maintaining existing service. Along with this, the process of teaching in South Africa has also suffered, not only because of the ineffective implementation of the OBE process, but also because of teachers being overburdened with "bureaucratic demands" (Donald *et al.*, 2010, p. 83). Numerous changes in the current OBE curriculum, over and above all the other challenges mentioned, have stifled the effective practice of OBE on classroom level and therefore we have seen the detrimental implications for the quality of teaching and learning in South Africa (Donald *et al.*, 2010).

For these reasons, South African and international educational professionals have, for the last few decades, been researching optimal conditions for effective teaching and learning (Malcolm & Alant, 2004; Woolfolk, 2007). Researchers in the field of educational psychology have, for example, investigated which variables have the most influence on

academic performance, learning and teaching (Coutinho, 2007). A number of variables have proven to have influence in this regard, however, what enlightens this research study is rather the fact that a learner's cognitive and metacognitive regulation is said to be one of the most critical factors influencing teaching and learning (Lee, Lim & Grabowski, 2010). The association of metacognition with 'good' education has become a point of focus in educational circles worldwide (Leutwyler, 2009). With many schools taking on the mission of cultivating an ethos of critical, life-long learning for their learners, the importance of facilitating the development of metacognition, as well as metacognitive awareness and thinking proficiency, is becoming an essential element of school curricula, especially due to the fact that many learners are not always successful in their awareness and regulation of their own learning (Coutinho, 2007; Lee *et al.*, 2010; Ritchhart, Turner & Hadar, 2009). It is for these, above mentioned reasons, that this research study aims to look at ways of informing teaching in order to enhance learners' metacognition. Keeping in line with the scope of this particular research study, it is important for the focus of this discussion to now taper to specifically highlight the relevance of Natural Sciences education in South Africa.

2.4 THE NATURAL SCIENCES LEARNING AREA

An explanation of Natural Sciences, as a learning area, has been given some attention in Section 1.5.1, with a description of the main components of the subject and how it fits into the school curriculum. That description highlights the diversity of the learning area with reference to the four Knowledge Areas that need to be covered in the Natural Sciences curriculum, namely Life and Living; Matter and Materials; Energy and Change; and Earth and Beyond (Department of Education, 2002a). The different outcomes of the subject were also referred to in Section 1.5.1, but their relevance make it important to describe each in more detail. This section therefore aims to provide a more in depth description of Natural Sciences, as a learning area in the South African school curriculum, but it also reviews science education internationally to position this research study adequately.

The nature of science is shaped by the desire to explore and understand the natural world. This exploration tends to take on the form of observation, testing of ideas or hypotheses, and it has evolved in such a way that science seems to form part of the "cultural heritage" of almost all countries (Department of Education, 2002a). According to the Revised National Curriculum Statement for Grades R - 9 (Schools) Natural Sciences (Department of Education, 2002a), 'science' is often characterised by the "possibility of making precise

statements which are susceptible to some sort of check or proof" (Department of Education, 2002a, p. 4), implying the central importance of inquiry in science.

Scientific inquiry forms an important component of all three of the Natural Sciences Learning Outcomes and, to be successful in scientific-inquiry, it is said that an individual requires two types of understanding, namely: 'substantive understanding' and 'procedural understanding' (Ben-David & Zohar, 2009, p. 1659). Substantive understanding involves knowledge of certain 'facts and principles', whereas procedural understanding is the thinking behind what is done in the scientific inquiry process (Ben-David & Zohar, 2009). Gott and Duggan (1995, in Ben-David & Zohar, 2009) ascertain that knowledge and understanding about the collection, analysis and interpretation of data are needed for learners to handle scientific evidence effectively. Many learners do not pick up these skills, unless they are taught explicitly, and research findings have shown that this is rarely the case in science classrooms (Ben-David & Zohar, 2009). From a social constructivist perspective, this links to the spontaneous concepts versus scientific concepts (refer to section 2.2). This procedural understanding, which forms such an essential part of science education, is considered to be a scientific concept that cannot be effectively 'learnt' from everyday experience as a spontaneous concept would be (Karpov, 2003). It needs to be taught explicitly.

Scientific inquiry, in which metacognition plays a fundamental role (Yore & Treagust, 2006), forms a very important part of the Natural Sciences curriculum in South Africa and can be found as influencing almost all parts of the learning area. Structured within the OBE methodology, Natural Sciences is considered to have certain learning outcomes (as mentioned in Chapter 1) and assessment standards. Assessment Standards are ways in which learners demonstrate their achievements within each of the above mentioned Natural Sciences Learning Outcomes (Department of Education, 2002a). These are connected to one another and are presented in Table 2.1.

Table 2.1: Natural Sciences Learning Outcomes and Assessment Standards

Learning Outcome	Assessment Standard
<p>1: Scientific Investigations</p> <p>The learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts</p>	<p>1: Scientific Investigations</p> <p>Planning investigations; Conducting investigations and collecting data; Evaluating data and communicating findings</p>
<p>2: Constructing Science Knowledge</p> <p>The learner will know and be able to interpret and apply scientific, technological and environmental knowledge</p>	<p>2: Constructing Science Knowledge</p> <p>Recalling meaningful information when needed; Categorising information to reduce complexity and look for patterns; Interpreting information; Applying knowledge to problems, that are not taught explicitly</p>
<p>3: Science, Society and the Environment</p> <p>The learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment.</p>	<p>3: Science, Society and the Environment</p> <p>Understanding science as a human endeavour in cultural contexts; Understanding sustainable use of the Earth's resources.</p>

(Source: Department of Education, 2002a).

Assessment is meant to provide indications of learner achievement in the most effective and proficient manner, at the same time ensuring that learners integrate and apply their knowledge and skills. Assessment is also intended to enable learners to "make judgements about their own performance, set goals for progress, and provoke further learning" (Department of Education, 2002a, p. 76), which is essentially metacognitive by nature. The argument explored in the rest of this section, reveals that Natural Sciences teaching in South Africa, as well as science education internationally is, unfortunately, not provoking learners' regulation and judgement of their thinking and learning performance, an essential part of

metacognition (Malcolm & Alant, 2004; Yore & Treagust, 2006). This highlights the need for adapted teaching methods.

While exploring South African trends and concerns in science education, the next few paragraphs simultaneously present a review of international developments, drawing connections to highlight how many international movements also influence the South African education system.

A number of studies on science education have been conducted worldwide, such as the *Trends in Mathematics and Science Study* (TIMSS), the Programme for International Student Assessment (PISA), the Relevance of Science Education (ROSE) and Science and Scientists: The SAS Study (Sjøberg, 2000). Many of these studies point to a similar conclusion: there tends to be poor performance levels in science education internationally, but even more so in developing countries (Department of Education, 2008; Giest & Lompscher, 2003; Guo, 2007; Sjøberg & Schreiner, 2010; Viljoen, 2010). This is a significant finding that science educators across the globe need to take into consideration, as it is well known that the majority of learners have difficulty with the learning tasks and demands that science education presents (Giest & Lompscher, 2003). There is an internationally recognised need for improved science education (van Eijck & Roth, 2007). Learners often experience considerable difficulties with scientific thinking and inquiry-based learning (Ben-David & Zohar, 2009). International comparisons, like the TIMSS and PISA, show significant problems concerning "application tasks, problem solving, and scientific argumentations, whereas reproductive tasks and skills were better mastered" (Giest & Lompscher, 2003, p. 267). The former require higher order thinking skills and therefore imply the need to develop such skills (metacognition included) in science classrooms worldwide.

Another factor, contributing to the downfall of science education, is that there seems to be a dominant orientation towards isolated learning, with non-situated facts that are very seldom applied or transferred to real life situations. This can create a difficulty in understanding with a "loss of sense and motivation in many students" (Giest & Lompscher, 2003, p. 267). This increases the necessity for effective instructional methods that can assist learners to develop good scientific thinking strategies (Ben-David & Zohar, 2009) and in so doing, hopefully, motivate their interest in science.

The general low performance experienced in science learning internationally brings with it a common 'phobia' for science that many learners have developed (Hartman, 2002c). Many of the research studies, such as TIMMS and PISA, conducted large scale studies, which only assess cognitive factors of learning, and none of the emotional factors associated with science education are taken into consideration (Sjøberg & Schreiner, 2010). ROSE on the other hand, is a widespread international cooperative research project that addresses the affective dimensions of how learners relate to science. It aims to gather and analyse information from learners about the factors that influence their attitude and motivation towards or against science. Findings show that, despite the common poor achievement in science education in developing countries, there tends to be a positive attitude towards science among adolescent groups in developing countries (Sjøberg & Schreiner, 2010). With South Africa being considered as a developing country, it may just be possible that the learners also possess this positive attitude towards the sciences. It may therefore be worthwhile to lean towards this positive attitude to help improve the level of science education in the country, as there is no doubt that improvement is needed (Giest & Lompscher, 2003).

What is unique about the sciences as learning areas, is that if the content of the subject is forgotten, the 'ethos' of the learning area remains, often leaving impressions that last long after school is finished, shaping behaviours, interests and attitudes even of adult life. As such, positive learning experiences in science can have long lasting positive effects; but poor experiences, associated with science, can contrastingly have long lasting detrimental effects (Sjøberg & Schreiner, 2010). A positive attitude towards science is considered to be an important learning goal in itself (Sjøberg & Schreiner, 2010). Incorporating metacognitive teaching strategies into the Natural Sciences classroom aims to enhance the learners' metacognition. With well developed metacognitive skills, it is likely that learners will no longer carry such a 'phobia' for science. In that way, it is hoped that more learners will begin to enjoy science and become interested in pursuing scientific studies and careers after school, and therefore would want to select scientific subjects to take until Grade 12.

With specific focus on science education in South Africa, when the country participated in recent studies such as the Southern and Eastern African Consortium for Monitoring Educational Quality (SAQMEC) and the TIMSS, there were few discrepancies to international findings. The research indicates that learning achievements in science (and mathematics) are significantly lower in South Africa than other participating countries,

including other African countries (Department of Education, 2008; Viljoen, 2010). It seems that South Africa's history continues to haunt its ability to progress (Department of Education, 2008; Malcolm & Alant, 2004), and a fragmented system of science education, which poorly serves the learners of the country, was inherited (Naidoo & Lewin, 1998).

Since the mid-1990's most research in science education in South Africa has focussed on aspects to aid the curriculum reformation. There seems to have been both qualitative and quantitative empirical research conducted with the focus placed on science in the higher grades of high school (Grade 10 to 12), and therefore specifically on Physics, Chemistry and Life Sciences, and also tertiary level science students (Malcolm & Alant, 2004). Of the areas where science education research has been focused, it is clear that there is still a need to continue research in both the learning and teaching of science. There is a need for research on science learning that is specifically focused on the processes of learning (Malcolm & Alant, 2004). As effective classroom learning depends almost completely on teaching, there is still a need for South African research to focus on effective classroom application of science education and teacher training and education (Malcolm & Alant, 2004; Yore & Treagust, 2006). There is also a need for local research in science education to offer almost immediate policy relevance, with a focus on implementation (Malcolm & Alant, 2004). Research by Muwanga-Zake (2001) has implied that if changes do not happen soon in the educational fields of South Africa, science education will face a crisis – the implications of which are already evident.

The obvious need for significant improvement in science education in South Africa is aggravated by the desperate need for an increased number of professionals in scientific careers, such as engineers and doctors, among others. These career fields need to be enhanced to strengthen the country's competitiveness and development (Department of Education, 2008; Ellis, 2001).

It is, however, also important to note that South African education has made progress. Over the last two decades, policy development in South African education has been extraordinary, with a particular focus on reformation in the sciences and mathematics learning areas (Malcolm & Alant, 2004). In addition to this, access to education and the numbers of learners passing has increased. Unfortunately, despite these improvements, the learners' levels of achievement in South Africa are not at the levels they should be, according to a conclusion, based on the Organisation for Economic Co-operation and Development (OECD) report

(Viljoen, 2010). There is still a serious need to develop strategies that can support teachers and learners in South Africa, to improve success rates in science (Department of Education, 2008). The National Strategy for Mathematics, Science and Technology Education (NSMSTE) was put in place, as a response to these challenges, and some progress has been made. Increased pass rates are a positive effect, but there is still a need to work with schools and teachers to encourage excellence and quality learning, not merely an increased number of low scoring passes (Department of Education, 2008).

The problems, depicted throughout the literature presented above, are leading many countries and organisations internationally to place much more time, money and energy into educational reform, to bring about systematic change, in not only the performance levels, but also the motivation and interest levels in science education (Ellis, 2001; Malcolm & Alant, 2004; van Eijck & Roth, 2007). Some of these efforts have had positive effects in South Africa, such as NSMSTE (Department of Education, 2008) mentioned above, but there are still a number of challenges to be dealt with (van Eijck & Roth, 2007).

Some of the focus of science educational reform is placed on including more 'hands-on' practical work in the science classroom (Ben-David & Zohar, 2009; Gott & Duggan, 2007, in Ramnarain, 2011; Yore & Treagust, 2006). In connection with this, another common modification of the science curricula is aimed at enhancing learners' scientific literacy (National Research Council [NRC], 2003; Organisation for Economic Co-operation and Development [OECD], 2006, in Michalsky, Mevarech & Haibi, 2009; Yore & Treagust, 2006). Scientific literacy is defined as the "capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (Michalsky *et al.*, 2009, p. 363). This forms part of Learning Outcome 2 and is essentially social constructivist by nature, as it views knowledge creation, or meaning making, as a construct formed through social interaction. Learners need to learn how to access scientific information from texts, as well as to interpret this information in order to enhance their scientific literacy skills, which represents another constructivist activity required for effective learning, and also an aspect of metacognition. The movement towards improving scientific literacy skills, and the consequent reform in science curricula, is based on the widespread agreement that the simple incorporation of more 'hands-on' activities may not be sufficient for advancing meaningful learning (Michalsky *et al.*, 2009, p. 363). They advocate that:

Learning science is something that students do, not something that is done to them. 'Hands-on' activities, while essential, are not enough; students must have 'minds-on' experiences as well.

This 'minds-on' experience referred to above brings one's focus to the importance of both cognitive and metacognitive skills in learning (Michalsky *et al.*, 2009, p. 363).

In South Africa, a basis of this curriculum reform is characterised by the introduction of scientific investigations (Learning Outcome 1) and inquiry in classroom practice. Science is typically considered to embody certain methods of inquiry, which are systematic in nature and maintain objectivity in order to promote reproducibility. These inquiry methods usually include formulating hypotheses, with the subsequent planning and execution of the investigation to test the hypotheses, as well as evaluating data and communicating findings (Ben-David & Zohar, 2009; Department of Education, 2002a; Ramnarain, 2011). In essence, this investigative approach to practical work aims to establish learner autonomy and independent learning, a concept that is advocated in the South African curriculum (Department of Education, 2002a; Ramnarain, 2011). Scientific inquiry, in the form of learner-centred and interactive instruction (possibly in the form of Vygotsky's social constructivist mediation), is also said to give learners an in-depth, "authentic understanding of the nature of scientific knowledge" and content, and to develop scientific thinking strategies as well (Ben-David & Zohar, 2009). This requires a shift from teacher-centred to learner-centred teaching approaches, where the teacher does not maintain the same amount of control, but rather takes on a more supportive and facilitating role to mediate learners' progress to greater autonomy (Ben-David & Zohar, 2009). From a Vygotskian perspective, this shift corresponds with transcendence to a new ZPD. Embedded in these changes, is also the need to develop learners' awareness and regulation of their thinking and learning in science education; to become the desired autonomous learner.

In the South African curriculum, the Natural Sciences learning area aims to not only promote scientific literacy, but also the development of a range of life skills (Department of Education, 2002a). In establishing scientific literacy, the Natural Sciences learning area promotes the development and use of science process skills in a range of settings, as well as the appreciation of the relationships and responsibilities between science, society and the environment. The ideal is for learners to develop these skills in an environment that "supports creativity, responsibility and growing confidence" (Department of Education, 2002a, p. 4), which unfortunately does not seem to be what is currently happening in many classrooms

around South Africa (Department of Education, 2008). In essence, this scientific literacy is aimed at facilitating learners' reasoning skills, as well as their investigating, reflecting, synthesising and communicating skills. In developing cultural heritage, these scientific skills and knowledge can be used to "prepare learners for active participation in a democratic society, that values human rights and promotes environmental responsibility" and other positive aspects (Department of Education, 2002a, p. 4). Accordingly, meaningful education should be centred on learners in such a way that it not only helps them understand scientific knowledge, but it also emphasises the contextual and environmental issues that are involved in science (Learning Outcome 3).

Across each of the three Learning Outcomes, the Natural Sciences learning area has a range of scientific process skills. These skills refer to the cognitive activities that a Natural Sciences learner needs to use in order to create meaning and structure of new information and experience. From a learning point of view, process skills are an essential means by which a learner engages with the world and "gains intellectual control of it through the formation of concepts" (Department of Education, 2002a, p. 13). From a teaching perspective, process skills can be viewed as 'building blocks' from which suitable science tasks can be created. The outline of different process skills can, for example, help teachers to construct questions which promote a variety of higher level cognitive thinking (metacognition) skills required for each of the Learning Outcomes (Department of Education, 2002a). Scientific process skills can therefore be helpful to teachers in designing lessons, assessments, marking-memoranda and instruments to record the daily participation of learners. When investigating metacognition in science education, as is being done in this research study, Thomas *et al.* (2008) stress the importance of both the content and process skills of the subject. For this reason, Table 2.2 represents a comparison of two sets of scientific process skills that are considered to form an essential part in the Natural Sciences curriculum. One set is that of the Department of Education (2002a), and the other is that of Goosen, Jacoby, Robinson and Snyman (2006). The Goosen *et al.* (2006) set of scientific process skills, overlaps somewhat with that of the Department of Education (2002a), but it was felt that, for the purpose of this thesis, neither list could be ignored, and hence, both have been represented in the table below.

Table 2.2: Scientific Process Skills

Scientific Process Skill (Department of Education, 2002a)	Description of the Process Skill. It involves the learner:	Scientific Process Skill (Goosen <i>et al.</i>, 2006)
<i>Observing and comparing</i>	Noting details about objects, organisms and events with and without prompting by the teacher, as well as noting similarities and differences, describing them in general terms, or describing them numerically.	*
<i>Measuring</i>	Using instruments accurately, reading scales and using intermediate points between divisions on scales, choosing appropriate instruments or appropriate scales on instruments, knowing when it is appropriate to measure, and choosing to do so without prompting by the teacher.	*
<i>Recording information</i>	Recording on a form which is prescribed (sentences, lists, tables, labelled diagram), selecting a suitable form in which to record the information when asked to do so, knowing when it is important to record, and doing so without being prompted by the teacher.	<i>Recording and measuring data</i> *
<i>Sorting and classifying</i>	Using a given rule to sort items into a table, mind map, list or other system, deciding on own rules for classifying, or choosing a suitable system such as a table, dichotomous key, or mind map.	<i>Synthesising knowledge to create new meaning (using written summaries, flow charts, diagrams, mind-maps, recording information, etcetera)</i>
		<i>Selecting key ideas</i>
<i>Interpreting information</i>	Creating meaning and structure in many ways, such as knowing how to get information from a book, and learning from the printed page. As well as changing the form of information to other forms in order to reveal its meaning, looking for patterns in recorded information, predicting, interpolating for missing data, making an inference from given information, perceiving and stating a relationship between two variables, and constructing a statement to describe a relationship between two variables.	<i>Interpreting information</i>
		<i>Communicating, analysing and evaluating acquired knowledge and applying it to new unfamiliar contexts</i>
<i>Predicting</i>	Using knowledge to decide what will happen if something is changed in a situation (Includes predicting from patterns in information, or interpreting a model of a system to predict how a change in one variable will cause a change in another	*

Scientific Process Skill (Department of Education, 2002a)	Description of the Process Skill. It involves the learner:	Scientific Process Skill (Goosen <i>et al.</i>, 2006)
	variable).	
<i>Hypothesising</i>	Naming possible factors which could have an effect on a situation, giving reasons why something has happened, stating a reason or cause for something, or using prior knowledge as well as information given in the task.	*
<i>Raising questions about a situation</i>	Thinking of questions which could be asked about a situation, recognising a question which can be answered by scientific investigation (as opposed to a question which science cannot answer), or rewording the question to make it scientifically testable.	*
<i>Planning science investigations (a composite of many skills)</i>	Rewording a vague question to make it into a testable prediction, deciding which variables matter in the problem or question, planning how to change one variable and keep the other variables constant (controlling variables), planning what variables to measure and how to measure them, knowing how to improve the accuracy and validity of the measurements, making inferences from results (their own results or someone else's results), and evaluating someone else's plan for a fair test.	<i>Designing and planning investigations (by</i> * <i>identifying a problem,</i> * <i>hypothesising;</i> <i>selecting apparatus;</i> <i>planning the experiment;</i> * <i>suggesting ways of recording results;</i> * <i>understand the need for verification or replication)</i>
<i>Conducting investigations</i>	Setting up a situation in which the change in the dependent variable can be observed, while controlling interfering variables, measuring the variables, recording data, interpreting data to make findings, and reporting in qualitative and quantitative terms.	<i>Handling equipment or apparatus</i>
		<i>Observing and comparing</i>
<i>Communicating science information:</i>	Reflecting on own learning and in building confidence as a person. It involves knowing when it is important to make extra effort to communicate one's ideas or results, and choosing an appropriate means to communicate with the specified audience.	

(Source: Department of Education, 2002a; Goosen *et al.*, 2006)

The manner in which the different scientific process skills are incorporated into this study is explained in detail in Section 3.5, where the relationship between these skills and metacognition is made explicit.

As was previously mentioned, the Natural Sciences curriculum of South Africa is expected to undergo revision to develop and implement CAPS, but the proposed changes are not expected to create major differences, and it seems that there will still be a central focus on the role of science investigations in both teaching and learning (Department of Basic Education, 2010; Ramnarain, 2011). Therefore the current curriculum proposals are incorporated for the purpose of this research inquiry. Within the South African context, the National Curriculum has provided a "much needed" framework for science education (Carré, 1998, p. 97). However, despite scientific inquiry forming a significant part of the Natural Sciences curriculum, research shows that many teachers teach this as content work instead of as a set of thinking skills to be applied (an aspect of metacognition) (Carré, 1998; Hester, 1994). For this reason, among others, there is now an emphasis on the importance of active learning which involves metacognition as one of the ways to conquer the challenges that science education presents (Hartman, 2002c; Thomas, 2006a).

The following section will attempt to look at those characteristics which contribute to effective learning and teaching. The purpose of this is to present the grounding of how metacognition forms part of good teaching and learning, linking to how it needs to be applied into science classrooms.

2.5 TEACHING AND LEARNING

Much of what was mentioned in the previous sections indicates some central characteristics essential for effective teaching and learning; there is however a lot more that can be said about both. Educational professionals have been researching the essence of effective teaching and learning for decades, with an interest in the factors that significantly influence them (Malcolm & Alant, 2004; Woolfolk, 2007). The following section will provide an account of teaching and learning from a Vygotskian social constructivist perspective to fit in with the theoretical orientation of this research inquiry. I begin with a description of learning as, in this context, I feel teaching is best valued when the elements of effective learning are first understood.

2.5.1 Learning

According to the Revised National Curriculum Statement (Department of Education, 2002a), the type of learner that is envisaged in South Africa, is one who will be inspired by the values

of his/her own personal development, but also those of the new South Africa. This learner is to act in the interest of others and the society, embodying democracy, equality, human dignity, life and social justice. Through the aid of the curriculum, this envisaged learner will be a lifelong learner who is confident and autonomous, as well as literate, numerate, multi-skilled, compassionate and respectful of the environment, and has the ability to participate as an active citizen in society (Department of Education, 2002a).

With the conception of the ideal South African learner in mind, it is important to look at what exactly constitutes *learning* as a concept. An array of explanations and definitions are available for understanding the essence of learning. For the purpose of this study, and therefore from a social constructivist perspective, the following definition for learning, as stated by the APA Guidelines for the Teaching of Educational Psychology, is selected because it views learning as:

[...] a process of creating meaningful representations of knowledge through internally mediated processes including self-awareness, self-questioning, and self-regulation.

(Gourgey, 2002, p. 17)

According to Azevedo (2009), learning involves the use of a number of self-regulatory processes such as planning, knowledge activation, metacognitive monitoring and regulation, as well as reflection. The twenty-first century now expects a lot more from all learners because it is no longer sufficient for them to merely have content knowledge, they also need to know "how to learn" (Wilson & Bai, 2010, p. 269). Learning is considered an active process that expects learners to "think about their thinking"- essentially, to be metacognitive (Wilson & Bai, 2010, p. 269). Hester (1994, p. vii) maintains that "[...] teaching-for-thinking is an important part of the educative process".

Lee *et al.* (2010) advocate that in order to comprehend complex topics, learners need to be selective in the attention they offer to events. They need to create meaning for such events by constructing relations between this new information and previously acquired, existing information, concepts and background knowledge. This forms the basis of social constructivism, as was discussed in Section 2.2. With this learning theory in mind, effective learning is considered to involve the learner choosing learning strategies that employ personally meaningful relationships that help him/her to successfully construct knowledge (Lee *et al.*, 2010).

In essence, effective learning partly involves self regulation (Dignath & Büttner, 2008; Lajoie, 2008). Self-regulated learning is generally understood to be a constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their "cognition, motivation, and behaviour" to keep in line with the goals they have set (Azevedo, 2009). During this learning process, an effective learner evaluates whether his/her strategies are helping him/her attain his/her learning goals, and after constant monitoring and comparison, make the necessary adjustments. All these concepts of self-regulation represent the essence of metacognition (discussed in detail in section 2.6 below) (Azevedo, 2009), once again implying how crucial metacognition is for effective learning.

Given the evidence of the significance of metacognition and self-regulation for learning, before scrutinising the central elements of metacognition (in section 2.6 below), it is essential to look into the requirements of effective teaching that can facilitate effective learning. (Wang *et al.*, 1990; Veenman & Spaans, 2005, in Whitebread, Coltman, Pasternak, Sangster, Grau, Bingham, Almeqdad & Demetriou, 2009).

2.5.2 Teaching

As is envisaged for South African learners, the Revised National Curriculum Statement (RNCS) (Department of Education, 2002a) offers an account of what they feel portrays the epitome of an effective South African teacher. The RNCS firstly notes that all teachers and educators represent central contributors to the transformation of South African education, and that teachers should be qualified, competent, dedicated and caring. *The South African Norms and Standards for Educators* (Department of Education, 2000; Malcolm & Alant, 2004) portrays the multidimensional role of a teacher in the classroom to include seven key roles: Firstly, the teacher, as a mediator of learning, is said to be the primary role, where the teacher is responsible for mediating the most effective learning possible for each of his/her learners. Secondly, the teacher, as an assessor of learning, focuses on how appropriate assessment procedures (including diagnostic assessment) need to be integrated into the teaching and learning process. The third role sees the teacher as an interpreter and designer of learning programmes and materials. This role involves the interpretation and adaptation of pertinent knowledge, information and proficiencies in such a way that the teacher can design a learning programme that is appropriate to the specific needs of his or her learners (Donald *et al.*, 2010). The teacher, as an expert or specialist, highlights his/her responsibility to stay up to date with developments in his/her area of expertise, be it the subject area, the level of

teaching (for example, foundation, intermediate or senior phase), or other areas of competency, like counselling or learning support. The fifth role views the teacher as a leader, role model, administrator and manager who can provide direction, goals, structure and guidance to his/her learners. Leadership is also said to involve flexibility in teaching styles, while meeting learners' needs. Managing involves creating a classroom situation that is organised and orderly, where students feel free to learn. As the classroom manager, a teacher must "provide a clear, safe, yet challenging structure for learning; good time management; systematic administration; and effective conflict management" (Donald *et al.*, 2010, p. 140). Another role highlights the teacher as a support provider who takes on the task of addressing barriers to learning. Finally the teacher must also accept the role of being a scholar and a lifelong learner (an essential part in the teaching profession), as well as a researcher (Department of Education, 2000). In addition to all these roles, the effective South African teacher is someone who is also a responsible community member and citizen (Department of Education, 2002a). The diversity of roles that the teacher fulfils seems overwhelming, but it also makes the importance of a teacher's role more apparent (Department of Education, 2002a).

One of the roles mentioned above, is that of the teacher as researcher (Department of Education, 2000). Conducting research as a teacher is said to be an important part of professional development because one cannot grow in one's understanding of knowledge, oneself, the learners, or the teaching and learning process, unless one is prepared to question, observe, evaluate, and then re-question aspects of teaching and learning. The Department of Education (2000) also stresses the necessity for teachers to help their learners think in a way that encourages research so that they too learn to question, observe, evaluate and re-question in a self-reflective manner (Loughran, 1996). There is a need for, what is now referred to as the South African Department of Basic Education, to implement strategies to develop a reflective, self-aware teaching population, who are able to study their own practice so as to provide the best possible learning situations for South African learners (Rossouw, 2009). This corresponds with the importance and value of action research in the classroom (Donald *et al.*, 2010), and therefore offers further support to the purpose of this research inquiry and of the chosen research design.

Keeping in mind what is considered to be 'good' learning explored in Section 2.5.1, one of the main tasks of schools today is to prepare learners for lifelong learning. This implies that an

initial goal is to enable students to learn and think independently (Giest & Lompscher, 2003) through teaching practice that is meaningful. Learning is not likely to have lasting positive results if teaching is not meaningful (Department of Education, 2002a). Independent (self-regulated) thinking is linked to the development of metacognitive skills in learners, but also in teachers. When a teacher reflects on how to facilitate good learning, the question often arises as to what or how one should teach to enable this 'good learning'. The problems, in science education specifically, like those mentioned in Section 2.4, cause many questions to arise, such as: "What can teachers do to maximize the effective construction of adequate science knowledge by students?"; and: "How can teachers maximize the opportunities for students to construct new schemata, new ways of thinking about the world?" (Giest & Lompscher, 2003, p. 267).

Wilson and Bai (2010) maintain that a teacher's understanding, of what is necessary for teaching and learning, has a significant role in his/her teaching practice, which directly impacts on their students' learning. In social constructivist terms, a teacher's perception of what constitutes 'good teaching' is based on his/her personal experience and exposure to specific social situations. A teacher's perception as to how he/she should teach therefore also influences the extent and quality of his/her learners' learning. From a Vygotskian social constructivist perspective, teaching needs to create 'dramatic events' (as referred to in Section 2.2) during the learner's school day that stimulates him/her to self-reflect and internalise this interaction, so that mental functioning and metacognition develops and learning occurs (Veresov, 2009).

From the social constructivist perspective of Giest and Lompscher (2003), there are three phases of teaching in science education: During the *first phase* of teaching, the teacher needs to create the conditions for a high degree of self-regulated learning and discovery learning, applying what the learner knows and has acquired thus far - within the learner's zone of actual development or performance. During this phase the teacher tries to stimulate cognitive conflicts that correspond with the main learning tasks, goals and teaching-learning content. This directs the learners' efforts to problem solving and reflection on what is known and what still needs to be known. This "conscious learning", as Giest and Lompscher (2003, p. 272) refer to it, mimics the metacognitive prerequisites of learning. During the *second phase* of teaching, more direct instruction and systematic learning within the ZPD, is expected. The main task in this phase is for the teacher to help learners achieve their own personal learning

goals, helping them acquire that which is necessary to know, and that which must be performed in order to solve problems and attain learning goals. The *third phase* is said to be that of developmental teaching. This occurs when the ZPD becomes the new zone of actual performance. In this phase, learners solve problems and work on projects by themselves, employing self-regulated learning and discovery and a new phase of indirect teaching starts, but this time on a higher level - opening the new zone of proximal development (Giest & Lompscher, 2003). Teaching creates that 'external pull' (as referred to in Section 2.2) that mediates a learner's transition from within the zone of actual development to within the zone of new proximal development (Donald *et al.*, 2010).

From the above, it is evident that the role of the teacher is understood as being closely aligned with that which is considered to be 'good learning' (Malcolm & Alant, 2004). With the importance of facilitating the development of learners' thinking skills and self-regulated learning, as well as the importance of the supportive role that metacognition plays in learning, the role of a teacher has been closely scrutinized. With the multiple references to metacognition in the sections above, a comprehensive discussion will follow which aims to provide a detailed description of metacognition and all that it entails.

2.6 METACOGNITION

A brief explanation of metacognition was given in Section 1.5.3, which explained some of the most generally accepted and common understandings of the concept. The following section aims to present a more in depth explanation of detailed aspects of metacognition, as well as to provide some historical and theoretical background about the development of this complex concept.

2.6.1 A background to metacognition

In 1976 the term metacognition was coined by John Flavell, an American developmental psychologist (Flavell, 1985; Yore & Treagust, 2006). It is however not an easily defined concept, purely because of the number of different understandings, perspectives, and varying depths of every definition offered (Thomas *et al.*, 2008; Zohar & Ben-David, 2009). The most generally accepted understanding of metacognition is "cognition about cognition" (Woolfolk, 2010, p. 270) or "thinking about thinking" (Veenmn *et al.*, in Shamir *et al.*, 2009, p. 47). Flavell, initially referred to metacognition as "any knowledge or cognitive activity that

[...] regulates any aspect of any cognitive activity" (Flavell *et al.*, 1993, in Shamir *et al.*, 2009, p.47). Adding to this somewhat inadequate definition, Flavell (1979, in Schraw, 2002, p. 18) described metacognition as:

"awareness of how one learns; awareness of when one does and does not understand; knowledge of how to use available information to achieve a goal; ability to judge the cognitive demands of a particular task; knowledge of what strategies to use for what purposes; and assessment of one's progress both during and after performance."

Adding to initial explanations such as this, Baker and Brown (1984, in Beng Lee, Teo & Bergin, 2009) highlighted the importance of regulation and control of thinking and learning as constituting an essential element of metacognition (Woolfolk, 2010). Coutinho (2007), Hartman (2002a), Leutwyler (2009), Michalsky *et al.* (2009) and Woolfolk (2010) are others who have contributed to the various understandings of metacognition. They note the significance of monitoring one's thoughts and task performance in metacognition. Since the initial discussions about metacognition, it is quite evident that much research has been carried out, significantly advancing Flavell's initial efforts (Veenman *et al.*, 2006), with a continuously increasing recognition being given to metacognitive research.

Theories of metacognition initially developed within the realms of cognitive theorists, but have since been adopted by a number of other learning theorists, such as cognitive constructivists and social constructivists, among others (Nelson & Narens, 1996; Woolfolk, 2010). The development of the concept of metacognition has attracted attention from researchers in both educational and psychological fields, particularly over the last three decades (Leutwyler, 2009).

A basic understanding of metacognition, as stated above, implies that metacognition is often understood as "cognition about cognition" (Woolfolk, 2010, p. 270), but in order to fully comprehend such a statement, one needs to be clear as to what is meant by the term *cognition*. Flavell (1985, in Sagor, 1999) contends that cognition is one of those concepts that remain ambiguous and imprecise in definition, and therefore one should avoid spending too much time and energy trying to come to a formal, or universal, definition. However, a traditional understanding of cognition tends to restrict it to the higher intellectual processes, like remembering, understanding, focusing and processing information (Gordon & Braun, 1985, in Sagor, 1999), or simply what we know and think (Sagor, 1999).

More modern day understandings of cognition, on the other hand, are closely linked to metacognition (Conford, s.a.; Livingston, 1997). In fact, Flavell (1979, in Livingston, 1997) himself acknowledges that metacognitive knowledge may not be different from cognitive knowledge because both cognitive and metacognitive strategies and skills involve cognition, but the distinction lies in how the information is used or applied (Conford, s.a.; Livingston, 1997). Cognitive strategies are used to help an individual to achieve a particular goal, whereas metacognition, or "thinking about thinking", involves overseeing whether a cognitive goal has been reached for example (Livingston, 1997, p. 1). Metacognitive experiences usually follow (or after metacognitive skills development they may precede) cognitive activity, either to orchestrate cognitive resources, or usually, occurring when cognition fails, and the individual attempts to rectify the situation (Roberts & Erdos, 1993, in Livingston, 1997).

This understanding that links cognition so closely with metacognition does not completely reject the traditional understanding of what constitutes cognition, but it is important to note that some cognitive and metacognitive strategies may overlap. For the purpose of this study, the metacognitive procedures and skills incorporated are explained explicitly; preventing any confusion as to whether they are considered to be cognitive or metacognitive in the context (Livingston, 1997). In this study, metacognition (as it is now commonly understood) refers to higher-order cognitive processes, or mental skills, that facilitate and support a number of elements in learning. These include making appropriate learning plans, incorporating the most effective skills and strategies to solve problems, making estimates of one's own performance, and regulating the extent of one's learning (Dunslosky & Thiede, 1998, in Coutinho, 2007). The level of one's metacognition is indicated by the degree to which a person is aware of what they do, and why they do it. This is known as metacognitive awareness and it implies that the more conscious one is of their own cognitive strategies, the more one can critically look at them, learn from them, adapt and refine them. From a social constructivist perspective, metacognition is very important because through using it, a person can actively engage with his/ her own thinking on a higher level (advancing his/her ZPD) (Donald *et al.*, 2010).

Since Flavell introduced the concept of metacognition in 1976, most authors have agreed that the construct can be differentiated into a *skills* and *knowledge* component. This two-factor model understands metacognition to be made up of knowledge about metacognitive

resources, also known as knowledge of cognition or metacognitive knowledge, and regulation of cognition or metacognitive skilfulness. Both are said to be equally critical factors (Beng Lee *et al.*, 2009; Cooper & Sandi-Urena, 2009; Hartman, 2002b; Magno, 2010). According to Cooper and Sandi-Urena (2009) and Desoete (2008), metacognitive knowledge can be divided up into declarative knowledge, procedural knowledge and conditional knowledge. Metacognitive skilfulness, on the other hand, involves prediction, planning, monitoring, and evaluation (Cooper & Sandi-Urena, 2009; Coutinho, 2007; Desoete, 2008).

Knowledge about metacognitive resources is understood as knowledge of the skills and strategies that may work best for oneself in the learning process, including how and when to use such strategies. Self-regulation of cognition, or metacognitive skilfulness, refers more specifically to those processes or activities that one incorporates to control one's thinking and learning (Coutinho, 2007).

The concept of metacognition is composed of numerous constituents, and several studies recognise the multidimensionality of metacognition as a construct (Thomas *et al.*, 2008). A number of different distinctions are made with regards to the components of metacognition, but many of these dimensions also relate to one another (Magno, 2010). Schraw and Dennison (1994, in Magno, 2010), Artzt and Armour-Thomas (1992, in Magno, 2010), as well as Baker (1989, in Magno, 2010), all have an original model of metacognition which consists of eight components. These include: declarative knowledge; procedural knowledge; conditional knowledge; planning; information management strategies; monitoring; debugging strategy; and evaluation of learning. Although distinction is made between the two-factor and eight-factor model, it is most generally accepted that knowledge about cognition refers to declarative, procedural and conditional knowledge, and, regulation of cognition refers to planning, information management, monitoring, debugging and evaluation during learning (Shamir, et al., 2009), thus implying that the elements of the eight-factor model are essentially subsumed into the two-factor model.

As was discussed in Section 1.5.3, *declarative knowledge* involves knowing what skills, strategies and resources are needed to carry out a task, and *procedural knowledge* is about knowing how to use these skills and strategies. Essentially, *conditional knowledge* is about when and why to apply certain skills, procedures and strategies (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2010). These subcomponents are metacognitive in nature as they involve thinking about one's state of knowledge and abilities, and essentially involve

metacognitive awareness (Beng Lee *et al.*, 2009; Hartman, 2002a). *Self-regulatory knowledge or executive management strategies*, on the other hand, aim to regulate thinking and learning. *Planning, monitoring, and evaluating* are the self-regulatory processes that make up these executive management skills. *Planning* involves making decisions as to "how much time to give to a task, which strategies to use, how to start, what resources to gather, what order to follow, what to skim and what to give intense attention to, and so on" (Woolfolk, 2010, p. 270). *Monitoring* involves checking one's progress along the way, whether one is maintaining short-term and long-term goals, and determining whether one is still 'on track' for the task. *Evaluating* is about making "judgements about the processes and outcomes of thinking and learning" (Gourgey, 2002; Hartman, 2002b; Hessels *et al.*, 2009; Woolfolk, 2010).

Another model looks at five factors of metacognition. These include: *inference ability; recognition of assumptions; deduction ability; interpretation ability and evaluation of arguments* (Magno, 2010). For the purpose of this study, however, I will be focusing on the combination of the two-factor model, and the eight-factor model that is essentially subsumed into the two-factor model. This is illustrated in figure 2.3.

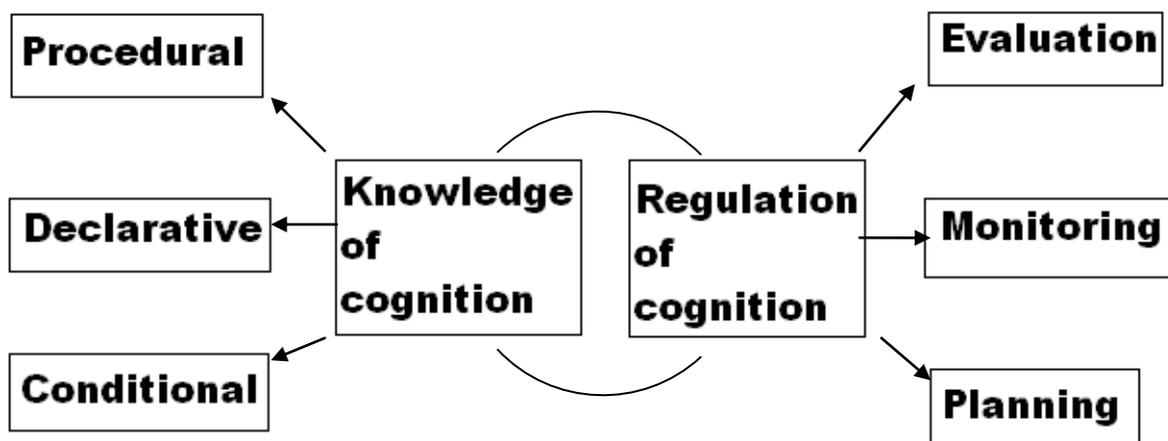


Figure 2.3: Model of metacognition (Source: adapted from Beng Lee *et al.*, 2009).

From a social constructivist and developmental perspective, metacognition can be understood as how one learns to monitor one's thinking, by knowing what to monitor (metacognitive knowledge). This is cultivated from experience, goal setting to gain understanding, as well as activation of strategies to reach goals and evaluate one's progress. Metacognitive skills (regulation of cognitions) are then developed through the interaction of such processes (Lajoie, 2008).

Flavell (1992) argued that metacognitive skills are especially likely to occur in situations that stimulate a lot of careful, highly conscious thinking. Strategies that may be employed in these metacognitive moments include self-evaluation and conscious direction of one's attention to the learning task (Li & Munby, 1996).

Another distinction needs to be made with regards to metacognitive skills versus metacognitive strategies. A strategy is said to be a cognitive activity that is selected to fit a particular situation. It tends to be a flexible process in that one can reflectively apply to numerous (problem solving) situations (Sagor, 1999). According to Hartman (2002a), a strategy is defined as "a conscious, deliberate use of a specific method". Skills on the other hand are understood to be highly efficient, automatic routine procedures that are applied consistently in the circumstances in which they are required (Sagor, 1999). Hartman (2002a) defines a skill as a "refined strategy which is used selectively, automatically and unconsciously as needed".

A distinction can be made between the metacognitive skills and the metacognitive strategies which a person can possess or develop. However, the terms become complicated when one wants to refer to metacognitive teaching that will enhance metacognitive skills, strategy awareness et cetera, in both learners and teachers. Metacognitive teaching may include certain skills that are metacognitive by nature, but they may also include general teaching strategies that are known to enhance metacognition in learners. Therefore, for the purpose of this research study, whenever metacognitive teaching and instruction methods are referred to, whether they be metacognitive skills or general teaching strategies, they will be referred to as *metacognitive teaching procedures*. These will aim to enhance learners' metacognitive knowledge and metacognitive skills (the activities undertaken by the participants to control or monitor and evaluate their own cognition) (Li & Munby, 1996).

The different metacognitive skills mentioned above resonate with many of the required Natural Sciences process skills that were listed in Section 2.4. 'Predicting' as a metacognitive skill links to hypothesising and predicting as Natural Sciences process skills. 'Planning' as a metacognitive skill is essential in different aspects of Natural Sciences assessments, as well as sorting and classifying, but also in planning scientific investigations. 'Metacognitive monitoring' may link to observing and comparing, measuring, recording information, as well as conducting investigations, among other Natural Sciences process skills. Lastly, 'evaluation' forms a critical part of metacognitive skills and this can quite easily be highlighted through

the interpretation of information in Natural Sciences, as well as raising questions about a situation. These explicit links between metacognitive skills and Natural Sciences process skills form a central part of this research study. However, it is important to note that these are not the only links between metacognition and science education. Many other aspects, some of which are universal to all school-based learning situations, will also be considered in Chapter 3. More detail with regards to the use of specific metacognitive procedures and Natural Sciences process skills of this study will be discussed in Section 3.5.

From a social constructivist perspective, where learning and behavior are dependent on the reciprocal interaction between a person and their environment, self-regulation cannot occur without interaction with the environment (Lajoie, 2008). For Vygotsky, self-regulation takes the form of "deliberate control of one's own attention, thoughts, and actions" achieved by social force systems (Fox & Riconscente, 2008, p. 385). Self-regulation is considered a voluntary activity involving the deliberate control and attention of one's thoughts. The concept of *self-regulated learning* links to the above explanation of metacognitive knowledge and skills, that focus on monitoring and self-regulatory mechanisms used to check the outcomes, planning, effectiveness-monitoring and evaluating strategies (Lajoie, 2008). In terms of learning and self-regulation, the literature offers numerous approaches to the conceptualisation of self-regulated learning (for example: Pintrich 2004; Pressley *et al.*, 1989; Simons, 1992 in Leutwyler, 2009). A comparison of these different approaches reveals that comprehensive self-regulated learning can only become possible when a learner possesses an array of strategies that can be engaged with adaptively and used intentionally, and which includes both cognitive and metacognitive strategies (Leutwyler, 2009). According to Leutwyler (2009, p. 113) "self-regulated learning is a pro-active, intentional, and reflexive form of learning that entails a sense of personal responsibility for learning: it is a dynamic interaction of 'skill and will'" implying that self-regulation is an integral part of metacognition (Leutwyler, 2009, p. 113).

Self-regulation is connected to one's capacity for reflective abstraction, which requires exposure to scientific concepts (as higher order cognitive functions defined in Section 2.2) and therefore school based instruction. Based on developmental theories, this is best achieved in adolescent years (Fox & Riconscente, 2008). Self-regulation occurs when mediation within the ZPD occurs, and these assisted instruction techniques are internalised, and become a

component of a learner's array of self-instruction, that is used easily and without assistance (Manning & Glasner, 1996).

The significant link between self-regulated learning strategies and metacognition lies in the regulation aspects of metacognition (Manning & Glasner, 1996). For Vygotsky, development of metacognition and self-regulation begins with a person's internalisation of their interactions with others (Fox & Riconscente, 2008), revealing the significance of a social constructivist outlook for this research study. Self-regulation and self-regulated learning are themselves very complex concepts, which represent major topics in educational research (Dignath & Büttner, 2008). Due attention, in terms of research, has therefore been, and should continue to be, focused on each of these aspects. Linking to this, one cannot ignore self-regulation as an essential component of metacognition. For the purpose of this research inquiry, however, the focus on self-regulation and self-regulated learning has to end at being an important factor contributing to metacognition (Leutwyler, 2009).

Professionals are increasingly recognising the importance of metacognition in teaching, learning and education (Gourgey, 2002; Hartman, 2002a; Yore & Treagust, 2006). Along with the detailed explanation of the major components of metacognition presented above, the following section will attempt to emphasise the importance of this link between metacognition, teaching and learning.

2.6.2 Metacognition in teaching and learning

International research has shown that there is a strong correlation between learners' effective metacognition and academic success (Coutinho, 2007; du Toit & Kotze, 2009; Hartman, 2002a; Kruger and Dunning, 1999; Veenman *et al.*, 2006; Yore & Treagust, 2006). The importance of being aware and in control of one's own thinking and learning has taken on a central role in effective teaching and learning (Hartman 2002b). An individual who acts metacognitively, with regards to their learning, knows how to learn because he/she is aware of what they already know, and what to do in order to gain new sufficient knowledge (Wilson & Bai, 2010). Conscious awareness and conscious regulation of one's learning is what makes a metacognitive person check for, and subsequently regulate, their own understanding, with the use of metacognitive strategies (Wilson & Bai, 2010). Metacognition involves knowing about one's prior knowledge, being aware of which prior knowledge is necessary for the learning situation at hand, and how to use this prior knowledge effectively (Guterman, 2003;

Manning & Glasner, 1996). With this increasing importance of metacognition in teaching and learning, it is understandable that research into metacognition is increasing internationally and a number of researchers promote the production of creative and innovative instructional methods based on metacognitive guidance (Michalsky *et al.*, 2009).

Most of the research conducted on metacognition, especially that which focuses on the incorporation of it into classroom practice, has been carried out in international settings (Watson, 2000). Much of this research was also conducted using quantitative methodology (Burchard & Swerdzewski, 2009; Busey & Arici, 2009; Huff & Nietfield, 2009; Karpicke, 2009; Kruger & Dunning, 1999; Maqsud, 1997; Montague & Bos, 1990; Van Ede & Coetzee, 1996). Many of these quantitative studies aim to draw comparisons and conclusions about the efficiency of certain metacognitive programmes implemented in schools. Some South African metacognitive research exists, much of which is quantitative and looks at the effects of metacognition on academic achievement (Maqsud, 1997). Other South African research looks statistically at the effects of implementing certain metacognitive tools into education (Cooper & Sandi-Urena, 2009; du Toit & Kotze, 2009; Van Ede & Coetzee, 1996). There is concern about the validity of qualitative methodologies, when researching metacognition (Thomas *et al.*, 2008), and therefore only a limited number of qualitative studies on metacognition exist. The qualitative metacognitive research that does exist tends to address concerns of validity, and some of these studies highlight the importance of metacognition in teaching and learning (Case & Gunstone, 2002; Ciardiello, 1998), while others look at factors that influence metacognitive development (Argyropoulos, 2010; Barak & Shakhman, 2008; Case & Gunstone, 2006; Stavast, 1991; Topham, 1991). There are even some research studies that focus on teacher metacognition (Barak & Shakhman, 2008; Sagor, 1999; Van der Walt & Maree, 2007).

Much of the metacognitive research in South African tends to focus on the incorporation of metacognition into the mathematics classroom (du Toit & Kotze, 2009; Reynolds, 2006; Van der Walt & Maree, 2007; van Jaarsveld, 2006). Some metacognitive research, based on science education, does however exist; such as the work of Georghiades (2004), Ben-David and Zohar (2009), Conner (2004), Case and Gunstone (2006), Schraw *et al.* (2006), Thomas (2006b); Sandi-Urena, Cooper & Stevens (2011) and Yore and Treagust (2006). This work tends to be internationally based, or conducted with learners in the higher secondary school years (Grades 10 to 12) or college students, with some research carried out in primary

schools. Very little research has been conducted to focus on the application of metacognitive procedures in the lower grades of South African high school Natural Sciences classrooms. It appears that there is a need for more South African based research, that adopts a (valid) qualitative approach to gain in depth understandings of both learners' and teachers' experiences, in terms of metacognition (Hessels *et al.*, 2009; Joseph, 2010; Malcolm & Alant, 2004), as well as the need to research teaching strategies to enhance metacognition (Hessels *et al.*, 2009; Joseph, 2010; Malcolm & Alant, 2004; Yore & Treagust, 2006; Van der Walt & Maree, 2007).

Despite the evident necessity of metacognition in teaching and learning, research has shown that there are certain areas of metacognition, or certain metacognitive skills and strategies; with which learners have difficulty (Connerly, 2006; Lipman, 1993; Manning & Glasnir, 1996). Invariably, learners fail to set appropriate goals in their learning, or they choose ineffective strategies to complete a task. Sometimes a learner easily disregards the importance of monitoring or evaluating his/her own progress, as well as fails to seek guidance and information from appropriate sources (Manning & Glasnir, 1996). In addition to this, due to the diversity of experiential background of every learner, teaching often fails to help learners to create a connection between their prior knowledge and educational efficiency (Watson, 2000). Not all learners develop and use metacognition spontaneously. Therefore, it is essential for teachers to provide explicit instruction of both metacognitive strategies and metacognitive knowledge, as well as to create opportunities for the learners to practice self-regulatory skills and to develop voluntary control over their own learning (Hartman, 2002a).

Lin (2001) explains that learners do not instinctively engage in metacognitive thinking, unless they are explicitly encouraged to do so through specific teaching activities. Metacognition in teaching has the aim of creating the correct conditions for a 'breakthrough' in learning situations for all learners (Watson, 2000). These breakthrough experiences involve feelings of control, moments of insight and amplified self-esteem (Watson, 2000). If metacognitive thinking is not explicitly incorporated into the classroom, one can assume that the chances of the learners developing their metacognition will be limited (Lin, 2001).

Joseph (2010) has acknowledged that by understanding metacognition and being familiar with learners' metacognition, a teacher can develop a better understanding of how his/her learners actually learn. This is reinforced by the Department of Education's Interim Policy for Early Childhood Development (1997) which states that teachers should generate a thorough

understanding of the essential skills of learning and make use of these to teach more effectively. Therefore, teachers who have a good understanding of metacognition, and who are familiar with their learners' metacognition, can develop a better understanding of how their learners truly learn (Joseph 2010; Wilson & Bai, 2010). Joseph (2010) claims that facilitating the development of learners' metacognition will ultimately be a valuable investment in their future.

It seems that there is a general concern that teachers are not making effective use of the information available to them about improving their learners' thinking skills (Green, 2005). This could possibly be accounted for by the inadequate attention that has been given to metacognition in teaching practice (Watson, 2000). Hawkins (1994), Manning and Glasner (1996), as well as Thomas (2006), all construe that the association between metacognitive theory and research needs to be better connected to classroom practice. Despite some research having been conducted on metacognition in education, the findings and recommendations are generally too vague for classroom application (Manning & Glasner, 1996). There seems to be a general deficit in the theoretical basis that informs teacher education and thinking (Manning & Payne, 1993), as well as a lack of useful guidelines available to teachers for the applications of metacognition in their classrooms (Goos *et al.*, 2002; Lin, 2001; Thomas, 2006a; Yore & Treagust, 2006).

At this point, I want to take a step out of the literature review and glance at this study from a global perspective. By now it is understood that teaching and learning are viewed from a social constructivist perspective for the purpose of this inquiry, and hence, it is through mediation that a learner internalises certain social interactions, such as effective teaching, which are then construed as learning (Kozulin, 2003). The link between teaching and learning is therefore mediated internalisation. If teaching for internalisation is to be adjusted in such a way that the learners' metacognition is improved, mediation will also have to be adapted. Specific metacognitive teaching procedures therefore act as 'symbolic' mediating tools in the construction of the learners' metacognition, and teachers act as the 'human' mediators, as referred to in Section 2.2. By customising mediation strategies in certain ways, they can be used to enhance learners' metacognition. This connects to the problem of practically applying metacognitive procedures into the classroom to enhance metacognition, as stated in the previous paragraph.

Coming back to the literature review, according to Clarke, Thomas and Vidakovic (2009, in Nyaumwe & Mtetwa, 2011) teachers have the responsibility to learn how to be flexible in their teaching in order to teach and mediate effectively. By encouraging a "culture of thinking and rethinking, constructing and reconstructing the process and ways of thinking during the preparation", effective teaching can result (Nyaumwe & Mtetwa, 2011). Teaching for effective thinking, for all intents and purposes, forms part of developing reflective and metacognitive thinking. This type of teaching aims to develop learners, who take responsibility for their own learning, are inventive, autonomous, and able to verify information for themselves, and not merely accept it. When teachers emphasise effective thinking, the outcomes of learning are improved (Hester, 1994 p. viii; Wilson & Wing Jan, 1993).

A growing body of research and theory has highlighted the importance of teachers' use of metacognitive knowledge and skills before, during and after instruction (Hartman, 2002b). A distinction must however be made between teaching *with* metacognition and teaching *for* metacognition. Teaching *with* metacognition essentially means that teachers need to think about their own thinking with regards to their teaching, and reflect on instructional goals, learner needs and characteristics, content and material, and all teaching strategies related to curriculum, instruction and assessment. In order to maximise instructional effectiveness, a teacher should be conducting this metacognitive thinking before, during and after each lesson (Hartman, 2002b). Teaching *for* metacognition on the other hand implies that teachers think about how they can activate and enhance their learners' metacognition (Hartman, 2002b) and how the teacher can facilitate his/her learners' metacognition and thinking about their own thinking (Hartman, 2002b). This links to the mediation process. For the purposes of this particular thesis the two are seen as intertwined elements, and hence, an association between them is always assumed.

Teaching metacognitively involves executive management metacognition in which the teacher plans what and how they are going to teach, and monitors their lesson/s while teaching, making the necessary adaptations as needed. Teaching metacognitively does not end there; it also involves evaluating one's teaching and the lesson itself (Hartman, 2002b). An effective teacher needs extensive knowledge of their subject area, but over and above this, they also need pedagogical knowledge, such as metacognitive knowledge about teaching strategies (Hartman, 2002c). A metacognitive teacher needs to be in touch with the teaching

strategies that form part of his/her repertoire. He/she needs a selection of different strategies at their disposal in order to meet different learner needs. This involves a comprehensive understanding of when, how and why to use certain teaching strategies in order to plan effectively for the lesson, to be flexible and able to respond, to select other approaches (if a lesson needs to be adapted unexpectedly), and to regulate their teaching (Hartman, 2002b).

In conjunction with the discussion above, with regards to teaching *with* or teaching *for* metacognition, the importance of teacher reflection becomes important. In order to teach in metacognitive ways while stimulating the learners' metacognitive development, it would seem quite logical that teacher self-reflection would at some stage need to form an integral part of the process - as it would in any metacognitive situation (Hartman, 2002b). Reflection is considered to be an integral part of any metacognitive activity. Other metacognitive meditational tools include the different metacognitive teaching procedures mentioned in Chapter 1. These are explained in detail in Section 3.5. Linking to reflection, one of the multiple roles of a teacher, as was mentioned previously in Section 2.5.2, is the role of being a lifelong learner, scholar and researcher. Action research offers a particularly effective means for teachers to research their own practice with intention of improving it (Donald *et al.*, 2010). A critical part of this process is reflection. According to McMillan and Schumacher (2001), being reflective requires more than simply self-monitoring and keeping track of decisions. It requires the researcher to constantly assess their actions and roles in the research process (McMillan & Schumacher, 2001). This can be viewed as parallel to the reflection required in metacognitive activities. More detail with regards to teacher-researcher reflection, in the action research process, will be provided in Section 3.6.

Linking metacognition to science teaching and learning, research on science education emphasises the importance of active learning that is meaningful and includes both teacher and learner metacognition (Ben-David & Zohar, 2009; Hartman, 2002c; Yore & Treagust, 2006). Not only does metacognition in science help learners develop and employ effective strategies for acquiring, understanding and applying difficult scientific skills and concepts, it also helps teachers to think about how they need to manage the curriculum, instruction and assessment, as well as to systematically reflect on their own teaching (Hartman, 2002c).

Resting on the underlying principles of social constructivism, this study aims to research how to enhance my Natural Sciences learners' metacognition; through incorporating metacognitive procedures into my teaching as a form of mediation.

2.7 SUMMARY OF CHAPTER

In this chapter the literature that was reviewed provided a central focus on metacognition in teaching and learning. Specific focus was placed on the value of metacognition in education, and the consequential needs for metacognition in South African education, and specifically in the Natural Sciences learning areas. Using social constructivism as the theoretical lens for this research study, a detailed explanation of social constructivism as a theoretical framework is provided in Chapter 2. The intention was for this literature review to contextualise the study and reveal the "niche to be occupied" by it (Henning *et al.*, 2004 in Oswald, 2010, p. 28). The next chapter aims to look at the research plan, as well as how this plan will be put into action.

CHAPTER 3

DESIGNING AND IMPLEMENTING THE INQUIRY

3.1 INTRODUCTION

This chapter will trace my conscious effort to position my research in ontological and epistemological terms, a process that will ultimately be framed by the choice of an appropriate research paradigm. Given the aim of this inquiry, namely, to investigate how I can improve my teaching practice and simultaneously enhance my Grade 9 learners' metacognition, it will be made evident throughout the chapter why practical, school-/classroom-based action research, with qualitative methodology, is found to be the most appropriate methodological approach within a paradigm of praxis.

This chapter will discuss the salient features of action research in general, as well as practical and school-/classroom-based action research. Details will be given about the advantages of an action research design in general, and also for this specific study. A section will also be dedicated to discuss the limitations and validation criteria for this methodology. The chapter will therefore include a discussion of the third and fourth stages of this research investigation as introduced in Chapter 1. Exploration of the third phase in this chapter will refer to the research design chosen for the study, and the fourth phase will indicate the methodology and methods of data collection and analysis (Denzin & Lincoln, 2005). The purpose is to provide a step by step map of what I hope to accomplish with regard to my fieldwork process and data interpretation (Oswald, 2010).

The theoretical framework of this study views the aims of the study from a social constructivist perspective because, through reflection and analysis of the process mentioned above, I aim to advance and develop my teaching in such a way that it can enhance my learners' metacognition. Consequently, the study will address the following primary research question:

How will the incorporation of metacognitive instruction improve my Natural Sciences teaching practice?

With the sub-question:

How will my learners' metacognition develop through my adapted teaching procedures?

Deciding on a methodology for a specific study entails establishing a clear idea of the desired gains of the study so that a methodology can be selected to best facilitate the research. Classroom-based research, in effect, puts one's conceptual and theoretical learning to the test (Roche, 2000). Through my research I will attempt to extend the boundaries of my own teaching skill and practice with regards to metacognition, while also enhancing my learners' metacognitive abilities. I thought Roche (2000, p. 33) stated it well in her similarly structured study when she said:

The knowledge that I hold about my practice is mine. The knowledge that I will gain through my study will be mine. My claim to that knowledge can be made public and can be used by other teachers to assist their acquisition of knowledge, just as I will engage with the work of other researchers in the field of [metacognition] to aid my understanding.

The methodology that I will apply to my study and the research paradigm I select, must be able to encompass the view quoted above. The sections to follow will attempt to highlight the research orientations that have been evaluated and are seen to be best suited for this research inquiry.

3.2 RESEARCH PARADIGM

The concept of a 'paradigm' is often considered as a set of beliefs that define, for their holder, the nature of the world, the individual's place in the world, and the possible relationships with or within that world (Hills & Mullett, 2000). Different research paradigms are characterized by the distinctive methodology and methods researchers incorporate to develop their assertions about reality (Adendorff, 2007). The question then arises: what is meant by 'methodology and method' with regards to research? This will be discussed in Section 3.4 and 3.6 below.

Within the educational field, the ontological issues remain irrespective of the paradigm involved. As a teacher, in a classroom, interacting with learners, I am connected to the sociology of their lives (family and home included), as well as the existential notion that they

bring to each situation, their distinctive biographies, personalities, and characters. I too come into the situation with my own biography, personality and character. We operate within a classroom, with structured school timetables and curricula. Therefore, the research paradigm that I select must take these ontological factors into consideration (Roche, 2000). My class is a unique, dynamic group of interacting individuals (myself included), who co-exist in the very real society of our school. Therefore, my research methodology needs to be able to embrace this ever-changing system (Roche, 2000).

In the research questions, forming the crux of this thesis, I ask myself: *How can I adapt my Natural Sciences teaching practice to enhance my learners' metacognition?* I therefore make the presumption that both the learners' metacognition, as well as my teaching practice need improvement. By investigating different ways to help my learners to develop better metacognitive skills, I will engage in literature and previous research, incorporating it to meet the needs of my learners, as well as my personal teaching needs. This will involve active research in which I link theory to practice (Roche, 2000). Many researchers, such as Lather (1986), Maclsaac (1996, in Adendorff, 2007), Morley (1991), O'Brien (1998) and Smith (1999), to name only a few, are of the view that more traditional epistemological structures, such as positivist and interpretive research paradigms, are inadequate for effectively dealing with research through action. Therefore, because the active nature of this research investigation needs to be accommodated, the most adequate paradigm in which this can happen sufficiently and successfully is the paradigm of praxis (O'Brien, 1998).

Gabel (1995) and Hughes (2002, in Adendorff, 2007) contend that praxis offers the crucial link between research and action, or theory and practice. Derived from Greek ancestry, Aristotle views praxis to be "the art of acting upon the conditions one faces in order to change them" (O'Brien, 1998, p. 8). This links with the emphasis that social constructivism places on action and participation in effective teaching and learning.

Both Smith (1999) and Bernstein (1983) believe praxis to imply that one cannot know beforehand the correct way to achieve certain situations, but rather that "[...] as we think about what we want to achieve, we alter the way we might achieve that" (Smith 1999, p. 3). This fits in appropriately with the flexible nature of the action research process which emerges as the researcher reflects on each of the previous research steps. Bridging the divide between research and practice, action research corresponds with a methodology that "engages people in a transformative process by cycling through several iterations of action and

reflection" (Hills & Mullett, 2006, p. 6). The paradigm of praxis seems to be most accommodating of action research (Kemmis, 2008; O'Brien, 1998) and it is therefore considered the most appropriate for encapsulating the worldview or paradigm of this research inquiry (Hills & Mullett, 2000). In the following section I will present my research design; portraying how it embraces this paradigm of praxis.

3.3 PHASE 3: RESEARCH DESIGN

Any research inquiry requires a strategy which highlights the key points to be addressed. This research design provides a flexible guideline which will connect my theoretical framework to the research methodology, and will also connect me, as the researcher, to the research site, research informants and the different sets of interpretive data (Babbie & Mouton, 2001; Denzin & Lincoln, 2005).

I have chosen practical, school-/classroom-based action research to encompass the design of this particular study (Fraenkel & Wallen, 2008; Patton, 2002). The reason being, that action research has a central aim of change, with an emphasis on solving a specific problem or problems within a context. The research itself explicitly becomes part of the change process, as it provides the opportunity for the people involved to become engaged in, and study their own problems, in order to solve them (Fraenkel & Wallen, 2008; Patton, 2002; Thomas 2009). Mouton (2001) claims that one can only solve the problems of the world through action and active intervention. This adds to the rationale for conducting this particular study with an action research design.

In addition to this, action research is not intended to generate findings or to generalize findings far beyond the context of study (Patton, 2002). This narrow focus allows the action research design to fit the purpose of this particular research inquiry, as the primary goal is not intended to produce findings generalized to the broader society. Action research, from a social constructivist perspective, offers the ideal combination of action, reflection, theory, and practice (Friedman & Rogers, 2009) because action research is:

... a disciplined process of inquiry, conducted by and for those taking the action. The primary reason for engaging in action research is to assist the actor in improving or refining his or her actions.

(Sagor, 2005)

For the past several decades, the practice of action research has been a fairly common mode of investigation in educational research, particularly among those researchers who are interested in classroom teaching practices and teacher education (Berg, 2009).

No other research design could be better suited for this metacognitive research inquiry because action research, as described by Lewin (who coined the phrase 'action research') encourages the development of reflective thought and renewed decision by "ordinary people" (Berg, 2009, p. 247). O'Hanlon (2003) defines action research as being overtly reconstructive, whilst embracing a transformative form of self-discovery, self-development and self-understanding. Interestingly enough, these facets of action research all form part of the characteristics of good metacognitive ability as well.

The typical cyclical process of action research requires a flexible outline of the steps intended for the research process (Armstrong & Moore, 2004; Baumfield *et al.*, 2008; Berg, 2009; Hopkins, 2002; Kemmis & McTaggart, 2005; Thomas, 2009). By way of contrast to other forms of research, action research design and data collection tend to be more informal, as the people in the situation are directly involved in gathering information to study themselves (Patton, 2002). This study will follow the cyclical sequence as indicated in Table 3.1:

Table 3.1: The sequence of the Action Research cycle pertinent to this study

Step One	Identify research problem within the natural classroom setting.
Step Two	Examine the problem and gather information to answer the research question by conducting a literature review to explore current literature relevant to the study.
Step Three	Develop an action plan to address the problems represented in the research question. This will include selecting a sample group to participate in the study.
Step Four	Implement action plan developed during Step 3
Step Five	Reflect on entire process and consequences to make decisions as to how to improve and proceed during the next cycle of action.

Action research is understood as research bringing about social action using a spiral of steps, each composed of a circle of action planning, with the basic idea of continual refinement of one's thinking, and reflection on the problem, how best to solve it, and move forward

(Thomas, 2009; Fraenkel & Wallen, 2008). A typical representation of this cyclical process is represented in Figure 3.1.

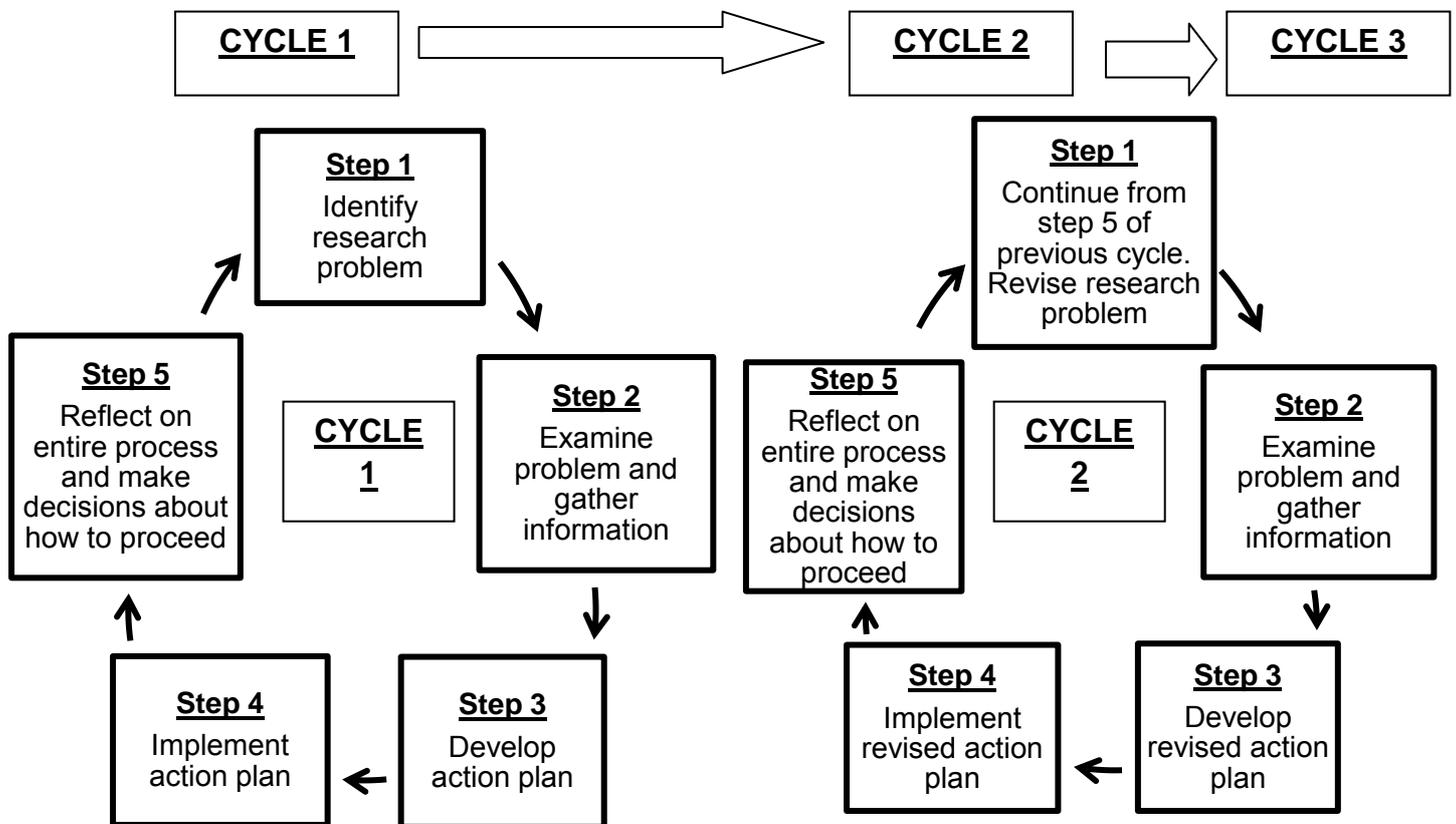


Figure 3.1: Action Research Cycle (Source: Adapted from Riding *et al.*, 1995.)

Supporters of action research have argued that it is one of the most effective ways to solve real-life problems; in contrast to basic research which is "largely irrelevant to what [...] (is happening) [...] on a day to day basis" (Patton, 2002, p. 223). Action research is said to offer immediate solutions to problems; where theoretical research often takes too long (Fraenkel, & Wallen, 2008). It has been argued that action research provides practical suggestions that can be easily applied; whereas more traditional research often produces findings which are not easily used by the everyday individual (Friedman & Rogers, 2009). Gay (1987, p. 9) states it well when saying: "action research provides immediate answers to problems that cannot wait for theoretical solutions". Action research does not however come free of criticism, and there are queries as to the validity and reliability of action research. These will be discussed throughout the sections that follow.

For many years action research has moved in and out of favour in the academic world, but today it represents a viable, practical strategy for social study which requires systematic, organised and self-reflective investigation (Berg, 2009). The validity of action research relies on its methodological focus. It needs to be systematic and well planned, but flexible, with continuous reflection and adaptation (Berg, 2009; Hopkins, 2002). Some sources (Kim, 2001; Lienert, 2002) portray action research as "the ideal research methodology when research in Education or the classroom has to be conducted" (Adendorff, 2007, p. 29).

There is a rich and diverse family of action research approaches (Reason & Riley, 2008). Practical action research, for example, has the primary purpose to improve practice (Fraenkel & Wallen, 2008) and is therefore well suited for this particular research inquiry. In the last two decades, there has been a strong movement towards teacher or classroom action research as teachers are being viewed as the experts, when it comes to teaching and improving their own practice (Cochran-Smith & Lytle, 1990; Santa & Santa, 1995). Teacher research gives a voice to practitioners, allowing them to communicate their wealth of knowledge to other practitioners, with the aim of improving their practice (Richardson, 1994; Rust & Meyers, 2003). This provides a rationale and method for teachers who wish to take more control of their professional lives (Hopkins, 2002). Action research in general is in fact said to have its most powerful success based on its ability to give practitioners a greater voice to enhance their professional development (O'Hanlon, 2003). It has been argued that teacher research is fundamentally different from traditional research, conducted by outside researchers (Cochran-Smith & Lytle, 1993), because teacher research may be more useful to teachers for the improvement of practice. Some argue that it is the only legitimate form of teaching research; as it produces more valid and relevant research for teachers' own classrooms (Carter, 1993, in Richardson, 1994).

For the reasons mentioned above, teacher research in the form of practical, school-/classroom-based action research is viewed as the most suitable research design for this inquiry. This type of research typically involves the use of qualitative interpretive modes of inquiry and data collection by a teacher, often with the support of academics, in order for the teacher to make judgments about improving his or her own practice (Denzin & Lincoln, 2005). This practical, school-/classroom-based action research will therefore involve me, as an individual and teacher, investigating a problem in my own classroom (Berg, 2009).

The next section will explore the research methodology chosen for the investigation, with explanations why it is considered the most appropriate.

3.4 RESEARCH METHODOLOGY

A question was raised in Section 3.2, as to what the frequently used research terms 'methodology' and 'method' encompass. Quite simply, 'methods' are most commonly understood as the techniques and procedures used in research to generate data (Hills & Mullet, 2000), which will be discussed in detail in Section 3.6 below. Research methodology, on the other hand, does not always present us with such a clear description (Le Grange, 2001). Focusing on the research process and the kinds of research procedures used, the methodology of a study is usually referred to as the central element influencing research design (Babbie & Mouton, 2001). Harding (1987, in Adendorff, 2007, p. 26) provides a more complex explanation, which states that methodology usually refers to the "theory of knowledge and the imperative framework guiding a particular research project".

The methodology of a study focuses on the research process and the different types of research procedures employed. These depend on the theoretical framework, the task at hand, and the overall aims of the particular study. The theoretical perception framing this study, namely social constructivism from a Vygotskian perspective, essentially puts forward the notion that learning is constructed through social interaction (Watson, 2000). Vygotsky places great emphasis on the importance of instruction, or mediated social situations as a method for constructing this knowledge (Karpov, 2003; Kozulin, 2003). It is these processes upon which I wish to reflect in this study. In order to conduct a thorough reflection and analysis of my teaching instruction and how this will influence specific aspects of my learners' learning (namely their metacognition), it is necessary for me to conduct an in-depth interactive research "using face-to-face techniques to collect data from people in their natural settings" - a basic description of qualitative research (McMillan & Schumacher, 2001, p. 35). Hence my selection of a qualitative methodology for this research inquiry.

On one level, qualitative research is widely understood as the presentation of data in a narration of words. On more complex levels, qualitative research is explained as being concerned with understanding subjective issues, with an emergent design, which is flexible and gets revised throughout the research process. A qualitative researcher tends to be immersed in the research, where he or she asserts that human behaviour is strongly

influenced by context and also cannot be understood without the subject's interpretation (McMillan & Schumacher, 2001; Oswald, 2010). The findings of qualitative research tend to produce "context-bound generalizations" (McMillan & Schumacher, 2001, p. 16), which mirror the limited goals for generalization of this pilot study. Based on the assumption that an individual's realities are socially constructed, through their perceptions of a situation, qualitative research is very much in line with this investigation's theoretical framework - social constructivism.

Taking into account the characteristics highlighted above, qualitative research is accepted to be the most appropriate method for providing a social constructivist basis for this action research study. Before describing the different qualitative methods of data collection, I will first reveal my personalized action research design for this study in the section to follow.

3.5 MY ACTION RESEARCH DESIGN

If the idea of enhancing my learners' metacognition by improving my teaching practice is the focus of this research inquiry, then I will need to evaluate and improve my practice, whilst reflecting on its effects, in a methodological and rigorous manner (Roche, 2000). The evaluation of this entire process will follow the cyclical nature of the above mentioned action research process (Figure 3.1). Table 3.2 represents that which I will cover in my research process.

Table 3.2: My action research cycle

Step	Action
Step 1	An initial action reflection, where I reflect on the metacognitive ability of my Grade 9 Natural Sciences learners, and simultaneously reflect on my teaching practice. This helps me to identify the research problem, namely, the need to enhance my learners' metacognition.
Step 2	An analysis of the problem where I determine that many of my learners show limited metacognitive abilities. A research review (discussed in Chapter 2) allowing me to explore current literature relevant to the research problem. Apart from much other relevant information (as noted in Chapter 2), this directed me to my hypothesis that metacognition can be enhanced through the incorporation of certain metacognitive teaching procedures.
Step 3	An intervention plan for improving my practice with the aim of enhancing my learners' metacognition is then proposed. In order to do this, I need to research what may enhance my learners' metacognition. In this plan, I also need to reflect on the best ways in which to conduct the research, how the informants will be selected, how the data will be collected and analysed, as well as any ethical issues that need to be reflected on.

Step	Action
Step 4	Implementation of the action plan, which involves data collection in collaboration with the learners, and analysis of this data, as well as constant reflection from my part, on the entire implementation process as well as the outcomes.
Step 5:	Based on the data interpretation, including analysis of my continuous reflections, I then reflect on the entire process. Analyzing the action plan as well as the outcomes allows me to make decisions as to how to proceed into the next cycle of action.

Steps 1 and 2 have already been discussed in detail in Chapters 1 and 2. Step 1 allowed me to realize the research problem, namely the need to enhance my teaching practice and my learners' metacognition. Step 2 helped me to understand the implications of this problem through literature research: to comprehend the importance of metacognition in education, and the need for it in science education. This step allowed me to see the need to incorporate metacognitive teaching procedures to overcome the research problem. Step 3 has been partly discussed in the first part of this chapter, with the selection of the most appropriate research paradigm (namely, praxis or action), research design (namely, action research), research methodology (namely, qualitative). The next part of the chapter will attempt to clarify the rest of Step 3 in detail, with a brief explanation of Steps 4 and 5. Details for Step 4 will be looked at primarily in Chapter 4, and Step 5 will be discussed in Chapters 4 and 5.

3.5.1 My Intervention Plan - A continuation of Step 3

As was referred to in Chapter 1 and 2; Vygotsky's social constructivism stresses that school instruction should include strategies which enhance learners' acquisition and internalisation of *scientific concepts* as conceptual processes (discussed in Section 2.2) in more appropriate ways. It is these concepts which develop a learner's thinking, problem solving and reflective consciousness (Karpov, 2003). I feel that there is a need to enhance the metacognitive abilities of some of my learners, including their knowledge of cognition (declarative, procedural, and conditional), as well as their regulation of cognition (evaluation, monitoring, and planning). The incorporation of *scientific concepts* (as higher mental functions) into my teaching must therefore be addressed to develop these afore mentioned aspects of metacognition.

For effective learning to occur, a learner needs to be an "active agent" in the learning activity (Ball & Wells, 2006, p. 190), both practically and cognitively (Donald *et al.*, 2010). Therefore, the teaching strategies/procedures and activities that I incorporate into my teaching should involve what the learner already knows, but they should also include new goals ("objects") to act on (Ball & Wells, 2006, p. 190) so that they can actively engage with the learning process. It will also be important to help my learners connect the familiar to the unfamiliar (Donald *et al.*, 2010) and encourage them to form their own learning goals (Ball & Wells, 2006), enhancing their ZPD. Teaching should not only focus on what is taught, but also on how it is taught. The 'object' of teaching is understood to be that which the learner needs to internalize. The 'tool' is that which is used to encourage this internalization. In this research study, the 'tools' will be myself as the teacher, the metacognitive teaching procedures I incorporate, the language used in the classroom, and Natural Sciences as a subject (Ball & Wells, 2006). This will be taken into consideration when planning my teaching practices so as to enhance my learners' metacognition.

In order to improve metacognition in my classroom as a whole, one of the broad approaches that I need to achieve, is to create an environment that supports a learning culture for metacognitive growth. One way to do this is by generating a general awareness of metacognition and simultaneously trying to improve my learners' knowledge and regulation of their cognition. Included in this broad goal, is the aim to foster a positive learning environment (Lin, 2001). Different strategies can be used to promote metacognitive development. In conjunction with social constructivism, these strategies are also understood as mediation tools, as described in Section 2.2 (Kozulin, 2003). The procedures used to create a classroom situation to foster metacognition are discussed in detail below.

In deciding on which strategies to incorporate in my metacognitive teaching, a lot of factors needed to be considered (Sagor, 1999). Palincsar and Ransom (1988, in Sagor, 1999) recommend that three criteria be taken into consideration when selecting which teaching procedures to incorporate into teaching: Firstly, these strategies need to be flexible across a range of classroom activities. Secondly, the teaching procedures need to create opportunity for each learner to interact with the task, while being able to monitor how successfully he/she understands the material. Thirdly, the benefit gained from the instruction strategy should outweigh the cost of it. For better clarity of the metacognitive teaching procedures, I provide a short explanation of each below, with its relevance for enhancing metacognition.

A very important strategy for teachers to help develop their learners' metacognition is to provide *models of metacognition* in the classroom. The range of methods available for teachers to use to model metacognition is vast, because anything that is considered to be metacognitive, can be modelled in such a way that learners can observe, identify, imitate and be motivated to use it. Many of the different metacognitive procedures mentioned below can be modelled, and some explanations of how to do this have been included with the relevant sections. Most commonly, however, the strategy used in the classroom for modelling metacognition, includes teachers thinking out-loud in order to externalize their thoughts in an 'expert way', showing learners how to make use of metacognitive knowledge and skills to tackle a variety of tasks. (Think-aloud techniques will be discussed in more detail in paragraphs to follow). Modelling also very often forms a component of scaffolding (Hartman, 2002a; Hartman, 2002b).

Scaffolding is an instructional technique that involves providing strong initial support (like models, cues, prompts, hints or partial solutions) to learners that is gradually withdrawn as the learners become more proficient in a given task or skill (Donald *et al.*, 2010; Gourgey, 2002; Guterman, 2003; Hartman, 2002b; Watson, 2000). The 'scaffold' is there to help learners to bridge the gap between what they are able to do on their own and what they are able to do with the guidance from a more-knowledgeable other (Hartman, 2002b). In other words, this instructional scaffold is aimed at a learner's ZPD in the form of assisted learning (Hartman, 2002b; Woolfolk, 2007). With scaffold instruction, the teacher (or more knowledgeable other) starts any new activity by modelling to the learners how to perform the task, guiding them every step of the way. The aim is for the learners to observe and internalize this, triggering independent thinking from the learner. Once it has been internalized, the learner can now use what he/she observed from the teacher and apply these skills to his/her own academic work. The teacher may still need to provide a few cues, prompts or additional modelling, at this point, when the learner has any difficulties. Gradually the learner plays a greater role and assumes more responsibility for self-instruction (Hartman, 2002b). Prompts, reminders or cue cards can act as scaffolding tools, as well as providing 'half-done' examples, reciprocal teaching, and checklists (Woolfolk, 2007).

One of the most significant goals of teaching, as mentioned upfront in Chapter 1, is for learners to be able to take what they learn in the initial context of the classroom and use it in other contexts, namely *transfer* the information (Ball & Wells, 2006; Connerly, 2006; Costa

& Kallick, 2000; Department of Education, 2002a; Galyam & Le Grange, 2005; Gourgey, 2002; Hester, 1994; Rusbult, s.a.; Schraw *et al.*, 2006; Watson, 2000; Williams & Sternberg, 1993). *Transfer* has been a focus of educational research for over a hundred years, and there are many complexities that formulate the concept of transfer (Woolfolk, 2010). For the purpose of this research investigation, the intricacies of transfer will not be explored. Transfer will be considered in its most basic form, where it is understood to be the ability to use skills learned in an initial context and to apply them to another. Transferring knowledge and skills is part of metacognition in that it requires self-regulation and awareness of one's cognition (Woolfolk, 2010). Basic transfer can be fostered simply by over-learning or practicing a skill until it is past the point of mastery. However, for higher-level transfer learners must first understand and form deep connections between new and existing knowledge. General principles can be applied in the classroom to promote transfer of knowledge and skills. These include creating a classroom environment that: 1) supports constructive learning; 2) encourages the development of self-regulation; 3) involves interaction and collaboration; 4) exposes learners to problems that have personal meaning or are of interest to them; 5) offers opportunities to practice learnt skills in similar and different situations (De Corte, 2003 in Woolfolk, 2010)

Something as simple as creating the *appropriate classroom* environment, as was mentioned above, can be supportive in developing learners' metacognition. An environment that has a supportive learning culture for metacognitive growth can be a crucial part of enhancing learners' metacognition. In an environment such as this, where learners feel encouraged and comfortable to share their metacognitive experience, and metacognitive mindfulness is valued, it is likely that learners will eventually adopt the habit of being reflective, and therefore metacognitive (Lin, 2001).

Summarizing is essentially about deciding what information is important - an essential aspect of learning, but learners must be taught how to summarise effectively. Ormrod (2004, in Woolfolk, 2010) provides some suggestions for teachers to help learners make useful summaries. These include asking your learners to: find or write a topic sentence for each paragraph or section; identify main ideas that cover the topics for each section; find supporting information for each main idea; remove any redundant or unnecessary information and details (Mills; 2009; Woolfolk, 2010). Teachers can strategize the development of summarizing skills in their lessons by scaffolding and starting off with paragraphs that guide

summaries with underlined words, headings in bold or other cues for identifying the main points. The paragraphs can initially be shorter, well-organised paragraphs, which eventually become longer, less-organised paragraphs. Learners should be able to compare and discuss their ideas with peers, providing evidence of why they think certain parts are more important (Woolfolk, 2010).

Graphic organisers are usually external visual representations that can be used to understand text and solve a variety of problems. Different graphic organising techniques exist, and they can be used to help learners to analyse texts, as well as to provide order, structure and comprehension to a given section of work, as they have to engage cognitively with the work in order to complete it (Hartman, 2002a; Woolfolk, 2010). Some graphic organisers, that can be used to help learners understand text, include flow charts, concept maps, Venn diagrams, cycles, mind-maps, and compare/contrast matrices and tables, among others. The most common way of teaching learners to use graphic organisers, is either through modelling, or scaffolding (Hartman, 2002a; Woolfolk, 2010). It is also useful if learners can compare and discuss completed graphic organisers (Woolfolk, 2010).

Thinking-aloud, as mentioned in the modelling section, is said to be an excellent technique for enhancing metacognitive knowledge and strategies (Hartman, 2002a). This is a technique of externalizing one's thought processes as one is engaged in a task that requires thinking or problem solving (Hartman, 2002a; Sagor, 1999). The idea behind it is for the thinker to say out loud all of the thoughts and feelings that occur while performing the task. This can be conducted, as explained earlier, with the teacher thinking aloud in a modelling set-up (Hartman, 2002a; Sagor, 1999). Alternatively, the learner can think aloud to herself, or to another learner. In the latter situation, the first learner acts as the thinker while the second learner acts as the analytic listener, examining the thinker's accuracy, pointing out errors, and keeping the thinker talking out-loud. This is also known as pair-problem solving (Hartman, 2002a). A number of benefits support the use of the think-aloud techniques with the collective reason for using it in this study being that it enhances self-regulation and metacognitive development because it helps learners to articulate their own thinking (Hartman, 2002a; Lin, 2001; Manning & Glasner, 1996; Thomas *et al.*, 2008).

Cooperative learning involves a form of collaborative learning or peer assisted learning where learners work together in a teaching-learning situation with a common goal (Donald *et al.*, 2010; Hartman, 2002b; Shamir *et al.*, 2009; Watson, 2000). There are three basic forms

of cooperative learning: tutoring (peer or cross-age) where one learner teaches another; pairs who work and learn with one another; and small groups of learners teaching and learning together (Hartman, 2002b). Being able to teach something requires a considerable depth of knowledge, understanding, organisation and memory of essential concepts, as well as reflection (Hartman, 2002b; Lasry, Charles, Whittaker & Lautman, 2009). By explaining something to someone else, a learner is able to retain this information better and connect new information with prior knowledge, while activating metacognition (Hartman, 2002b; Goos *et al.*, 2002; Whitebread *et al.*, 2009; Woolfolk, 2007). Apart from this, it is also more enjoyable and motivating for learners to work with their peers, and this can also enhance their social skills (Shamir *et al.*, 2009; Watson, 2000). With cooperative learning, the teacher no longer assumes an instructive role transmitting knowledge. Instead he/she becomes a manager and facilitator, who needs to train learners to work cooperatively, structure groups, assign roles, select and prepare instructional material, and monitor and evaluate learner performance (Hartman, 2002b). This links with Vygotsky's theory, discussed in Chapter 2, which focuses on the importance of the mediation process in facilitating cognitive development, such as learning (Kozulin, 2003; Vygotsky, 1978).

Reciprocal teaching is another form of cooperative learning where the teacher and learner switch positions from time to time (Donald *et al.*, 2010). After the teacher demonstrates how to handle a certain task, learners take turns to explain it to the rest of the group. This offers both the teacher and the learner an opportunity to gain insight into the learner's quality of understanding. The teacher can provide feedback to the learner regarding her monitoring strategies, facilitating the learners' self-regulation (Daniels *et al.*, 2007; Sagor, 1999). Effective reciprocal teaching, according to Palinscar (1986, in Woolfolk, 2007), includes shifting the responsibility from teacher to learner in a gradual fashion, and ensuring that the difficulty of the task and the learner's ability match. The teacher must also carefully observe the 'teaching' of the learner to determine how the learner is thinking and what kind of instruction the learner needs (Woolfolk, 2007).

Teacher questioning and *self-questioning* are strategies effective for promoting self-direction in learners (Bondy, 1987, in Sagor 1999; Hartman, 2002b; Palinscar, 1988, in Sagor, 1999; Short & Weissberg-Benchell, 1989, in Sagor, 1999). *Teacher questioning* is an important part of classroom discourse to enhance metacognition (Ramnarain, 2011). This questioning aims to probe and prompt metacognitive knowledge and skills in learners, where they reflect and

rethink some of their thoughts and actions (Ramnarain, 2011). *Self-questioning*, however, can help learners to guide their own learning, by enhancing their performance before, during, and after a given task, which can also improve self-awareness and control over thinking. Self-questioning can improve long-term retention of knowledge and skills, as well as the ability to transfer these (Hartman, 2002a). A teacher can model self-questioning, as well as discuss and illustrate how it can be used in school and everyday life circumstances. There are many different ways in which learners can learn to self-question, but it is important that they get the opportunities to develop the skill of self-questioning from explicit instruction as well as practice in a diversity of situations (Hartman, 2002a). Simple self-advice statements and questions can be taught to learners, such as, "*Stop and think!*" or "*What do I have to do here?*"; "*How does this relate to what I already know?*" and "*What else do I need to know before I begin?*" Questions like these evoke a learners metacognitive thinking (Sagor, 1999). Examples of questions at different metacognitive levels in Natural Sciences are shown in Table 3.3.

Table 3.3: Questioning at different metacognitive levels

Planning:	Monitoring:	Evaluating
How can I design research to test this hypothesis?	Does the research design validly test this hypothesis?	How effective was my experimental design?
What are all of the critical variables to be considered?	Should I try a different approach?	Were my conclusions justified by the results?
Which variables need to be controlled?	Am I recording all the observations accurately?	How could I be a more accurate observer and recorder next time?

(Source: Adapted from Hartman, 2002a).

In essence, the self-questioning technique helps a learner to take control of his/her own learning, which represents an essential aspect of metacognition (Sagor, 1999). Mevarech and Kramarski (1997, in Kramarski & Michalsky, 2009) designed a metacognitive questioning technique, that could be used initially by the teacher for questioning the learners and eventually the learners can use it for self-questioning. The design includes four types of questioning: comprehension, connection, strategy, and reflection. Comprehension questions aim to look at the problem to be solved. Connection questions prompt learners to understanding of deeper connections. Strategy questions encourage learners to put a plan and

monitoring system in place, and reflection questions encourage learners to evaluate the different perspectives regarding their plan (Kramarski & Michalsky, 2009).

Self-regulation is another important facet of metacognition, and therefore, of effective learning as well (Kistner *et al.*, 2010; Lin, 2001). For Vygotsky, self-regulation takes the form of the "deliberate control of one's own attention, thoughts, and actions" (Fox & Riconscente, 2008, p. 385). The development of self-regulation proceeds along the path of internalization of language-based social interaction (such as, the formulations in school-based instruction with exposure to scientific concepts). Vygotsky outlines three basic stages in the development of self-regulation. These move from a child having his/her attention initially directed by adults (more knowledgeable others) by means of their indicative words, to being able to direct the attention of others, again with the use and understanding of directive language. After this, self-regulation continues to develop as a learner is able to direct his/her own attention by the use of verbal stimuli, which are initially external in the form of private speech, and later in the form of internalized inner speech and thoughts. Inner speech is considered to be one of the ways that the internalization process (knowledge construction) occurs (Ball & Wells, 2006). Self-regulation can contain a number of different facets, but in general, it is understood as planning, monitoring and evaluating (Engelbrecht, 1995, in Sagor, 1999).

Another crucial aspect of self-regulation, and the most basic form of self-organisation of behaviour, is voluntary attention. This is the ability to direct one's mental focus toward a given situation, aspect or task (Fox & Riconscente, 2008). A metacognitive teacher will find ways to enhance the learners' cognitive ability to determine the most efficient strategies to focus on and complete tasks (planning), as well as helping the learner to find ways of checking his/her understanding and performance while busy with a task (monitoring). The teacher will also need to provide opportunities for learners to appraise the effectiveness of their strategies (evaluation) (Sagor, 1999).

There are numerous ways of enhancing self-regulation in a classroom (Dignath *et al.*, 2008, in Whitebread *et al.*, 2009; Hattie *et al.*, 1996 in Whitebread *et al.*, 2009; Kistner *et al.*, 2010). Strategies may be as simple as making metacognitive thinking more explicit in one's classroom, thinking-aloud when demonstrating, or explicitly noting learners' metacognitive behaviour (Whitebread *et al.*, 2009). Another strategy that I will employ in my classroom is known as "KWL" (Woolfolk, 2010, p. 275). KWL is an acronym for a method of regulating

one's learning. The K is to prompt the learner to ask herself: *What do I already know about this subject?* The learner then asks herself the W question, namely: *What do I want to know?* At the end of the inquiry, the learner then asks him-/herself: *What have I learned?* This technique can also be modelled by the teacher before the learners are asked to do it by themselves. This in itself is a way of scaffolding the skill as well.

With a specific focus on self-regulation, to enhance metacognition in the Natural Sciences classroom, the "I DREAM A" technique can be incorporated as a metacognitive teaching procedure (Hartman, 2002c, p. 188). This technique incorporates both thinking-aloud techniques and questioning strategies. Each capital letter of the acronym stands for a component of the problem solving process, with the acronym representing a guide to help the learner remember executive management skills for planning, monitoring and evaluating problem solving. The first four letters represent planning steps that can be conducted in any order, namely: Identify and define; Digram; Recall; Explore alternatives. The next two letter focus on Applying and Monitoring the plan, and the final letter stands for Assessment where the learner evaluates their solutions to the problem (Hartman, 2002c).

As part of self-regulation, within metacognition, Zimmerman (1998, in Bembenutty, 2009) argues that a self-reflective phase should occur, where learners engage in self-evaluation in which they compare their performance with their goals and identify errors (Bembenutty, 2009; Meijer, Veenman *et al.*, 2006). *Error-analysis* is seen as part of self-regulation, as it is a tactic that will help a learner to regulate their thinking which will help the next time they have to do a similar task. Error-analysis is an important metacognitive skill to be enhanced because many learners, who receive marked assessments or tasks back from teachers, often ignore the feedback which could be very helpful to improve their future performance. Learners should be encouraged to reflect on the feedback they have received, how that feedback is best interpreted and how it can be used to improve their future performance (Hartman, 2002a). An example of an error-analysis model that can be taught to learners to help enhance their metacognition includes the following questions:

1. WHAT answer did I have AND what is the correct answer? OR

WHAT did I do wrong AND what should I have done?

2. WHY did I choose the wrong answer? OR

WHY did I do it incorrectly?

3. HOW will I remember what I now know is the correct answer? OR

HOW will I make sure I don't make the same mistake again?

For each of the questions the learners must ensure to focus on the content of each of the errors rather than focus on general causes, such as 'not studying enough' (Hartman, 2002a).

Another strategy to enhance metacognition, which includes a combination of tactics, is known as the Self-Regulated Learning Pedagogy (SRLP) (Manning & Glasner, 1996). This is a metacognitive technique that can incorporate a number of other metacognitive procedure as well, such as the think-aloud technique, as well as modelling from the teacher or peers, and self-dialogue from the learners themselves. The idea is for this technique to teach learners how to think - not what to think - and how to approach, follow through, and finish tasks accurately and promptly (Manning & Glasner, 1996). The key words, initially explicitly modelled by the teacher with a thinking-aloud style, are: ASK (defining the problem); TELL (self-guiding); TRY (self-coping), CHECK (self-correcting), and CHEER (self-reinforcing). Self-dialogue or self-instructions are crucial to every one of the six steps of the SRLP. Following the Vygotskian sequence for internalization, they can initially be spoken-aloud, then softly, and then silently to oneself (Manning & Glasner, 1996). A teacher can, depending on his/her judgment of the learners' needs, incorporate any one of these levels of self-talk.

Having discussed all the different strategies I will employ in my teaching, it is important to note that there is not much use in incorporating all these different techniques, to enhance metacognition, if I myself do not make use of metacognitive knowledge and skills. I need to be aware of my thoughts and feelings as I conduct each lesson, and I need to reflect on these so as to appropriately adapt my teaching. Self-directed teaching (Manning & Payne, 1989 in Sagor, 1999) involves the teacher regulating her own teaching in a metacognitive process. It is also important for me to know how and when to tailor my teaching methods to fit the needs of the learners. For this reason, part of the data collection methods (as referred to in Section 3.6.3), will include my own reflections on the sessions. Having said this, I cannot neglect to add that my learners' values and interests also need to be given high priority in the selection and presentation of the Natural Sciences curriculum. For this reason, the learners will also be asked to reflect, as one of my data collection methods (as referred to in Section 3.6.3), and I

will take these reflections into consideration when adapting my teaching in metacognitive ways.

Not only am I required to make decisions about which strategies to use, but I also need to decide on how to plan and execute my lessons in order to achieve the goals of the strategies I have selected (Spring, 1985, in Sagor, 1999). I have decided to incorporate Sternberg's (in Spring, 1985, in Sagor, 1999) set of four metacomponents, namely: *planning*, *strategies*, *monitoring*, and *evaluating* to make decisions about how to conduct my lessons, as I feel it mirrors the action research process selected for this study, and it also demands different metacognitive skills from me. *Planning* will expect me to decide which materials are required for the task, as well as the concepts, information and understanding that the learners need in order to tackle the task. Selecting *strategies* will involve deciding on the most appropriate way/s to carry out the task (for example, modelling, collaborative learning or summarizing). This will also include making the relevance of these procedures/strategies known to the learners. *Monitoring* learning will involve generating opportunities to monitor the degree and quality of learning. *Evaluation* of the above will allow me to decide on how to progress with my teaching instruction (Sagor, 1999).

3.5.2 A Timetable of My Intervention Plan

Taking into account what was discussed in Section 2.2 about the different scientific concepts and process skills, that need to be incorporated into the Natural Sciences Curriculum, as well as the different aspects of metacognition, that need to be enhanced, I have devised a plan on to how best to adapt my teaching within my Grade 9 Natural Sciences lessons. Addendum G represents a timetable for my intervention plan which reveals my selected metacognitive teaching procedures, employed to enhance the desired metacognitive skills in my learners. It also includes examples of how I will do so in the Natural Sciences lessons with the different scientific concepts and process skills that need to be fostered. An example of a specific metacognitive lesson plan to be used in the study can be viewed in Addendum F.

The metacognitive teaching procedures, discussed above and listed in Addendum G, will be employed into my Grade 9 Natural Sciences lessons over a five week period. The normal lesson content will be taught, but this will be a time of metacognitive focus, in terms of my lessons, and I will collect data to help me reflect on the influence of these lessons on my learners' metacognition. Five weeks was decided upon, as the data collection timeframe, as

this provides enough time for all the scientific process skills and concepts to be covered, and the selected metacognitive teaching procedures to be employed. This timeframe also allows for the learners to reflect on the process, their progress and metacognitive development.

The selected metacognitive teaching methods will be incorporated explicitly into my classroom instruction throughout the five week period. Explicit teaching involves informing my learners by providing them with some information about the meaning and importance of the particular strategies involved, as well as how to employ, monitor and evaluate them. The reason I have decided to incorporate them explicitly, rather than implicitly, is because explicitly informed teaching is said to enhance a learner's transfer of knowledge and skill, by explaining to him/her how, when and where to use specific activities (Brown *et al.*, 1981, in Kistner *et al.*, 2010; Veenman, 2007, in Kistner *et al.*, 2010). Pintrich (2002, in Kistner *et al.*, 2010) postulates the need for explicit teaching of metacognitive knowledge and skill. I will therefore also begin the first lesson of the five week research period by briefly explaining to my learners what metacognition is and how the lessons to follow will aim to enhance this skill in them.

Each lesson with my Grade 9 Natural Sciences class, over the five week period, will have a particular emphasis on intensive metacognitive exposure. The content of each lesson will continue to follow the normal school curriculum, but the way of teaching this content will be adapted. The structure of every individual lesson, as well as the collection of lessons as a whole, will borrow structure from Giest and Lompsher (2003), which emphasizes Vygotsky's social constructivism and the ZPD. This structure was discussed in detail in Section 2.5.2 and will therefore only be briefly mentioned again here. The first phase of each lesson will begin with me creating conditions for a high degree of self-regulated and discovery learning, within the learners' zones of actual performance. Moving into the second phase, I will focus on more directive instruction and systematic learning in the learners' ZPDs. The third phase of developmental teaching will involve opening the new ZPD for the learners, where self-regulated and discovery learning take the lead.

With a flexible plan in mind on how to conduct my lessons in a metacognitive way, I now need to look at the last part of step 3 in my action plan, which includes the different qualitative research methods to be utilized.

3.6 PHASE 4: RESEARCH METHODS

3.6.1 Research Context

Oswald (2010) argues that the research genre and research questions are significantly influential when deciding on the appropriate location and informants for a research inquiry. In this inquiry I want to enhance my learners' metacognition by adapting my own teaching methods with an action research approach, and therefore, it only seems logical that the research must be conducted within one of my classroom teaching environments.

Gaining entry into the research site usually requires taking time to establish a good relationship with all the individuals at the site (McMillan & Schumacher, 2001). With this research inquiry I am at an advantage, due to the fact that I already form part of the research site; as it is the high school where I currently teach. The quality of research usually depends on the degree of natural behaviour from the informants in front of the researcher. Having taught the particular class, from which the informants will be selected, for over a year and a half, I feel satisfied that they will behave more like themselves before me as the researcher, than if I were to be an outside, unknown researcher. Of course, the learners will be aware that they are part of my investigation to improve my teaching while improving their 'thinking about their thinking' and this could cause an unnatural response from them. This must be taken into consideration when interpreting data, but with the five week time period of data intake, it is hoped that my informants will become used to the idea, and not react in unnatural ways. The informants will also be continuously encouraged to provide their most natural and honest responses to all matters involved in the research. Nevertheless, I must still ensure that I maintain their trust and attend to confidentiality, while always being respectful (McMillan & Schumacher, 2001).

For the purpose of this study, I agree with Guitierrez (2002, p. 319) that it is difficult to avoid using "social categories" in some instances, and in order to position myself and my learners within this socio-cultural setting, a frame of reference is required. In this way I am able to work with cultural-historical differences to enrich my research by highlighting the diversity in data collected. The high school at which the research will be conducted, and the particular class of learners involved, has a range of learners from different socio-economic backgrounds, who are from a variety of cultural, racial and language groups. The school is a single-gender, female school in the Winelands region of the Western Cape, South Africa. If I

were to describe the ethos of the school, I would have to say there is an underlying culture of learning and academic performance, with a strong drive towards developing holistic learners, who have had exposure to a diversity of social, cultural, sporting and academic experience during their school careers.

The diversity of the research setting is exemplified in the specific Grade 9 class involved in the research. This particular class of twenty-seven learners is made up of a combination of coloured, black and white learners, who have home languages ranging from Afrikaans, to isiXhosa, to English. The school uses English as the Language of Learning and Teaching, and therefore all these learners are fluent and literate in English. The learners in the class also represent a range of academic performance levels. The heterogeneity of this class makes it a diverse group of learners, who bring an interesting complexity of experiences to the classroom, which could add to the richness of the findings of this study.

Having taught all the learners for over a year and a half, I have developed, what I would refer to as, a 'strong bond' with them. This, as well as my personal teaching style and their characters, is what I feel allows the learners to feel open and comfortable to speak their minds in class and express their thoughts, feelings and opinions. I hope that this will work to my advantage in the research, as the nature of the data collection requires open and honest responses from the learner informants.

Having chosen the context for the research, the next section will provide an explanation of the methods incorporated for selecting the informants.

3.6.2 Selection of 'Informants'

A target population is defined as all the group members to whom the researcher wishes to generalise the results of the research (Mertens & McLaughlin, 2004, in Bosch, 2007). As it is not always possible to collect data from all group members in the target population, a sample group is selected from that population group. This sample group includes all members from whom data will be collected.

Purposeful sampling aims to “yield insights” and gain “in-depth understanding”, from participants, who are considered to be “information-rich”, and will be able to shed light on the research questions (Patton, 2002, p. 230). Different strategies can be used to select a sample from the target population and a combination of strategies has been chosen for this

study. The target population for the study will include my Grade 9 Natural Sciences class. A Grade 9 group was chosen as the target population for the study as existing evidence strongly supports that it is in these adolescent years that the capacity for higher cognitive functioning, such as metacognition, develops remarkably (Fox & Riconscente, 2008; Goos *et al.*, 2002; Hartman, 2002a; Leutwyler, 2009; Manning & Glasner, 1996). It is also in the Grade 9 year that learners must choose subjects for the rest of their high school career, based on their future career orientations. It is for this reason that I think it is important to enhance their science learning as there is such a need for individuals to embrace science careers in South Africa (Sjøberg & Schreiner, 2010). In addition to this, the target population was selected, as not much South African science education research (on metacognition) has focused on this age group (Malcolm & Alant, 2004; Van der Walt & Maree, 2007).

Purposeful sampling will be used to select the informants from the class members and the informants will be asked to participate on a voluntary basis as they may offer 'information-rich' data that could add value to the research (McMillan & Schumacher, 2001). Patton (2002) claims that there are no rules for sample sizes in qualitative research, as it depends on the purpose of the research and what can be accomplished with available time and resources. As this study only aims to act as a pilot study on a smaller scale for future research, a small sample group from a narrowed down target population is necessary. The limited time, and the fact that this only forms a fifty-percent research study as of my Masters degree, also means that the study need not be too vast.

From my Grade 9 Natural Sciences class, nine learners will be asked to voluntarily act as collaborative participants (informants) in the study. The sample size was decided on as it represents a third of the class, and so that a diverse representation of the class can be selected. These learners will be asked to participate based on their meeting certain criteria. This criterion sampling is one method of purposeful sampling, which involves employing cases based on certain predetermined criteria (Patton, 2002). Working with the diversity in my classroom, for the purposes of this research inquiry, criterion based sampling will be employed with the following criteria for selection: a) academic achievement group and b) cultural-language diversity group. The first criterion, namely the academic achievement group, will help me to select a diverse sample of learners based on their academic achievement aggregate for the end of the second school term. I will select three learners from a lower academic achievement range (aggregates of 60% and below), three learners from a

higher academic achievement range (aggregates of 80% and above), and three learners from an average academic achievement range (aggregates of 61-79%). These learners will be further selected, based on the second criterion, namely their cultural-language group. This selection will simply ensure that the composition of learners in the sample come from a diverse academic, as well as cultural and language range; providing a more diverse group of informants for enriched data collection and findings. This diversity aims to mimic that of the target population, but apart from this, the sample will also match the target population in that it will include only female learners of the 14 to 16 year age group. The biographical information of the informants will be provided in Table 4.1 in Chapter 4.

3.6.3 Methods of Data Collection

Methods of data collection and construction, chosen for a study, usually correspond with the particular research question(s) to be addressed. Data collection methods, in action research, have a tendency to be qualitative in nature, with an emphasis on discovery and interpretation (Borgia & Schuler, 1996, in Adendorff, 2007). In action research, practitioners tend to value and interpret their informants' experience and thoughts, which is contradictory to many traditional research approaches (Lienert, 2004).

Collecting data in school-based action research has a threefold purpose: Firstly the data is meant to help the researcher determine, what is happening in their research setting, as most research data aims to do. In addition to this, action research data aims to help the researcher determine whether the goal of the research was attained, and how the various elements of the research plan contributed to this success or failure. Lastly the data helps the researcher to determine what can be learned from the research study that may help to enlighten aspects of the teaching-learning process (Sagor, 2005).

The nature of this particular, school-based, action research study is such that I aim to collect data that can help determine the development of my learners' metacognition, as a result of my adapted teaching procedures. In Section 2.2, I explained, from a social constructivist perspective, how learning and development occur. In summary, this learning theory implies that learning occurs when a social (inter-mental) interaction, such as a teaching episode, is internalised by a learner, transferring the inter-mental process to an intra-mental process. Metacognition, being a higher order mental process, would also be involved in this intra-mental process. As I am aiming to research my own teaching and the development thereof, it

is important to acknowledge that my view of my own teaching is not the only important factor to consider. I also need to look at how the teaching sessions influence my learners' metacognition and therefore how they internalise the teaching episodes, in order for me to gain an idea of the effectiveness of my adapted teaching strategies. The difficulty, therefore, will lie with me trying to research my learners' intra-mental metacognitive processes, which are not directly observable (Hofer & Sinatra, 2010; Thomas *et al.*, 2008). Hence, my unit of analysis can not only be my own teaching practice. It must also include my learners' metacognitive ability. However, in order to 'see' this metacognitive ability, I will need to use what they externalize in order to understand what, and how, they have internalized (their metacognition). This process is represented in Figure 3.2, an extension of Figure 2.1 in Chapter 2.

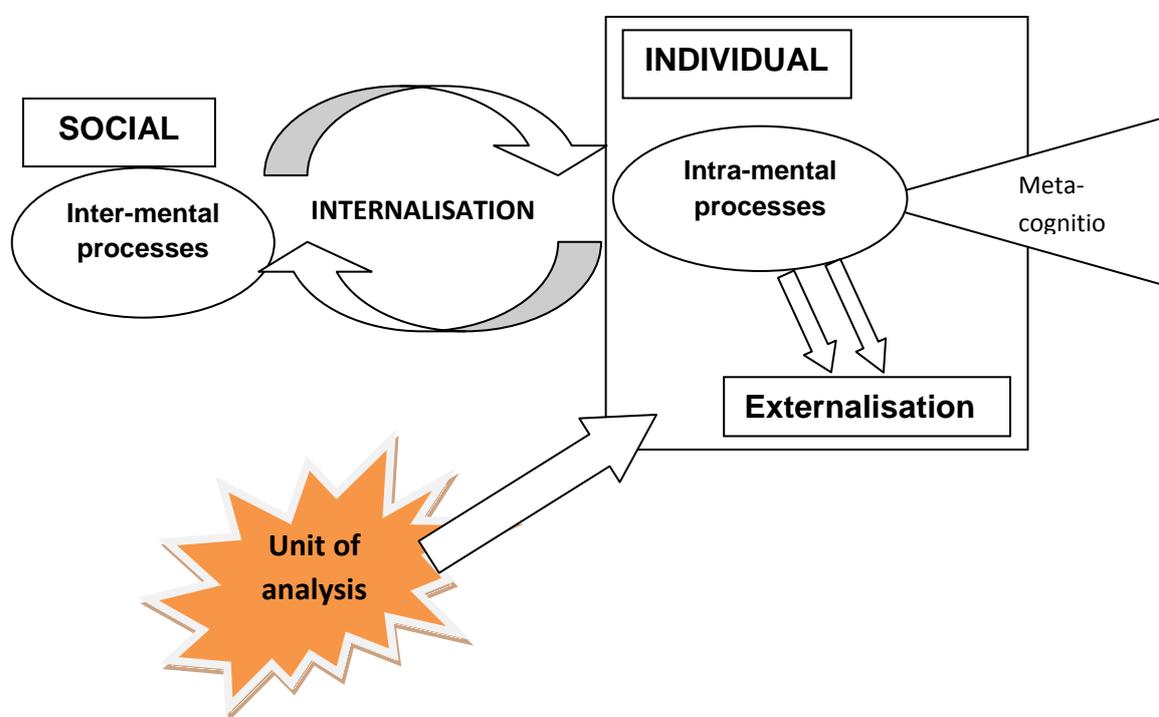


Figure 3.2: Internalisation and externalization process

Internalisation and externalisation are said to be two inseparably intertwined human activities. Internalisation has been explained above as the reproduction of a once social concept, in the form of an internal mental concept. Externalisation on the other hand involves a transformative construction, of that internalised concept, in the form of a newly created construct (Engeström, 1999; Engeström & Miettinen, 1999). Internalisation was once the focus of much research, but today, externalisation has become an equally central theme (Engeström & Miettinen, 1999). The data collection methods, which I aim to include in this

investigation, need to be able to capture the externalization of my learners' metacognitive abilities.

There are many challenges with measuring metacognition; as learners are not always accurate in their judgments of their own metacognition (Hofer & Sinatra, 2010; Thomas *et al.*, 2008). It is, however, argued that this accuracy does increase with a learner's age (Hofer & Sinatra, 2010). This study involves young adolescents, and it is therefore assumed that their ability to express their understanding and judgments accurately is somewhat better developed, but other strategies have been put in place to ensure that data collection does not rely exclusively on the learners' judgments of their own thinking and learning. Observations, that form part of my research journal, will add to the degree of accuracy in researching learners' metacognition (Whitebread *et al.*, 2009). The data that depend on learner interpretations, such as the learner reflections, are supported by providing added structure, of which details are discussed in sections below.

The preferred methods of data collection in action research include methods like interviews, interactive journals, field notes, detailed descriptions of people, place and events, and observations, among others (Adendorff, 2007). By employing a number of data collection methods, the accuracy, complexity and depth of the inquiry are improved (Flick, 2002, in Denzin & Lincoln, 2005). This is often understood as a triangulation technique to improve validity (Baumfield *et al.*, 2008; Galyam & Le Grange, 2005; Lillis, 2001; Henning, van Rensburg & Smit, 2004; Kemmis & McTaggart, 2005; McMillan & Schumacher, 2001; Silverman, 2010; Walker, 1998), which, along with other issues of validity and reliability, will be discussed in Section 3.8 below.

At this point it is important to refer to Addendum G and the references that were made to 'Reflections', 'Questionnaire' and 'Interview'. There are essentially two data collection phases that can be designated to this research inquiry. During phase one, my entire Grade 9 Natural Sciences class will (with their assent and their parents' consent) have the opportunity to experience, and to gain from, my metacognitively enhanced Natural Sciences lessons (See Section 3.9 for the ethical reasoning behind this decision). Throughout this phase, data collection will occur in the form of my own research journal which will include my reflections on the process. The entire Grade 9 class will be asked to reflect on their learning and development in this process (as it forms part of metacognitive development), but it will only be in the second phase of data collection that I will ask 9 learners in the class to

voluntarily participate in the rest of the research process; acting as informants. This phase will involve me accessing their session reflections on the process thus far, to be used in the research inquiry as data. These 9 informants will then be asked to participate in an open-ended questionnaire, as well as a focus-group interview. I will continue my research journal and reflections throughout phase 2 of the data collection process (Table 3.4 represents the outline of this data collection process). The following discussion provides details of the different methods of data collection used in this study, so that sufficient data is gathered to address the research questions.

3.6.3.1 Keeping a research journal

Keeping a research journal is emphasised as an important research tool in action research (Le Grange, 2001; Rowley, 2003). It offers a valuable and efficient way for the researcher to preserve field observations, but requires immense discipline. By providing routine recordings of all data, happenings, and activities, that are relevant for the progress of my study, a research journal can provide me with valuable chronological facts of the ongoing research (Adendorff, 2007; O'Hanlon, 2003; Thomas, 2009; Watson, 2000; Wilson & Wing Jan, 1993). The benefit of journal entries is that they help with observing patterns, themes and connections; analysing events; interpreting information and making tentative conclusions (Hubbard & Power, 2003).

According to Rowley (2003), a journal is a note of observations and experience, and "a record of the researcher's involvement in a project" (Hughes, 1996, p. 1, in Adendorff, 2007, p. 40). However, Meloy (1994, in Le Grange, 2001) warns that a journal should not merely be a record of facts, but that the researcher's reflection on experience should be included to provide insight into the cognitive and behavioural elements of the situation. It can therefore provide a "retrospective comparison of journal entries" (Rowley, 2003, p. 135). A research journal acts as a combination of a research log and a reflection diary (Baumfield *et al.*, 2008, p. 65).

Adendorff (2007) cites Hughes' (1996) four reasons for keeping a research journal, which I have also used in formulating the rationale for utilising this data construction method. These include: 1) generating a record of the investigation process, my thinking, as well as the study as a whole; 2) providing material for reflection; 3) providing data on the research process; and 4) recording the development of my research skills. An additional rationale for the use of

a journal include using it to explore my own practices by employing it as a mirror to reflect my actions, as well as using it to gain confidence in making a record of research and to gain experience in writing down my thoughts (Hughes, 1996, in Adendorff, 2007).

The contents of a research journal may vary, but literature shows that the most important aspects to cover include: 1) summaries of that which transpires every day research takes place; 2) narratives of any interactions (for instance conversations, interviews, planning); 3) questions or relevant topics, that the researcher wishes to investigate or follow up; 4) any ideas, notions, thoughts, feelings, intentions and so forth; 5) relevant diagrams or drawings; 6) perceptions (for example on the progress learners have made), reflections, observations; 7) reflections on journal entries, as well as plans for future action (Baumfield *et al.*, 2008).

With the above in mind, I thought it important to note that Dewey (1966, O'Hanlon, 2003, p. 31) defines reflection as "the reconstruction or reorganisation of experience, which requires looking through one's mind to focus on a past experience". Reflections occur through inquiries that question the experience, so as to understand it better. Reflective practice requires a commitment to "learning from experience and evidence" rather than learning from certain prescriptions for behaviour (O'Hanlon, 2003). According to Boud, Keogh and Walker (1985, in Loughran, 1996, p. 3):

Reflection is an important human activity in which people recapture their experience, think about it, mull it over and evaluate it. It is this working with experience that is important in learning.

Expanding on Figure 3.2, Figure 3.3 represents how part of my reflection on the research process will be conducted.

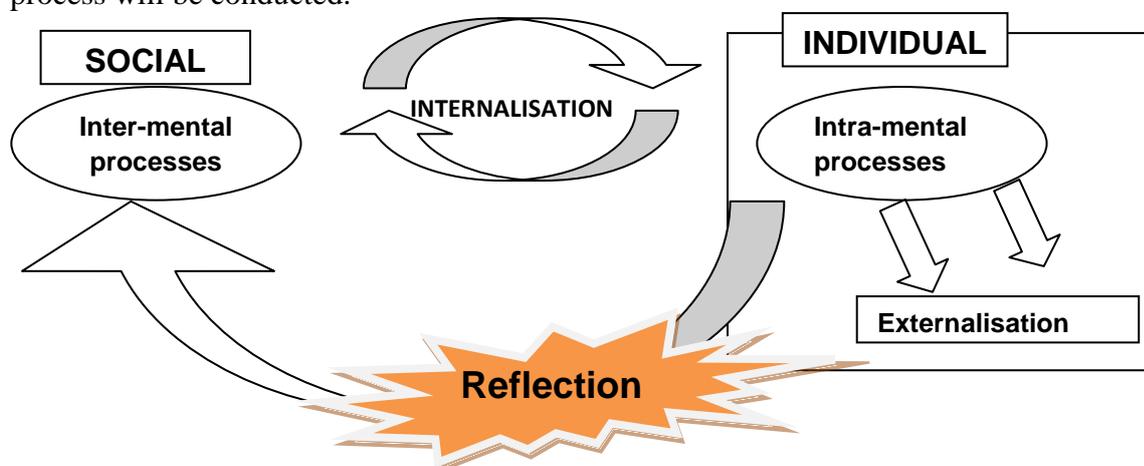


Figure 3.3: Reflection cycle

From what the learners externalize in the classroom, I will make reflections that will, in effect, influence the way that I decide to conduct my teaching (social, inter-mental processes). This essentially mirrors the typical action research cycle, which is depicted below in figure 3.4.

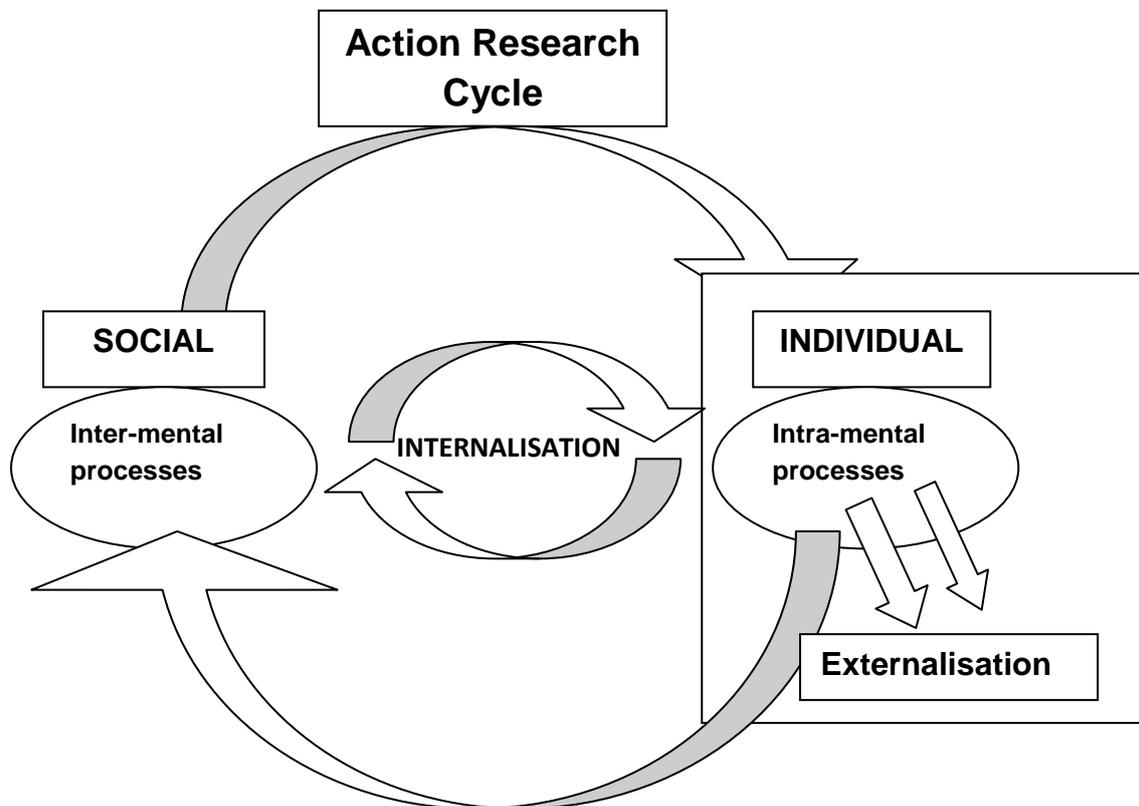


Figure 3.4: Reflection and the Action Research Cycle

The validity of personal reflections and research journals as data has been questioned (Baumfield *et al.*, 2008; Thomas *et al.*, 2008). However, many have contradicted this statement, claiming that the thoughts and feelings of the researcher are of the utmost importance, especially in action research. It is important, however, to make accurate recordings of data in one's research journal, as this improves the validity of it (Baumfield *et al.*, 2008). Apart from accurate recordings, disciplined practice to ensure that regular and thorough recordings are made, will also improve validity of the research (Adendorff, 2007). Therefore, my reflections and research journal will occur continuously throughout phase one and two of data collection

3.6.3.2 *Learner reflections*

As part of phase one of the data collection process, but also as part of the process for enhancing metacognition (described in section 3.5), the learners will be provided with opportunities to express their thoughts about their metacognitive development (Thomas *et al.*, 2008) and their learning process (Baumfield *et al.*, 2008; Connerly, 2006; Shamir *et al.*, 2009). These opportunities will occur in the form of weekly reflections (refer to Addendum H) (Conner, 2004; Thomas *et al.*, 2008). The entire Grade 9 class will be encouraged to make these reflections; as reflection on one's learning is an important part of developing metacognition. However, it will only be the 9 informants' reflections that will be used as data for the research. These informants will be encouraged to make any additional reflections between the allocated reflection times, for me to use as part of the data (Baumfield *et al.*, 2008; Connerly, 2006; Shamir *et al.*, 2009). The idea is to incorporate the informants' regular reflections to enhance my own reflections on the entire process; so that I can make appropriate decisions when constructing my teaching and lesson plans.

It was previously mentioned that metacognition can be quite an abstract topic that learners may not always be able to reflect on accurately (Hofer & Sinatra, 2010; Thomas *et al.*, 2008). This accusation is primarily related to young children's judgments of their metacognition, but to ensure validity for this study with adolescents, it will still be taken into due consideration. Therefore, in the reflections, the learners will be provided with a number of open ended questions and reflection prompts (Thomas *et al.*, 2008) (refer to Addendum H) specifically formulated to gain an in-depth picture of each learner's metacognitive skill and awareness (Conner, 2004). Data, in the form of learner reflections, rely on their honest appraisal and explanation of "what is going on in their heads" (Baumfield *et al.*, 2008, p. 53). Therefore, over and above the validity and reliability strategies (some of which have already been mentioned), the learners will be encouraged to be as honest as possible when reflecting.

3.6.3.3 *Open-ended questionnaire*

Questionnaires are a widely used technique for obtaining information. The purpose of the questionnaire and the nature of the study usually determine which type of questionnaire will be employed for that inquiry (McMillan & Schumacher, 2001). I have decided to incorporate an open-ended questionnaire for this inquiry, with the focus being placed on 'open-ended' responses to the questions. An open-ended questionnaire can be used to gain qualitative data,

in which the participant is required to provide their individually constructed reaction, enabling access to their idiosyncratic responses (McMillan & Shumacher, 2001).

It must, however, be considered that a learner's written understanding and expression abilities may influence the quality of the data gained from written open-ended questionnaires (Whitebread *et al.*, 2009). This is not recognized to be a hugely significant problem with older children, as it is with younger children (Whitebread *et al.*, 2009). Nevertheless, this validity issue will be addressed by providing a focus-group interview opportunity for the informants (McMillan & Schumacher, 2001) in which I can clarify any of their written responses on the questionnaires if necessary.

During the second phase of data collection, an open-ended questionnaire (refer to Addendum I) will be given to the sample group of the 9 learner informants. The questionnaire will aim to gain an idea of these informants' awareness of their own metacognitive development. These nine learners will also be asked to voluntarily act as informants in a focus-group interview, following their completion of the questionnaire, where additional information may be asked, or previous data clarified.

3.6.3.4 Focus group interview

After the five-weeks of metacognitively focused research lessons are complete, and the nine learners from the informant sample have each completed the open-ended questionnaire, they will be asked to voluntarily participate in a focus group interview. Interviews are a common form of data collection as they can have added benefits over other written and non-verbal techniques. Interviews allow a researcher to engage with participants who may not be able to provide written expression of their thoughts and feelings. They allow the researcher to pick up on both verbal and non-verbal cues, as well as to motivate the participants to engage in the process of sharing their thoughts (McMillan & Schumacher, 2001). Interviewing is said to be one of the most effective mediums through which we can attempt to understand others (Fontana & Frey, 2005). The interview is also viewed as being a necessary part of metacognitive research, as it offers the informants a chance to reflection in which they can consider their metacognitive experience (Thomas, s.a.)

I concur with Fontana and Frey's (2005, p. 698) opinion that an interview is the result of a dialogical exchange between the researcher and informant which "leads to the creation of a collaborative effort". In line with the social constructivist perspective, there is an active

nature to this “dialogical exchange”, in which all parties are involved in the construction of knowledge (Fontana & Frey's, 2005, p. 698). It is also important for me to reflect on what is accomplished in the interview (Fontana & Frey, 2005), and this will obviously form part of my research journal.

The focus group interview has been an important aspect of qualitative research for a long time, and its use seems to be increasing (Kamberelis & Demitriadis, 2005). As a data collection technique, it relies on the "systematic questioning of several participants simultaneously in either a formal or informal setting" (Oswald, 2010, p. 195). These interviews are very useful in gaining rich and extensive data of a diverse nature of information as they allow the researcher the opportunity to focus on the multiplicity of the informants' perspectives (De Vos, Strydom, Fouche & Delport, 2005). They provide a non-threatening environment; as they can purposefully reduce the authority of the researcher (Kamberelis & Demitriadis, 2005). The purpose is to stimulate discussion on a topic that the informants may have difficulty talking about as attentively in an individual interview, and informants may encourage others to articulate their thoughts or even realize what their own views are (Bogdan & Biklen, 2007; O'Hanlon, 2003).

As the group's dynamics always influence its members' responses (O'Hanlon, 2003), it is essential for me, as the interviewer, to encourage everyone in the group to participate and to prevent certain members from dominating the conversation; so that a rich set of data may be constructed (Henning *et al.*, 2004). I should also reflect on the different dynamics within the group, with regard to the influence it may have on data collected from the interview (O'Hanlon, 2003). It is also important to be able to decode some of the terms which the learners may use to explain their thoughts and feelings (Henning *et al.*, 2004). In order to minimize potential bias, it will be imperative for me to attempt to remain as neutral as possible and try to act as a facilitator through which information is exchanged.

Another way to increase the validity of interviews is for me to offer the informants an opportunity to check my perceptions. If I write down my perceptions of their answers and offer them the opportunity at a later stage to read these and make corrections if need be, the accuracy of the data will be enhanced (McMillan & Schumacher, 2001). This is also referred to as "member-checking" and is discussed further in Section 3.8 (Sagor, 2005, p. 130).

In this study, one focus group interview will be conducted towards the end of the data collection period of research, acting as a complement to the data already constructed (O'Hanlon, 2003). An interview guide will be used to provide a framework of issues, leading to possible questions, in the form of a semi-structured interview (Thomas, 2009) (Addendum J). The data generated will be analysed with the aim of understanding if and how the learners' metacognitive abilities have developed with the introduction of explicit metacognitive teaching procedures. The interview can also provide an opportunity for clarification of data previously collected (Baumfield *et al.*, 2008; Fox & Riconscente, 2008; Thomas, 2009).

3.6.3.5 Time table of data collection

Table 3.4 provides a flexible outline for the data collection and analysis throughout this action research cycle.

Table 3.4: Timetable of data collection and analysis

Week	Phase of data collection	Activity
Before formal data collection		Problem formulation; Literature research; etc.
1 - 4	1	Metacognitive instruction; Research Journal; (Data analysis)
	2	Learner Reflection
5	2	Metacognitive instruction; Research Journal; Open-ended questionnaire; Focus group interview; (Data analysis)
6 and onwards		Final data interpretation and analysis Research findings, conclusions and presentation of data

Data will be captured and edited throughout the data collection process. This is necessary for my continuous self-reflection. To keep track of all the data collected, a data-collection table will be created in which the learners' metacognitive progress will be recorded, making it easier to recognize emerging themes. This table will also have space for any findings and interpretations that are made through my own reflections of all the data collected (Baumfield *et al.*, 2008). This, along with an analysis log in my research journal, will be used to keep track of the emergent themes and metacognitive development of the learners which will be noted throughout the data-collection process (Baumfield *et al.*, 2008; Galyam & Le Grange,

2005). The next section attempts to explore the methods of data analysis used to facilitate the handling of collected data.

3.7 PHASE 5: METHOD OF DATA ANALYSIS

Throughout the research process, data that is collected, will be recorded and analysed on a continuous basis. Whilst the data is being collected, it needs to be organised and studied in such a way that the natural divisions (themes) can be identified. This may involve a series of coded notes or memos created to aid understanding the data. Data may be segmented into "meaningful units and categorised according to an organising system" derived from the data itself (O'Hanlon, 2003, p. 46). From some of the data collected, namely: the learner reflections, open-ended questionnaires, the focus-group interview, field notes, observations and so forth, data in the form of my reflections and analysis will be created in my research journal (O'Hanlon, 2003). At this stage, an honest, open and emergent interpretation must be provided from my part, so that I am free to engage with the complexities of the patterns that may emerge, which may not necessarily have been incorporated in my initial design (Holliday 2007).

The use of coding schemes to collect, study and interpret metacognitive and self-regulatory processes, has become increasingly important (Azevedo, 2009). Theoretically based coding systems, based on metacognitive knowledge and regulation, will be used in this inquiry to summarise the data; in order to examine and conceptualise it; while also indentifying, categorising and comparing general themes (Azevedo, 2009).

When looking at action research data, with reference to this inquiry, the aim is to trace any trends or changes in the informants' metacognition, in the effort to address the research questions. Additionally, data analysis tries to accomplish an understanding of those factors that contributed to the changes (Sagor, 2005). The analysis of data in this research will look for patterns in the data as well (Sagor, 2005). The different divisions, emerging in the data, must then be divided into distinguished themes. Themes will be extracted from the data by looking at the content of the different data forms, noting any trends (Berg, 2009; Sagor, 2005). An analysis log may aid the thoroughness of this process (Baumfield *et al.*, 2008). The construction of a timeline of events can also assist the identification of trends over time (Sagor, 2005), but the organising logic of the discussion needs not follow the chronological order in which the data was collected (Holliday 2007). The focus-group interview will be

audio-recorded and transcribed verbatim, with the same intention of continuing the identification of emerging themes (Berg, 2009). Categorisation at this stage must also remain tentative; as it must be flexible for possible modification at a later stage. The data may need to be looked at again in a cyclical nature, and therefore there needs to be room for adaptation in data analysis (O'Hanlon, 2003).

Data will be compared by identifying similarities and differences, as well as unexpected findings (O'Hanlon, 2003), as these unexpected truths may differ from my own dominant perspective. I therefore need to remain true to that which is found in the research setting (Oswald, 2010). My reflections on the data collection and analysis will act as 'tentative assertions'; which are a combination of empirical data and my intuitions (Sagor, 2005). Although intuitions do not form a part of scientific analytical strategies, Sagor (2005) advises that the use of a participating researcher's active intuitions, are important and useful components of findings and interpretations in action research.

The last part of this action research cycle will then involve a final reflection on the entire process, providing a holistic thematic analysis of all the data and emerging themes (Holliday 2007). Examples of this, and the previously mentioned data coding and analysis techniques, will be presented in Chapter 4 and as Addendum L. I will need to use these interpretations of the research to determine how my teaching practice has developed, whether or not this has enhanced the metacognition of my learners, and if so, in what ways. Once these conclusions have been made, I hope to have sufficient data to address my initial research questions. The reflection on this cycle of the action research process will then form the basis for the next cycle of action. The actual analysis and discussion of the data will occur in Chapter 4, and the reflections relevant to future cycles in this action research inquiry will be referred to in Chapter 5.

3.8 VALIDATION AND RELIABILITY OF THE INQUIRY

Advocators of action research agree that validity and reliability are principles that cannot be ignored if credibility is to be awarded (Borgia & Schuler, 1996, in Adendorff, 2007; Dick, 2000; Lather, 1986; Weiner, 2003; Winter, 1989, in Adendorff, 2007). In qualitative research the basic concepts of validity are not applied in the same manner in which they are applied to quantitative research (Neuman, 2006, in Oswald, 2010). In ensuring the validity of a study, a

researcher guarantees that the data actually reflects the phenomena that they claim to. Reliability on the other hand refers to the accuracy of data collected (Sagor, 2005).

Where the validity of action research is questioned, I refer to the following quote of Elliot (1991, in Hopkins, 2002, p. 43): "action-research 'theories' are not validated independently and then applied to practice. They are validated through practice". Winter (1996) maintains that in action research emphasis should not focus on the validity of findings, but rather on how rigorously the procedures are used. Henning *et al.* (2004) concur that the validity of a research inquiry is enhanced by "good craftsmanship", implying precision throughout the research process (Oswald, 2010, p. 202). For this reason, rigorous and systematic methodology will be adopted for this study.

Classroom action research has been around for a long time, but has gone through times of criticism and favour. Critics have questioned the teacher's ability to self-reflect and make judgments based on their reflections (Denzin & Lincoln, 2005). To avoid this "data collector bias", I must be scrupulous about not allowing my awareness of the intentions of the study to influence my view on the results that I obtain, and note where my subjective opinion is being used (Fraenkel & Wallen, 2008, p. 595). My personal experience and training in educational psychology and research methodology will also increase the validity of the data that I collect (Gay, 1987). The point to be emphasised is that of the researcher's reflexivity, summed up by Delmont (1992, in Walker, 1998, p. 250):

Each researcher is her own best data collection instrument, as long as she is constantly self-conscious about her role, her interactions, and her theoretical and empirical material as it accumulates. As long as qualitative researchers are reflexive, making all their processes explicit, then issues of reliability and validity are served.

Throughout the presentation of this research I have aimed to make my own positioning, with regard to personal perspectives, apparent, while providing solid reasoning for my decisions made. This is in an attempt to be transparent in my personal views and values (O'Hanlon, 2003). "Reflective critique" of one's research process in which the researcher thinks critically about what he/she has versus what is still required, is also an essential part of this open communication for improved validity (Winter, 1989 p. 43, in Adendorff, 2007, p. 54).

My reflection on the entire process aims to provide additional clarity of the reasoning behind certain decisions made throughout the research process. This open communication can also

be attained by "taking data and tentative interpretations back to the people from whom they were derived and asking them if the results are plausible" (Merriam, 1998, p. 204, in Oswald, 2010, p. 203). In this research study, tentative interpretations of data will be validated by using this procedure, commonly known as 'member checking' (O'Hanlon, 2003; Sagor, 2005; Silverman, 2010). The focus group interview will also provide a secondary opportunity to gain additional confirmation of interpretations from selected informants; as this data collection method acts as a complimentary strategy to the other qualitative data collection activities.

To increase the validity of the study, another procedure will be incorporated, known as 'cycling', in which I shift between action and reflection several times within the study (Reason & Riley, 2008). This allows the researcher to refine their understanding of the situation being investigated (Dick, 2000). By challenging initial information and interpretations, I will not only get richer data, but it will have increased validity as well (Reason & Riley, 2008). Working closely with my supervisor and co-supervisor as peer-consultants, is another strategy put in place so that external views can be placed on the research process to monitor their validity (Baumfield *et al.*, 2008; McMillan & Schumacher, 2001).

With respect to validity, reliability and research quality, Weiner (2003) argues in support of action research on the condition that rigorous and high quality 'alternative frameworks' are used. To address this, and other issues of validity in the research, the technique of triangulation will be employed, in which three or more different data sources are used. These methods aim to provide 'multiple perspectives' and to cross-check data collected; thereby strengthening the validity of the inferences made from them (Baumfield *et al.*, 2008; Borgia & Schuler, 1996, in Adendorff, 2007; Galyam & Le Grange, 2005; Lillis, 2001; Henning, van Rensburg & Smit, 2004; Kemmis & McTaggart, 2005; McMillan & Schumacher, 2001; O'Hanlon, 2003; Silverman, 2010; Walker, 1998). In this research inquiry, I endeavour to apply various data collection techniques and instruments, such as a research journal, learner reflections, an open-ended questionnaire, and a focus-group interview, for the triangulation process; in order to achieve greater validity.

It is quite apparent that action research challenges many assumptions of a traditional empiricist stance to research. Action research, in line with the social constructivist perspective of this inquiry, challenges the ownership of knowledge and refutes the idea of

there being a fixed reality. By its very nature, action research cannot be critiqued from differing paradigms (Roche, 2000). Winter (1986, in Roche, 2000), in fact, argues that action research is a new paradigm with a solid theoretical grounding. However, as with all research, verification must be produced to support any claims made by the researcher.

3.9 ETHICAL CONSIDERATIONS

As Dick (2002, p. 21) puts it: "Ethical issues are inherent in any research study", and therefore, I too must address the ethical concerns related to my inquiry. Four principles guiding ethical research include: autonomy and respect; nonmaleficence; beneficence; and justice (Allan, 2008; Brydon-Miller, 2008; Oswald, 2010). These ethical principles are of significant importance in action research and are therefore also ethical considerations for this research inquiry. Adopting Wassenaar's (2006) framework, which includes the above four ethical principles for social sciences research, the following practical principles will be applied to this investigation.

Firstly, a partnership in which the research is conducted in collaboration with the informants, being driven by the needs and priorities of the informants, must be developed through the research (Wassenaar, 2006). In my inquiry, the informants' involvement, honest responses, reflections about their metacognitive development, and their views about the research, are crucial. Without their collaborative input, the findings would be irrelevant. Simultaneously, the aims of this research are directed by the perceived need to enhance these learners' metacognition. Action research (and therefore this study) inherently values this respect principle even further because it assumes that all individuals have the capacity to contribute to the process of knowledge generation (Brydon-Miller, 2008).

Secondly, research needs to provide an extent of social value in order to be considered ethical (Allan, 2008; Wasenaar, 2006). The research questions of this study attempt, through the research process, to enhance the learners' metacognitive abilities, while contributing to the development of my teaching practice. The latter could be of added benefit to others in society, such as teachers, researchers, and others. To add to the ethical social value of this research inquiry, I feel that all the learners in the research population (namely, my whole Grade 9 Natural Sciences class) have the right to benefit from my metacognitively adapted teaching procedures. If I choose to work with only a select sample for the entire process, I feel that this would disadvantage the rest of the class group not involved. It was for this

reason of maintaining the ethical principles that I decided to split the data collection into two phases: to include my entire Grade 9 Natural Sciences class in the first phase, so that they can all have the opportunity to gain from the sessions; and to work with only 9 learners as informants in the second phase.

Adding to this social value of the study, Greenwood and Levin (in Brydon-Miller, 2008, p. 199) see action research as "central to the enactment of a commitment to democratic social transformation through social research". Values that underlie most forms of action research include participation in democratic processes and improvement of human life. The benefits of a research study therefore need to outweigh the risks involved. With the presentation of the problem statement, along with a rationale for the research in Section 1.2, it is clear that the research benefits outweigh the risks.

The ethical principle of respect is valued due to the fact that it provides research informants with the opportunity to decline to participate in the particular study, and this is addressed in the informed assent and informed consent process (Brydon-Miller, 2008). Informed assent to participate is required from the informants (Addendum D), and their parents (Addendum E), as well as the school (Addendum C), must provide their informed consent before the research can be considered ethical. Before ethical consent can be given, relevant parties must be appropriately informed about the study (including the benefits and risks). Additionally, informants must be notified that it is voluntary to participate, and they have the right to decline or withdraw from the study at any point. Lastly, this consent should be formalised in writing (Allan, 2008; Health Professions Council of South Africa, 2007a; Wassenaar, 2006).

Respect for the informants' privacy and reputation also need to be taken into account. This will be addressed by ensuring that no names or identities of any of the learner informants will be exposed (Rust & Meyers, 2003). This links to maintaining the confidentiality of informants' identifying data (Rust & Meyers, 2003; Wassenaar, 2006). In this research inquiry, the confidentiality will be maintained with the use of pseudonyms for both the school and the informants. The informants will be asked to choose their own pseudonym. Winter (1996) maintains that the researcher is responsible for maintaining the confidentiality of a study. The sample informants will be invited to participate in the study on a voluntary basis, with the assurance that they may at any time withdraw from the study with no consequences (Allan, 2008; Health Professions Council of South Africa, 2007a). This covers the justice principle of ethics. Ethical clearance from both the supervising university's ethics committee (Addendum

A), as well as the Western Cape Education Department (Addendum B), also forms part of the ethical conduct for this research inquiry.

In addition to the above, by including the following inquiry skills and validity procedures, the quality of the study can be improved. Firstly, I will need to be present by incorporating empathy and resonance, while also being open to the meaning that I, and others, give to experiences. I need to be open to reframing the defining assumptions that I pose on a context. Being aware during the research process of the relationship between my purposes, my norms and theories, my bodily practice, and the outside world, is important during the inquiry. I will need to be aware of any lack of congruency between these different facets and adjust them accordingly. I will also need to identify and manage emotional states in various ways (Reason & Riley, 2008) and I will, therefore, need to reflect on my research process regularly; so as to "develop ... [my] understanding of the ethical implications associated with social and educational investigation" (Burgess, 1989, p. 8).

By embodying ethics within my own practice as an action researcher, I will need to begin with a critical examination of myself as an individual researcher in this process, articulating my own value system, my multiple identities, locations of power and privilege, and how these influence my interaction with others and the research process (Brydon-Miller, 2008). At the same time, I will need to keep in mind that the learners who participate in the study also have their own sets of values and systems of power. Working with learners, I will have to reflect on my recognition of the ethical demands of the teacher-learner relationship, and attempt to understand and monitor this relationship, including the power-dynamics, to ensure that my primary goal remains in the best interests of the learners (Brydon-Miller, 2008). To ignore this would be ethically inappropriate. The issue of protection of parties involved in the research process must also be addressed. Coercion can be an issue in any form of research, action research included. Therefore, in order to address this, understanding the problem within the context of the "close, committed relationships that typify action research settings" requires thorough interpretation and reflection (Brydon-Miller, 2008, p. 202). This will help me to maintain my ethical commitments to the research study and informants.

Any research inquiry faces ethical issues that need to be addressed. This section aimed to provide a thorough explanation of the ethical considerations of this research study.

3.10 SUMMARY OF THE CHAPTER

This chapter has in effect provided a detailed account of Step 3 of the action research cycle for this research inquiry. This essentially involved information about the research paradigm chosen for this study, along with phase 3 of the cyclical action plan which involved a detailed explanation of the research design and methodology. Phase 4 formed part of this, and it provided an explanation of the research methods. Phase 5 ended the chapter with a description of the data analysis, validity, reliability and ethical consideration for the research. The next chapter will attempt to provide a detailed account of Step 4 of the action research cycle as it presents a detailed account of the implementation of the action plan.

CHAPTER 4

RESEARCH FINDINGS AND DISCUSSION

4.1 INTRODUCTION

As discussed in Chapter 1 and 3, the primary research question this study aimed to address, was:

How will the incorporation of metacognitive instruction improve my Natural Sciences teaching practice?

The sub-question which was formulated was:

How will my Natural Sciences learners' metacognition develop through my adapted teaching procedures?

In this chapter, Step 5 of the action research cycle will be addressed in an effort to provide answers to the above research questions. Step 5 involves my reflection on the entire process, so as to make informed decisions about how to improve and proceed during the next cycle of action. Up to this point, steps 1 to 4 have already been conducted. Step 1 involved my initial reflection, which allowed me to identify the research problem. Step 2 involved my practical and theoretical research and analysis of the problems, while Step 3 incorporated my proposed intervention and research plan to tackle the research problems. Step 4 involved the implementation of this intervention plan, and the collection of data throughout the implementation process.

During Step 4, data was continuously collected, in various forms. As was discussed in Section 3.6.3 and 3.7, data was collected in the form of learner reflections throughout the five week process (Addendum H). Towards the end of the implementation process, one open-ended questionnaire (Addendum I) and a focus-group interview (transcribed verbatim in Addendum L) were also used. Apart from this, my field notes and observations, in addition to my reflections and interpretations of the entire process, were collected throughout, in the form of my reflection journal (Addendum K) (O'Hanlon, 2003). The function of data

collected from the informants, was for it to act as a representation of the larger Grade 9 Natural Sciences class. It has therefore, for the most, been analysed as such. The informants' biographical particulars are presented in Table 4.1.

Table 4.1: A presentation of the biographical information of informants

Informants (Pseudonym)	Age	Average academic achievement (Natural Sciences)	Cultural-language group
P-1 Lee	15 yrs	59 % (Medium)	English, Coloured
P-2 Saskia	15 yrs	43 % (Low)	English, White
P-3 Dylan	14 yrs	52 % (Low)	Afrikaans, White
P-4 Lesley	16 yrs	66% (Medium)	English/Afrikaans, White
P-5 Lena	15 yrs	95% (High)	German/Afrikaans, White
P-6 Mavis	15 yrs	67% (Medium)	Xhosa, Black
P-7 Zayaan	15 yrs	37 % (Low)	English, Coloured
P-8 Noma	15 yrs	89% (High)	Afrikaans/English, White
P-9 Innocentia	14 yrs	86 (High)	Zulu, Black

Attention was given to the data analysis process in Section 3.7. In summary, the data collected was analysed using a theoretically founded coding scheme based on metacognitive knowledge, regulation and awareness. This enabled me to summarise the data so that it could be examined and conceptualised in an attempt to identify, categorise and compare prominent themes (Azevedo, 2008) (Addendum L). To aid the analysis of the data, an analysis log and timeline of events formed part of my reflection journal (Baumfield *et al.*, 2008; Holliday, 2007). The aim of data analysis was to identify any trends and/or significant changes that occurred over the five week implementation process, and then to extract themes, based on the codes and categories which emerge from the data (Berg, 2009; Sagor, 2005).

The last part of this action research cycle involves a final reflection on the entire research process. This reflection will include the analysis of data explored in this chapter. This reflection is therefore only presented at the end of Chapter 5.

This chapter will, however, start with an exposition of the research findings with the intention of attending to the research questions. The findings will be presented under the main themes and categories that were identified during the qualitative interpretation and holistic thematic analysis of the data collected.

The data generated with the help of the informants, was viewed as the externalisation of that which they internalised (metacognitively) over the five week implementation process. In reference to Section 3.6.3, my understanding of what the learners internalised during the intervention was made possible through their externalisations. These externalisations occurred in the form of their responses in the reflections, open-ended questionnaires, and the focus-group interview (Engeström, 1999). The evidence that I encountered in their externalisations acted as my unit of analysis and, therefore, provides evidence of their internalisation of the five week metacognitive process. Furthermore, my reflection journal does not only function as a form of data, but it also aided my analysis of both the learners' and my own progress. Analysis of all this data, allowed me to identify major trends and themes.

In the following sections, after presenting the most prominent themes that emerged from the data, the findings will be discussed in relation to existing literature to attend to the research questions. Table 4.2 provides a summary of the themes and categories which emerged during data analysis.

Table 4.2: Themes and Categories

Themes	Categories
1. Learners' Metacognitive development	Metacognitive Awareness: <ul style="list-style-type: none"> - Knowledge of Cognition - Regulation of Cognition - Reflection
2. Metacognition and the ideal learner	(Discussed as a complete theme)
3. Development of teaching practice	Enhanced teaching style and procedures Uniqueness of learner

4.2 RESEARCH FINDINGS

This section aims to present the themes which emerged during data analysis. The themes are presented in the order outlined in Table 4.2, with the sub-question of this research inquiry being addressed before the primary question. The reason for this is that the evidence of enhanced teaching practice was viewed, for the purpose of this research inquiry, through the metacognitive development of the learners, who were exposed to it.

4.2.1 Learners' metacognitive development

One central aim of this research inquiry was to observe, and reflect on, how my Grade 9 Natural Sciences learners' metacognition would change through the incorporation of adapted teaching procedures. Social constructivism states that learning is a unique construction of knowledge due to a social interaction which is relevant to a learner's specific ZPD (Donald *et al.*, 2010; Giest & Lompscher, 2003; Veresov, 2009). It is therefore expected that each learner's learning experience would be unique depending on their individual circumstances. During the five week intervention, each learner responded differently to the metacognitively orientated teaching procedures that I employed in the Natural Sciences lessons, as they were constructing knowledge in relation to their own ZPD (Blanton *et al.*, 1998). For the purpose of this thesis, and due to the nature of the particular research design, a detailed account of each informant's unique progress is not presented. Instead, I present common trends and themes which have emerged. I introduce only some of the personal responses of the informants, which I feel are relevant to support the discussion of the findings, into the text.

In order to critically reflect on my metacognitively adapted teaching procedures, I need to analyse any developments in my learners' metacognition. As was mentioned in Section 3.6.3, metacognition, being a higher order intra-mental skill, is not directly observable (Hofer & Sinatra, 2010). Therefore, in order to 'observe' their metacognitive gains, I needed to analyse what my learners externalised so as to understand what, and how, they have internalised the incorporated metacognitive knowledge and strategies. In order to reflect on this 'change in my learners' metacognition', I therefore needed to gain an idea of how their metacognition developed over the five week implementation period.

For many of the learner informants, who participated in this research study, development of their metacognition was clearly evident from their reflection comments. In many comments, the informants implied that they had experienced a marked improvement in their

metacognitive abilities throughout the research process. Exposing their enhanced metacognitive awareness with these comments also made it evident as to how the learners' thinking about their thinking had improved. In addition to this, as the teacher-researcher, I also noticed, in a number of ways, marked improvements in many of my learners' metacognition.

The limited metacognitive ability of some learners, and the clearly evident need for improved metacognition, was recognised in the data collected at the beginning of the five week process (namely, the error-analysis and initial learner reflections). This provides further evidence, which supports one of the research problems that I incorporated into Chapter 1 as Step 1 of my action research process, namely, the need to improve learners' metacognition, particularly in science education. It also opens the floor for me to make evident the impact that these adapted metacognitive teaching procedures had on Grade 9 learners in the Natural Sciences classroom. I therefore start this section by providing some insight into the limited metacognitive abilities that some learners portrayed both before, and in the early stages of, the implementation of my metacognitive intervention. Presenting information on the learners' initially limited metacognition, has the intention of facilitating the reader's understanding of the progress and development of their metacognitive abilities.

The first part of evidence, that supported my views on the need for improved metacognition in many learners, was the informants' academic results at the beginning of the five week process in comparison with their reported abilities to think about their thinking. Research has shown a strong direct link between good metacognitive ability and high academic performance, and vice versa (Coutinho, 2007; du Toit & Kotze, 2009). I therefore expected to detect that the informants, who achieved within the average to lower academic ranges in Natural Sciences, would experience more limited metacognition. Not only did this imply their need for more effective learning experiences, it also meant that developing their metacognition could provide a positive contribution to bring about this improvement.

During the initial stages of data collection, when I began with the implementation of the adapted metacognitive instruction, it was clear that a number of the learners experienced limited metacognition. This was evident in their limited knowledge of cognition and regulation of cognition. From the informants' comments in the open-ended questionnaire and focus group interview, all of them revealed that their initial metacognitive abilities had required improvement, some more so than others. In order to make evident these initially

limited metacognitive abilities, I would need to reveal the learners lack and/or limitation in what is considered to be metacognition. It is therefore important to remember that metacognition can be understood as more than 'thinking about one's thinking' (Veenman *et al.*, 2009, in Shamir *et al.*, 2009). It involves the interplay of knowledge of cognition, which includes declarative, procedural and conditional knowledge, as well as regulation of cognition, which includes planning, monitoring and evaluation of thinking (Beng Lee *et al.*, 2009).

One informant, Lee (average academic performance), revealed in her reflections, in the initial stages of the intervention process, that she did not know which skills to use for certain tasks. This revealed a poor declarative knowledge. Dylan (low academic performance) commented in one reflection that in order to correct each mistake, and to avoid making the mistakes again in the future, she needed to "write slower and correct spelling". Her inability, to specify how she could improve her spelling, implied poor metacognitive awareness. The fact that, throughout that particular reflection and in assessments which followed, she never attempted to regulate these problems, further revealed an initially restricted metacognitive ability. Despite improving in other aspects of metacognition, Dylan showed an inability to regulate her cognition to incorporate alternative strategies to improve her spelling.

More evidence of this limited metacognition was evident from other informants, but Lee's initially inadequate knowledge of cognition provided a good example. She commented, in the error-analysis reflection, that in order to improve her test answering technique, she needed to allocate equal time to each question in a test or exam. From this, it is clear that Lee's declarative knowledge and procedural knowledge were clearly limited. Declarative knowledge is understood as knowing which skills, strategies and resources to use when doing a particular task, whereas procedural knowledge involves knowing how to use those skills and strategies (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2007). Different questions in any assessment require a different amount of time allocated, therefore using an equal amount of time for each question would not work to Lee's advantage. This is an example of poor declarative and procedural knowledge.

Poor transfer of skills and knowledge was revealed in the initial stages of the intervention process, when many learners presented poor conditional knowledge in their initial reflections. An inability to employ skills learnt in the Natural Sciences classroom, in other situations, where they may be useful, was also evident in the initial data collected. Conditional

knowledge, a different part of knowledge of cognition, involves the individual's ability to know when and why to apply certain skills, strategies and procedures (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2007). This transfer of knowledge, beyond the instruction setting, linking it to real life experience, requires deeper thinking and learning (Gourgey, 2002). Therefore, as a critical element of good metacognition and good learning, a limited conditional knowledge or the inability to transfer skills and knowledge, may indicate limited metacognition. The data, discussed at the beginning of this paragraph, therefore supports the need for improved metacognition.

In addition to this, during the initial stages of the data collection process, Zayaan (low academic performance) showed limited regulation of cognition by her inability to manage her time effectively. As previously mentioned, regulation of cognition is also an important element of metacognition (Beng Lee *et al.*, 2009). In her first reflection activity, Zayaan's reason, for not being able to complete her error-analysis activity and test-corrections, was that she "ran out of time". In the focus-group interview I asked her whether this comment had also applied to her past tests, exams and assignments. She responded to this by saying that she had, prior to the five week intervention process, often experienced difficulty with finishing different activities in the allotted time. This indicated that she experienced a limited ability to regulate her thinking behaviour even prior to the metacognitive intervention.

There was other evidence of poor regulation of metacognition; including poor planning, monitoring and evaluation (Hartman, 2002a; Woolfolk, 2010). Learners, like Saskia (low academic performance), reflected in the error-analysis exercise that rushing through the paper, was one of the most common reasons for poor achievement in tests and exams. In the focus-group interview, Dylan commented that she had always just learnt her work "parrot-fashion", going over the work multiple times. This implied a poor knowledge of cognition and a limited ability to regulate cognition. From a social constructivist perspective, this type of learning would lack any true internalisation, in which thinking and reflective consciousness is fostered. Hence, no metacognition plays a role (Karpov, 2003).

Another aspect of metacognitive regulation includes the ability to manage one's time effectively (Woolfolk, 2010). At the beginning of the five week cycle, many learners in the classroom did not use their time effectively. When tasks or activities were given, some learners tended to chat with friends or do other things, reflecting poor time management and planning. This could, however, also be linked to the motivation levels of the learners, which

will be discussed in a Section 4.2.3.2. It seems that over the course of the metacognitively enhanced lessons, more and more learners started to stay on task. Some reflected in the later stages that they were in fact starting to regulate their cognition by planning, monitoring and evaluating their time usage better, showing improved metacognition.

From a metacognitive perspective, conscious control of thinking, as well as reflection, all form part of good metacognition and learning (Veenman *et al.*, 2006; Yore & Treagust, 2006). The data showed that one of the most common areas, that the informants felt they needed to improve, was the degree to which they read their test and exam questions thoroughly. They agreed that they needed to read more consciously to get a more comprehensive understanding of the questions, before they answered them. Saskia, Dylan, Zayaan and Mavis (average academic performance) all expressed, during the focus-group interview, that this 'non-thorough/unconscious reading' of questions was the root of many of their errors in tests and exams. The reflection activities seemed to facilitate the learners' realisation of this, encouraging intentional, conscious thinking, characteristic of good learning and metacognition. The importance of reflections, as a metacognitive teaching procedure, will be discussed in Section 4.2.1.1.

The limited metacognitive experiences portrayed in the previous paragraphs, represent the need for metacognitive improvement for those learners, in the average to low academic ranges. It was, however, evident from the data collected towards the end of the intervention programme, that the higher achieving informants also experienced metacognitive gains. This signifies that these learners also had an initial need for metacognitive improvement, despite this need not being as evident as that of the other informants. This will be discussed further in different parts of the rest of this chapter.

The data presented above, indicates the need for all the informants to improve their metacognition in some way. Not only does this create the opportunity for me to provide evidence of their improved metacognitive ability after the intervention process, but it also reiterates part of the rationale for this research study.

4.2.1.1 Metacognitive Awareness: Knowledge of Cognition

Having revealed some of the evidence, supporting the need for improved metacognition in a number of learners from my Grade 9 Natural Sciences class, it is now important to share findings with regard to their metacognitive improvements throughout the implementation

process. The learners' metacognitive development was revealed in various ways, such as their enhanced awareness of their metacognition: with their improved knowledge and regulation of cognition; as well as their improved ability to reflect on their thinking. Knowledge and regulation of cognition have already been referred to as aspects of metacognition (Beng Lee *et al.*, 2009). Good reflection, on the other hand, also forms part of metacognition because when a person reflects on his/her thinking and learning, he/she actually thinks about thinking in a reflectively conscious manner (Karpov, 2003).

Social constructivism understands reflection to be an important part in the process of internalisation for learning, where inner speech, often in the form of personal reflection, is required (Ball & Wells, 2006). In response to the question on how the five week process has influenced their metacognition, one of the informants responded:

The experience has been interesting, and it has opened, well like taught me things that I didn't know about myself, like the way I prefer to study. (Innocentia, high academic performance: Focus-group interview)

This supports Innocentia's improved awareness of her cognitive knowledge. Zayaan also attested to developing an enhanced awareness of her knowledge of cognition:

I have learnt that if I think about a certain set of work thoroughly, understanding what is being asked from me, and really reading the question thoroughly, I can answer it to the best of my ability. (Zayaan: Reflection)

Lena's (high academic performance) view of the entire five week process revealed that the intervention had also enhanced her metacognitive awareness of her own knowledge of cognition:

It was very positive for me because I was thinking more about planning when to study ... and now I am always thinking ... (Lena: Focus-group interview)

From the data, it was clear that every informant (high, middle and low academic performing) felt that, in one way or another, the five weeks of metacognitively adapted Natural Sciences lessons had helped to improve her thinking about her own thinking. Some informants remarked that the process had specifically helped them to improve their metacognitive knowledge, as they realised what methods work best for them. From a social constructivist perspective, this realisation, and improved metacognition, implies that the informants truly

internalised the learning opportunities presented to them. It also implies that the metacognitive meditational tools, that I employed, were effective for improving their metacognition.

Adding to this, Zayaan expressed a number of times in the data that the intervention had provided her with the opportunity to realise that the use of the concept mapping technique, as well as the co-operative learning opportunities, were the two techniques that she found really helped her to think about her own thinking. She felt that this, in turn, had improved her school work. Noma (high academic performance), on the other hand, found the 'I DREAM A' method and the SRLP technique to be effective techniques for her. However, she also felt that teaching the class in reciprocal teaching and the co-operative learning activities were even more useful for her metacognitive and learning development. In fact, she mentioned that the latter two techniques had not only improved her metacognitive awareness and knowledge of cognition, but they had also allowed her to realise that she would like to go into a Life Sciences teaching career.

While learning, Miss Butterfield gave me the opportunity to teach and talk to the class, and I realised how much I enjoyed it and now I know for sure that I want to become a teacher. (Noma: Focus-group interview)

Lee's enhanced knowledge of cognition was also evident in her comment about the effectiveness of co-operative learning for enhancing her metacognition. She felt that this technique was really effective as it required her to think more about the work:

... because you need to understand something completely before you can teach it to someone else. (Lee: Focus-group interview)

From this statement, it is not only evident that the metacognitive teaching activity facilitated Lee's appropriation, but the lesson content also became part of her internalised thinking repertoire. Consequently, this also enhanced her metacognition, specifically, her knowledge of cognition (Kozulin, 2003).

The data indicated that Saskia's knowledge of cognition had also improved when she agreed with Lee about the effectiveness of the co-operative learning technique for enhancing metacognition and learning. Saskia added that:

When you have to teach one another ... you really have to know what you're saying. (Saskia: Focus-group interview)

Mavis reflected that the co-operative learning experiences had also helped her in her capacity as a learner. She explained that the guided participation (Kozulin, 2003) she experienced during the SRLP technique was even more useful to her for improving her metacognition because:

You got to monitor what you know and didn't know and try to know why I did not know it. (Mavis: Open-ended questionnaire)

The learners' enhanced metacognitive awareness and knowledge of cognition, was further evident from the data. For example, Dylan commented in the focus-group interview that the SRLP method was effective for her because she liked to be able to cheer herself on when doing a task. Innocentia found that procedures like the SRLP and the 'I DREAM A' procedures, where she got the opportunity to monitor her progress, had a positive influence on her metacognitive development. In response to the question about how she now thinks differently about monitoring and thinking about her progress, she responded:

If I monitor my progress, it is easier for me to know if some techniques really work for me. (Dylan: Reflection)

An additional benefit of this teaching process was evident in Innocentia and Lesley's (average academic performance) comments (in the open-ended questionnaires) that the 'I DREAM A' technique was particularly useful for scientific investigations as they felt it helped make them seem "simpler/easier" (Innocentia).

Lee reflected that she had also thought the 'I DREAM A' technique was very effective in enhancing her metacognitive abilities. She also expressed that the co-operative learning, reciprocal teaching, graphic organisers and error-analysis, were the techniques that she would want to use regularly in the future. Both Saskia and Innocentia concurred that the graphic organisers were very effective techniques, which they would incorporate again when learning and studying. This implied their metacognitive awareness of conditional knowledge.

Towards the end of the five week process, some learners revealed improved conditional knowledge in their ability to better realise where they could use their knowledge and skills in other situations. Lee revealed her improved metacognitive ability to transfer skills and

knowledge, when she explained in the focus group interview, that she could use some of the newly learnt techniques in other subjects. Towards the end of the data collection process, other informants revealed their improved metacognitive ability and conditional knowledge to transfer skills, by making comments such as:

I apply these skills in my everyday life because that is how useful they are.
(Mavis: Open-ended questionnaire)

By the end of the process the informants, who were unable to do so beforehand, were now able to reflect effectively on where and when they could employ the techniques they had learnt in the Natural Sciences lessons. Zayaan, for example, commented in the focus-group interview:

... in the beginning I didn't really understand what you were doing with us ... but towards the end, I could see ... how I could use it [metacognitive techniques] when I have to study for a test.

In data collected towards the end of the five week process, the informants started to make comments which confirmed their improved declarative knowledge. Many commented that the use of concept maps and other graphic organising techniques had really helped them to improve how they think about their work. However, the data collected in the initial stages of the process, revealed how the informants had thought that these techniques were not useful and required too much effort. In fact, many moaned and complained when they were given a summary or graphic organising technique to do. Interestingly, by the end of the five week process many learners were asking to do graphic organisers, particularly the concept map, which they did not initially enjoy doing. This change in approach to the activities is discussed in more detail in Section 4.2.3.2, but it provides evidence of the informants' enhanced declarative knowledge.

During the focus group interview, when questioning the learners about their thinking and learning, they tended to think about their answers before giving them - something I noticed they seldom did in Natural Sciences lessons prior to this intervention process. When reflecting on this in my reflection journal, and after corroborating it with the informants, some confirmed my assumption that this could be put down to their improved metacognitive abilities:

Before you answer a question, [now] you really first think about the question. And then, like in a test, I used to, if I didn't understand a question, I would carry on. But now, by thinking and using my metacognition I really think about it and can answer it (Zayaan: Focus-group interview).

Before, when I wrote a test and got something wrong, I just sort of made up an excuse, but now I think, 'Ok, I didn't do this or I didn't do that', and I can actually fix it. (Noma: Focus-group interview).

A significant confirmation of better metacognitive awareness was revealed when the majority of the informants (Noma; Innocentia; Lesly, Zayaan; and Saskia: Focus-group interview) explained to me that before the five week metacognitive teaching process, they would usually forget the work they had learnt for a Natural Sciences test or exam almost immediately after writing it. In the focus group interview they revealed how they felt that, even two weeks after the last Natural Sciences test, they would still be able to write the test. The general consensus was that the information was still in their heads, and they would continue to remember it for a lot longer. This reveals improved metacognition and learning because in order for work to be 'remembered for longer' it must first be effectively internalised (Kozulin, 2003).

Such metacognitive moments are a true indication of improved metacognition, specifically, improved knowledge of cognition. Another such moment occurred during the focus group interview. Dylan revealed her enhanced metacognitive knowledge with the following comment about the adapted teaching sessions:

It also helps you because you kind of need to go back into your brain to fetch the information and then you can write it down. (Dylan: Focus-group interview)

Lesley added to Dylan's comment, making evident her enhanced metacognition:

So it's like you just have to find the key word and unlock it. (Lesley: Focus-group interview)

Furthermore, in response to the question in the open-ended questionnaire about what she has liked and disliked about the Natural Sciences over the five week period, Innocentia commented:

I liked the aspects of learning more about how our minds think and by opening different, new doors to our minds especially when we do different maps, teaching each other and reflecting on what we truly know. (Innocentia: Open-ended questionnaire)

The exposition of data in this section provides a representation of both the informants, and my own, experiences of the five week teaching intervention in Natural Sciences, with particular reference to metacognitive awareness and knowledge of cognition.

4.2.1.2 Metacognitive Awareness: Regulation of Cognition

As with the improvement in the metacognitive knowledge of cognition, presented in the previous section, throughout the intervention process, many of the informants also revealed an improvement in their metacognitive regulation of cognition (Beng Lee *et al.*, 2009). This was confirmed by some informant responses, which explained how the implemented techniques had helped them to plan, monitor and evaluate their thinking processes better:

I never used mind maps before because it took up a lot of time, and my notes were just like, under each other (bullet form) ... and if you keep on reading in the same order you get bored after a while. So after doing the mind maps ... it keeps you focused more ... it almost keeps your mind more active. (Lesley: Focus-group interview).

Enhanced regulation of cognition was also shown by comments, such as those made by Innocentia, Lesley and Dylan. These comments indicated that the intervention process had allowed them to realise that:

By thinking more about the questions, it is easier to get all the points needed for answering it. (Innocentia: Reflection)

If I don't participate, for example, asking questions and answering them in class, I find it hard to concentrate. (Lesley: Reflection)

I always did it (work) at the last minute and only finished half, but now I do a little everyday and make time valable [available] for when to do what ... I make a timetable for when to do homework, study, projects. (Dylan: Reflection)

One of the factors, which seemed to significantly contribute to the learners' improved metacognitive awareness of their cognitive regulation, was the actual reflection activities:

Every time you thought about it, you just understood your work better and better. (Lee: Focus-group interview)

You have to think back and think about what you did. (Saskia: Focus-group interview)

Very helpful, especially when we ask our self why we made a mistake and how we can fix it. It shows me what I need to focus on. And I realised that when I write the test I need to read the question paper properly and go through every answer again afterwards. (Noma: Open-ended questionnaire)

Other informants, like Saskia, Mavis and Zayaan, provided data which indicated that they felt the five weeks had contributed to their improved metacognitive regulating abilities because their results in tests and activities had improved. In the Natural Sciences test, which coincidentally occurred during the five weeks of intervention, Zayaan achieved 33% higher, while Saskia improved by 31%; Dylan by 16%; Lee and Noma by 9%, and Mavis by 5%. This supported the positive relationship between metacognition and academic improvement (Coutinho, 2007; du Toit & Kotze, 2009). Some of the informants' academic results at the end of the data collection period also further supported this relationship. These post-intervention academic results are evident in Table 4.3 below.

Table 4.3: Post-Intervention Natural Sciences Academic Results

Informants (Pseudonym)	Average academic achievement at beginning of process	Average academic achievement at end of process
P-1 Lee	59 %	70%
P-2 Saskia	43 %	78%
P-3 Dylan	52 %	71%
P-4 Lesley	66%	64%
P-5 Lena	95%	87%
P-6 Mavis	67%	80%
P-7 Zayaan	37 %	60%
P-8 Noma	89%	87%
P-9 Innocentia	86%	73%

As is evident in the data presented in Table 4.3, the informants who originally attained middle to low range academic scores, experienced a more significant improvement in their academic achievements after the metacognitive interventions when compared to the initially higher achieving learners. These two sets of academic results may not be directly comparable due to a number of possible factors which could influence test and exam performance. However, the significant improvements in most of the initially low and medium achieving informants, further supports the benefit of developing learners metacognitive skills. Interpretation of this evidence, along with other data represented throughout this section, has indicated that exposure to metacognitive teaching procedures, such as those presented in this study, improves learners' metacognition, which in turn, can improve their overall academic ability (Coutinho, 2007; Veenman *et al.*, 2006; Yore & Treagust, 2006).

Enhanced regulation of cognition, in the form of improved metacognitive evaluation abilities, was also evident from the data:

I never used to question myself as I thought what I was doing was correct without thinking about it. It (the intervention) was useful because now I know why I do most things because I always ask myself 'Do I need to do this' or (am I doing it) because I saw some-body else do[es] it. (Mavis: Open-ended questionnaire)

This was further reiterated in the open-ended questionnaire, when Mavis commented that the difference she had noticed in Natural Sciences, over the five week period, was that:

It was very different as we were taught how to question our way of thinking and reasoning instead of just being taught the work.

The above provides evidence as to how the informants' metacognitive regulation skills were enhanced during the five week process. From the data, the learners' metacognitive development, during this process, is further confirmed by their awareness of the effectiveness of reflecting on their personal thinking and learning, as well as their improved ability to reflect on their own thinking. These points are discussed separately in the section below.

4.2.1.3 Reflection

Data revealed that the informants had come to the consensus that the reflection activities, over the five week period, contributed significantly to the development of their metacognition. This seems credible when one considers that reflection forms a significant

part of metacognition itself, as reflections are essentially thinking about one's thinking and learning (Karpov, 2003; Veenman *et al.*, 2006; Yore & Treagust, 2006). Therefore, because reflection requires, and forms part of, metacognition, improved reflection can act as an indicator of improved metacognition. Some of the informants commented on the importance of reflections for the development of their metacognition. Lee, for example, commented in the open-ended questionnaire, that the reflections forced "you to think about your work more".

It is, however, also important to refer to how the development of many learners' metacognition was mirrored in their improved ability to reflect. During the beginning stages, of the five week process, many of the learners left vast amounts of their reflections blank or provided very vague reflections. Over the five week process however, a general trend was for these learners to write a lot more in their reflections and provide more detail about how their thinking and learning was developing. Zayaan, for example, even made the comment in the open-ended questionnaire, that her initial reflections were very limited compared to her final ones:

In the beginning I didn't have much to answer on the reflections. But after a few more lessons I could fill up all the questions and answer it. I've learnt to think about something thoroughly and the reflections helped me do so. (They) also helped me understand how all the strategies benefit me, and the way I learn.

At the end of the five week process, in the focus group interview, Zayaan made a comment about her preferred thinking and learning styles. This immediately revealed her improved metacognitive awareness and improved ability to reflect on her thinking. Some of the other informants commented that initially, even though they sometimes knew what they wanted to say, they struggled to put it down in words. It was clear from those informants, who agreed with this, that their ability to express their thoughts improved throughout their reflection opportunities. This was evident from more detailed and internally introspective reflections.

In the open-ended questionnaire, Saskia wrote that being compelled to do the reflections required her to think back on the work done over the week. Before the five weeks of metacognitive teaching exposure, she "usually would not think about it (the work) after a lesson". Both Lee and Saskia commented in the focus-group interview that they would find reflection activities useful in all of their learning areas, not only Natural Sciences. This further supports the effectiveness of metacognitive teaching procedures to enhance transfer of

knowledge, as was made evident in Section 4.2.1. These informants added that the reflections require one to really think about one's thinking, work and learning.

Lena provided additional value about how the reflection activities had helped improve her metacognition, specifically her knowledge and regulation of cognition:

While writing my reflections, I actually thought about what new techniques we learned during the week and I sort of started thinking about which of these would help me in the future, and which ones I actually don't like and don't want to use anymore. I also realised where my weaknesses in studying are. (Lena: Focus-group interview)

I also had a chance [in the reflections] to think about what I must change in the way I study, think about my work and [how I] do my projects. (Lena: Open-ended questionnaire)

Reflections are helpful and hard to answer, but once you have done them they really changed the way of thinking about your own studying, working and thinking. (Lena: Open-ended questionnaire)

However, despite the general trend of improved reflection ability experienced by the informants, not all were fully aware of why this happened. For one informant, despite being aware that her thinking about her own thinking had improved in some way over the five week intervention, she showed a limited ability to reflect or interpret this awareness:

Interviewer: Do you think you think any differently than you used to?

Mavis: Ya.

Interviewer: How?

Mavis: I don't really know how. I just can now say that I need to know this and this.

(Focus-group interview)

Mavis' metacognition seemed to develop over the five week period but this statement of hers could imply that there is still further room for metacognitive improvement.

Something else, which I noticed in the initial stages of the research, was that many learners in the class showed feelings of annoyance and irritation when I presented them with another reflection activity. However, despite this, by the end of the process, the majority of informants agreed with Saskia's comment in the focus-group interview. This comment

basically construed that Saskia would like to continue doing reflections in Natural Sciences and her other subjects because of how effective they had been for her learning. Dylan agreed by responding in the focus-group interview, "we should really get them all the time". This implies that during the five week process, the informants had started to realise some of the benefits that the metacognitive teaching procedures could have on their thinking and learning. Their enhanced thinking and learning, as a result of the intervention processes, had clearly motivated them to enlist more of these effective strategies.

In summary of this theme on the Learners' Metacognitive Development, the evidence demonstrates how the metacognitive instructional procedures, incorporated into my Grade 9 Natural Sciences lessons, had a positive impact on the development of my learners' metacognition.

4.2.2 Metacognition and the ideal learner

In Section 2.5.1, a description was presented of the Revised National Curriculum Statement's envisaged goals for the ideal South African learner. Accordingly, this learner would be motivated to develop in a personal capacity, but also as a citizen of the country. He/she would act in the interest of others whilst embodying democracy, equality, human dignity and social justice. In addition to this, he/she would be an independent lifelong learner who is a literate, numerate, multi-skilled, and an actively engaged, democratic citizen (Department of Education, 2002a). The influence, which the employed metacognitive teaching procedures had on facilitating the development of the envisaged South Africa learner, was clearly evident.

One sub-theme that surfaced showed the effectiveness of my metacognitively adapted teaching procedures to facilitate active learning and the development of autonomous learners. These are two of the, afore mentioned, characteristics envisaged for the ideal South African learner (Department of Education, 2002a). Saskia was not the only informant to remark on the effects of my incorporation of active learning procedures, that compelled the learners to think metacognitively in order to construct knowledge, but she commented:

I find that it is sometimes easier just to copy notes of [off] the board, but when I actually summarise [summarise] it myself, making my own notes, it becomes a lot easier when studying [studying] for tests as I have then learnt it better when summarising it myself. (Saskia: Open-ended questionnaire)

Saskia's 'minds-on' experience not only revealed how the techniques employed in the classroom encouraged her to engage in the work and act autonomously, but, as a result, this essentially 'dramatic event', as Vygotsky would categorise it (Veresov, 2009) (discussed in Section 2.2), forced reflective consciousness and true internalisation of the learning content, implying enhanced metacognition and independent thinking (Karpov, 2003).

Lesley added that:

Making our own notes made me understand the work better. I could also do it in my own words which made studying a lot easier. (Lesley: Open-ended questionnaire)

The teaching procedures which required the learners to be more actively engaged, did not only contribute to facilitating Lesley's metacognitive breakthroughs (Watson, 2000), but they also facilitated the development of some of the key characteristics of the envisaged South African learner (Department of Education, 2002a). This is further evident in the comments made by one informant:

Now we had to make notes on the work ourselves ... and discussed it a lot more... we got much more involved in the topic and the work. (Lena: Open-ended questionnaire)

I like thinking more about the work and doing more exercises on the information rather than just writing it down. This made it easier for me to understand it as I had to read through the information and understand it before making notes or doing exercises on it. It was then easier to study it later. (Lena: Open-ended questionnaire)

The learners reflected on how being 'forced' to learn independently and actively during the five weeks had really helped to bring about metacognitive gains and enhanced their understanding of the work. However, they also revealed how these techniques compelled them to think more consciously about their learning in general. When I reflected on these active and independent learning opportunities in my research journal, I also found them to be a very effective means of facilitating the construction of knowledge. This is discussed further in Section 4.2.3.1.

During the focus-group interview, the majority of informants attested that they would like me to continue using a number of the intervention teaching procedures. This discussion led to their realisation that many of the procedures, after being learnt and practiced, could be used

by the learners themselves, without a teacher's presence. This would require taking responsibility for their individual learning, as well as self-discipline and perseverance. The informants agreed that they wanted to commit to this, having experienced the benefits, but that it would also be useful for them if I continued to encourage them and incorporate the procedures as well. Once again, this indicates the potential of the metacognitively orientated teaching procedures to create the envisaged South African citizens, who take ownership of their learning and are responsible, as well as self-disciplined (Department of Education, 2002a).

These metacognitive teaching procedures have therefore shown their potential to encourage the development of autonomy, active-learning, self-discipline, responsibility, and undoubtedly, more conscious thinking, some of the envisaged characteristics of the ideal South African learner (Department of Education, 2002a). Having now presented an account of what transpired, when I employed various metacognitive teaching procedures in my Grade 9 Natural Sciences classroom, the next section presents the findings which reveal how my Natural Sciences teaching practice improved during this process.

4.2.3 Development of teaching practice

The central aim of this research inquiry was to investigate how the incorporation of metacognitive teaching instruction would improve my Natural Sciences teaching practice. The themes, discussed above, have highlighted the secondary aim of the research; namely, how the learners' metacognition developed with the incorporation of these adapted teaching procedures. These findings essentially inform the main aim of the study. Therefore the following section will present the themes which provide evidence of the improvement in my teaching practice.

From a social constructivist perspective, in order for learning to occur, a specific social interaction must be internalised. Mediation is a way of facilitating this internalisation and an example of a mediating tool is teaching (Kozulin, 2003). In Section 2.5.2, a discussion was presented on what is considered to be 'good teaching'. In summary of this, the main characteristics of good teaching are evident in teaching that facilitates the development of the type of learner envisaged for South Africa (Department of Education, 2000, in Donald *et al.*, 2010; Malcolm & Alant, 2004). Good teaching practice also enables independent learning

and thinking, while preparing students to be lifelong learners (Giest & Lompscher, 2003). Additionally, a good teacher is said to be someone who is self-reflective and self-aware (Rossouw, 2009), and he/she encourages learners to have inquiring minds (Loughran, 1996). In line with Vygotsky's description of how learning is constructed, an effective teacher is also one who creates 'dramatic events' which cause learners to internalise and self-reflect; enhancing their metacognition (Veresov, 2009). From the data collected in this research, it is evident that by using certain metacognitive teaching procedures, the internalisation process, and hence the learning process, was improved for many of my Grade 9 Natural Sciences learners. This implies that metacognitive teaching procedures can enhance teaching practice.

My reflections, throughout the entire intervention process, did not only act as data, but they also formed an integral part of my own metacognition. If I had not employed my own metacognitive strategies, knowledge and awareness, throughout the five week intervention, I doubt that the learners' metacognition would have improved in the way that it did. Further reflection on this makes the importance of a teacher's metacognitive behaviour, as well as his/her way of thinking and being, evident. It also demonstrates how teacher metacognition plays a significant role in effective teaching.

4.2.3.1 Enhanced teaching style and procedures

The data collected has made it clear that the intervention process has helped my learners improve their metacognition. In addition to this, throughout the data collection process, I also reflected on the various teaching procedures that I incorporated and their consequent contributions to my teaching practice.

As was discussed in previous sections, the teaching procedures that I employed clearly facilitated development of the ideal South African learner by encouraging active and independent learning and thinking (Giest & Lompscher, 2003). This is considered to be part of good teaching practice (Department of Education, 2000, in Donald *et al.*, 2010; Malcolm & Alant, 2004). These teaching procedures, therefore, form part of the gains achieved in my teaching practice.

Furthermore, by facilitating processes, whereby learners make their own notes about work, or develop their own scientific investigations to test a hypothesis for example, my teaching procedures provided the opportunity for many learners to realise they can work more autonomously and engage more actively in their work.

With my incorporation of the metacognitive teaching procedures, where the learners had to work more autonomously being actively engaged with the work, they acquired the concepts more consciously:

... really helped because when it came to the test it felt like I already knew the stuff before I even had to study it (Noma: Focus-group interview)

and,

... the work kind of stays with you (Lee: Focus-group interview).

As autonomous, active and conscious learning is considered an aim of effective teaching (Giest & Lompscher, 2003), I therefore consider these teaching procedures to be an element of my improved teaching practice.

When I referred to the latter in the focus group interview, it led to a discussion, which indicated that the informants viewed my 'new' ways of teaching as better than my 'old' techniques. For example, according to my students, I would previously talk about a section of work, while allowing them to copy notes from the power-point projector. The learners commented that when I did this, it actually inhibited their learning for reasons such as:

I can't always listen to your explanation because I can't really listen and write because I want to make sure I write down the correct thing. (Lena: Focus-group interview)

Sometimes I would try to keep up with you as you are talking, and I would write things down then differently. (Saskia: Focus-group interview)

I have therefore, through this intervention process, realised how I could do things differently in my Natural Sciences classroom, so that my learners can learn more effectively.

Encouraging the learners to do the work themselves in an independent manner; making their own notes, summaries, graphic organisers and so forth, also contributed to the enhanced focus and engagement that they put into the lessons. Lena explained in the focus-group interview how these procedures forced her to concentrate and make her summaries as accurately as possible. This was because she had come to realise that those were the only class notes she would have to work from when it comes to studying for her tests and exams. Not only does this technique seem to improve the levels of attention the learners give in the

classroom, but to do this, the learners also need to monitor and evaluate their own summaries, notes and graphic organisers, ensuring all relevant information is included. In that way, it also indicates that it contributed to their enhanced metacognition (Beng Lee, 2009).

The same can be said for the co-operative learning opportunities and the reciprocal-teaching techniques. The informants remarked, and I previously mentioned, that these two techniques helped to enhance, not only their metacognition, but in turn, their learning as well. Innocentia, among others, was of the opinion that "as you teach others you teach yourself" (Open-ended questionnaire). The informants' comments, my own reflections, and the positive influence that these procedures have had on the learners' metacognition and learning, allows me to think that co-operative learning and reciprocal teaching are techniques that have enhanced my teaching practice. I will therefore continue to use them in the future.

I have developed a similar opinion about many of the other procedures that I employed over the five week intervention, namely: the regulation techniques like SRLP and 'I DREAM A'; the error-analysis; graphic organisers; teacher questioning; and most definitely, the learner reflections, which acted both as a means of data collection, and as a metacognitive teaching procedure. The positive learner responses, as well as my observations of the positive effects on the learners' metacognition, have encouraged me to use these techniques again in my newly improved teaching practices.

In response to a question on the usefulness of graphic organisers, Noma responded that they are:

Very, very, very useful! I always thought concept maps were a waste of time and I would be better off without them, but they really work and help a lot. (Noma: Open-ended questionnaire)

I did however also come to realise that the teaching procedures, such as 'teacher think-aloud' and 'teacher modelling', were not as successful. I made this conclusion because I did not notice these techniques to have a significant impact on the learners' metacognitive development, and the informants did not particularly reflect on them either. In my research journal, I did however indicate that I was possibly not explicit enough in my explanation of these techniques, which may have resulted in the learners not being very aware of the techniques.

In today's lesson, the learners did not carry out the think-aloud activities as well as they had employed other techniques. My concern is that I possibly did not explain how to do the technique well enough, or I possibly rushed the explanation and demonstration. (Teacher-researcher: Reflection Journal)

Having said this, through my reflections, I also noticed that, for me, these two techniques were somewhat uncomfortable and difficult to carry out. This may be a reason for their limited effectiveness. Consequently, I cannot make a valid, unbiased judgement as to whether these two techniques are useful or not.

At this point, I must also refer to the fact that, during my journal reflection entries, and from reading the informants reflections on a weekly basis, I realised that I needed to be more explicit in my explanations of all the different metacognitive techniques that I employed. In the nature of action research, after reflecting on this, I tried to improve my explanatory technique with each lesson that I presented. This seemed to be more effective. I do, however, feel that I could still work on this in the future so as to further enhance my teaching practice.

During the five weeks, with the aid of my observations in the classroom, my journal reflection entries and the learner reflections, I noticed that some of the groups were struggling to keep track of all the newly incorporated metacognitive techniques which I employed. Since I was working explicitly in the way I incorporated these techniques, I decided at one stage in the five weeks to do a quick 'recap' of all the procedures I had incorporated. The data showed that this helped my learners reflect better on the different techniques and therefore improved their metacognitive abilities. My interpretation of this finding has led me to view this technique of 'recapping' as valuable for incorporation as an improved teaching practice. I will also take note, when using them in the future, to not rush through the techniques as quickly as I did during the first part of the implementation process.

Having considered the above, it is also important to mention the 'messiness of research' which provided challenges for my teaching throughout the intervention process. As is the nature of any school, school days sometimes change due to unexpected events. This meant that some of the plans I had put in place for implementing the metacognitive teaching procedures into my Grade 9 Natural Sciences class, were sometimes interrupted. In my research journal, I reflected how this further reiterates "how important it is to thoroughly plan lessons, while also being flexible" (Reflection Journal). This also fore-grounded the importance of being

both willing and able to adapt when necessary, and consequently, this experience has enriched my teaching practice.

As was discussed in Chapter 2, one of the factors that need to be addressed in science education is that of the perceived difficulty, and underlying 'phobia', that some learners have of science (Hartman, 2002c). Lee's reflection on the entire five week process implied how the metacognitive teaching procedures, that I employed, may be a way to address this problem:

This just made me realise that science can be difficult, but if you break up the work for yourself, using the mind map and maybe summaries, then you can understand the work better, and you don't have to live under the perception that everything is too difficult to handle. (Lee: Focus-group interview)

Comments from other informants also implied that the teaching procedures, that I incorporated with scientific investigations, such as the cooperative learning and think-aloud activities, helped them to deal better with some of the perceived difficulties in science.

We focused more on the work that we didn't quite understand. For example, scientific investigations. Now it's a lot better. (Lesley: Open-ended questionnaire)

Even though writing scientific investigations all the time was annoying, it helped me a lot because I always got confused with the variables and how I was supposed to write them. (Lesley: Open-ended questionnaire)

I quite disliked it (the section on Resources from our Earth) 'cause it took too long, but in the end it was for my own good and it benefitted me a lot. (Noma: Reflection)

These comments also show that through these adapted teaching procedures, the learners have started to become aware that in order to improve, it is sometimes necessary to do the things that one does not always enjoy. Motivation plays a key role here, but that will be discussed more in depth in Section 4.2.3.2.

As part of the intervention, I also created an opportunity for the learners to think-aloud, when doing their scientific investigations. They did this in small groups, which allowed them to explore their ideas with one another. Not only did this allow each learner to monitor and evaluate her own thinking better, but it also gave her the individualised attention by which her thoughts, about a specific scientific method, could be explored, critiqued and improved. A teacher may, however, struggle to do this in a class of thirty or more learners. With the

difficulties experienced in science education (Malcolm & Alant, 2004; Naaidoo & Lewin, 1998; Yore & Treagust, 2006), this technique for improved teaching may just act as a step towards addressing these issues.

Reflecting on the different metacognitive activities, that I incorporated into the lessons, I noticed how effective cooperative learning was for enhancing learning and metacognition. There were, however, certain important aspects to consider, when including it in one's lesson. Firstly, I found it important to give the learners adequate time to prepare their work, and secondly, it worked well to pair-up the learners, with one high achiever and one lower achieving learner, working together. In this way, the higher achieving learner has an opportunity to go through their understanding of the work with someone checking his/her accuracy. At the same time, the lower achieving learner gets an opportunity to have it explained to him/her by a more knowledgeable peer, and then has the opportunity to explain it back to this peer, who then evaluates the progress (Karpov, 2003). During the adapted lessons, I also made a point to only give the learners cooperative learning opportunities for sections of work, which I thought were within their ZPD. A mediational tool, such as cooperative learning, is said to be most effective in aiding teaching instruction, when it is directed at a certain point in the learners' ZPD (Veresov, 2009). When I felt a section may be too difficult for them to explain to one another, I rather used teacher modelling or another technique in which I conducted the explanation to broaden their ZPD and facilitate their learning.

I noticed, during the five weeks, that the use of visual aids, in the form of graphic organisers, pictures and models, provided more realistic experiences for the learners and aided the construction of their knowledge. For example, in the section on contraceptive measures in reproduction, I noticed that many learners did not actually know what many of the different forms of contraception looked like. To facilitate a better understanding, I brought pictures and actual examples, and this seemed to allow for a more accurate construction of knowledge. Using visual representations can therefore be considered as a technique which improves teaching, as it enhances a learner's understanding.

The above represented the different metacognitive teaching procedures, which demonstrated the ability to contribute to the improvement of my teaching practice. The next part of this section emphasises how important the classroom environment can be for creating an atmosphere conducive to learning. Throughout the data collection process, I reflected in my

research journal about the classroom atmosphere that I tried to create, and how this influenced the learners' learning and metacognition. Linked to this is my relationship with the learners, as well as my personality, my mood and emotions. These factors can influence the classroom atmosphere and have a significant impact on the effectiveness of the learning that takes place in the classroom (Woolfolk, 2007).

For the majority of the five week teaching process, there was what I, and the informants, described as a welcoming environment which invited questions and discussion. However, an interesting event happened in the initial stages of the implementation process. I felt my learners were not working effectively, and they felt that the teaching procedures I was employing were annoying and a waste of their time:

Today's lesson was not a productive one. I felt that the negative classroom atmosphere really inhibited the learning experiences in the classroom, and therefore the learners' metacognition would very unlikely have been positively influenced. (Teacher-researcher: Reflection Journal)

During this session the classroom atmosphere was not positive, and many of the informants not only reflected on this, but when we discussed it in the focus group interview, they made some valuable comments, such as, when there is a negative classroom environment:

You're not in the mood to listen to the teacher because you are angry with her.
(Dylan: Focus-group interview)

It was also interesting to hear that this 'undesirable atmosphere' did, nevertheless, compel Dylan to do her work for fear of getting into trouble. This could allow one to think that a negative atmosphere triggers learners to work. To the contrary, Dylan added to this that, despite the fact that she was compelled to work, because of the negative classroom atmosphere; she was not concentrating on her work or actively engaging in it. Other informants also commented that they could, for example not remember what section of work had been covered that day. This implies that effective teaching does not take place with an uncomfortable atmosphere in the lesson. Reflecting on this has contributed to the advancement of my teaching practice: a negative classroom atmosphere is not conducive to effective learning, and therefore cannot be considered as part of effective teaching. This once again reiterates the reality of the teaching world and how, as an effective teacher, one needs to adapt ones teaching procedures to meet the needs of the learners in one's class.

From the data collected, the point explored above, is further reiterated from the opposite perspective. A positive and encouraging classroom environment can provide an effective environment for learning, and hence also metacognitive development. Noma said:

I used to just study the work parrot fashion when I didn't understand, but I now feel more open to asking questions and because of all the different ways we are learning and assessing ourselves, I find I understand much better. (Noma: Open-ended questionnaire)

A positive and encouraging classroom atmosphere is therefore particularly important in a Natural Sciences classroom, as there are often topics that can be embarrassing or awkward for some learners. As the section of work on Human Reproduction had to be completed during the five weeks of research implementation, this finding was particularly evident from the informants' comments and from some of my observations. Lee commented in one of her reflections that:

We discussed things that would usually be awkward, more freely.

Something else which seemed effective in creating a positive learning environment, and encouraged learners' questioning, was using a question box. For those learners who I noticed wanted to ask questions, but felt too shy to do so, I placed a sealed box at the front of the classroom. I encouraged the learners to put any questions they have in writing, and slip them into the box, anonymously if they wished. I then answered these questions to the entire class, without revealing who had asked the question. This worked very well for many learners. Not only did it allow them to feel free to ask questions, it also showed them my respect for them and their privacy. Inadvertently, this also encouraged the development of their inquiring minds, providing an atmosphere in which their metacognition and effective learning could be fostered. Using a question box as a meditational tool can accordingly also be considered as an aspect of good teaching (Loughran, 1996),

Apart from these situations, my own reflections and metacognitive actions also helped me to plan, monitor, evaluate and regulate my own teaching practice. This also helped in the process of improving my teaching practice. The reflection opportunities encouraged me to become more self-aware and reflective, and therefore should form an important part of enhanced teaching practice (Veresov, 2009).

This section has revealed how my teaching practice was enhanced through my adapted teaching style and procedures. The theme *Uniqueness of the learner* that is discussed in the next section also formed an important part of the development of my teaching practice over the five week period.

4.2.3.2 *Uniqueness of the learner*

One of the most substantial findings from this study, showed how important it is to take the uniqueness of one's learners into consideration to teach more effectively. My learners' uniqueness in terms of their preferred learning styles, their personalities, their ZPD's and so on, was evident from the fact that the interventions allowed the informants to realise their preferred techniques for enhancing metacognition, as well as their interests which encouraged their metacognitive moments. The importance of my learners' uniqueness was further apparent as different informants' metacognition developed at different rates and to varying degrees.

The uniqueness of each individual learner influences how they personally adapt to, reflect on, and develop, with the adapted teaching procedures. Noma was able to reflect on the fact that she learns best when speaking out loud, especially when teaching someone else. She also noted that she preferred the 'I DREAM A' technique more than the SRLP method. Her metacognitive awareness was therefore revealed in her improved metacognitive knowledge and awareness of her own preferred learning methods and styles.

In response to a question about how the five week process had informed her about her preferred ways of thinking and learning, Zayaan responded:

Thinking about what you learned, and making sense of it, really helps you answer a question thoroughly. Using a concept map helps me study much better ... and understand the work [better]. Teaching someone else also helps me understand the work. Mind maps on the other hand doesn't [don't] really help me. (Zayaan: Open-ended questionnaire)

As was mentioned in Section 4.2.1.3, some informants felt that doing the reflections required immense effort (particularly in the beginning) whereas others commented:

... it wasn't actually that much of a pain. (Lee: Focus-group interview)

This implies that each individual learner experiences the teaching techniques in a unique way. As a teacher, one needs to be conscious of this so that the teaching procedures can be adapted accordingly.

In connection to the uniqueness of each learner, this research has shown that a learner's personal interest in a topic can also significantly influence their learning of the specific topic. Interpretation of the data, collected in this research, revealed how important it is for a teacher to adapt the lesson content to target the learners' interests.

I'm more interested in biology work, therefore I pay better attention to it and I participate in class. Physics I don't like at all so I tend to focus less in class because I'm not interested in it (Lesley: Reflection).

Not only does Lesley's comment above reveal the importance of stimulating learners' interests to improve their focus, but it also shows an episode of enhanced metacognitive awareness for Lesley.

Saskia commented in her reflections, and in the focus-group interview, that for her, the incorporation of concept maps and flow diagrams was more interesting than writing in point form, and for this reason she found it easier to study from them.

From the data, in my research journal, it was evident that I also reflected on improved conditional knowledge and ability to transfer, when the learners were interested in the subject content, in comparison to when they were not. When dealing with issues of the menstrual cycle for example, a topic relevant to many teenage girls, many of the informants reported to have used the knowledge learnt in class, and applied it to their own lives.

It was clear from the data that many of the learners came to realise that their personal interest in a topic has a significant impact on their learning. Zayaan commented in the focus-group interview that with one of the sections of work covered in the five weeks, she was very interested in the content, and was therefore more motivated to do her work. I asked her what she planned to do when she encounters sections of work in the future that do not interest her. Her response to this was:

I've just got to make it interesting for myself. (Zayaan: Focus-group interview)

Not only does this realisation of the importance that *interest* plays in learning reveal the learners' improved metacognitive awareness, but it also emphasises the importance for teachers to be aware of their learners' interests. Teachers will then be more knowledgeable about how to make topics more interesting and relevant for their learners, and link the work to their ZPD (Chaiklin, 2003; Karpov, 2003).

Motivation can also go hand in hand with interest, as the level of interest that a learner has in a particular section of work, can determine the extent to which they are motivated to actively engage with that work (Woolfolk, 2010). It is quite clear from Saskia's response in the focus-group interview that she found it easier to be motivated to do work when the topic is interesting. Motivation can also stand alone as an independent variable that effects learning (Woolfolk, 2007). In response to my question as to why they were motivated to work towards achieving better results in Natural Sciences, one informant's reasoning was that:

... you feel better about yourself. (Lesley: Focus-group interview)

Not only does this indicate the importance of a learner's motivation in learning, but the teaching procedures incorporated over the five weeks also facilitated the learners' personal goal setting in Natural Sciences. This involves not only the motivation to achieve certain goals, but it also requires metacognition in the nature of planning, monitoring, evaluating and regulating one's cognition in order to attain those goals. Lee's reasoning behind setting goals was:

... you want good marks so that you can tell yourself that you set yourself that goal and you worked hard to get there. And you can tell yourself, well I'm not doing too well, you must work harder to get there. (Lee: Focus-group interview)

The general consensus gained from the informants was that many of the metacognitively adapted teaching procedures, that I employed in my Natural Sciences classroom, required the learners to become more actively engaged with their work. They also had to set small personal goals to motivate themselves along the way. Not always having had to work as independently and be as actively engaged in their Natural Sciences work, a lot of effort and personal motivation was required from the learners, which they initially seemed to resent and were reluctant to put in. An interesting phenomenon actually happened over the five week period: the general trend was for these same learners, who initially complained, to realise the positive effects of their increased efforts and engagement. This realisation had further

positive effects because it motivated the learners to continue to put in the hard work; as the process compelled them to start working towards internalised goals of better understanding, more conscious learning and so forth. One of these metacognitively motivated moments is highlighted by Lesley's comment in the open-ended questionnaire:

If I participate in class I feel more focused on my work.

Another significant incident which had to do with motivation, in connection to the graphic organisers and the reflection activities, was made evident in the data. In the beginning of the five week process, when I gave my learners various graphic organisers and reflections to complete, many learners in the class were not motivated to do them. Many gave the impression that it required an immense amount of effort that they were not happy to put in. A fascinating trend over the five weeks was identified: while I continued to get the learners to do reflections and graphic organisers, by the end of the process, the learners were *asking* to do concept maps and reflections as they found that these techniques provided them with the most effective learning and 'minds-on' opportunities.

Dylan's improved metacognitive awareness, over the five week period, made her realise that:

I have to participate more. I have to study more and really think when doing my work. I must not be lazy. (Dylan: Open-ended questionnaire)

From what she reported in the data, Dylan's laziness was one of the areas that she recognised needed improvement. This once again emphasises the importance that a learner's motivation plays in their improved learning and metacognition. It was also interesting to note that in the focus-group interview, Dylan commented that she found the SRLP method to be one of her favourite techniques, due to the fact that she got to 'cheer' herself on. She liked this because: "I tell myself I can do it". This clearly indicates the relevance of motivation in learning and the benefits that these teaching procedures can have on enhancing motivation. Responsibility and self-discipline are also likely to play a role in this, but these have already been discussed in Section 4.2.2.

The data presented here, clearly indicates the importance of being aware of the uniqueness and diversity of the learners in one's classroom, if one aims to construct learning opportunities that are meaningful.

Now that the main research findings have been presented under the relevant themes, the next section will involve a discussion of these findings.

4.3 DISCUSSION OF RESEARCH FINDINGS

4.3.1 Introduction

In the previous section, the relevant findings, identified from the data collected, were presented. In this next section, I will introduce the next part of step 5 of the action research cycle. This section involves a discussion of the analysis of these findings in relation to the literature and theoretical framework of the study. The findings will then be used to inform suggestions and recommendations for future cycles in this and/or other research investigations. These will be presented in Chapter 5 and will formulate the final part of step 5 in this action research process.

This research inquiry has focused on addressing current challenges in modern day education (Chisholm, 2003; Donald *et al.*, 2010; Malcolm & Alant, 2004), with a particular emphasis on science education in South Africa (Department of Education, 2008; Viljoen, 2010). The need to facilitate effective teaching and learning in science education in South Africa was the driving rationale behind this study (Malcolm & Alant, 2004; Yore & Treagust, 2006). For the purpose of this investigation, it was important to note that local and international research shows the need for improved teaching and learning. Part of the reason this research study was started, is because I also recognised the need for the learners in my Natural Sciences classes to become more effective and active learners as well as thinkers. As a teacher who is passionate about facilitating effective learning in my classroom, this triggered my investigation to find ways to adapt my teaching practice and to enhance learners' conscious thinking and learning. In my position as an educational psychologist in training, the intention was for these findings to improve my knowledge, so that I, in turn, would be able to share it with other educational professionals with whom I may work in the future.

Due to the high regard that effective metacognition has been given for promoting academic success (Coutinho, 2007; du Toit & Kotze, 2009; Hartman, 2002a; Veenman *et al.*, 2006), this research inquiry has shown that the incorporation of certain teaching procedures can improve teaching in such a way that it can enhance learners' metacognition. This was conducted through the use of the Natural Sciences learning area as a mediation tool (Kozulin,

2003). The evidence of these findings was presented in the previous part of this chapter, but is briefly summarised in the next section.

4.3.2 Summary of findings

From various interpretations of the data, collected over the five week research period, some relevant themes emerged. Some of the findings within these themes directly address the research questions, while others were unexpected.

One of the most prominent findings that emerged revealed that, by incorporating many of the adapted teaching procedures into my Grade 9 Natural Sciences lessons, my learners' metacognitive development can be enhanced. Findings from all the data collected, as presented in Section 4.2.1, indicated that through incorporation of the previously mentioned adapted teaching procedures, my Grade 9 Natural Sciences learners became more metacognitively aware in terms of their knowledge of cognition and their regulation of cognition (Beng Lee, 2009). This advancement in metacognition was also evident by the informants' improved ability to reflect on their thinking and learning.

Not only did these teaching procedures enhance my learners' metacognition, some of them also demonstrated the ability to facilitate the development of certain characteristics of the envisaged South African learner (Department of Education, 2002a). Certain teaching techniques seemed to compel learners to be more pro-active and responsible about their learning, while becoming more self-disciplined and autonomous learners, thinking more consciously about their work and their life in general.

It was also evident that my Natural Sciences teaching practice developed over the five week implementation period. From the externalised responses of the learners, and from my own reflections, I became aware of which teaching styles and procedures were effective for enhancing learners' metacognition and for improving their learning in my Grade 9 Natural Sciences classroom. In the same way, it became evident to me which methods were not effective, and/or how they needed to be modified in order to better enhance learner metacognition.

The findings consequently indicated that the research questions were adequately addressed through this investigation. Through this process I have gained an idea of how to improve my Natural Sciences teaching practice by employing certain metacognitive teaching procedures. This was indirectly made evident by addressing my second research goal, namely: demonstrating how the adapted teaching procedures enhanced my learners' metacognition. A more detailed discussion of these relevant findings is presented below.

4.3.3 Enhanced Natural Sciences teaching

There is a need for research to look at ways of informing teaching to improve learners' metacognition (Coutinho, 2007; Lee *et al.*, 2010; Ritchhart *et al.*, 2009). Part of the strength of this research study was made evident because it demonstrated how, many of the teaching procedures that I employed, can be successful in enhancing learner metacognition and academic achievement. The findings from this investigation could consequently also be useful for informing research that will enhance teaching practice.

With the somewhat unsuccessful attempts to enhance teaching and learning in South Africa (Chisholm, 2003; Donald *et al.*, 2010; Malcolm & Alant, 2004), there is still a vital need to find methods to facilitate effective teaching; which can bring about effective learning (Malcolm & Alant, 2004; Woolfolk, 2007). For that reason, the findings from this study may also be relevant for South African education. Changes in the curriculum have been implemented to achieve certain educational goals in South Africa (Department of Education, 2002a). By incorporating the metacognitive teaching strategies in my Grade 9 Natural Sciences classroom, some of these goals were achieved. For example, some of the teaching procedures, that I employed, encouraged active, independent learning, where the learners became engaged in their work and took responsibility for their learning. Not only does this imply that the adapted teaching procedures facilitated the development of the envisaged ideal South African learner (Department of Education, 2002a), but reflection on this formed part of my improved teaching practice. These teaching procedures, in which the learners were forced to be more actively engaged, also had the resultant benefit of creating the opportunity for deeper, more conscious learning and concentration. The informants said that as a result, they understood the work better and would remember it for longer. These findings clearly indicate that the teaching processes created 'dramatic events' where the content of the subject was actively internalised as learning (Veresov, 2009).

My reflections, and consequent analysis, of the informants' data, have shown to be useful in aiding the advancement of my teaching practice. I have used these reflection opportunities to learn, by internalising information, and constructing new knowledge on better ways to teach. The data has helped me to become aware of how to incorporate the teaching procedures so that they are effective in facilitating learner metacognitive development, as well as how not to implement some techniques. For example, some informants mentioned that they had difficulty when I talked while they had to write things down because they could not get all of the information correctly. Having experienced this, I adapted my style and technique so that my learners gain the most effective learning opportunity. In addition to this, I have come to realise that certain techniques needed more explicit explanation than what I had provided in the five week implementation. In order to do this, I would need to be completely comfortable with the techniques that I employ. It also seemed quite useful to present the learners with a 'recap' list of all the different metacognitive techniques that I had employed, including how each one worked. This provided the learners with a holistic representation of all the procedures, so that they could apply them better. Due to the mediating ability that this had, I would definitively consider incorporating these 'recap' lists into my future teaching practice. In addition to this, I also came to realise how important it was to be well prepared for one's lessons (Woolfolk, 2007), but that it was just as important to be flexible enough to adjust to the learners' needs or when faced with any disruption.

Not only did the learner reflection opportunities enable the advancement of my teaching, they also seemed to be an effective means for facilitating the development of the learners' metacognition. This was evident not only from the informants' comments, but also from their improved ability to reflect over the five week period. I therefore think that the reflection opportunities may act as useful teaching tools in the future. Their relevance is even further reiterated in that one of the aims of OBE is to develop reflective learners (Department of Education, 2002a)

Another very relevant factor that emerged from the data, indicated the importance of the teacher creating a classroom atmosphere that is positive and conducive to learning. An environment that is welcoming and comfortable for the learners, demonstrated to allow for much more effective metacognitive development and learning.

In addition to this, the teaching procedures that I incorporated during the implementation process, also demonstrated to be effective in terms of aiding science education in South

Africa, and possibly even internationally. This was partly because they have shown to provoke learners to think, evaluate and regulate their thinking and learning performance - a goal that is commonly aspired to in science education globally (Malcolm & Alant, 2004; Yore & Treagust, 2006). This research may consequently add value to the international need for improved science education (Malcolm & Alant, 2004; Yore & Treagust, 2006).

Furthermore, some of the metacognitive teaching procedures seemed to help learners work better with scientific investigations; something that many of them said they had found very difficult in the past. This perceived difficulty meant that many learners were not motivated to do scientific investigations. Some of the employed techniques gave the learners the opportunity to truly engage with scientific investigations and therefore also to understand how to approach it better. With the problems experienced in science education in general, where learners often develop a 'phobia' of science (Hartman, 2002c), these metacognitive teaching techniques may be effective in minimising the preconceived ideas that many learners have of science. The techniques demonstrated the ability to make a challenging aspect of science, like scientific investigations, easier for learners, while simultaneously improving their metacognition. Accordingly, one could deduce that an increase in metacognition in Natural Sciences, may lead to an improved understanding of science, which in turn decreases a learner's 'phobia' of science (Hartman, 2002c). The benefit of this is particularly important in Grade 9 Natural Sciences because the learners' 'phobia' for the subject could be a factor which prevents them from being encouraged to take a science subject in Grade 10. By improving their metacognition, within Natural Sciences field in Grade 9, this may have the potential to overcome the problem of learners being discouraged to take science in higher grades. This may also help alleviate the problem of limited numbers of professionals who venture into scientific career fields (Department of Education, 2008; Ellis, 2001).

Further implications of this action research cycle also meant that my Natural Sciences teaching practice has improved. This is because the process allowed me the opportunity to use certain new techniques to facilitate my learners reasoning, investigating and reflecting skills in science (Department of Education, 2002a), while simultaneously enhancing their metacognition (Coutinho, 2007; Lee *et al.*, 2010; Ritchhart *et al.*, 2009). I can therefore use this acquired knowledge and continue incorporating these improved practices in my teaching career. Additionally, in my capacity as a future educational psychologist, I may also be able

to use this information to help other teachers improve their teaching practice, to enhance their learners' metacognition, in Natural Sciences. This is particularly relevant given the need for research to focus on effective classroom application of science education (Malcolm & Alant, 2004; Yore & Treagust, 2006). The relevance of these findings is also evident in the agreement that the association between metacognitive theory and research needs to be better connected in classroom practice (Hawkins, 199; Manning & Glasnir, 1996; Thomas, 2006).

This section presented a discussion of the ways in which this action research process has demonstrated the ability to improve my teaching practice, specifically in Natural Sciences. This was evident through my personal reflection on the process, but also through my learners' improved metacognitive development, which seemed to be a result of the employed teaching procedures. For this reason, the next section aims to discuss how this adapted teaching practice brought about this enhancement of learners' metacognition.

4.3.4 Teaching for improved metacognition

Metacognition has demonstrated to have advantages for improving academic ability (Coutinho, 2007; du Toit & Kotze, 2009; Veenman *et al.*, 2006). Additionally, Joseph (2010) claims that by understanding learners' metacognition, a teacher can better understand how his/her learners learn, and consequently, their teaching may be improved. Joseph (2010) further states that facilitating the development of learners' metacognition will ultimately be a valuable investment into their future. This research study has shown particular relevance because the teaching techniques employed, seem to have enhanced the learners' metacognitive abilities, while simultaneously improving my own teaching practice. This section aims to discuss the evidence of how my learners' metacognition developed over the five week intervention process. These findings are analysed from a social constructivist view of learning: the learners' enhanced metacognition is understood as having developed along with their construction of knowledge, as an internalisation of the social interactions of teaching, over the five weeks. This construction of knowledge occurred through the use of metacognitively orientated mediation techniques (Blanton *et al.*, 1998; Kozulin, 2003; Veresov, 2009).

A significant trend, detected during data analysis, was for my learners' metacognitive abilities to improve over the five week teaching period. The most distinctive indication of this was evident in the clear improvements of the learners' metacognitive skills at the end of the

intervention, compared to their skills at the beginning. Without explicit intervention, a limited metacognitive ability is not entirely unexpected, as research has shown that many learners experience limited metacognition (Connerly, 2006; Lipman, 1993). In fact, Manning and Glasnir (1996) allude to this by referring to the commonality that there is for learners to fail to set appropriate learning goals; to choose effective strategies to complete tasks; to regard the importance of monitoring or evaluating their progress; to seek guidance and information from appropriate sources. As not all learners instinctively engage in metacognitive thinking, it is very important for teachers to provide explicit instruction, which encourages the use and development of metacognition (Hartman, 2002a). The general improvement of my learners' metacognition over the five weeks was evident in a number of ways, but each proved to be a result (either direct or indirect) of the adapted teaching strategies that I employed.

Certain teaching techniques seemed to be more effective than others. This was due to the particularly positive influence of some techniques on the development of the learners' knowledge of their cognition, including the development of their declarative, procedural and conditional knowledge (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2010). This was clear from the learners' improved knowledge of cognition, that became evident in their enhanced declarative knowledge and metacognitive awareness of which strategies they had to use and incorporate for specific learning tasks (Woolfolk, 2010). The process also seemed to help many of the learners to improve their knowledge and metacognitive awareness of which strategies work best for them when it comes to their learning, and why these work better than others. Apart from this, the learners also showed an improved ability to recognise the relevance of many of the different procedures by experiencing and becoming aware of their positive effect on learning. This not only shows that the learners improved their metacognitive awareness and declarative knowledge (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2010), but it also addresses yet another one of the intended outcomes of OBE for South African learners, namely: to explore a variety of strategies, in order to learn more effectively (Department of Education, 2002a).

Many of my learners also showed improved procedural knowledge due to the fact that they had developed an improved understanding of how to use some of the newly learnt techniques (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2010). Numerous metacognitively enhanced moments or 'breakthroughs' were observed or reflected on during the five week period (Watson, 2000). In comparison with the limited metacognition experienced at the

beginning stages of the process, these metacognitive moments further reiterated the learners' improved metacognitive abilities.

Another significant finding, that revealed improved metacognition, was evident in the learners' improved conditional knowledge (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2010). Their awareness and desire to use these implemented techniques in future learning situations, indicates the effectiveness of these metacognitive teaching techniques to develop conditional knowledge that learners will transfer to other situations. To be able to transfer skills and knowledge from the initial learning situation, one needs to have actively engaged with the work, and really have thought about it in order to effectively internalise it, and apply it to new situations (Kozulin, 2003).

Some informants were able to reflect that they could think more effectively in situations in everyday life, using the new techniques learnt in the Natural Sciences classroom. This further revealed their improved conditional knowledge. For example, some commented that concept maps and positive-negative comparisons could be used to deal with everyday problems; from peer pressure to party planning. This ability to transfer skills and knowledge across situations is not only an important aspect of metacognition, but from a social constructivist perspective, it is also considered an essential factor of effective learning (Chaiklin, 2003). Coincidentally, this is also one of the ideals for the effective South African learner (Department of Education, 2002a). The ability to transfer knowledge beyond the initial learning situation is therefore a reflection that true learning has occurred, where a learner has actively internalised the knowledge, enabling him/her to use it in other situations.

With the transfer of skills and knowledge being such an important part of effective learning (Ball & Wells, 2006; Connerly, 2006; Department of Education, 2002a), and the need for learners to develop a range of skills in a variety of settings (Department of Education, 2002a), consequent research has been focused on transfer in education (Woolfolk, 2010). For educational purposes, it is significant to note here that the metacognitive teaching strategies, which I employed in this intervention process, have shown to enhance transfer. It may also act as an important point to consider when education policy developers and teacher training institutes, reflect on developing the envisaged, ideal South African learner for improved education (Department of Education, 2002a).

The transfer of skills and knowledge, from the original learning situation to other situations, such as that indicated above, is particularly relevant for the improvement of science education. Research has shown that skills learnt in science are very seldom applied or transferred to real life situations (Giest & Lompscher, 2003). From a social constructivist perspective, learning occurs if a social situation is internalised by actively constructing knowledge in relation to what is already known (Veresov, 2009). Accordingly, the inability to transfer skills and knowledge may influence the ability of learners to understand the content, which may further negatively influence their motivation for the subject (Giest & Lompscher, 2003). This reiterates the importance for effective instructional methods to assist learners to develop good thinking strategies (Ben David & Zohar, 2009). In so doing, this may instil interest and motivation for science as a subject.

In the research process, an improvement in metacognitive awareness also emerged in a way that was not expected. Some of the strategies employed helped a couple of learners, not only to enhance their metacognition, but also triggered the learners thinking about future careers. A particular goal of OBE is for education to encourage learners to think about and explore further education opportunities and career fields (Department of Education, 2002a). Consequently, these teaching procedures have demonstrated to partly address this envisaged outcome. Research has also shown the need for better science education (Roth & Garnier, 2007; Yore & Treagust, 2006), as well as a need for more people to venture into scientific career fields (Department of Education, 2008; Ellis, 2001). In addition to this, there is a need for better science teaching (Ben-David & Zohar, 2009; Malcolm & Alant, 2004; Yore & Treagust, 2006). From what Noma said about her experience of certain employed teaching procedures, mentioned in Section 4.2.1.1, it may be possible for these metacognitively enhanced teaching procedures in Natural Sciences, to encourage individuals, to orientate themselves more positively towards science and/or education career fields.

In addition to the above, the metacognitive instructional procedures also seemed to enhance my learners' metacognition in their improved regulation of cognition. This was evident by the learners' improved ability, and awareness of this ability, to plan, monitor and regulate their cognition (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2010). For a learner to regulate their cognition, the learning opportunity they experience needs to become an internalised repertoire of self-instruction, which can be performed easily without further external mediation (Manning & Glasner, 1996). From a social constructivist perspective, this

emphasises the relevance of the teaching procedures that I employed, not only for enhancing metacognition, but also for improving the learning opportunity (Veresov, 2009).

Apart from the data, which revealed improved planning, monitoring and regulation of cognition, enhanced regulation of cognition was also evident from some of the learners' improved academic ability (Coutinho, 2007; du Toit & Kotze, 2009; Kruger & Dunning, 1999). Development in regulation of cognition was even further evident from the learners' improved awareness of their academic achievements, their goal setting, and their regulation of learning to achieve certain goals. Azevedo (2009) says that effective learning involves the use of a number of self-regulatory processes, such as planning, knowledge activation, metacognitive monitoring, regulation and reflection. Self-regulation involves learning that is pro-active, intentional and reflexive, and it entails a sense of personal responsibility for learning (Leutwyler, 2009). As part of metacognition, but also as part of the development of autonomous, self-regulatory South African citizens, the improved academic successes, in conjunction with the improved metacognition, supports the positive influence of the employed teaching strategies, for developing some of the characteristics envisaged for the ideal South African learner (Department of Education, 2002a).

This metacognitive regulating behaviour was further evident in many of the informants' improved awareness of the ways to better regulate their test and exam behaviour. Some informants reported that they now regulated their study habits better, and many said that some of the teaching techniques made them think more consciously about answering questions. These techniques also compelled the learners to check answers and to go through their work and check for errors before handing it in. This shows how the teaching procedures, which I introduced into the Natural Sciences classroom, helped learners to monitor and evaluate their progress better (Manning & Glasnir, 1996).

Improved metacognitive regulation was even further implied by the informants enhanced evaluation abilities (Beng Lee *et al.*, 2009; Hartman, 2002a; Woolfolk, 2010). The learners revealed this through their reflections and comments in the focus-group interview, which implied that their self-questioning skills had improved and become more frequent over the five week period. According to them, the activities that I incorporated, forced them to question their ways of thinking a lot more than in the past, and hence, encouraged an improvement in their metacognition.

The improved ability to reflect further indicated my learners improved metacognition. Apart from being a data collection method, the learner reflections also formed part of metacognitive skill and ability (Karpov, 2003; Veenman *et al.*, 2006; Yore & Treagust, 2006). Many of the informants, particularly those from average to low academic achievement range, revealed a limited ability to reflect in the initial stages of the data collection process. Either the reflections revealed poor insight into their thinking about their thinking, or they were very vague, implying a limited ability to reflect on their thinking. By the end of the five weeks, these same learners were writing insightful and detailed reflections, even running out of space on their reflection pages. One may argue that the initial limited ability to reflect could have been due to a limited ability to express thoughts in a written format, but the fact that the learners' ability to reflect improved, as part of their improved metacognition, is evidence against this. However, as a means of overcoming any validity concerns related to this, the learners were also given the focus-group interview opportunity to reflect their thoughts verbally, and for me to make any further clarifications of their written reflections. Some of the informants commented that it was easier to express their thoughts verbally than in written format, but their improved written reflections indicated that they did in fact have the ability for written expression of their thinking.

I have therefore interpreted these benefits of the learner reflection activities, as being evidence that this is a useful technique to bring into my improved teaching practice. Even the informants of this study reported that reflections had forced them to think about their work more. They had to think back about what had been covered over the week, which enhanced their regulation of their thinking and learning. This added to their metacognition gains because they became even more aware of what they already knew, and what they needed to do in order to attain sufficient knowledge (Wilson & Bai, 2010).

Taking into consideration the metacognitive and learning benefits of employing the adapted teaching procedures into my Grade 9 Natural Sciences lessons, I have to conclude that most of these techniques can be considered to form an integral part of my improved teaching practice.

4.3.5 Teaching that considers the uniqueness of the learner

The characteristics, mentioned in the previous section, highlight the different factors that a teacher would need to be aware of, and regulate, so that effective teaching for metacognitive

development could occur. In addition to this, something which also emerged as an important factor, for a teacher to consider, is the uniqueness of the learners that he/she teaches. From a social constructivist perspective, learning occurs because of a social interaction between a learner and a more knowledgeable other. The learner's previous knowledge and experience will influence the unique way in which he/she perceives this new learning experience to construct new knowledge. The learner's previous experience, can consequently determine whether new learning occurs at all (Donald *et al.*, 2010; Giest & Lompscher, 2003; Kozulin, 2003; Veresov, 2009). Therefore, because the factors which make an individual unique also influence how they learn, it is important for teachers to take cognisance of the individuality of the different learners they teach.

According to Vygotsky's model on childhood development, that which is perceived as interesting to a child will change with his/her age period (Chaiklin, 2003). The implication of this for teaching is that lesson content needs to be mediated in such a way that it is meaningful to the learners so that internalisation can occur. Therefore, lesson content must not only remain within the learners ZPD, but it must also target their interests; so that it can be meaningful, and effective learning can occur (Chaiklin, 2003).

The uniqueness of learners also became relevant when the data revealed how the informants had, through the five weeks adapted teaching process, come to realise their preferred methods of learning. Not only does this imply the positive effect that the techniques had on the development of the learners' metacognitive awareness and knowledge of cognition (Coutinho, 2007; Donald *et al.*, 2010; Lee *et al.*, 2010; Ritchhart *et al.*, 2009), but as the teacher, who was made aware of this through my reflections, I can now make allowances to incorporate this knowledge into my teaching.

The importance that interest plays in learning also demonstrated to be an important factor in learning and metacognition in this study. This finding has shown to be relevant in education for some time (Woolfolk, 2007). Not only did the learners in this research realise how their interest in the lesson content significantly influenced their learning, as a teacher I realised this as well. Therefore, as part of my improved teaching practice, I need to be aware of the diversity of the learners in my class, as well as their particular stage of development according to Vygotsky's childhood model (Chaiklin, 2003). This will facilitate my understanding of the learners' interests, so that the lesson content can be shaped to accommodate them, and work can be targeted at a level within their ZPD's (Manning &

Glasnir, 1996; Woolfolk, 2010). The intention of this would be to motivate learners to remain actively engaged with their work.

The degree to which a learner is motivated to work towards a personal learning goal can also have a significant impact on their metacognitive and learning development (Department of Education, 2002a). From a social constructivist perspective, this is an essential factor that will affect teaching because "[one] finds no internal push to growth without a corresponding external pull" (Donald *et al.*, 2010, p. 81). This implies that motivation is needed, but so is the external pull from social interaction, such as teaching. It is important to mention here what I deduced from the learners' responses: From the teaching opportunities, where the learners had to actively engage with the work independently, and put in effort, they started to develop an intrinsic motivation to understand the work better, and to engage in more conscious learning. Intrinsic motivation is a goal of many 'ideal' teaching situations (Woolfolk, 2007), and the fact that these teaching procedures could facilitate it, makes them part of good teaching practice. Apart from that, this finding also reiterates how the teaching procedures encouraged the learners to take ownership of, and responsibility for, their learning (Department of Education, 2002a).

Another factor, linked to the uniqueness of learners, which seemed to play a central role in their metacognitive development in this research study, was the academic achievement levels of the learners. Some of the low and average achieving informants recognised their improved metacognition by their improved results in tests during the five week period, while others simply recognised their more 'minds-on' experiences. It was this range of learners who tended to reflect on, and show, the most marked improvement in their metacognitive abilities over the five weeks. This is not completely unexpected because effective metacognition has proven to be a significant determinant of academic achievement (Coutinho, 2007; du Toit & Kotze, 2009; Veenman *et al.*, 2006). One may therefore argue that this finding was such because the learners, who were already achieving well, in terms of academics, have most likely already developed a range of metacognitive skills. However, even the informants, who already achieved in the higher academic range, still showed improved metacognition as a result of the five week process. One informant, Lena, who is categorised into the higher achieving group, commented in her reflections, in the open-ended questionnaire, and in the focus-group interview, that the adapted teaching procedures helped her to a certain degree, but that she had employed many of the strategies herself, before this process. She did,

however, also comment that despite having used some of these skills and techniques before, she found the entire process useful because it helped her to decide which techniques suited her best. In addition to this, she attested that the process had helped her to perfect some of the metacognitive skills that she already employed. In response to a question about how she thought differently about her thinking skills, after the five week intervention, Lena responded in the open-ended questionnaire that:

I now think that they are important. They help you to plan, think, organise and then act. They help you to study and work better.

The other informants from the higher achieving group did not reflect quite the same experience as Lena. Innocentia and Noma merely commented that they felt that the intervention process had significantly enhanced their metacognition.

One last finding that became relevant, in terms of the uniqueness of the learner influencing teaching and metacognitive development, was that of culture and learning. The limited nature of this particular research leaves little room to investigate the complex influence of culture on learning and metacognition. This is an issue that has the potential to form a part of future research into the topic of metacognition. However, in this inquiry, the data made me aware of the importance of culture in teaching and learning, particularly when I covered the section on Human Reproduction with the Grade 9's. Reading the informants reflections, and my reflection entries, made me realise how my own personality and culture can determine, to a large extent, the way that I approach topics in Natural Sciences. As a teacher, I feel the need to create an atmosphere where the learners can feel encouraged to ask questions so that they can learn from the opportunity. I therefore tend to approach topics quite openly. In the focus group interview, Lena, who has been brought up in a predominantly German household, commented that she felt open to discuss issues, that others may find sensitive, in the reproductive section. Mavis on the other hand commented in one of her reflections that she felt:

In black communities it is difficult to talk about reproduction, therefore I listen to gain more knowledge and to learn things (that are) important.

This reiterates the role that the uniqueness of the learner, specifically their cultural heritage, can have on their learning opportunities. It also reveals Mavis' improved metacognitive awareness and regulation. She realised the nature of her personal learning circumstances, and

she made the necessary accommodations to ensure she was still able to learn from the opportunities presented to her.

From the above interpretations, and from analysis of all the collected data, I have realised that with the five weeks of metacognitively enhanced teaching procedures, all learners' metacognition improved in some way. The uniqueness of how each learner interprets and constructs knowledge, as well as their unique characteristics, influence the nature, degree and pace of metacognitive development. As a teacher, one needs to take cognisance of this.

4.4 SUMMARY OF CHAPTER

Analysis of the data collected in this research inquiry, has indicated that by incorporating certain metacognitive instruction procedures into my Grade 9 Natural Sciences classroom, I was able to facilitate the development of all aspects of learners' metacognition. These techniques have had the added benefit of contributing to the development of the ideal South African learner, and consequently offer effective methods to improve my teaching instruction. The need for improved teaching and learning in South Africa, and internationally, particularly in science education, highlighted the relevance of this study. Having revealed the effectiveness of the various metacognitive teaching procedures for enhancing metacognition, attending to the secondary aim of the research, this process has also addressed the primary aim of facilitating the improvement of my teaching practice.

Chapter 5 will aim to inform the next cycle of this action research, and therefore presents my concluding remarks, recommendations and implications for future research. The strengths and weaknesses of this research inquiry will also be discussed, concluding the final step of this action research process.

CHAPTER 5

CONCLUDING REMARKS, IMPLICATIONS, LIMITATIONS AND STRENGTHS

5.1 INTRODUCTION

This research study aimed to gain insight a propos the incorporation of metacognitive instruction procedures into my Grade 9 Natural Sciences lessons. It particularly investigated the implications of these teaching procedures for my teaching practice, as well as their influence on the development of my learners' metacognition. To approach these research questions, one cycle of an action research process was conducted, from within a qualitative paradigm of praxis. This research process provided me, as teacher-researcher, with a better understanding of how the teaching procedures can be incorporated to enhance my learners' metacognition. Subsequently, the process also informed my Natural Sciences teaching practice in order to improve it.

This chapter represents the final part of step 5 of this action research process, as referred to in Section 3.5. It will therefore present some concluding remarks on the main research findings, followed by recommendations that have transpired from the analysis of these findings. The limitations and strengths of the study will also be discussed. The chapter will conclude with suggestions for future research, as well as a final reflection on the entire research process.

5.2 CONCLUDING REMARKS

Education, both locally and globally, faces many challenges with regards to enhancing teaching and learning (Chisholm, 2003; Donald *et al.*, 2010; Giest & Lompscher, 2003; Malcolm & Alant, 2004). In science education, more specifically, there is a real need for improved teaching to address some of the problems encountered (Department of Education, 2008; Viljoen, 2010). The necessity to develop South African citizens, who are effective, independent and conscious thinkers, has also become more apparent. As a result, there is a strong need for improved teaching and learning to facilitate this development (Department of Education, 2002a; Giest & Lompscher, 2003). Research that focuses on improved teaching

practices in general, but also specifically in science education, is needed to address the educational problems experienced (Malcolm & Alant, 2004; Yore & Treagust, 2006). The findings of such research would then need to inform teacher development and teacher training; so that the benefits can be extended even further.

From my own experience as a Natural Sciences teacher, I have realized that not only do many of my learners share these difficulties, as revealed in science education research (Department of Education, 2008; Viljoen, 2010), but I have also noticed that many of them experience a limited metacognitive ability. My reflections triggered my interest to investigate ways to improve my teaching practice in order to facilitate my learners' improved metacognition and science learning. Due to the proven link between metacognition and improved academic achievement, I wanted to investigate methods of improving my teaching by enhancing my learners' metacognition. This was intended to facilitate their ability to tackle some of the academic challenges they face. By doing this, an indirect aim of this research was also to improve their learning in Natural Sciences.

In the first place, my research findings indicate that by employing certain, metacognitively adapted, teaching procedures into Natural Sciences, it can enhance the learners' metacognitive development. Some learners showed more significant improvements than others, but they all revealed some form of enhanced metacognition. The learners, who initially showed more limited metacognitive ability, tended to demonstrate a more marked improvement in their metacognition throughout the implementation process. These learners were also those who achieved in the average to low academic ranges (Coutinho, 2007; du Toit & Kotze, 2009; Veenman *et al.*, 2006). For the learners in the higher academic range, enhanced metacognition was also achieved, but for some this was more in the sense of improving already employed metacognitive strategies, or improved metacognitive awareness.

The learners' enhanced metacognition was evident by their improved awareness of their knowledge and regulation of cognition. The employed teaching procedures demonstrated the ability to develop their knowledge of cognition by facilitating their awareness of which learning strategies were the most effective for them personally, as well as how best to employ these strategies. The adapted teaching was also useful in advancing the learners ability to transfer their newly acquired metacognitive knowledge and skills to other situations. To be able to do this, a learner would first have to truly internalize what they learnt, and this in turn would require conscious and reflexive thinking (Gourgey, 2002). In addition to this, many

learners experienced metacognitive breakthroughs and 'minds-on' experiences as a result of the metacognitive teaching procedures.

By employing the adapted teaching procedures, it was evident that these procedures could also enhance learners' metacognition in terms of their regulation of cognition. These procedures seemed to help learners advance their planning, monitoring and evaluation of learning and cognition. The benefit of this was evident in their improved ability to regulate their class-work, their studying, their test and exam writing behaviour, their homework, as well as their scientific investigation skills. The self-regulatory aspect of learning and metacognition was further evident in the increased abilities of the learners to work independently, and realize the benefits of this autonomy for their learning. Some learners also commented that the teaching process benefited them because it trained them to 'self-question' and to reflect on their own thinking and learning.

Furthermore, interpretation of the research findings revealed that the employed teaching processes had the added benefit of facilitating the development of the envisaged ideal South African learner (Department of Education, 2002a). This was evident from the metacognitive activities that encouraged more independent, self-regulatory behaviour from the learners, which required them to become more actively engaged in their work. Unexpectedly, the employed teaching strategies even aided some learners' career orientation, because through the procedures they became more aware of what they would like to do one day. Some techniques also fostered the learners' realization of the importance for them to take responsibility for their learning, and act in a self-disciplined manner. These characteristics also form some of those envisaged for the ideal South African learner to become a responsible democratic citizen (Department of Education, 2002a). The above mentioned findings therefore reveal the importance of metacognitive development, and hence, the need for metacognitively orientated teaching to help acquire these ideals.

Lastly, this research has shown that by employing the various teaching procedures, and through reflecting and altering this process, my teaching practice has improved because I am now better able to mediate the enhancement of my learners' metacognition and learning in Natural Sciences. With the benefits of the adapted teaching procedures presented in the previous paragraphs, it is quite apparent how my adapted teaching strategies have improved my teaching practice. In addition to this, the learners' requests for me to continue employing

many of the procedures, after the implementation process, affirms the benefits that the adapted teaching, and consequent learning opportunities, created.

Reflection on my teaching also proved to be a valuable part of the process for improving my teaching practice. It therefore needs to be incorporated into my teaching in the future. These reflection opportunities allowed me to realize a number of aspects about my teaching, on which I could improve. Reflections also proved beneficial for informing the better implementation of the employed teaching procedures. For example, by reflecting I began to appreciate the need for thorough, explicit explanation of each procedure. In addition to this, the reflections made me realize the value of using a visual summary of all the new techniques employed. From the reflections, I became more aware of the importance of linking the lesson content with the learners' interests, while targeting the work within the learners' ZPD's. Apart from this, the reflections presented the advantage of creating a positive classroom atmosphere. I became conscious that a pleasant classroom environment, where the learners are encouraged to participate and their inquiring minds are supported, cannot be ignored as a central aspect of improved teaching practice.

Forming part of my improved teaching practice, awareness and understanding of the uniqueness of the learners, seems to be a necessity. Due to their unique background knowledge and personal experience, learners not only respond differently to the different teaching procedures, but they also develop differently in terms of their metacognition. The role that culture plays in promoting or inhibiting metacognitive development and learning was also something that became an important aspect to be kept in mind when teaching. In addition to all this, working with the learners' ZPD's and unique interests, seemed to be essential to keep the learners motivated. Furthermore, the importance of intrinsic motivation, in terms of self-regulation and personal goal-setting, seemed to be an important aspect of my adapted and improved teaching practice.

5.3 IMPLICATIONS

This research process has revealed many insights, as mentioned in the previous paragraphs. Interpretations of these insights highlight numerous implications, and from these, suggestions have been made for consideration when future cycles of this action research process are conducted. These are presented in the paragraphs to follow.

As a Natural Sciences teacher, given the benefits evident from this research investigation, it would be sensible for me to continue to employ the teaching techniques that I introduced into my classroom. I would however need to be mindful of the difficulties that I experienced with some of these techniques, and make the necessary adaptations. It may be useful to attempt to employ similar techniques into my other classes, as the benefits of the teaching procedures could likely be experienced there as well. As part of this process, it would be important to continue my reflections, while incorporating reflection activities for the learners as well. In this way they can also continue their metacognitive development, and I can be made more aware of the uniqueness of the learners that I teach.

Other teachers should also be encouraged to employ metacognitive teaching procedures. The findings of this research could be made available to other teachers and educational specialists, particularly those in the science fields. From these adapted procedures, their own deductions can be made, and similar procedures could be employed in their classrooms.

Furthermore, the knowledge and experience that I have gained from this research process can be used in my future capacity as an educational psychologist to help other teachers and educational specialists to understand metacognition and the importance of incorporating it into one's classroom. Apart from this, due to the practical nature of this research, the knowledge could also be used to facilitate other teachers' inclusion of the teaching procedures into their classrooms. To aid this process, it may be useful to include information from the analysis and interpretation of the findings of this study, into teacher training and development situations. It may be effective for this training to involve a strong practical component where teachers, or teachers in training, are shown how to employ metacognition into their teaching practice.

Apart from this, a further implication of the study is for educational policy makers in the Natural Sciences field to take cognizance of the information gained from these findings when developing new educational curricula policies for example. With recent changes being made in the National Curriculum, this may be of particular importance. This point is therefore further discussed in Section 5.6. Furthermore, Natural Sciences textbook authors may also benefit from using these findings to aid metacognition when putting together textbook activities.

5.4 LIMITATIONS

The scope of this study was fairly narrow, due to the size of the sample. Qualitative research is usually characterised by a small sample size, however, widening the sample would help to increase the potential to generalize the research findings.

Something that may be viewed as limiting the research, is the short time frame allocated for implementing the research intervention plan. Bearing in mind that this was only a fifty-percent thesis study, future research with a longer timeframe, may provide findings that reflect a more comprehensive understanding about the long-term effects of the intervention process. This may also add insight into the degree to which the learners' metacognitively enhanced skills can be transferred to future situations. Another focus-group interview or reflection opportunity a few months after the intervention process may also give similar insight.

The fact that this study only placed focus on the Natural Sciences learning area, may also be viewed as a limitation to the research, as the implications of the process in other learning areas may also prove to be beneficial. In addition to this, the study was conducted with Grade 9 learners only. Learners in the other grades may also benefit from such research. However, research with learners who are much younger, may not provide them with a similar experience, as it has been proven that the potential for metacognition only truly develops in adolescent years (Fox & Riconscente, 2008; Goos *et al.*, 2002; Leutwyler, 2009).

Unexpected findings of the research also opened doors for further self improvement. Little focus was placed on the role of motivation or culture in learning and metacognition in this study. Despite recognizing their importance, the scope of this research did not allow for an in depth analysis of these factors, even though they demonstrated to be very valuable determinants of learning and metacognition.

5.5 STRENGTHS OF THE STUDY

One of the most prominent strengths of this research is the nature of the study itself, and more specifically, the research design. Using action research presented the opportunity to practically experience, and to gain an in-depth analysis of how to improve my teaching practice to enhance learners' metacognition. I gained insight as to which techniques aided the improvement of my teaching, as well as how best to implement them. I also realized, which

techniques the learners liked and disliked, and which they found most effective for the development of their learning and metacognitive development. Action research truly proved to be the most effective research design for addressing the specific research questions of this study.

By employing an action research design, and working from a paradigm of praxis, the practical nature of the study also meant that implications and suggestions elicited from the findings could be used as such. Teachers, for example, may be able to obtain practical suggestions from this study. If the study had been implemented with a design other than action research, similar benefits may not have been attained. For this reason, the study also creates the potential to provide valuable, practical information for teacher training and development, which may facilitate the implementation of metacognitively enhanced teaching practice outside the range of this research sample.

A further strength of the study was evident in the extent to which learners benefited from the research process. The teaching procedures that I employed have demonstrated the ability to enhance the learners' metacognitive abilities which, for many of them, consequently improved their school work and the quality of their learning. For some it had a positive effect on their career choice, and for others it contributed to the acquisition of lifelong learning skills. Having created active learning opportunities and conscious thinking experiences, the process has also proved to enable learners' progression towards becoming envisaged South African citizens (Department of Education, 2002a). The informants even expressed their gratitude for having been invited to participate in the process.

5.6 FURTHER RESEARCH POSSIBILITIES

This research study took on the format of the first cycle of an action research process. This had the intention of informing future research cycles within this particular line of research. This section therefore presents suggestions for future action cycles, but it also includes a section on diverged research possibilities that may emerge from this particular study.

When conducting the next cycle of this action research process, it would firstly be important to consider all the limitations mentioned in Section 5.4. Bearing in mind the fact that this study only acted as a pilot study for future research, and that it was only for the purpose of a fifty-percent master's thesis, the scope was somewhat limited. Future cycles would likely

benefit from a broadened research scope. These cycles could, for example, look at using a broader sample of learners, or work with learners across different age groups. However, they would need to take into account the limited ability of younger children to develop metacognitively (Fox & Riconscente, 2008; Goos *et al.*, 2002; Leutwyler, 2009).

Having previously mentioned the problems experienced in science education in South Africa (Malcolm & Alant, 2004; Yore & Treagust, 2006), future cycles within the Natural Sciences field would not be unwarranted. However, insight into the transferability of the benefits of this research process may also prove beneficial in other learning areas. In education in general, there is in need of practical research for improving teaching and learning (Malcolm & Alant, 2004). Therefore, future cycles could also look into the application of the teaching procedures in other learning areas, or alternatively, they could look at the ability of learners to transfer their metacognitive skills to other subject areas.

Conducting future cycles may also address the issue of gaining more insight into the long term effects of the employed teaching procedures. Future cycles will not only be able to investigate the effects of more continued metacognitive teaching, but they may be able to explore the learners' ability to use their metacognitive techniques over a longer period of time.

Additionally, this research cycle was conducted during a time when the National Curriculum was in a state of transition. New Curriculum and Assessment Policy Statements (CAPS) were being drafted for all the learning areas. The final draft version of the Natural Sciences Curriculum and Assessment Policy Statements (CAPS) indicates possible changes to the Natural Sciences curriculum and assessment methods. Analysis of the draft version of this new policy shows slight modifications, such as those in the layout of subject aims and objectives, compared to the previous Revised National Curriculum Statement Grades R-9 (Department of Education, 2002a). Therefore, it would be important in future research cycles to take into consideration any changes to the Natural Sciences learning area when planning the research.

For future research that may materialize from this investigation, it may prove useful to investigate pre- and in-service teacher training, and the ways to enable teachers to take on similar metacognitively orientated teaching procedures. Extending this research even further; future investigations could look at the capabilities of both new and experienced teachers to

implement such strategies, with the intention of optimizing these implementation abilities. This may help to address the dire need that South Africa has for improved teaching practice (Wilson & Bai, 2010).

5.7 CONCLUDING REFLECTIONS

Throughout this research process, I have become increasingly aware of my passion for facilitating good teaching opportunities, which construct effective learning experiences for my learners. In addition to this, I realized the value of creating learning situations, where my learners can reflect on, internalize, and think about their work in ways that will continue to have an impact in the future. I have also come to appreciate the responsibility that teachers have to research, and/or reflect on, their teaching practice in order to continuously improve it. As a teacher, and future educational psychologist, I now truly recognize the value of becoming a lifelong learner who embraces personal and professional change and development.

In South Africa, the need to improve teaching practice, for effective learning, has become increasingly important (Malcolm & Alant, 2004). At the same time, the benefits of metacognition for improving learning are gradually becoming more recognized (Ben-David & Zohar, 2009; Hartman, 2002c; Yore & Treagust, 2006). Educational professionals therefore need to embrace this prospective relationship between metacognition, teaching and learning, so that teaching can become the fruitful vocation it has the potential to be.

Teachers need to be trained to incorporate metacognition into their classrooms so that learners may reap the learning benefits of improved metacognition. The Department of Education should also take cognizance of this in order to create opportunities for metacognitive teaching to foster better learning in school environments. Teacher training institutions should also recognise the value of metacognition in teaching so that they can prepare teachers adequately for effective implementation of suitable teaching procedures. In addition to all the above, educational psychologists also have the responsibility to distribute their knowledge and expertise with teachers and schools to facilitate effective thinking school societies.

In conclusion, as the teacher-researcher in this research investigation, I am grateful that this process has provided me with the personal, and practical, experience of incorporating

metacognitively orientated teaching procedures into my Natural Sciences classroom. The benefits of this were not only evident in the learners' improved metacognition, but also in my own improved teaching practice. These benefits may be valuable for teachers and other educational professionals because enhancing learner metacognition, through improved teaching practice, may have the potential to significantly impact learning. As Stenhouse (1983, in O'Hanlon, 2003, p. 31) puts it:

It is teachers in the end who will change the world of education.

Reflecting on this entire research process, the personal and professional growth that I have made throughout has been demanding at times, but rewarding overall. Having started the research process with this first action research cycle, I hope to have the opportunity to continue the research process with future cycles, where the benefits of the findings may be explored even further.

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ADDENDUM A

LETTER OF ETHICAL CLEARANCE - UNIVERSITY OF STELLENBOSCH



UNIVERSITEIT • STELLENBOSCH • UNIVERSITY
jou kennisvenoot • your knowledge partner

28 July 2011

Tel.: 021 - 808-9183
Enquiries: Sidney Engelbrecht
Email: sidney@sun.ac.za

Reference No. 468/2010
[Revised Title]

Ms A Butterfield
Department of Educational Psychology
University of Stellenbosch
STELLENBOSCH
7602

Ms A Butterfield

LETTER OF ETHICS CLEARANCE

With regards to your application, I would like to inform you that the project, *Enhancing Metacognition Through Natural Sciences Teaching*, has been approved on condition that:

1. The researcher/s remain within the procedures and protocols indicated in the proposal;
2. The researcher/s stay within the boundaries of applicable national legislation, institutional guidelines, and applicable standards of scientific rigor that are followed within this field of study and that
3. Any substantive changes to this research project should be brought to the attention of the Ethics Committee with a view to obtain ethical clearance for it.

We wish you success with your research activities.

Best regards



Sidney Engelbrecht
MR SF ENGELBRECHT

Secretary: Research Ethics Committee: Human Research (Humanoria)

ADDENDUM B**LETTER OF ETHICAL CLEARANCE - WESTERN CAPE EDUCATION****DEPARTMENT**

Wes-Kaap Onderwysdepartement

Western Cape Education Department

ISebe leMfundo leNtshona Koloni

Miss Alexandra Butterfield
110 Welgevonden Blvd
Stellenbosch
7600

Dear Miss Alexandra Butterfield

RESEARCH PROPOSAL: IMPROVING NATURAL SCIENCE TEACHING FOR GRADE 9 LEARNERS TO ENHANCE METACOGNITION

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **20 January 2011 till 30 June 2011**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

The Director: Research Services

**Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000**

We wish you success in your research.

Kind regards.

Signed: Audrey T Wyngaard

for: **HEAD: EDUCATION**

DATE: 19 January 2011

ADDENDUM C

LETTER OF SCHOOL CONSENT AS A RESEARCH SETTING

To whom it may concern

REQUEST TO CONDUCT RESEARCH: M.ED. STUDY PROJECT

I hereby request permission to conduct the under-mentioned research study at your school. The study aims to improve my teaching practice, as well as enhance the learners' metacognition.

Title of the research study:

IMPROVING NATURAL SCIENCE TEACHING FOR GRADE 9 LEARNERS TO ENHANCE METACOGNITION

Researcher:

Ms Alexandra Butterfield

Purpose of the Study:

The aim of this study is to investigate how teaching practice can be improved through incorporating metacognitive teaching procedures into the Natural Sciences curriculum to enhance learners' metacognition. Insight gained from this study could improve my own teaching practice, improve the metacognition of the learners involved, and further the field of metacognitive teaching and learning.

Research instrument:

The research process will involve a series of six to eight lessons (approximately 50 minutes each) once a week for six to eight weeks. The participants would keep reflection diaries and work books throughout the entire process. They would also participate in one focus group interview.

Confidentiality:

Confidentiality will be maintained by means of providing each participant with a pseudo name, and all data collected will be kept under lock-and-key, or password protected, where only I, the researcher, has access to it. Any information that is obtained in connection with

this study and that can be identified with the learners will remain confidential and will be disclosed only with the permission of the participant or as required by law.

The information gained from the study will form part of a thesis which will be available to others for academic purposes. No names or identities of any participant, or the school, involved will be disclosed in the final thesis.

Identification of the investigator:

If you have any questions or concerns about the research, please feel free to contact:

Ms Alexandra Butterfield (principal investigator): 14266164@sun.ac.za, or

Dr M.M. Oswald (Supervisor): mmoswald@sun.ac.za, telephone number: 021 8082306.

Yours sincerely

Alexandra Butterfield
Researcher

SIGNATURE OF PRINCIPAL

The information above was adequately explained to me by the researcher, Alexandra Butterfield. I was given the opportunity to ask questions and these questions were answered to my satisfaction.

I hereby consent to the completion of the proposed study at Rhenish Girls' High School.

NAME OF PRINCIPAL

Signature of PRINCIPAL

Date

ADDENDUM D**STELLENBOSCH UNIVERSITY****ASSENT TO PARTICIPATE IN RESEARCH**

***IMPROVING NATURAL SCIENCE TEACHING FOR GRADE 9 LEARNERS TO ENHANCE
METACOGNITION***

You are asked to take part in a research study conducted by Alexandra Butterfield (MEd Psych Student from the Department of Education at Stellenbosch University), and currently your Natural Sciences teacher. The research will form part of the completion of a master's thesis. You were selected as a possible participant in this study because you form part of the research population.

1. BACKGROUND TO THE STUDY:

Metacognition is commonly known as *thinking about one's thinking*. It is a higher order cognitive skill that helps an individual think more effectively and comprehensively about what it is that they learn and think about. By enhancing metacognitive skills, people are better able to regulate their learning (plan, monitor and evaluate), as well as have a better understanding of their cognition (knowing when, how and why to apply strategies to problems). Overall, well developed metacognition can help a person to learn more effectively, problem solve better, focus and manage time and skills better, and organise learning more effectively. It is for this reason that I (the teacher-researcher) would like to incorporate methods of teaching into the classroom to help enhance my learners' metacognitive skills.

2. PURPOSE OF THE STUDY:

The aim of this study is to investigate how teaching practice can be improved, through incorporating metacognitive teaching procedures into the Natural Sciences curriculum, to enhance learners' metacognition. Insight gained from this study aims to have a positive effect on the learning of those involved, and in so doing, inform teaching practice so as to improve it.

3. STRUCTURE AND PROCEDURES OF THE STUDY

The study will take place mostly in the Natural Sciences lessons, where I will incorporate certain metacognitive teaching strategies into my teaching that aim to help my learners enhance their metacognition. This will in no way interfere with the usual school curriculum. The normal lesson content will be covered.

If you voluntarily agree to participate in this study, you would be asked to do the following:

- i. Write *reflections* about the lessons conducted

At a later stage, possibly form part of a group of 9 learners, who will act as informants to provide information about how they have experienced the metacognitive teaching lessons. Each of these 9 learners will be asked to:

- ii. Complete a *questionnaire* asking her opinions, thoughts and comments on the metacognitive teaching process, as well as provide her thoughts about her own metacognitive development (this will be conducted after school hours).
- iii. Participate in a *focus-group interview* with the other 8 learners in which she may be asked to

further explain her opinions, thoughts and comments on the metacognitive teaching process, as well as her thoughts about her own metacognitive development. This interview will be conducted at a time which does not interfere with the school day and will take approximately 1 to 1.5 hours.

4. POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This study aims to enhance your metacognitive skills, through incorporating metacognitive teaching strategies, which has the potential to improve your learning and thinking abilities. This, therefore, has the potential to inform my teaching practice so as to improve it.

This study may form a foundation for future research in the development of effective instructional strategies for teachers to improve learners' metacognition.

5. POTENTIAL RISKS AND DISCOMFORTS

The reflections offer an opportunity for you to express thoughts and feelings which *you* feel comfortable sharing.

In the unlikely case that there will be questions asked during the interview that you may feel uncomfortable answering, please note that you do not have to answer them.

6. PAYMENT FOR PARTICIPATION

No form of remuneration will be provided to the participants of this study.

7. ETHICS AND CONFIDENTIALITY

Any information obtained in connection with this study, and that can be identified with you, will remain confidential, and will be disclosed only with the permission, or in the unlikely event, as requested by law. Confidentiality will be maintained by means of providing each participant with a pseudonym (fake-name), and all data collected will be kept under lock-and-key, or password protected, where only I, the researcher, and my supervisor, have access to it.

The information gained from the study will form part of a thesis which will be available to others for academic purposes. No names or identities of any participant, or the school, involved will be disclosed in the final thesis.

If you are asked to participate in the focus-group interview the interview will be voice-recorded, with your permission, purely to provide an accurate account of the interview and what is said by the learners involved.

If you are willing to participate in the study, you will be consulted regularly to confirm that you are comfortable with the data collected (relevant to you). You have the right to review any interpretations and audio-recordings and make adaptations if you feel it necessary. The audio-tapes will be erased once the thesis has been submitted and graded.

8. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer and still remain in the study. The researcher may withdraw you from this research if circumstances arise which warrant doing so.

9. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

- The researcher, Ms Alexandra Butterfield
 - Contact number: 021 8876807 (During school hours)

- Email Address: 14266164@sun.ac.za
- The supervisor of the study, Dr. Marietjie Oswald
 - Telephone number: 021 808 2037
 - Email Address: mmoswald@sun.ac.za

10. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your assent at any time and discontinue your participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact Ms Malené Fouché at the Unit for Research Development of the University of Stellenbosch on telephone number 021 8084623.

SIGNATURE OF RESEARCH PARTICIPANT

The information above was provided to me by Alexandra Butterfield. I was given the opportunity to ask questions, and if necessary, these questions were answered to my satisfaction.

I _____ hereby assent to the voluntarily participation in this study. I am happy to participate in:

- i. writing *reflections* about the lessons conducted

SIGNATURE OF PARTICIPANT

DATE

AND/OR

- ii. completing the *questionnaire*

SIGNATURE OF PARTICIPANT

DATE

AND/OR

- iii. the *focus group interview* (with audio-recording)

SIGNATURE OF PARTICIPANT

DATE

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _____ and that she was encouraged and given ample time to ask me any questions.

Alexandra Butterfield (Researcher)

Date

ADDENDUM E**STELLENBOSCH UNIVERSITY****CONSENT TO PARTICIPATE IN RESEARCH**

***IMPROVING NATURAL SCIENCE TEACHING FOR GRADE 9 LEARNERS TO ENHANCE
METACOGNITION***

You are asked to provide your informed consent allowing your daughter _____ to participate in a research study conducted by Alexandra Butterfield (MEd Psych student from the Department of Education at Stellenbosch University) and your daughter's Natural Sciences teacher. The research study will form part of the completion of a master's thesis. Your daughter was selected as a possible participant in this study because she forms part of the research population.

1. BACKGROUND TO THE STUDY:

Metacognition is commonly known as *thinking about one's thinking*. It is a higher order cognitive skill that helps an individual think more effectively and comprehensively about what it is that they learn and think about. By enhancing metacognitive skills, one is better able to regulate their learning (plan, monitor and evaluate), as well as have a better understanding of their cognition (knowing when, how and why to apply strategies to problems). Overall, well developed metacognition can help a person to learn more effectively, problem solve better, focus and manage time and skills better, and organise learning more effectively. It is for this reason that I (the teacher-researcher) would like to incorporate methods of teaching into the classroom to help enhance my learners' metacognitive skills.

2. PURPOSE OF THE STUDY:

The aim of this study is to investigate how teaching practice can be improved through incorporating metacognitive teaching procedures into the Natural Sciences curriculum to enhance learners' metacognition. Insight gained from this study aims to have a positive effect on the learning of those involved, and in so doing, inform teaching practice so as to improve it.

3. STRUCTURE AND PROCEDURES OF THE STUDY

The study will take place mostly in the Natural Sciences lessons, where I will incorporate certain metacognitive teaching strategies into my teaching that aim to help the learners enhance their metacognition. This will in no way interfere with the usual school curriculum. The normal lesson content will be covered.

If you consent to your daughter's voluntary participation in this study, she would be asked to do the following:

- i. Write *reflections* about the lessons conducted

She may at a later stage be asked to form part of a group of 9 learners who will act as informants to provide information about how they have experienced the metacognitive teaching lessons. Each of these 9 learners will be asked to:

- ii. Complete a *questionnaire* asking her opinions, thoughts and comments on the metacognitive teaching process, as well as provide her thoughts about her own metacognitive development (this will be conducted after school hours).
- iii. Participate in a *focus-group interview* with the other 8 learners in which she may be asked to

further explain her opinions, thoughts and comments on the metacognitive teaching process, as well as her thoughts about her own metacognitive development. This interview will be conducted at a time which does not interfere with your daughter's school day and will be approximately 1 to 1.5 hours.

4. POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This study aims to enhance your daughter's metacognitive skills, through incorporating metacognitive teaching strategies, which has the potential to improve her learning and thinking abilities. This therefore has the potential to inform my teaching practice so as to improve it.

This study may form a foundation for future research in the development of effective instructional strategies for teachers to improve learners' metacognition.

5. POTENTIAL RISKS AND DISCOMFORTS

The reflections offer an opportunity for your daughter to express thoughts and feelings which *she* feels comfortable sharing.

In the unlikely case that there will be questions asked during the interview that your daughter may feel uncomfortable answering, please note that she is not compelled to answer any such questions.

6. PAYMENT FOR PARTICIPATION

No form of remuneration will be provided to the participants of this study.

7. ETHICS AND CONFIDENTIALITY

Any information obtained in connection with this study, and that can be identified with your daughter, will remain confidential, and will be disclosed only with the permission of the participant, or in the unlikely event, as requested by law. Confidentiality will be maintained by means of providing each participant with a pseudonym (fake-name), and all data collected will be kept under lock-and-key, or password protected, where only I, the researcher, and my supervisor, have access to it.

The information gained from the study will form part of a thesis which will be available to others for academic purposes. No names or identities of any participant, or the school, involved will be disclosed in the final thesis.

If your daughter is asked to participate in the focus-group interview, with both you and your daughter's consent, the interview will be voice-recorded purely to provide an accurate account of the interview and what is said by the learners.

If your daughter is willing to participate in the study, she will be consulted regularly to confirm that she is comfortable with the data collected (pertaining to her). She has the right to review any interpretations and audio-recordings and make adaptations if she feels it necessary. The audio-tapes will be erased once the thesis has been submitted and graded.

8. PARTICIPATION AND WITHDRAWAL

Your daughter can choose whether to be in this study or not. If she volunteers to be in this study, she may withdraw at any time without consequences of any kind. She may also refuse to answer any questions she does not want to answer and still remain in the study. The researcher may withdraw her from this research if circumstances arise which warrant doing so.

9. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

- The researcher, Ms Alexandra Butterfield
 - Contact number: 021 8876807 (During school hours)
 - Email Address: 14266164@sun.ac.za

- The supervisor of the study, Dr. Marietjie Oswald
 - Telephone number: 021 808 2037
 - Email Address: mmoswald@sun.ac.za

10. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue your daughter's participation without penalty. You are not waiving any legal claims, rights or remedies because of your daughter's participation in this research study. If you have questions regarding your daughter's rights as a research participant, contact Ms Malené Fouché at the Unit for Research Development of the University of Stellenbosch on telephone number 021 8084623.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE
--

The information above was provided to me by Alexandra Butterfield. I was given the opportunity to ask questions, and if necessary, these questions were answered to my satisfaction.

I hereby consent to the voluntarily participation of my daughter _____ in this study. I consent to her participating in:

i.	writing <i>reflections</i> about the lessons conducted	
	_____	_____
	SIGNATURE OF PARENT OR LEGAL GUARDIAN	DATE

AND/OR

ii.	completing the <i>questionnaire</i>	
	_____	_____
	SIGNATURE OF PARENT OR LEGAL GUARDIAN	DATE

AND/OR

iii.	the <i>focus group interview</i> (with audio-recording)	
	_____	_____
	SIGNATURE OF PARENT OR LEGAL GUARDIAN	DATE

NAME OF PARENT OR LEGAL GAURDIAN

Signature of Parent or Legal guardian

Date

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to

_____.

Alexandra Butterfield (Researcher)

Date

ADDENDUM F

Grade 9 Natural Sciences

Example of Metacognitive Lesson Plans

LESSON 1:

INTRODUCTION:

Explanation of metacognition

Brief explanation of what metacognition is and why it can be of benefit to the learners, and how the lessons will be structured differently for the next 5 weeks to help enhance their metacognition.

LESSON CONTENT - Go through June exam papers (LO1 & LO2 & LO3)

Learners must go through their exam papers to make corrections of their mistakes. The following procedures are used:

1. Modelling metacognition (Self-questioning & think aloud) - be explicit (explain what self-questioning and think-aloud is and how it can be of use)

Teacher models going through an exam paper and how use it for self regulation:

4. WHAT answer did I have AND what is the correct answer? OR
WHAT did I do wrong AND what should I have done?
5. WHY did I choose the wrong answer? OR
WHY did I do it incorrectly?
6. HOW will I remember what I now know is the correct answer? OR
HOW will I make sure I don't make the same mistake again?

(For each of the questions the learners must ensure to focus on the content of each of the errors rather than focus on general causes, such as 'not studying enough')

Teacher models: Co-operative learning (pairs work & learn) - be explicit (explain what co-operative learning is and how it can be of use)

- a. Who to ask?
- b. How to ask?

The learners then go through their exam papers and for each incorrect answer they ask themselves the above set of questions:

2. Self-regulation: Error-analysis - be explicit (explain what self-regulation and error-analysis are and how they can be useful)

Learner carry out own error analysis for entire question paper

1. WHAT answer did I have AND what is the correct answer? OR

- WHAT did I do wrong AND what should I have done?
2. WHY did I choose the wrong answer? OR
WHY did I do it incorrectly?
 3. HOW will I remember what I now know is the correct answer? OR
HOW will I make sure I don't make the same mistake again?
 3. Co-operative learning (pairs work & learn together)
 - Learners can ask certain class members to help them understand where they went wrong & other learners available to help explain
 - I walk around and observe processes to check
 4. Appropriate classroom environment
 - a. Atmosphere promoting metacognition created, learners feel welcome to use metacognition where are b and c

CLOSURE

- Teacher concludes the lesson by revising the metacognitive procedures introduced in the lesson:
 - o self-questioning
 - o think-aloud
 - o self-regulation and error-analysis
 - o co-operative learning

LESSON 2

INTRODUCTION:

Ask learners to think back to the previous lessons on alternative energy and recap, as a class discussion, what they can remember

LESSON CONTENT- Alternative energy sources - scientific investigation (LO1 & LO2)

1. Provide learners with research question → Which energy source (solar, wind, or water) is most reliable?
2. Teacher models questions to **ask self (out-loud thinking)**, with all of the steps of the scientific method involved (**Self-regulation**):

Planning:	Monitoring:	Evaluating
How can I design research to test this hypothesis?	Does the research design validly test this hypothesis?	How effective was my experimental design?
What are all of the critical variables to be considered?	Should I try a different approach?	Were my conclusions justified by the results?
Which variables need to be controlled?	Am I recording all the observations accurately?	How could I be a more accurate observer and recorder next time?

3. Learners create scientific investigation on their own (all parts included) → continuously **self-monitoring** along the way (using technique just explained)
4. Teacher re-models and describes **co-operative learning** (already conducted in a previous session)
5. **Pair-up (co-operative learning)**, and explain method & thinking behind it to other learner. Correct and monitor thoughts. Make necessary adjustments
6. Class discussion about one/two good versions → **teacher models think aloud**

CLOSURE

Teacher asks learners to write down how and when they may use the techniques learned in that lesson again (**self-regulation and transfer**)

ADDENDUM G**Timetable of my intervention plan**

Term 3 2011				
Date	Days	Lesson Content	Scientific Concepts or process skills	Metacognitive teaching
18	Mon			
19	Tues	Explanation of metacognition Go through June exam papers	Accessing information; Analyse and evaluate acquired knowledge and apply it to new unfamiliar context; Raising questions about a situation; Predicting	- Modelling metacognition (Self-questioning & think aloud) - Self-regulation: Error-analysis - Co-operative learning (pairs work & learn together) - Appropriate classroom environment
20	Wed	Finish going through June exam	Accessing information; Analyse and evaluate acquired knowledge and apply it to new unfamiliar context; Raising questions about a situation; Predicting	- Finish Self-regulation: Error analysis - Transfer of these skills/knowledge: teacher questioning - Reflection on process - Refer to prompted answer page - Self-regulation (Monitor progress - think of goals to improve & how to reach these)
21	Thurs	Uses of Minerals & fossil fuels	Selecting key ideas; Synthesis of knowledge to create new meaning; Sorting and classifying; Flow charts, diagrams, mind-maps	- Modelling of organisation of concepts - think -aloud - Teacher modelling → graphic organiser - Summarising → modelled - Learners do own graphic organiser (involves summarizing) - Scaffolding - Teacher questioning - Appropriate classroom environment
22	Fri	Alternative energy sources <div style="border: 1px solid black; padding: 5px; text-align: center;">REFLECTION (H/W)</div>	Selecting key ideas; Synthesis of knowledge to create new meaning; Sorting and classifying; Flow charts, diagrams, mind-maps	- Teacher questioning - Teacher modelling - Graphic organiser concept map - Learners do own graphic organiser (involves summarizing) - Appropriate classroom environment
25	Mon	Alternative energy sources	Recall and describe knowledge; Sorting and classifying; Interpreting information; Hypothesising; Communicating science information	- Teacher modelling - think aloud - SRLP technique CASS ASSESSMENT
26	Tues			

27	Wed	Efficient & economical use of energy sources	Selecting key ideas; Synthesis of knowledge to create new meaning; Sorting and classifying; Flow charts, diagrams, mind-maps	<ul style="list-style-type: none"> - Co-operative learning - Graphic organiser (already modelled) - Appropriate classroom environment - Self-directed teaching
28	Thurs	Alternative energy sources - scientific investigation REFLECTION (H/W)	Design and plan investigations: <ul style="list-style-type: none"> - identifying a problem, - hypothesising; - selecting apparatus; - planning the experiment; - Observing and comparing - Measuring - recording results; - understand the need for verification or replication 	<ul style="list-style-type: none"> - Self-regulation - Teacher modelling → think aloud & self-questioning - Self-questioning & monitoring - Think aloud collaborative learning (peer) - Self-directed teaching - Transfer of skills
29	Fri			
1	Mon			
2	Tues	Introduction to reproduction	Accessing information; Recall and describe knowledge; Analyse and evaluate acquired knowledge and apply it to new unfamiliar contexts; Raising questions about a situation	<ul style="list-style-type: none"> - Teacher modelling & questioning - Learner reflection/self-regulation - Appropriate classroom environment - Self-directed teaching
3	Wed	Reproduction (types included) Female reproductive system	Selecting key ideas; Synthesis of knowledge to create new meaning; Sorting and classifying; Flow charts, diagrams, mind-maps	<ul style="list-style-type: none"> - Teacher questioning - Appropriate classroom environment - Scaffolding - Teacher Modelling - Graphic organisers - Self-directed teaching
4	Thurs	Sex cells / gametes REFLECTION (H/W)	Selecting key ideas; Synthesis of knowledge to create new meaning; Sorting and classifying; Flow charts, diagrams, mind-maps	<ul style="list-style-type: none"> - Self-regulation (quick assessment) - Teacher modelling - Scaffolding - Transfer - Graphic organisers - Summarizing - Self-directed teaching
5	Fri	Menstruation	Accessing information; Recall and describe knowledge; Analyse and evaluate acquired knowledge and apply it to new unfamiliar contexts; Raising questions about a situation	<ul style="list-style-type: none"> - Teacher questioning - Appropriate classroom environment - Reciprocal teaching - Self-questioning - Self-regulation - Self-directed teaching
8	Monday	School holiday		
9	Tuesday	Public holiday		

10	Wed	Fertilisation & conception	Accessing information; Recall and describe knowledge; Analyse and evaluate acquired knowledge and apply it to new unfamiliar contexts; Raising questions about a situation	<ul style="list-style-type: none"> - Think out loud - Cooperative learning - Appropriate classroom environment - Self-monitoring (regulation) - Self-directed teaching
11	Thurs	Contraception REFLECTION (H/W)	Accessing information; Selecting key ideas; Synthesis of knowledge to create new meaning; Recall and describe knowledge; Raising questions about a situation; Interpreting information; Communicating science information	<ul style="list-style-type: none"> - Teacher questioning - Reciprocal teaching - Appropriate classroom environment - Self-directed teaching
12	Fri			
15	Mon			
16	Tues	Pregnancy & placenta QUESTIONNAIRE (for informants)	Accessing information; Selecting key ideas; Synthesis of knowledge to create new meaning; Raising questions about a situation; Interpreting information;	<ul style="list-style-type: none"> - Teacher questioning - Summarising - Visual aids - Self-directed teaching
17	Wed	Taking care of your unborn baby	Design and plan investigations: <ul style="list-style-type: none"> - Identifying a problem, - Hypothesising; - Selecting apparatus; - Planning the experiment; - Observing and comparing - Measuring - Recording results; - Understand the need for verification or replication 	<ul style="list-style-type: none"> - I-DREAM A technique (self-questioning & self-regulation) - Modelling - Appropriate classroom environment - Cooperative learning - Self-directed teaching
18	Thurs	Birth & breastfeeding	Accessing information; Selecting key ideas; Synthesis of knowledge to create new meaning; Recall and describe knowledge; Raising questions about a situation; Interpreting information; Communicating science information	<ul style="list-style-type: none"> - Teacher questioning - Modelling - Summarising - Graphic organisers - Self-directed teaching
19	Fri	The entire reproductive process INTERVIEW (for informants)	Accessing information; Recall and describe knowledge; Raising questions about a situation; Communicating science information	<ul style="list-style-type: none"> - Self questioning - Self-regulation - Graphic organisers - Self-directed teaching

ADDENDUM H

GRADE 9 Natural Sciences

REFLECTION: WEEK 1

My reflections

What are my thoughts on this week's Natural Sciences (NS) lessons?

1a

- What stood out about what I learnt in NS this week?

What have I learnt over the last week in NS?

1b

- What helped me learn this?

What has the teacher done *differently* in the lessons that stood out? What was the purpose of her doing this?

1c

What skills did I learn this week in NS?

1d

When, where (other than in the classroom/test situation) and how will I use these skills again?

○ When?

○ Where?

- How?

Why do people ask questions?

1e

What type of questions is helpful to me?

What is a hard/easy question?

How do I feel when my teacher asks me a question?

What was difficult about this week's NS lessons?

1f

- Why was this difficult?

From what I learnt this week in Natural Sciences, it is important to remember that

1g

A question I now have is ... / What I need to do now is ...

1h

- I am confused about ... / I wonder ... / I am stuck on

How will I approach my work differently now that I have experienced this week's lessons?

1i

- The next task or activity I am given, I will now

Other thoughts, comments or questions that I have ...

1j

ADDENDUM I**GRADE 9 NATURAL SCIENCES****Open-ended questionnaire**

*Please use the following questions to guide your reflection. Be as specific as possible in your answers and try to avoid vague answers. Please answer **all** the questions and be as detailed as possible in your explanations.*

1. In what way has the last 5 weeks of Natural Sciences lessons differed from how Natural Sciences have been taught to you in the past?

2. How have you learned about yourself as a learner over the last 5 weeks through participating in the different activities in Natural Sciences?

For example:

What more do you know about your preferred ways of learning and thinking?

What are your insights about helpful and less helpful strategies?

Do you know how to help yourself get a better understanding of something? If so, what is it that you do?

3. How helpful have you found the reflection activities for engaging (interacting) with the different knowledge and skills you have learnt in Natural Sciences over the last 5 weeks?

4. For each of the following, please indicate how and why they were useful or not useful to you. (Please remember to indicate **how** and **why** they were or were not useful).

Activity	How & why it was useful	How & why it was not useful
When the teacher demonstrated her way of thinking by saying it out-loud		
How the teacher tried to help you think of ways to use your skills in other situations or places.		
Being taught how to summarise		
Being taught how to use graphic organisers like concept maps, flow charts, cycles etc		
Thinking aloud with a partner		
Thinking aloud to yourself		
Acting as the teacher yourself, and the teacher acting as the learner		
Teaching other classmates		

Constantly being asked questions which make you have to think about what you are doing?		
Using the KWL technique: K: What do I already know? W: What do I want to know? L: What have I learned?		
The 'I DREAM A' technique: I: identify D: diagram R: recall E: explore A: applying M: monitoring A: assessment		
Having to check, self-correct and reflect on your errors after a test/exam		
The SRLP method: Ask; Tell; Try; Check; Cheer		

5. What were the aspects of the Natural Sciences lessons over the last 5 weeks that you particularly liked and disliked?

After the last 5 weeks of Natural Sciences lessons:

- a. How do you now think differently about your own 'thinking skills'?

- b. How do you now think differently about *planning* activities or tasks?

- c. How do you now think differently about *monitoring* your progress?

- d. How do you now think differently about *evaluating* or checking your progress?

6. How will you approach your work differently after the last 5 weeks of Natural Sciences lessons?

7. Do you have any other comments, suggestions or thoughts which you would like to add to your reflection?

ADDENDUM J

FOCUS GROUP INTERVIEW GUIDE

Interview Guide - Focus group interview

August 2011

1. Introduction and preliminaries

- 1.1. *Welcome & thank you for agreeing to participate - act as informants*
- 1.2. *Motivation: explanation and purpose of the focus group*
 - To check/verify data
 - To enrich data
- 1.3. *Confidentiality and anonymity*
 - Remind of criteria in assent and consent form
 - Voice record → anonymous with pseudonym
- 1.4. *Format*
 - Conversational (speak slowly and clearly) - be as honest as possible
 - Try not to speak over others
 - Try to give detailed answers - not just yes/no
- 1.5. *Length of interview*
 - 1 hour to 1.5 hours
- 1.6. *Discuss & remind about:*
 - *Tape recorder / Video recorder*
 - *Assent for this*

2. Background information for each learner

- 2.1. *Confirm what is already known about the learners*
- 2.2. *Find out any additional information that is needed.*
 - Introduce themselves
 - Give pseudonym (also a way of checking recording)
 - Give age, home language & cultural group

3. Rapport building and creating a comfortable place for discussion

4. General metacognitive development

- 4.1. *Please describe any **experiences** you have had from being taught Natural Sciences with Metacognitive teaching procedures.*

Prompt

- a. Tell me about your **personal change & growth** over the last 5 weeks in terms of **learning and thinking**.
 - Has anything **changed**?
 - Why or why not?

4.2 You all noted in your **goals** that you wanted to do better in NS. Can I ask you each to tell me what your reasoning for that may be?

Prompt

- Subject choice or career choice?

5 Teaching procedures

5.1 Of the teaching activities and procedures:

- Were there any that were more effective than others?
- Were there any that you preferred? Why?

5.2 Some of you mentioned that the **reflections** really helped you in different ways. Can you elaborate on this?

Prompt

a. Some of you said that you enjoyed the **teaching and working with others** (collaborative learning) and found it useful others not so much. Can anyone comment of this?

5.3 Some of you seemed to take on the different techniques very **quickly and easily**. Can you tell me about this?

5.4 Many of you remarked that you were able to write more in your later reflections compared to the initial ones. Can you tell me about this?

5.5 Some of you mentioned in your final questionnaire that you felt you were getting much more involved in the work these last 5 weeks. Can you elaborate on this for me?

6. Classroom atmosphere

On the day that the classroom environment was not such a 'happy one', can you tell me, how was your thinking and learning effected because of the classroom atmosphere?

Prompt

- Were you working more effectively than usual?

7. Process in general

7.1 Overall, have the adapted teaching techniques I have used helped you to:

7.1.1 **Think more about your thinking?**

7.1.2 **Think about and/or work in better ways with your learning** (in order to consciously work in a certain way) you first need to think about it)?

7.2 Do you think that you would have become aware about all these things about your thinking and learning had the last 5 weeks of NS not happened?

8 Learning in the future

- 8.1 You have been taught and exposed to a whole lot of new skills and different teaching techniques.

Do you think you would continue to use these in other settings in the future or not, and how?

9 Additional information

- 9.1 Are there any further comments **and/or** suggestions?

- even concerning the way it was taught?

- 9.2 Is there any additional information that you wish for me to know?

10 Closure and Thank you

ADDENDUM K

Example of teacher-researcher research journal entry

25 July 2011

Structure of the lesson

Today's lesson had to be switched with the lesson planned for 27 July as the school was taking photos today. This meant some learners would be out of the classroom and therefore I could not do an assessment (for marks) with them today as planned - some may be called out half way through the lesson. Therefore, instead of wasting the lesson and doing nothing, I decided to carry out the activities I had planned for the 27th.

In the very first part of the lesson I took in the reflections the learners had to do. I got the sense that the learners feel the reflections are extra work for them which is not as important as homework.

I first began by explaining what co-operative learning is and I did this by asking the learners to think about what the word co-operation means to them. In hindsight, I should have put more into this explanation about the benefits of co-operative learning, and discussed with the learners more about when and how it could be useful. After explaining the lesson activity and putting the learners into pairs (I tended to place a weaker learner with a stronger learner), they got started with the activity of going through the sections allocated to them. After 20 minutes, I suggested they now 'teach' one another. Some learners seemed to really make use of the opportunity whereas others didn't make optimum use of their time. Some of them worked better when preparing by themselves, but didn't seem to do well when they had to explain to one another. It seemed some of the learners didn't take it very seriously either. A possibility for the next time I do cooperative learning is to ask them to assess the manner in which the other learner teaches. In this way, the learners may be motivated to work enthusiastically when doing the activity. A better explanation at the beginning, including an explanation of the benefits of cooperative learning, may have also increased enthusiasm or dedication for the activity.

Some of the learners seemed uncertain as to how to teach their peer, whereas others seemed to thrive in the experience. One learner commented that she did not know what information to include and what to leave out. When learners asked me for the answers to certain questions, I suggested that they try, when teaching their peer, to ask the peer for advice, as this was part of the point of the activity. I will be interested to see how the learners reflect on this activity. I feel they should have had more time to better engage with their topics and possibly bring some information from home to add to it. However, despite this, some of the learners did very well when explaining to their partners. They showed insight that proved they had truly thought about what it is they wanted to say when they taught their partner. It also seemed to work well having a stronger and a weaker learner together as the stronger one (more knowledgeable peer) could guide the other learner, but this stronger learner also got the opportunity to regulate her thinking.

A summary at the end, including the main concepts covered, as well as a 'recap' of the teaching technique employed, could also have proven useful in better facilitating the learning process.

My reflections

I get the feeling that I am rushing through and not explaining explicitly enough, each of the metacognitive procedures introduced. Not only did I get this feeling in today's lesson, but I also realized this when I gave the learners their homework to complete a concept map in this session (which they have done in the last session). Quite a number of learners did not know what to do. Many seemed concerned they were not going to fit it all on one page showing that they don't understand that only the major concepts are needed. Another learner seemed confused thinking it must contain positives and negatives like the last concept map. This clearly implies that I need to improve my explanations of the purpose of the different metacognitive tools I incorporate. One way to improve this is to from now on spend more time explicitly explaining what the procedures are and what the benefits of them can be. To try and improve the process as it stands now, I could possibly include a summary of the different metacognitive procedures used up until this point in one of the next lessons, recapping those used thus far.

Some learners also did not make effective use of their time sitting at the end of the lesson, not doing anything when they could be completing their homework. I have in the past experienced these learners complaining that they have no time, or run out of time for school work, and now I notice they waste time. This is evidence of poor metacognition. Hopefully, over the next few weeks, the learners will start to employ the metacognitive techniques they have learnt to overcome this limited metacognition.

I did however notice at the end of the session, after encouraging the learners to make use of the last little bit of the lesson more effectively, that some actually started using the time effectively.

I am still finding it difficult to keep track of everything that is going on in the class at the same time. I keep a note book with me now as well as a class list to note anything of relevance that happens in the class that is of relevance.

Re-arranging the lesson plans was a bit frustrating today/ I had planned to get the learners to plan for the co-operative teaching before-hand (preparation as home work from the session before) so that they could come into the lesson with well prepared work to 'teach' their partner. However, this was one of the things that I needed to learn from for the future. It also makes me realise how important it is to be flexible in one's lessons. I tried to make the cooperative teaching activity work in the situation, and instead allocated the learners a certain time to do their planning and their 'teaching'. I announced when each time slot was up. This worked alright, but I think that it would have worked better had the learners had a chance to prepare at home the day before.

ADDENDUM L**Portion of transcription from the focus group interview**

Speaker	<u>PORTION OF THE TRANSCRIPTION FROM THE FOCUS GROUP INTERVIEW</u>	Coding	Comments
Interviewer/ researcher:	Ok. So I want to start off with a sort of general question, before asking more specific questions to some of you. So like I mentioned earlier, just try to not speak over one another when answering. Ok, so if we think about metacognition, and how your metacognition has developed over the last five weeks, well just more than 5 weeks, where I have been implementing certain ways of teaching metacognitively, I want you to think about what your experience has been like with this new metacognitive teaching? If you can think of that? Who wants to get the ball rolling? Yes [Innocentia]		
Innocentia:	Um, the experience, has been like interesting, and it has <u>opened, well like, taught me things that I didn't know about myself, like the way that I prefer to study.</u> Like usually, I would just read,	Met Awa - Dec	Improved metacognition: declarative knowledge
Interviewer/ researcher:	Um, huh		
Innocentia:	And then that's how I study, but now, like, I use concepts maps and stuff, that's <u>like really helped me a lot</u> and just basically, like I have learnt of the many mistakes that I do, and better ways to study.	Met Awa - Dec	
Interviewer/ researcher:	Ok, alright. Yup?		
Lena:	Umm, I, umm, well it was <u>very positive for me</u> because I was <u>thinking more about planning when to study.</u> And before, I just sort of like started studying, and <u>now I am always thinking</u> of doing mind maps, and ...	Met Awa Plan (Met Reg) Met Awa	Improved metacognition due to intervention
Interviewer/ researcher:	Sorry, you mean now as in, after these 5 weeks?		
Lena:	Ya. But kind of also during the 5 weeks. <u>I think more about this now than I used to.</u> I like, ya, I use more mind maps...	Met Awa	Improved metacognition
Interviewer/ Researcher:	Than what? What did you used to do?		
Lena:	I used to just go through like the work, and study it like that, but with mind maps I use more colours and also <u>the mind map is set out in a way that I can remember it better, I don't know why, but it helps me.</u>	Met Awa	Poor metacognition - need for improvement
Interviewer/ researcher:	Ok, when you said you used to go through your work, what did you do when you went through your work?		

Lena:	Um, I didn't, well <u>sometimes I made mind maps, but I didn't always do them, like very seldomly and now that we already did them in class. I could use them when studying.</u> And because it's easier for me to study from mind maps, it was easier to study.	Met Awa - Dec	Poor metacognition - need for improvement
Interviewer/ researcher:	Did you find that you only realized that in these five weeks, or did you always know that mind maps worked [cross talk] well for you?		
Lena:	No, I always thought that mind maps were, I didn't really like them, and <u>I thought that it was a lus to do them,</u> and ... (group laughter)	MV & S-disc	Motivation needed, as well as self-discipline
Interviewer/ researcher:	Who agrees? Do you agree? Yes, you [Saskia], [Zayaan] agrees, [Mavis] and [Innocentia], and [Lesley], and [Noma]? I am just saying them out loud for the purpose of the voice recorder and so that I remember.		
	Ok so you are <u>really realizing now that that works for you?</u>	Met awa-dec	Improved metacognitive awareness of methods that are useful for themselves
Lena:	Ya that really helps.		
Interviewer/ researcher:	Ok, [Lesley].		
Lesley:	Ok, I also <u>never used mind maps before, 'cause also because it took up a lot of your time, and my notes were just like, under each other (She means bullet point summaries) and if you keep on reading in the same order, you get bored after a while.</u> So after doing the mind maps, I saw by looking all over the page, it keeps you like almost <u>focused more,</u> 'cause you're not reading like, straight under each other, so now in my notes I always do it in a mind map, so that some of the note will be on this side, and others on this side (<i>pointing to opposite sides of an imaginary piece of paper</i>) just so that you can cross over the page so that it keeps me focused, and I use way more colour.	M Strat Met awa - dec Mon; Eva	Teaching strategy employed Poor metacognition in the past Improved regulation of cognition
Interviewer/ researcher:	So it's almost like it <u>keeps your mind more active?</u>	MO	'Minds on' metacognitive episode of learners
Lesley:	<u>Ya,</u> because reading bullet form in one straight line in the same direction the whole time, almost makes you easily bored. <u>But by looking all over the page and looking for where the notes are it, ah... almost keeps your mind more active.</u>	Met awa Met awa	
Interviewer/ researcher:	Ok, so you think the mind map and the different positions of the content, as well as colour helps you study better and you can focus better in that way.		
Lesley:	Ja.		
Interviewer/ researcher:	[Dylan]?		
Dylan:	I know it's sort of wrong, but I <u>used to do it parrot fashion,</u> because at our old school it was always like, "you guys need to go <u>over your work, and over it and over it</u> " like a parrot, but now I don't know if I use mind maps or not because I use a combination because I put the important things in there <u>'cause I use more information than what a</u>	Met awa Plan, mon, eva	Improved metacognition Poor regulation of cognition Poor evaluation of

	<u>mind map normally uses.</u>	eva	cognition
Interviewer/ researcher:	So you feel you put...		
Dylan:	More information. Because if I only put a little bit of information then I think you know like I'm not gonna get it right in the test		
Interviewer/ researcher:	Uh huh, uh huh		
Dylan:	Because then I might not be able to know the whole answer.		
Interviewer/ researcher:	Ok ok. So when you say you used to learn it parrot fashion, what did you do?		
Dylan:	<u>I used to read it like a story book. Like you read the things that you've summarized over and over.</u>	Met awa	Poor metacognitive skills in the past
Interviewer/ researcher:	And just read? Did you just read, read, read? Read it through and through?		
Dylan:	Ya.		
Interviewer/ researcher:	Did you say it to yourself?		
Dylan:	No, you just like read it in your mind like you read a book.		
Interviewer/ researcher:	Ok. [Noma]?		
Noma:	<u>Well it was definitely different. Because in other classes you would just write down the information (from the board). You wouldn't like make a mind map of it. That really helped because when it came to the test it felt like I already knew the stuff before I even had to study it. But, my way of studying, I realized now during this 5 weeks, that saying the work aloud really helps me. That's like the main thing. 'Cause when I taught in class about fertilization and the menstrual cycle and everything, when I started studying it was like, ah I already know this. Yay. So ya, the oral, saying it out loud really helps me. I realized that in these 5 weeks.</u>	GTP & TS Met Awa- mon	Evidence of an effective teaching procedure & improved teaching practice
Interviewer/ researcher:	Um, so do you feel that this has just happened in the last 5 week that you've come to this realisation? You didn't really know about this before.		
Noma:	I knew it slightly before, but I didn't do it as much so, ya.		
Interviewer/ researcher:	So you have really confirmed that for yourself now?		
Noma:	Ya.		
Interviewer/ researcher:	[Lee]?		

<p>Lee:</p>	<p><u>What I want to say, is like kind of what [Noma] said, is that 'cause you go over the work in class, like you made us say it and practice it more, and the mind maps. So the work kind of stays with you. So when you study, you don't really have to focus that much on the work, 'cause you know it already. And also, the methods, you know you asked us in the reflections where else you could use it. And over this 5 weeks, we could use it in other classes as well, using the same methods. You know, when you have to study in other subjects, you think to use like a mind map, because if it helps us in science it could help us in another class.</u></p>	<p>GTP; TS; T-prac; Met awa</p>	<p>Improved teaching practice, effective teaching procedures & improved metacognition</p>
<p>Saskia:</p>	<p>Yes, like I found that <u>copying off the board for example is easier, but then when we made the mind maps, when studying it's much easier 'cause then I knew it</u> (already from the having to do the mind maps).</p>	<p>Con & trans</p>	<p>Improved conditional knowledge and the ability to transfer skills</p>
<p>Interviewer/ researcher:</p>	<p>I wanted to asked you all a question just now, but I think I'll bring it in here. A couple of you in the reflection said that it is easier copying straight off the board?</p>	<p>MV & S-disc</p>	<p>The positive effects of motivation & self-discipline</p>
<p>Saskia:</p>	<p>Yes, it is easier copying off the board, but then when you're studying, after doing mind maps, when <u>I saw my marks were much better.</u></p>	<p>Met Awa: Mon & Eva</p>	<p>Improved metacognition; improved academic ability</p>
<p>Interviewer/ researcher:</p>	<p>Yes. So [Dylan], what did you find what better for you? Copying off the board, or having to do the work yourself?</p>		
<p>Dylan:</p>	<p>No, I like writing stuff down, but when you write the stuff down, <u>you don't really know it.</u> And because I have got a bad eye, sometimes I copy things incorrectly off the board and <u>I leave stuff out.</u></p>	<p>Met Awa; eva</p>	<p>Learner regulation of cognition</p>
<p>Interviewer/ researcher:</p>	<p>Ok</p>		
<p>Dylan:</p>	<p>So, mind maps are easier because I can basically see everything. But <u>I don't always know if I have enough information. That's why I use summaries as well.</u></p>	<p>Met awa; dec & eva</p>	<p>Improved metacognitive both regulation & knowledge of cognition</p>
<p>Interviewer/ researcher:</p>	<p>But a mind map is a form of a summary essentially?</p>		
<p>Dylan:</p>	<p><u>Ya, but you know, like, I find it easier to study the mind maps, if I say it like an oral, because if I say it like an oral, I need to know all the stuff.</u></p>	<p>Met awa</p>	<p>Learner improved metacognition</p>
<p>Interviewer/ researcher:</p>	<p>So am I correct in saying, that you also felt, that sometimes <u>there was a bit more effort required when you do it yourself.</u></p>		
<p>Dylan:</p>	<p><u>Yes, like in the first week it was a lus.</u></p>		
<p>Group</p>	<p>Mmm, <u>ya (aggreance from most of the group)</u></p>	<p>MV; S-Disc</p>	<p>Effort required proves effective. Need motivation and perseverance</p>
<p>Interviewer/ researcher:</p>	<p>Ya, I noticed [Me and the group laugh]. But, so you <u>did find that it is actually better for you to write it yourself, and make your own note of it?</u></p>		

Group	<u>Ya</u> [general consensus]		
Interviewer/ researcher:	Ok.		
Zayaan:	Ya, and like after you've done a section and you asked us to make the mind maps (it was actually concept maps) you can just go back to these notes, and it's much easier, because <u>now you can know just where you have to focus on.</u>	Met awa: mon & eva	More focus given
Dylan:	Ya, like you don't have to <u>waste time doing the notes again, because</u> it is already simplified form.	Plan	Improved regulation of cognition
Zayaan:	Ya, especially the concept maps. It definitely helped		
Lena:	<u>Also when we have to write the work down (from the board) you explain it at the same time, I can't always listen to you explanation because I can't really listen and write because I wanna make sure like, I write down the correct thing.</u>	T-Prac & TS	My own reflection to improve my teaching practice
Interviewer/ researcher:	So if I am talking and you are trying to write, it's difficult to focus on what I am saying, and write?		
Lena:	Ya, and <u>if you do the mind map yourself, or the notes yourself, then you think about it more than by writing it down and listening.</u>	Met awa: dec & proc	
Interviewer/ researcher:	<u>You are almost forced to think?</u>	GTP	Teaching practice forced learners to think
Group	<u>Ya. Ya. [Group consensus]</u>		
Dylan:	And <u>sometimes I try write down what ma'am says and I forget about the writing on the board.</u>	Met awa	Used to reflect on & improve my teaching practice
Group	(group laughter)		
Interviewer/ researcher:	Ok, so let me just check for my own sake, so you girls find it difficult when like I put something up on the board, let's say, the old style of working versus this new style. Did you find it difficult when I am talking for you to copy it down at the same time?		
Dylan:	Because we don't want to waste your time, by like writing the stuff down.		
Saskia:	And even though you say stop writing, it is so tempting to just write.		
Interviewer/ researcher:	Ok. So it was difficult for you? And that's what I actually want to know. <u>That it wasn't as effective trying to write while I am talking?</u>	Met Awa: eva & mon	Learner regulation of cognition
Saskia:	Yes, I sometimes would try to keep up with you as you are talking, and <u>I would write things down then differently (Incorrectly)</u>		
Noma:	Because sometimes when we are writing and you are talking, you might say something that is important and that we might need to know for a test, and then we don't catch that.		

Interviewer/ researcher:	Mmm, ok.		
Lesley:	Ma'am, I used to have a teacher, this was in primary school, and before we started the lesson, she told us to read through that section, and then explained it to us. And then after she explained it to us, then we would write down what she put on the board. So when we read, we more or less know what's going on, but then she explains it to us, but we still write it down as well then afterwards. And that also really worked well.		
Interviewer/ researcher:	Ya. And that would be nice, the problem is ... [talking over one another]		
Saskia:	People get bored then as well.		
Interviewer/ researcher:	Yes, bored. Also, time. <u>People read at different paces. Now what the ideal would be is to say to you, read this chapter for homework tonight, we are doing it tomorrow, [talk over one another]</u>	T-Prac; GTP; MV & S-disc	Used to reflect on for my improved teaching practice
Dylan:	Half the class wouldn't		
Interviewer/ researcher:	But who would actually read it. So if we could do it in class it would work ideally, but that would only be if we had the time.		
Lena:	But that's also your own <u>responsibility</u> .	S-disc	Ideal SA learner
Interviewer/ researcher:	Absolutely		
Lena:	<u>If you wanna know the work and you don't read it then it's your problem</u>	S-disc & MV	Ideal SA learner
Interviewer/ researcher:	That's a nice suggestion		
Saskia:	<u>I think it also helps now that the topic is interesting.</u>	Int	Teacher reflection for my teaching practice
Interviewer/ researcher:	True, ok. Now you want to read and know about it. I actually want to ask you about that just now. [Mavis] how do you feel that you have grown, developed, changed, or do you think you have grown, developed or changed in terms of thinking and learning over the last 5 weeks.		
Mavis:	<u>I think I do, it has helped because my Natural Science marks have improved.</u>	Met awa	Improved academic ability from intervention
Interviewer/ researcher:	Um huh		
Mavis:	Ya, <u>so I think it has helped.</u>	Met Awa	Improved metacognition due to intervention