Manifestations of metacognitive activity in an upper undergraduate organic chemistry laboratory

By

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ABSTRACT

This study was carried out to investigate how metacognitive activity, particularly cognitive regulation, manifests in the collaborative planning of chemistry practical investigations by senior undergraduate students in a simulated industrial project. The participating students worked in *home* groups to evaluate three synthetic routes for a given compound, and decided on a preferred route while considering the criteria of cost, technical challenge, and environmental impact. This is consistent with the jigsaw learning technique. During the planning session, the students who were evaluating the same synthetic routes convened in *specialist* groups to draw up detailed experimental procedures for their routes.

Audio recordings of the two *specialist* and the four *home* group discussions were purposively selected, transcribed, and analysed for manifestations of metacognitive regulation. This study started with a partial theory of what constitutes cognitive regulation in collaborative group discussions, and as the research progressed, verbal indicators of each component of cognitive regulation were inductively determined from analysing the pilot study data. These were then compiled into a coding scheme. The coding scheme was further refined following recommendations of an analytic audience. The students' self-reports were collected through retrospective stimulated recall interviews and were used to triangulate the findings inferred from the group discussions. This study has made important theoretical and methodological contributions.

The coding scheme proved to be both conceptually and methodologically useful in that it allowed for fine-grained coding. The system of coding interrogated not only the manifestations of metacognitive regulation at play (*planning*, *monitoring*, *control* and *evaluation*), but facilitated an in-depth look at the types of regulation, i.e. *self* or *other,* the areas where students applied their efforts towards regulation (*cognition*, *behaviour* and *task performance*) as well as the depth of cognitive regulation (*low* or *high*). The coding scheme went beyond serving as a tool for characterising manifestations of metacognitive activity, it developed into a framework which provides a finer theoretical elucidation of the social nature of metacognition.

I show in this thesis how in group work metacognitive activity was found to be predominantly other-regulatory, manifesting mostly as control and monitoring, with much fewer instances of

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planning and evaluation. These observations were made across all groups despite the differences in social context. The low occurrence of planning, evaluation and high-level regulation seemed to suggest a hierarchy in terms of the level of difficulty of metacognitive regulation. An even deeper look revealed that individual patterns of regulation differed in terms of individual dispositions and personal goals. Investigating the transferability of the individual patterns of regulation increased the originality of this study. Both the personal characteristics (extrovert vs introvert) and the personal style of regulation (assertive vs tentative) were found to be transferable and not group dependent.

The findings of this study show that peer interaction in collaborative tasks can facilitate achievement of collective conceptual understanding and learning gain through inter-individual regulation in social contexts. However, students find planning, evaluation and high-level regulation challenging, especially in social contexts. I suggest that concerted efforts should be made to teach students to make the most of group work by identifying and introducing instructional strategies that develop the desirable skills of egalitarian collaboration and the more difficult aspects of cognitive regulation and high-level engagement. Strategies such as metacognitive prompts, teaching students about team development techniques and exposing students to collaborative ill-structured tasks could be helpful in this regard. Some suggestions have also been made in terms of directions for future research.

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DECLARATION

I, Kgadi Clarrie Mathabathe, declare that the thesis/dissertation, which I hereby submit for the degree of Doctor of Philosophy (mathematics and science education) at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE:

DATE: 02 June 2016

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DEDICATION

I registered for my PhD degree in 2013. In January 2014 I lost my brother. In January 2015 I lost my mother. In July 2016 my father passed away. I dedicate this thesis to my departed brother, Lawrence Nushi Maponyane, mother, Johanna Lihloka Maponyane and my late father, Robert Boy Maponyane. They looked forward to seeing me complete my studies but never lived to see it happen. *Robalang ka kgotso Bakwena!*

I also dedicate this work to my husband, Neo Lucas Mathabathe and my son, Neo Tshegofatso Mathabathe. Your love and support pushed me to do more when I felt like giving up. God knows how many times I wanted to quit. *Ke a leboga!*

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I wish to thank the chemistry staff and third year organic chemistry students of 2013 and 2014. By allowing me to participate in your project and to be part of your classrooms, you made this study possible. I am eternally grateful for your support and understanding.

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Last but not in any way least, I would like to thank my two sisters, Maisy and Sekedi and my brother Sammy, my in-laws the Mathabathes and my esteemed colleagues. Your advice and support kept me strong.

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LIST OF ABBREVIATIONS

Abbreviations

SSMR:	Socially Shared Metacognitive Regulation
RC:	Regulatory Checklist
RLSQs:	Reflective Learning Strategy Questionnaires
CD:	Compact Disc
PLAN:	Planning
MON:	Monitoring
CTRL:	Control
EVAL:	Evaluation
COGN(C):	Cognition about the chemistry concepts
COGN (T):	Cognition about the task
BEHAV:	Behaviour
TASK:	Task performance
CAQDAS:	Computer Assisted Qualitative Data Analysis Software
SR:	Self-regulation
OR:	Other-regulation
Non-MR:	Non Metacognitive Regulation
MR:	Metacognitive Regulation
LL:	Low-Level
HL:	High-Level
SI:	Seek Information
GI:	Give Information
noCJ:	No Conceptual Justification
SM:	Seek Meaning
VM:	Volunteer Meaning
CJ:	Conceptual Justification
ST:	Stimulate Thinking
SG:	Specialist Group
HG:	Home Group
IND INT:	Individual Interview
SG INT:	Specialist Group Interview
MSDS:	Materials Safety Data Sheet

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LIST OF FIGURES

Figures are numbered according to chapters they relate to (Chapters 1, 2, 3, 4, 5, 6, and 7)

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LIST OF APPENDICES

Appendices are numbered according to chapters they relate to (Chapters 1, 2, 3, and 4)

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GLOSSARY

Laboratory activity: the hands-on component of the organic chemistry course, which entails conducting experiments in a laboratory setting.

Lecturer: instructor of the course.

Teaching assistant: postgraduate chemistry student employed on a part time basis to offer academic support to students during laboratory activities.

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CHAPTER 1

INTRODUCTION TO THE STUDY

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CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 Introduction

In science education literature, it is widely recognised that the enrichment of students' cognitive development while they learn and master subject matter should be accompanied by the simultaneous development of metacognitive capabilities. High metacognitive ability is associated with desirable attributes such as self-regulated learning, academic success, and problem solving (Rickey & Stacy, 2000). This study emerged from an interest in the manifestations of metacognition in undergraduate chemistry, a subject generally known to be a gateway course that hampers the progress of students enrolled in science programmes. Through this study, I aimed to explore metacognitive activity in the undergraduate laboratory, an environment about which little is known in this regard.

1.2 Background and rationale of the study

As a university student I had first-hand experience of following instructions to carry out experiments in the laboratory without critically thinking about and evaluating the process and purpose of the exercise. This made it difficult for me to interpret my results and write a laboratory report with insight and understanding. I am of the view that when students understand what they are doing they become actively involved and they can reason and justify every step or come up with an even better way of carrying out some steps in an experiment. Monitoring and regulating their learning and understanding while carrying out an experiment become easier and necessary activities. This argument is also advanced by scholars who argue for the consideration and inclusion of self-regulated learning measures in teaching and learning environments. Metacognition as a component of self-regulated learning has been highlighted as a key component for achieving learning with understanding in the teaching and learning of chemistry (Rickey & Stacy, 2000).

Metacognition is defined as "students' *awareness* of their cognitive processes, and the *regulation* of these processes in order to achieve a particular goal" (Goos, Galbraith, & Renshaw, 2002, p.

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193). I believe that metacognition is imbedded in scientific inquiry because successful inquiry requires a scientist to constantly reflect on and direct his/her thinking towards the desired outcome. Although much research on metacognition in science education exists (Zion, Michalsky, & Mevarech, 2005; Zohar & Dori, 2012), research linking metacognition with laboratory activities is rare (Veenman, 2012). Much research has resulted in rich descriptions of indicators of metacognition as it pertains to solving mathematical problems (Iiskala, Vauras, & Lehtinen, 2004), and studying for reading comprehension (Koch, 2001), but what does it mean in the chemistry laboratory when trying to plan for an investigation, master practical manipulations, set up apparatus, observe, troubleshoot and regulate experimental conditions?

While contemplating the best way to go about conducting research on metacognition in a chemistry laboratory context, it so happened that the instructors of a third year organic chemistry module at the University of Pretoria had also been working on revamping laboratory instruction in their third year organic chemistry course. The experiments carried out had been recipe based and the learning outcomes were judged to be unsatisfactory. This format of laboratory training failed to promote in-depth learning and understanding. In an attempt to improve laboratory activities from being traditional to more engaging, the lecturers were prepared to explore various alternative laboratory instruction styles. They wished to explore activities that could engage students in active and deep learning. To allow for proper scaffolding and mastery, they decided to explore a structure that would allow students to start with the more familiar, traditional type of experiments and gradually move to the more cognitively demanding tasks. This presented a good opportunity to explore various forms of laboratory instructional approaches, especially approaches conducive to the development of self-regulated learning. This study was thus framed as part of a bigger project for revamping third year organic chemistry laboratory activities.

Amongst laboratory instructional approaches selected by the lecturers was an inquiry-based activity which they called the simulated industrial project. The simulated industrial project had a fairly intricate design which was carefully structured to create a safe environment in which skills such as problem solving, communication, collaboration, reflection and metacognitive abilities could be developed. The development of such skills would be fostered by incorporating elements of inquiry, contextualisation, collaborative and reflective learning into the laboratory design. The details of each element i.e. inquiry, contextualisation, collaborative and reflective learning, and

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how each pertains to the simulated industrial project have been presented in chapter 3 as an extract from a published article (Pilcher, Riley, Mathabathe, & Potgieter, 2015). For the convenience of the reader the paper has been attached as Appendix 1.1 with all the supplementary material easily accessible from the journal website. My primary interest was that of identifying manifestations of metacognition particularly in the initial stages of the simulated industrial project.

1.3 Research context

Although much more detail on the industrial project is provided in chapter 3 and is available in a published article, this section serves to give the reader a brief description of what the project entailed with a view of facilitating a better understanding of the terminology used in the research questions presented in section 1.7.

The simulated industrial project was designed to model what a new graduate is likely to experience when transitioning into an industrial environment. Students took on the role of professional chemists working for a hypothetical company. The company had identified an opportunity in the market to produce and distribute an organic chemical compound *methyl 3-phenylpropionate*. However, there were three possible synthetic routes that could be used to produce the compound. The chemists were tasked with experimentally evaluating the three routes and advising which route was the most cost effective, environmentally friendly and least technically challenging. The project consisted of four practical sessions spread over a period of four weeks. Figure 1.1 gives an overview of how the activities were organised in the implementation of the simulated industrial project.

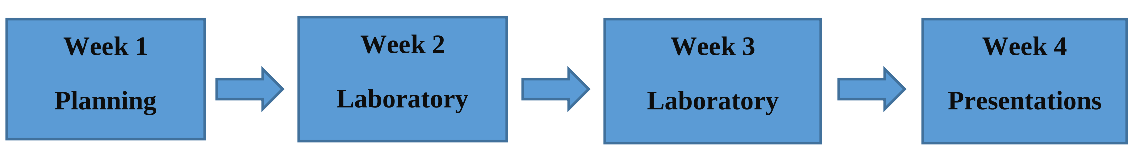

Figure 1.1 An overview of how sessions were structured in the simulated industrial project

The planning session in week 1 took place in a classroom setting which could be arranged to allow for group work. Students worked at their individual work stations in the laboratory during

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weeks two and three for sessions of six hours per week. Week four was set aside for presentations wherein small groups of "chemists" were given an opportunity to present their findings and recommendations to the hypothetical company board and their peers. The context of the current study was the planning session (week 1) of the simulated industrial project.

The jigsaw group learning technique (Aronson, 2000) was used in this study. The name of this learning technique is based on the fact that, similar to a jigsaw puzzle, each piece (each student's contribution) is important for successful task completion (Aronson, 2000). The students were placed in *home groups* of two to three, and were provided condensed experimental procedures in a format that they would encounter in scientific journal articles (as opposed to conventional, recipe based instructions). Each student was given the responsibility of experimentally evaluating one of the three synthetic routes and giving feedback to his/her home group, assisting the group to make an informed decision and to give a final recommendation. However, to do this, the students had to first work together in *specialist groups* of four or five made up of students from other home groups who had been allocated the same synthetic route. The members of the specialist groups worked together during the planning session to generate detailed experimental procedures for their routes by extrapolating important data from the given resources.

The assumptions underlying the current study are as follows:

- The inquiry laboratory is an environment that is conducive to stimulating metacognitive activity.
- In a collaborative environment individuals have to articulate and justify their ideas and thoughts to their peers. This exchange improves concept formation and provides an opportunity for individual and collective monitoring and regulation. Verbal communication obtained from such instances serves as useful information from which indicators of metacognition can be inferred.
- Incorporating scaffolding for metacognitive reflection encourages students to critically evaluate and regulate their learning efforts while carrying out their tasks.

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1.4 The research problem

Most science education researchers agree that while traditional laboratory instruction succeeds in developing manipulation skills, it often fails to achieve gains in conceptual understanding (Gunstone & Champagne, 1990) or to prepare students by developing problem solving skills that are necessary for the workplace and postgraduate research. Chemical educators should understand the importance of metacognition for two reasons, namely, "awareness of one's thoughts is important for developing an understanding of ideas" (Rickey & Stacy, 2000, p. 915), and awareness and control of thinking may promote carrying out experiments with understanding. Amongst an array of commonly used laboratory instruction styles, inquiry-based approaches have been reported to maximise the likelihood that students will engage in fruitful metacognition (Schraw, Crippen & Hartley, 2006; White & Frederiksen, 1998). However, little research exists on how metacognitive regulation manifests in inquiry-based laboratory contexts, particularly in the planning of practical investigations.

Scholars who have studied metacognition in chemistry laboratory contexts have focused on how creating conducive learning environments plays a role in enhancing students' metacognitive abilities. Interventions used to this effect include the introduction of models, instructional tools such as flow diagrams, and modifying laboratory training approaches to include collaborative and reflective learning (Davidowitz & Rollnick, 2003; Sandi-Urena, Cooper & Stevens, 2012). Identifying and characterising indicators of metacognitive regulation inherent in inquiry-based laboratory activities may assist practitioners to gauge whether or not the interventions put in place actually elicit the prized skills of self-regulated learning and problem-solving.

The challenge that exists in this field of research lies with the fact that metacognitive regulation is a covert mechanism taking place in the mind of the students. Scholars involved in this area of research have, however, shown that metacognitive regulation can be inferred from verbal and non-verbal behaviour when students think aloud or when they engage with their peers during social interactions (Veenman, 2007; Whitebread, Coltman, Pasternak, Sangster, Grau, Bingham & Demetriou, 2009). This study was thus conducted with the aim of identifying metacognitive regulatory processes inherent in the collaborative planning of practical investigations, and to determine how these processes manifest.

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1.5 Conceptual framework

John Flavell (1979) and Ann Brown (1978) were amongst the scholars who introduced the concept of metacognition to education. Numerous definitions of metacognition and its components have since been formulated (Lai, 2011). In this study, metacognition is conceptualised as having two components, i.e. cognitive knowledge/awareness, and cognitive regulation (Schraw et al., 2006), with the key aspects of cognitive regulation identified as planning/forethought, monitoring, control, and evaluation. A review of the literature reveals that, traditionally, the construct of metacognition was defined from an individualistic stance (Brown, 1987; Flavell, 1979). More recently, the social aspect of cognitive regulation has been recognised with scholars advancing that similar metacognitive regulatory processes may be observed when students work in groups. This aspect has been formalised in theories developed by scholars such as Goos et al. (2002), Iiskala et al. (2004) and Volet, Vauras and Salonen (2009). The centrality of collaboration in the context of this study necessitated the incorporation of these social dimensions into the conceptual framework that I used in this study. A more detailed discussion of the theory that underpinned this study is available in Chapter 2.

1.6 Scope of the study

The scope of the current study was limited to manifestations of cognitive regulation, particularly verbal demonstrations of planning, monitoring, control, and evaluation during the planning of practical investigations in the simulated industrial project. The decision to collect and analyse data during the planning stage, as opposed to the other three stages dedicated to laboratory work and group presentations, was driven by the expectation that the talk in the planning session would be easily accessible for audio recording, and data collection would therefore be less intrusive. In addition to this consideration, the exploration of metacognitive regulation inherent in the planning of investigations during inquiry-based laboratory activities was highlighted as important. This missing aspect is needed in research on metacognition in laboratory contexts (Krystyniak & Heikkinen, 2007). More detail on how the data was collected, analysed and triangulated will follow in Chapters 3 and 4.

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1.7 Concept clarification

The unit of analysis in this research was manifestations of metacognitive activity, particularly verbal demonstrations of planning, monitoring, control, and evaluation in collaborative learning contexts. In the following sub-sections, I briefly elaborate how the key concepts were defined for the purposes of this study.

1.7.1 Manifestations

I adopted the online Cambridge dictionary's definition of manifestation as a sign or indication of something happening. In this study, manifestations were inferred from verbalisations that were indicative of cognitive regulation.

1.7.2 Metacognitive activity

Flavell (1979) recognised the constituent parts of metacognition as metacognitive knowledge, metacognitive experiences, and metacognitive strategies (also known as metacognitive regulation). The term 'metacognitive activity' is used by some scholars to refer to metacognitive experiences, i.e. the act of searching one's long term memory to establish if one knows or does not know something. Some scholars use the same term to refer to the act of regulating cognitive activities during task performance (Kung & Linder, 2007). In the current study, the term was used to refer to the latter. The online Merriam-Webster dictionary defines activity as "the state of being active". For the purposes of this study, the term 'metacognitive activity' referred to the demonstration of planning, monitoring, control, and evaluation of own or others' cognitive activities by students while they perform a task. In this research, the terms metacognitive activity, metacognitive regulation, regulation of cognition, and cognitive regulation were used synonymously.

1.7.3 Collaborative learning context

Collaborative learning is characterised by a context in which a group of no more than four students work together towards a common goal and engage in negotiations and discussions to produce a learning product. The concept of *collaborative* learning as a group work approach and how it differs from *cooperative* learning, as adopted from the work of several researchers (Brodie & Pournara, 2005; Vauras, Iiskala, Kajamies, Kinnunen & Lehtinen, 2003), has been explained in detail in Chapter 2 (Section 2.7.2).

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1.8 Aim and research questions

The aim of the current study was to identify and characterise manifestations of metacognitive activity, particularly cognitive regulation, during the planning of practical investigations by groups of students in the simulated industrial project. To this end collaborative specialist and home group discussions were captured and analysed for manifestations of metacognitive activity.

This study was guided by the following primary research question:

Primary research question: How does metacognitive activity manifest in students' verbal contributions during the collaborative planning of practical investigations?

The primary research question was broken down into the following secondary research questions, referred to as research questions 1, 2 and 3 throughout the thesis.

Secondary research questions

Research question 1: What aspects of metacognitive regulation manifest as students plan investigations in collaborative learning groups?

Research question 2: How does metacognitive regulation manifest during specialist group discussions?

Research question 3: How does metacognitive regulation manifest during home group discussions?

1.9 Researcher positionality

I am of the opinion that the indicators of metacognitive activity can be best explored using a qualitative case study approach. The sustained and intensive experience of the researcher with the participants introduces a range of ethical and personal issues into the qualitative research process (Locke, Spirduso & Silverman, 2013). This concern warrants qualitative researchers to reflectively identify their biases, values, and personal backgrounds, and explain how they believe such biases may have shaped their research practice and interpretations (Cresswell, 2014). This reflection constitutes researcher positionality. Maher and Tetreault (1994) describe positionality as the researcher's position as defined by race, gender, class, and other socially significant dimensions. In the next paragraphs, I will provide a portrait of myself as a researcher in an

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attempt to show how my positionality may have influenced the decisions and interpretations that I made during the study.

I am a black female living in Pretoria, South Africa. I was born and grew up in a rural township situated in the area of Hammanskraal, north of Pretoria, called Temba, which means 'Hope'. My home language is a mixture of Setswana and Sepedi (Northern Sotho) because my mother was Setswana speaking and my father grew up speaking Sepedi. The two languages are somewhat similar, but contain certain nuances that distinguish them from one another. However, a Sepedi speaking person can understand most of what a Setswana speaking person is saying. My basic education was completed in the township schools of Temba where the medium of instruction was a mixture of English and Setswana. All of the schools that I attended could be classified as poorly resourced and academically poor performing. My father was a general worker at a major arms company and my mother worked as a domestic worker and seamstress. I was born in 1981 and obtained my basic education at a time when apartheid was still a reality in South Africa. This meant that whether my parents could afford it or not, I was not allowed access to the best schools in town.

I had to study hard and my philosophy is, and always has been, that academic performance can be traced back to learning effort and strategies. Although one of my brothers had studied up to high school level, I found myself always struggling with school work. I had to learn to work hard and figure things out for myself. Intelligence, for me, is not something that one is born with or without. I am a firm believer in the incremental theory of intelligence, i.e. intelligence improves with time and effort (Ehrlinger, 2008). The hard work paid off because from Grade 1 until Grade 11, I always made the list of top five performers in the schools that I attended. Grade 12 was, however, a wakeup call for me. When I reached grade 12, somehow things changed but my learning strategies stayed the same. No matter how hard I tried, I could not adapt my strategies to earn a pass in mathematics and science. Although I managed to pass all my languages at higher Grade (Setswana, Afrikaans and English) with a B, and Biology with an A, my poor performance in mathematics and science resulted in me losing a bursary with a reputable energy company in South Africa and a place in the engineering faculty at the University of Witwatersrand. If I had any hope of making it and escaping the vicious cycle of poverty that I had grown up in, I had to pick myself up and try again.

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I used the little money that my parents had saved up to enrol in a Further Education and Training College in town to improve my mathematics and science marks. Being taught by some of the best teachers in mathematics and science opened up my mind and exposed me to ways of learning that I had never encountered before. For the first time in my schooling years, I participated in hands-on activities and carried out science experiments. I was determined to make my parents proud so I studied hard. At the end of that year, I not only managed to improve my marks, but the college gave me an award for the best performance in mathematics and science. Improved marks earned me a place in one of the top universities in South Africa, the University of Pretoria. I was accepted for both my first choice, chemical engineering, and second choice, Bachelor of Science degree in science education and I had to choose between the two. I eventually opted for my second choice because I thought that with that degree I could go back home and make a difference in the teaching of mathematics and science.

Completing a four year Bachelor of Science degree in science education meant that my training as a teacher would be different from the training received by teachers trained in colleges and the Faculty of Education. Twelve years of my basic education and most of my university undergraduate training were grounded in the sciences in the disciplines of physics, chemistry, mathematics, and the life sciences. The BSc in science education degree comprised three years of coursework in the science faculty and one year of coursework in the Faculty of Education.

During my first year of studying chemistry at university, I struggled and had no time to participate in study groups since I was a day scholar. I sat for long hours in the library studying and making sense of all the content that I had to learn. It was a struggle, but I managed. My class mates would ask to meet with me after class so I could explain the work to them and they always remarked that I was a natural born teacher. Somehow, they understood when I explained the concepts to them. I enjoyed these moments because I learned that the more I took time to figure things out for myself and teach my peers, the more I understood the concepts. That year, I obtained final scores above 70% for the majority of my courses. Although I was not familiar with the educational psychology terminology, I have always been conscious of my thinking, particularly in my years as a university student. Even when conditions were not conducive, I always reflected on my level of understanding and my study methods to identify factors I could change to improve my academic performance.

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After completing my undergraduate degree, I taught mathematics and science in high schools in Temba for two years before joining the university as a junior lecturer. For three years, I taught general chemistry to students enrolled in an academic development programme for unprepared students. I then joined the Faculty of Education as a lecturer where my responsibilities included presenting both content and teaching methodology courses to pre- and in-service secondary school science teachers. While teaching in these schools, I completed a part-time honours degree in curriculum design and instructional development offered by the Faculty of Education. It was during this time that I was introduced to qualitative research as a possible research approach, as well as to the theories underpinning social science research.

Cresswell (2014) highlights four philosophical worldviews that researchers bring to inquiry, namely, post-positivism, constructivism, pragmatism and transformatory worldviews. I believe that my outlook was influenced by positivist science views as a result of the years that I spent in the natural sciences. However, the time spent learning about education, learning theories, educational research, and teaching in schools inculcated a constructivist worldview. It was therefore not surprising that a pragmatic worldview influenced my choice of research approach when conducting research for my Master of Science degree in science education. In my Master's research, I used a mixed methods approach to investigate the accuracy of confidence judgements made by students in the academic development programme regarding their chemistry performance. The quantitative data enabled me to determine the impact of teaching on the confidence judgements students make about their performance. However, the qualitative data allowed for descriptions in terms of factors that students relied on when making these judgements. My worldview has been influenced by a combination of positivist and constructivist worldviews. I believe that cause and effect relationships can be established through research, but also that the analysis of research data can yield rich descriptions of the participants and how they experience the particular phenomenon of interest.

I cannot escape the fact that my philosophical worldview and values influenced how I interpreted the data in the current study. I believe that students' thinking is made visible in verbal expressions, which is why research aimed at gaining rich descriptions of indicators and patterns of metacognitive regulation in collaborative contexts is best carried out by using qualitative rather than quantitative measures. I must acknowledge, however, that having the students

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perceive me as an authority figure (lecturer) may have elicited socially desirable responses when I interacted with them during the follow-up interviews. I see the need to bring this concern to the reader's attention because it poses a potential threat to the trustworthiness of the findings presented in this thesis. I do believe, however, that the research approach I followed and the measures I put in place to address issues of trustworthiness enabled me to generate findings in terms of indicators of metacognitive activity and patterns of cognitive regulation that are both transferable and useful.

1.10 Possible contributions of the study

1.10.1 Contribution to theory

The review of literature revealed that there is a great need for researchers to invest in the development of analytical tools, such as observational measures and coding schemes, to boost the types of data obtained through interviews and questionnaires (Azevedo, 2009). This study was conducted with the hope that the emerging findings would contribute to the growing body of knowledge in the field of research on metacognition in science education, more specifically, in illuminating key indicators of metacognitive regulation inherent in the collaborative planning of laboratory practical investigations. Azevedo (2009) states that the field of research on metacognition would benefit from a detailed taxonomy of the metacognitive and regulatory processes used in various teaching and learning contexts, "A detailed taxonomy would enhance researchers' ability to investigate and measure the role of each metacognitive and self-regulatory process under different learning conditions, instructional contexts, etc." (Azevedo, 2009, p. 93).

This study was conducted with the aim of making a contribution towards the formulation of a framework or definition of metacognition as it pertains to the collaborative planning of chemistry practical investigations. The aim was also to contribute to theory particularly towards a better understanding of how the social aspect of metacognitive regulation is influenced by the social context, the nature of the task and individual dispositions.

1.10.2 Contribution to practice

The short term goal of providing students with opportunities to develop their higher order cognitive skills (which include the ability to extrapolate data from summarised experimental

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procedures, careful analysis of observations, application of knowledge, and ability to draw conclusions based on findings) and metacognitive abilities during laboratory activities was envisioned so that students can understand what they are doing while working in the laboratory, and may be able to transfer the knowledge and skills acquired to unfamiliar situations. This may influence how they carry out experiments and may also enhance their thinking and understanding of what they observe. It could also assist them to make connections between what they observe on a macroscopic level with what is taking place on a microscopic level. The long term goal is, however, to develop their cognitive and metacognitive abilities in preparation for the world of work, either as researchers or technicians in the field.

Azevedo (2009) asserts that focusing on and understanding how metacognitive activity plays out can be instrumental in enhancing the design of learning environments that contain the necessary instructional support to accommodate and develop metacognitive skills. It is good that metacognition and the role it plays in enhancing learning, problem solving, transfer, and conceptual understanding is being given increasing importance by researchers in the field. However, it is important for researchers to propose practical strategies and methods that can be used in every day classrooms to enable instructors to identify and enhance metacognitive activity at work. Through my study, I aimed to provide supportive evidence, rich descriptions of the manifestations of regulation, as well as the factors that I observed to influence these manifestations during the collaborative planning of chemistry practical investigations. This was done in the hope of assisting practitioners to identify possible instructional strategies they can implement in their classrooms to develop the skills of metacognitive regulation. The analytical framework developed in this study may also serve as a useful tool for ascertaining the extent to which teaching and learning interventions put in place succeed in eliciting the desired skills of self and social regulated learning.

1.11 Sequence of the research report

My thesis consists of eight chapters. In Chapter 1, I give an overview of the study describing the background, problem statement, rationale, research context, scope of the study, as well as the research questions that guided the research process. Scholars agree that metacognition is a fuzzy construct that needs to be clearly defined given the many ways that different researchers have described it. Therefore, Chapter 2 consists of a review of the literature that pertains to

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metacognition, the social aspect of metacognitive regulation, the conceptual framework underpinning this study, as well as the definition of metacognition that I subscribed to. I also use Chapter 2 to highlight the instructional methods that were used to develop regulatory skills and show how some of these methods were incorporated in the design of the simulated industrial project. Chapter 3 is a detailed account of the research methodology. I describe the criteria I used to select the participants, as well as how the pilot study data informed the design of the main study.

Chapter 4 serves as a form of an audit trail where I describe in detail how the coding scheme for analysing specialist and home group discussions was developed, refined and validated. I also use excerpts from one of the specialist group discussions to illustrate how I assigned codes to their statements. Chapters 5 and 6 constitute the findings chapters where I present with great detail the results for each of the two groups of students whose specialist and home group discussions I analysed in order to answer secondary Research Questions 2 and 3. Chapter 7 is a cross-case analysis of the two specialist groups and four individuals chosen from these groups for further analysis of their contributions in subsequent home group discussions. I show how the two groups (*Team Kagiso* and *Team Bettie*) and the four individuals (Kagiso, Leonard, Bettie and Ansie) were similar and different in terms of how they regulated cognitive activities within their groups, both at the individual and inter-individual levels. Chapter 8 concludes this thesis by providing an overview of what the study set out to achieve, the main findings of the study, how the findings relate to current research, as well as implications for teaching, and recommendations for future research. The references and appendices are included thereafter for easy cross-referencing.

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CHAPTER 2

LITERATURE REVIEW

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In Chapter 1, I described the context of the current study as manifestations of metacognitive regulation, particularly verbal demonstrations of planning, monitoring, control and evaluation during the planning of chemistry practical investigations. Given the different ways that scholars define or conceptualise the construct of metacognition, researchers are advised to clearly articulate the theoretical model or framework that they choose to adhere to in their studies (Azevedo, 2009). For this reason, the literature review conducted and presented in this chapter serves the purpose of describing ways in which metacognition is defined by different scholars with the ultimate aim of arriving at a detailed description of the theoretical framework underpinning the current study. In this chapter, I also present the current state of science education research in the field of metacognition, particularly metacognition in chemistry laboratory training. The literature read for this purpose served to identify gaps in this field, and also enabled me to identify the potential contribution of my study to current research. This chapter concludes with a brief discussion of how the literature reviewed informed the analysis and interpretation of the data in this study

2.2 Metacognition: definition of the construct

Many scholars in the field describe metacognition as a complex construct because it is characterised by diverse definitions. John Flavell is famous for introducing the concept of metacognition to education in the 1970s, and he defined the construct broadly as "cognition about cognitive phenomena," or more simply "thinking about thinking" (Flavell, 1979, p. 906). Numerous definitions of metacognition have since been offered by various scholars in the field (Brown, 1987; Cross & Paris, 1988; Schraw et al., 2006; Wilson, 1998). According to Zohar and Barzilai (2013) "Even if many frameworks diverge from the one proposed by Flavell (1979) and his colleagues, there are at least some common grounds for comparisons" (p. 122). Most scholars agree that metacognition consists of two components, namely, knowledge of cognition, and regulation of cognition, which is sometimes referred to as cognitive knowledge and cognitive regulation respectively (Lai, 2011; Schraw & Dennison, 1994). Flavell (1979) recognises a third component as metacognitive experiences, and describes these experiences as insights or

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perceptions that an individual undergoes during cognition, such as, "I'm not understanding this." Flavell (1979) further asserts that these experiences serve as 'quality control' checks that help learners revise their predictions and goals. Several frameworks have been developed to categorise the constituent parts of metacognition. In her review of metacognition, Lai (2011) includes a table, as shown below (Table 2.1), in which she organises the components from each of these frameworks to facilitate comparisons among them. In her comparison Lai (2011), shows that different frameworks use different terminology to describe the same components of metacognition.

Table 2.1 Typology of metacognitive components (adapted from Lai, 2011)

Component of metacognition	Type	Term	Citation
Cognitive knowledge	Knowledge about oneself as a learner and factors affecting cognition.	Person and task knowledge.	Flavell (1979)
		Self-appraisal.	Paris and Winograd (1990)
		Epistemological understanding.	Kuhn and Dean (2004)
		Declarative knowledge.	Cross and Paris (1988) Schraw et al. (2006) Schraw and Moshman, 1995
	Awareness and management of cognition, including knowledge about strategies	Procedural knowledge.	Cross and Paris (1988) Kuhn and Dean (2004) Schraw et al. (2006)
		Strategy knowledge.	Flavell (1979)
	Knowledge about why and when to use a given strategy.	Conditional knowledge.	Schraw et al. (2006)
Cognitive regulation	Identification and selection of appropriate strategies and allocation of resources.	Planning.	Cross and Paris (1988) Paris and Winograd (1990) Schraw et al. (2006) Schraw and Moshman (1995) Whitebread et al. (2009)
	Attending to and being aware of comprehension and task performance.	Monitoring or regulating.	Cross and Paris (1988) Paris and Winograd (1990) Schraw et al. (2006) Schraw and Moshman (1995) Whitebread et al. (2009)
		Cognitive experiences.	Flavell (1979)
	Assessing the processes and products of one's learning, and revisiting and revising learning goals.	Evaluating.	Cross and Paris (1988) Paris and Winograd (1990) Schraw et al. (2006) Schraw and Moshman (1995) Whitebread et al. (2009)

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Table 2.1 shows that Flavell (1979) identifies the subcomponents of cognitive knowledge as person, task, and strategy knowledge, with person knowledge comprising "everything you could come to believe about the nature of yourself and other people as cognitive processors" (p. 907). Task knowledge has to do with the information available to an individual during a cognitive enterprise, such as task demands and level of difficulty. The third subcomponent has to do with the knowledge about "what strategies are likely to be effective in achieving what sub-goals and goals in what sorts of cognitive undertakings" (p. 907).

Subsequent metacognition researchers offer a slightly different framework for categorising cognitive knowledge (Lai, 2011), for example, several researchers use the concepts of declarative, procedural, and conditional knowledge to distinguish cognitive knowledge types (Schraw et al., 2006; Schraw & Moshman, 1995). Schraw et al. (2006) portray declarative cognitive knowledge as knowledge about oneself as a learner and what factors might influence one's performance. An example provided by Schraw et al. (2006) to describe this subcomponent of cognitive knowledge is that knowing the limitations of their memory systems, most adults then plan accordingly. Procedural knowledge, alternatively, is described as knowledge about strategies and other procedures for effective learning (Cross & Paris, 1988; Kuhn & Dean, 2004; Schraw et al., 2006). Schraw et al. (2006) introduce a fourth subcomponent, conditional cognitive knowledge, and describe it as knowledge of why and when to use a particular strategy, pointing out that individuals with a high degree of conditional knowledge are better able to assess the demands of a specific learning situation and, in turn, select strategies that are most appropriate for that situation. This description is consistent with Flavell's (1979) knowledge of strategy variables.

The other component of metacognition is cognitive regulation. Flavell (1979) discusses cognitive regulation in the context of goals (or tasks) and actions (or strategies). He describes goals as "objectives of a cognitive enterprise" and actions as "cognitions or other behaviours employed to achieve them" (p. 906). Subsequent researchers argue that cognitive regulation includes activities of planning, monitoring or regulating, and evaluating (Paris & Winograd, 1990; Schraw & Moshman, 1995; Whitebread et al., 2009). It is important to note that the frameworks described by Lai (2011) do not make a distinction between the subcomponents of monitoring and regulating, also known as control. However, subsequent scholars make distinctions between the

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characteristics of monitoring and control (Whitebread et al., 2009). Figure 2.1 is a concept map that I have used to show how metacognition is conceptualised in the current study.

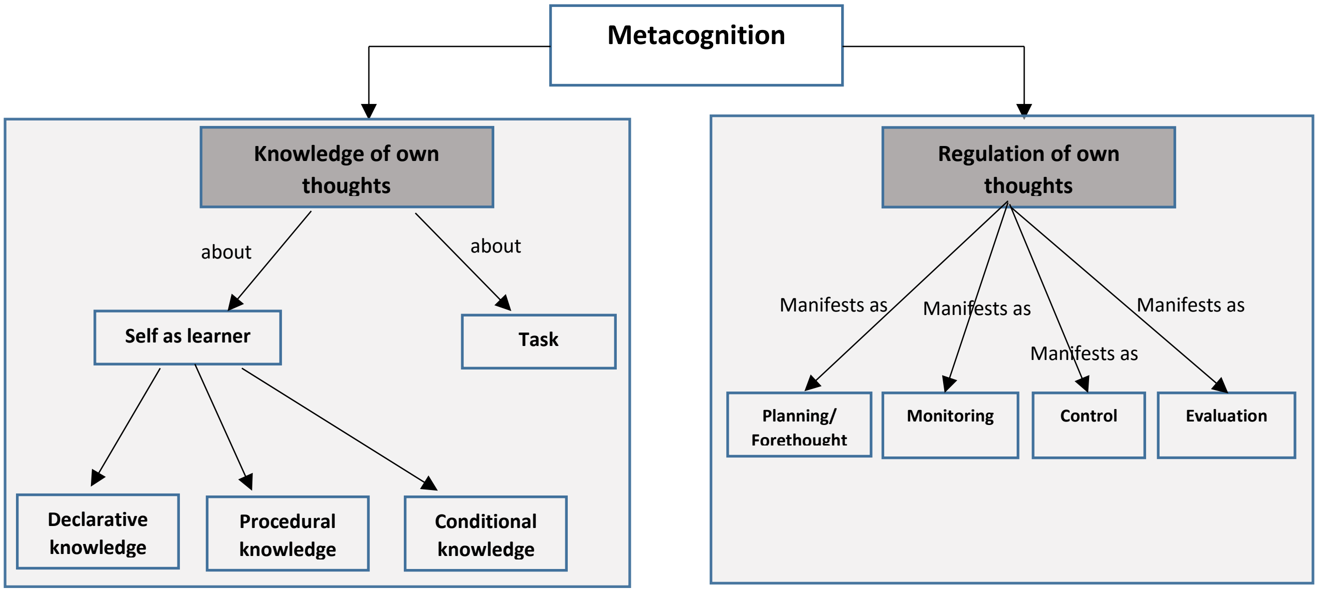

Figure 2.1 Components and sub-components of metacognition

I subscribe to Schraw et al.'s (2006) conceptualisation of metacognition as consisting of two components, namely, knowledge of cognition and regulation of cognition. In this study, I focused on how the regulation of cognition manifests in a collaborative learning context. However, to illustrate my understanding of how the two components differ, I will elaborate further on how both are conceptualised in this research.

2.2.1 Knowledge of cognition

The knowledge of person (self) and task variables emerges from Flavell's (1979) framework as components of cognitive knowledge. Task variables include the knowledge that we have about the task, such as the mental and tangible resources necessary for task completion, and task difficulty. Person knowledge, which is defined as the knowledge that we have about ourselves as learners, is further distinguished into declarative, procedural, and conditional knowledge (Cross & Paris, 1988; Schraw et al., 2006). Declarative knowledge refers to our understanding of what factors influence our performance of a task (Cross & Paris, 1988). Procedural knowledge is defined as the repertoire of task performance strategies that we have accumulated over time

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(Schraw et al., 2006), and conditional knowledge includes the knowledge that we have about when and why to use those particular strategies (Cross & Paris, 1988; Schraw et al., 2006).

2.2.2 Regulation of cognition

Cognitive regulation, which is a primary focus of this study, is conceptualised as consisting of four sub-components, i.e. planning, monitoring, control, and evaluation. Planning, also described as forethought by Pintrich (2000), involves projecting forward, selecting the strategies necessary for task performance, allocating resources, setting goals, negotiating roles and responsibilities, and clarifying task demands and expectations (Cross & Paris, 1988; DiDonato, 2013; Khosa & Volet, 2014; Schraw et al., 2006; Whitebread et al., 2009). Monitoring is characterised by self-testing, checking and assessing thinking or understanding in connection with content, resources, procedures and strategies that are necessary for task performance (Schraw et al., 2006). The behaviours associated with monitoring serve as a means for comparing understanding and performance against standards or learning goals (DiDonato, 2013). Control is defined as a regulatory process that shifts the cognitive flow toward optimal task performance or conceptual understanding (Khosa & Volet, 2014). It is further characterised by behaviour that is expressed with the intention of influencing the way an individual has been thinking (about task, content, instructions or procedures) to enhance task performance. Evaluation includes actions taken to appraise learning processes, as well as the products of task performance. It is usually characterised by evaluative statements or judgements that we make about our thinking, understanding and task performance (Pintrich, 2000). In the literature, there seems to be no apparent hierarchy amongst the subcomponents of cognitive regulation, although, some scholars point out that planning and evaluation seem to be the more sophisticated and rare forms of cognitive regulation, reporting that planning and evaluation are mostly displayed by expert learners (Ertmer & Newby, 1996).

Reviewing the literature revealed that most scholars who have made important contributions in clarifying the manner in which cognitive regulation should be conceptualised and operationalised have dealt with metacognition in purely individualistic terms. In contemporary research, arguments have been put forward with supporting evidence to show that it is possible to observe similar regulatory processes at the inter-individual level (Goos et al., 2002; Iiskala et al., 2004;

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Volet et al., 2009), which gave rise to the term 'social regulation'. The details of what the social aspect of cognitive regulation entails are presented in the next in section.

2.3 The social aspect of cognitive regulation

Iiskala et al. (2004), who coined the term *socially-shared metacognitive regulation* (SSMR), argue that during episodes of true collaboration, cognitive regulation may be observed to fluctuate among three levels: *self*, *other* and *shared* regulation. The authors share King's (1998) understanding of true collaboration as entailing more than the effective division of labour consistent with cooperative work, but rather meeting the criteria of comparable expertise, interactivity, interdependence and reciprocity in interaction and activity amongst team members (Vauras et al., 2003).

Self-regulation is described as the process of monitoring and controlling individual performance. Regulation at the inter-individual level manifests either as other- or shared regulation. Other-regulation refers to an unequal engagement "in which one partner masters a key element of the task but the other(s) does not, so that one partner instructs the other(s)" (Whitebread et al., 2009, p. 67). This form of regulation is consistent with Vygotskian ideas (Vygotsky, 1978), which emphasise the mediation of knowledge and skills by more capable others. Shared regulation constitutes the egalitarian, complementary monitoring and regulation of the task by participants possessing equal status in terms of expertise and conceptual understanding. Whitebread et al. (2009) concur with the classification of other- and shared regulation as inter-individual level regulation. The authors used the terms intra and interpersonal regulation to distinguish between self- and inter-individual regulation. The terms intrapersonal and interpersonal were adopted in the current study and have been used throughout the thesis to refer to regulation at the individual (self-regulation) and inter-individual (other/shared regulation) levels respectively. The Socially Shared Metacognitive Regulation (SSMR) theory was found to be a suitable framework and was adapted for the purposes of this research with specific interest in manifestations of cognitive regulation during collaborative group discussions.

As alluded to in Chapter 1, the simulated industrial project was designed to incorporate elements of collaborative learning with the aim of eliciting social interaction, regulation of cognition, and the ultimate enactment of laboratory work with understanding. Working collaboratively requires participants to monitor and regulate the reciprocal use of the joint understanding of the task, and

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obliges participants to articulate and make explicit their ideas and conceptions to others, making their thinking visible (Iiskala et al., 2004). The findings, as reported in various studies and cited in this literature review, were used as a lens to identify behaviour that is indicative of metacognitive activity in a social laboratory context. This study was therefore based on a social view of cognitive regulation. It became important, therefore, to clearly delineate how manifestations of social regulation are conceptualised in this research. A description of what is included in this view is elaborated on in the next section.

2.4 Theoretical framework

My understanding of a theoretical or conceptual framework is that it is a theory that gives a tentative explanation of what is being studied. To be useful in the development of scientific knowledge, a theoretical framework should adhere to specific criteria. “A theory should (1) provide a simple explanation of the observed relations relevant to a phenomenon, (2) should be consistent with both the observed relations and an already established body of knowledge, (3) is considered a tentative explanation and should provide means for verification and revision, and (4) should stimulate further research in areas that need investigation” (Anfara & Mertz, 2006, p. xiii). Furthermore, a good theory should be (1) simple, (2) testable, (3) novel, (4) supportive of other theories, (5) internally consistent, and (6) predictive (Agnew & Pyke, 1969). The design of the theoretical framework underpinning this study was guided by these criteria. The theoretical framework (Figure 2.2) as it was constructed aimed to provide a tentative description of the regulation of cognition in a collaborative laboratory context. The theoretical framework was also designed to provide a simple explanation and representation of the relationships between the subcomponents of metacognitive regulation as they pertained to the phenomenon under study.

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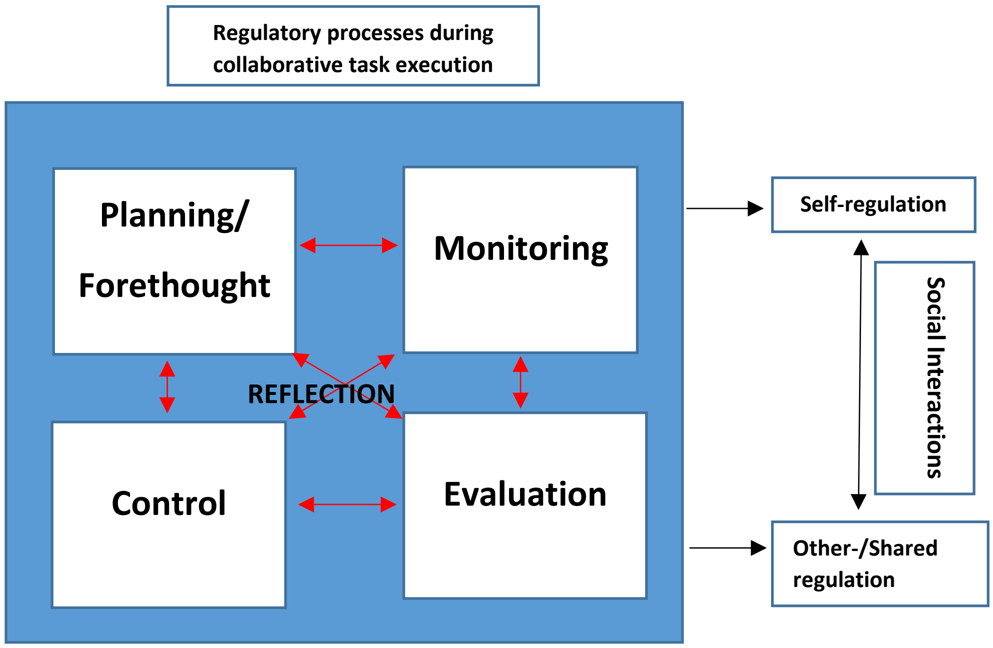

Figure 2.2 An overview of cognitive regulatory processes inherent in collaborative task execution

The theoretical framework constitutes a simple and tentative explanation of the regulatory processes that were expected to occur when students carried out collaborative tasks. The blue square represents reflection, which underlies the cognitive regulation processes of planning, monitoring, control, and evaluation. Reflection is key as students need to constantly think about their cognitive processes and critically evaluate this thinking individually and collaboratively while carrying out a task. In describing the qualitative differences that exist between novice and expert learners, Ertmer and Newby (1996) identify reflection as providing a critical link between the knowledge construction (cognition) and the regulation of the learning process (metacognition). The framework shows that manifestations of planning, monitoring, control, and evaluation are iterative processes that students go through to achieve successful task completion. This study was carried out under the assumption that each regulatory process has verbal behaviours associated with it from which the regulation of cognition can be inferred.

The theoretical framework also showed that the incorporation of collaboration results in the regulation of cognition, which manifests at two levels: at the individual level as self-regulation, and amongst peers as other- or shared regulation. The interplay between intrapersonal and interpersonal regulation is facilitated by the social interaction inherent in collaborative tasks. The

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theoretical framework is predictive in a sense that it serves as a tentative explanation of the regulatory processes, as well as the relationships between these processes in a collaborative learning context. The details of how the theoretical framework informed the design of the analytical framework used in this research to identify and characterise the manifestations of cognitive regulation is provided in Chapter 4. The next section is dedicated to describing the landscape of research on metacognition in the field of science education, particularly metacognitive regulation in chemistry laboratory training.

2.5 Research on metacognition in science education

The field of metacognition in science education in the current decade has undergone rapid growth and expansion as compared to the past decade. Systematic review studies conducted by Zohar and Barzilai (2013) have indicated that the study of metacognition in science education research has been carried out predominantly in the context of biology, and with special interest in the association of metacognition with constructs such as concept knowledge, higher order thinking, inquiry learning, as well as reflective thinking. The recurrence of terms such as 'laboratory' and 'experiments' under the inquiry learning construct was found to signify that 'hands-on experimentation' remains a recurring practice in the inquiry learning that relates to metacognition. Reflection was also found to be closely related to the inquiry learning construct that indicates the role reflective thinking plays in promoting scientific thinking and inquiry. This observation affirms the assertion that metacognitive skilfulnesss or metacognitive regulation is an intrinsic part of science practices (Sandi-Urena et al., 2012).

The literature on chemistry laboratory training indicates that previous research (e.g. Hofstein, Navon, Kipnis & Mamlok-Naaman, 2005; Krystyniak & Heikkinen, 2007) has demonstrated how the introduction of extended, open-inquiry laboratory investigations has resulted in less reliance on instructor guidance, and has fostered the use of scientific process skills and higher-order thinking by students, two aspects that are integral to the development of metacognitive abilities. Little evidence exists to demonstrate how laboratory instruction at college level affects student learning outcomes or supports increased cognitive and metacognitive development (Sandi-Urena et al., 2012). Studies that link cognitive regulation and learning in areas such as reading comprehension (Koch, 2001), scientific inquiry skills (Zion et al., 2005), and mathematical problem solving (Mevarech & Fridkin, 2006) have been productive, indicating that

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investigating how the student laboratory could be used to support the development of metacognitive skills could inform teaching and learning in this context (Lippmann Kung & Linder, 2007).

The short term goal of developing thinking and metacognitive skills in the laboratory should be to enable students to carry out experiments with understanding (Hofstein & Lunetta, 2004). The long term goal should include developing their problem solving skills in preparation for industry as technicians or researchers in the field. Although most research on cognitive regulation processes has been conducted in reading and studying expository science text, relatively little is known about these processes in chemistry laboratories. The current study was conducted to address the much needed research on the cognitive regulatory processes inherent in the planning of extended, inquiry-based laboratory investigations (Krystyniak & Heikkinen, 2007).

2.6 Best practices employed for the development of cognitive regulatory skills

Approaches frequently used to develop the skills necessary for the regulation of cognition may be classified into implicit and explicit instruction. Explicit metacognitive instructional practices that are often employed in science education research include metacognitive prompts, reflective writing, practice and training, teacher led metacognitive discussions, student led metacognitive discussions, thinking frames, information and communications technology (ICT) use for metacognitive instruction, concept mapping, and other visual representations and metacognitive modelling by the teacher (Zohar & Barzilai, 2013). Implicit instruction includes the creation of conducive environments to support reflective discourse, such as inquiry-based learning and collaboration, amongst many others (Schraw et al., 2006).

Much of the research conducted on cognitive regulatory skills has shown metacognitive instruction to have positive effects on learners' performance in fields such as reading (Boulware-Gooden, Carreker, Thornhill, & Joshi, 2007), mathematics (Dignath & Buttner, 2008), and problem solving (Anat Zohar & David, 2008). In other instances, metacognitive instruction was applied to improve students' knowledge and conceptual understanding (Zohar & Barzilai, 2013). Although metacognitive abilities, i.e. knowledge and the regulation of cognition, are reported to be late-developing (Baird & White, 1996), adults often struggle to articulate what they know about their thinking, i.e. many adults fail to explain their expert knowledge and performance and often fail to spontaneously transfer domain-specific knowledge to a new setting (Schraw et al.,

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2006). However, metacognition may be developed by placing students in learning contexts that encourage them to exercise their metacognitive abilities. In the next few paragraphs, I will discuss how various methods have been used to explicitly and implicitly support metacognitive activity in learning contexts.

2.6.1 Explicit instruction in regulation of cognition

The use of metacognitive prompts during science instruction is the most frequently employed explicit metacognitive instructional practice. Metacognitive prompts have been reported to be useful in helping students to be more strategic and systematic when solving problems (King, 1991). Studies by Conner (2007), Peters and Kitsantas (2010) and Wu and Pedersen (2011) are examples of studies in which metacognitive prompts were used as a reminder to encourage students to activate their metacognitive competencies during science learning. Veenman (2012) notes that often in studies on metacognitive practices, a distinction is made between metacognitive instruction in the beginning of task performance, during task performance, and at the end of task performance.

At the onset of task performance, task preparatory metacognitive prompts often include activities such as reading and analysing the task assignment, activating prior knowledge, goal setting, and planning. Metacognitive prompts that are introduced during task performance serve the purpose of guiding and controlling task execution. These activities include systematically following a plan or deliberately changing that plan, monitoring and checking, note-taking, and time and resource management. The purpose of metacognitive prompts introduced at the end of task execution is to encourage a student to evaluate and interpret the outcome, and to allow an individual to learn from his or her course of action for future occasions. These include evaluating one's performance against the goal or target product, recapitulating, and reflection on the learning process.

Veenman (2012) argues that often, the metacognitive activities employed in different domains are derived from similar metacognitive grounds of planning, monitoring, and evaluation. To substantiate, Veenman (2012) explains that orientation activities for text studying tasks and problem solving vary. Metacognitive activities that are employed at the onset of text studying may include reading the title and subheadings, scanning the text to get an overview, activating

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prior knowledge, setting goals for reading, and getting hold of test expectations. Alternatively, preparatory metacognitive activities in the context of problem-solving may include reading the problem statement, activating prior knowledge, setting goals, making a drawing representing the problem, establishing what is given and what is asked for, and predicting a plausible outcome. The domain general nature of metacognitive activities and the skills they emanate from means that these activities and skills may be transferred across unfamiliar tasks and domains.

Schraw (1998) designed and used what he called a regulatory checklist (RC). The checklist was used as an overarching heuristic factor that facilitates the regulation of cognition. Schraw (1998) incorporated the three categories of planning, monitoring, and evaluation. Each category consisted of reflective prompts that were exemplary of the regulatory strategy being elicited. Questions such as, *What is the nature of task? What kind of information and strategies do I need?* were asked to encourage students to engage in planning. Monitoring included questions that prompted students to check their level of understanding and task performance during task execution, e.g. *Do I have a clear understanding of what I am doing? Am I reaching my goals?* Evaluation was elicited through reflective prompts that encouraged students to make judgements about their level of task completion, e.g. *Have I reached my goal?* Questions such as, *What worked?* and *What did not work?* encouraged students to evaluate their task performance strategies and this assessment formed the basis of other efforts to enhance performance.

Students who were required to complete metacognitive prompts during task execution have been found to outperform control students in problem solving, asking strategic questions, and elaborating on information (King, 1991). In a study conducted with the aim of providing a picture of what metacognition means in a tertiary engineering context, Case, Gunstone and Lewis (2001) identified key shifts when a learner-centred approach with embedded reflection was used. The key shifts observed included the valuing of conceptual understanding over problem-solving, a more metacognitively informed use of resources, strategic use of external judgments for self-assessment, and a shift towards a sense of purpose for learning beyond the subject.

Interventions that employ embedded reflection prompts have proved to be effective as tools for the explicit development of metacognitive skills (Molenaar, Sleegers, & van Boxtel, 2014). However, little research has been done to showcase the implementation of scaffolding methods

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in ill-structured domains such as the one inherent in the simulated industrial project (Ge & Land, 2004). In one study that has been conducted with the primary focus of examining how question prompts support learners in ill-structured problem-solving contexts, students who were prompted were observed to significantly outperform their peers who did not receive any prompts (Ge & Land, 2003).

However, in their study, Papadopoulos, Demetriadis, Stamelos and Tsoukalas (2009) observed no statistically significant difference in the post-test performance of prompted and non-prompted students. The authors attributed this lack of difference to the two hour period of time allocated to studying. A statistically significant difference was, however, observed by the same authors in a previous study when students were given a week to engage with the prompts and the study material (Demetriadis, Papadopoulos, Stamelos & Fischer, 2008). The results suggested that the impact of prompting is not traceable in students' performance when a restricted study time with limited learning materials is used. Scholars who wish to conduct similar research are advised to make provision for a study time that would allow ample opportunity for the students to engage with the prompts and the given study material (Papadopoulos et al., 2009). Researchers are also warned of the 'over-prompting-effect', a pivotal point after which the prompts start to have a negative impact on the process of learning (Kalyuga, Ayres, Chandler & Sweller, 2003; Nückles, Hübner & Renkl, 2008). Researchers are therefore advised to think carefully about the number of prompts and time given to students to engage with the prompts.

In line with the metacognitive practices reported on in the literature, in this study, metacognitive thinking was encouraged by way of Reflective Learning Strategy Questionnaires (RLSQs, included as Appendices 2.1 to 2.4) with activity specific reflective prompts introduced before, during, and after task execution. The details about the questionnaires and how they were designed and used for this purpose are available in Chapter 3, as well as in a published article included in this thesis as Appendix 1.1.

2.6.2 Collaboration as a tool for implicit training in regulation of cognition

Several studies have shown that peer interaction inherent in collaborative learning activities can have positive effects on the development of metacognitive skills (Chan, 2012; Grau & Whitebread, 2012). In this context, student-student and student-staff interactions play an

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important role in how students monitor and regulate their thinking and task performance. Social interaction inherent in collaboration provides students with opportunities to reflect on their thinking and make their thoughts explicit (Schraw et al., 2006).

Collaboration is only one approach to group work. Group work is defined differently by different teachers and researchers. Some describe it as learners sitting together, sharing resources and working individually on the same task, while others disagree with this definition. Brodie and Pournara (2005) argue for Penlington and Stoker's (1998) definition of group work, which is that it constitutes appropriate project work, group and individual assignments, discussion between the teacher and learners, as well as amongst learners. This might as well be a description of whole-class teaching as it does not give an indication to teachers of how they can work with groups. A more elaborate definition is offered by Cohen (1994), who describes group work as “students working together in a group small enough so that everyone can participate on a task that has been clearly assigned. Moreover, students are expected to carry out their task without direct and immediate supervision of the teacher” (p. 1). Cohen’s (1994) definition makes a clear distinction between learner and teacher activities during group work.

In their attempts to enable researchers, policy-makers, and practitioners to distinguish between particular forms of group work, Brodie and Pournara (2005) identify the five approaches to group work as cooperative, collaborative, socio-cultural, socio-political, and situated. These two scholars argue that the five approaches differ in terms of their theoretical perspectives of learning, the nature of the tasks given to learners, the nature of interactions between learners, the organisation of groups and the assignment of roles, as well as the role of the teacher. In the next paragraphs, I discuss each group work approach briefly with occasional reference to how the approach pertains to this study.

The cooperative approach, also referred to as motivational approaches, constitutes group work that promotes peer teaching and accountability by assigning roles and responsibilities. Researchers who support this group work approach argue that the accountability ascribed to each individual within the group motivates learners to participate and contribute. In the simulated industrial project, which served as the context for this study, the jigsaw cooperative learning technique was used to avoid having each student experimentally evaluate each of the three synthetic routes on their own. The name of this learning technique is based on the fact that,

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similar to a jigsaw puzzle, each piece (a student's allocated role) is important for the successful completion of the task (Aronson, 2000). The task of experimentally evaluating all three routes in the laboratory would have been too overwhelming for individual students, considering that this was something that they had encountered for the first time. The sharing of task activities in the home groups was meant to reduce cognitive loads, making provision for an enhanced cognitive and metacognitive activity.

The cooperative learning approach is criticised for not promoting negotiations, and not eliciting discussion and conflicting views. Kozar (2010) finds that with cooperation, all of the participants can complete their allocated parts separately and bring their results to the table. Having each member specialise in an aspect of the task denies the other team members the opportunity to question and critically evaluate what is brought forward as feedback. Members have expert status in that each is perceived as a specialist in a specific part of the task. The danger here is that not being in a position to question the information may result in team members accepting flawed information, which could perpetuate misconceptions and jeopardise the quality of the final product. Kozar (2010) asserts that it is for these reasons that it is important to distinguish between cooperative and collaborative learning.

Collaboration, alternatively, demands direct interaction among individuals to produce a product. Collaboration involves negotiations, discussions, and accommodating others' perspectives. During the simulated industrial project, cooperative learning characterised the type of engagement observed in the home groups. However, discussions in the specialist groups that focused on generating detailed experimental procedures for a common synthetic route were characteristic of collaborative learning. The specialist group discussions were compared to the home group discussions and were found to generate rich data in terms of instances of social cognitive regulation.

Another characteristic of collaborative approaches, also known as developmental approaches, is that these approaches encourage learners to work as a team in order to make substantial progress on a task that none of them would be able to carry out on their own (Brodie & Pournara, 2005). In terms of the simulated industrial project, extrapolating the data from the various resources and drawing up detailed experimental procedures was a task that could be better managed by a team rather than one individual. Having each member work on a common task levelled the playing

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field and gave members equal status. Working on a common task and having access to the same information meant that peers were empowered to raise conflicting views and critique one another's thinking.

In fact, the proponents of the collaborative approaches to group work encourage cognitive conflict, and view the notion of disagreements between group members as a means of enabling knowledge construction. This approach is based on the premise that the resolution of conflicting views transforms thinking and leads to conceptual growth. This perspective of learning draws on the Piagetian, Radical Constructivist and Social Constructivist Theories about how knowledge is constructed (Brodie & Pournara, 2005). As much as the strength of collaboration lies in eliciting conflicting views, its limitation also lies in the social conflict that it creates.

In their case study focusing on the social processes of knowledge construction displayed by secondary school physics learners working in different peer interaction modes, Alexopoulou and Driver (1996) observed a complex interrelation of conceptual, contextual and social factors that influence discussion processes and subsequent learning in these settings. An in-depth analysis of the Greek learners' group discussions revealed that peer interactions were more constrained and difficult in pairs than in fours. Similar patterns of interaction between students working in mixed gender pairs were observed by Tolmie and Howe (1993). The existence of conflicting perspectives during collaborative group discussions seemed to help only in instances when one or both peers were willing to openly acknowledge their differences and explore their ideas without turning their disagreements into interpersonal conflicts (Alexopoulou & Driver, 1996). The manner in which peers interacted depended mostly on the participants' individual dispositions and goals. In the current study, similar patterns in terms of conflict were observed in a group of two students, as well as in groups of four students.

An in-depth analysis of the progressive and regressive discussion of four students revealed that, on the one hand, the social support offered by one of the team members helped to diffuse interpersonal tension in the progressive team. On the other hand, turning differences in physics reasoning into personal conflicts by members in the regressive team resulted in peers failing to clarify their understanding. Alexopoulou and Driver (1996) observed true collaboration and better facilitation of learning during group discussions when students openly shared their suggestions and objections with their peers. However, a safe and supportive classroom

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atmosphere was necessary for students to be open about their views and demonstrate a willingness to negotiate these alongside alternative ones (Alexopoulou & Driver, 1996).

Students who avoided conflict were observed not to benefit from the platform of engagement provided through collaborative learning. The students sometimes used role play to diffuse the social tension and disagreements inherent in team work. Competitive attitudes, aggression, and peer pressure were observed to also prevent students from raising objections and entering into meaningful negotiations. Overall, the students' progress or regression in physics reasoning seemed to depend on them raising objections, and their willingness to enter into negotiations and to confront the implications of social conflict.

The dynamics of the social interactions inherent in collaborative group work can be explained by Bruce Tuckman's (1965) forming, storming, norming and performing team development model (Wilson, 2010). Although the model mostly applies to team building in the business sector, it also finds relevance in collaboration when applied in academic contexts. The model describes that from inception until successful task completion, teams tend to go through the phases or stages of forming, storming, norming, and performing. The phases that teams go through may make or break collaboration within the team. During the forming stage, each member gradually warms up to the idea of working in a team. Everyone looks up to the team leader, accepting his/her guidance and maintaining a polite but distant relationship with the other members. Wilson (2010) warns that at this stage, there is likely to be baggage of past experiences of working in a group, which may result in affected team members being hesitant, cautious or defensive in their participation. Each member's role within the group structure in terms of expectations and responsibilities should be clearly outlined at this stage and the team leader should model the behaviour that he or she wishes to see the team members display.

Storming, as the name suggests, represents a time of tension and conflict. This is a time when everyone strives to establish their place and value within the group structure. Individuals are more concerned about the impression that they are making, as well as how their regulatory efforts are received or supported by fellow team members rather than about the task at hand. At this stage, team members are observed to battle with feelings of inadequacy, want to be respected, and try to prove their worth to the team leader. Carol Wilson (2010) warns that this is a make or break stage where factions have the potential of forming with team members being

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ostracised. Team members can survive this stage by viewing suggestions brought forth by their peers as contributions rather than criticism. Wilson (2010) asserts that it is critical at this stage for team members to be given the leeway to do things their way wherever possible.

Teams that reach the norming stage often succeed in achieving their goals of task completion as roles and relationships are established and everyone has identified their place within the team. This is a stage when regulatory efforts and creativity are encouraged with a view to enhancing task performance and achieving set goals.

Performing constitutes the fourth stage of the team development model. At this stage, Wilson (2010) compares the running of the team to a well-oiled machine with a lot of healthy conflict interspersed with fun and humour. Ten years after creating the model, Bruce Tuckman added a fifth stage, which he labelled adjourning, a term he used to describe the breakup of a team upon task completion. The adjourning stage is argued to give a sense of closure to the team. The way adjourning is handled within a team can have a profound effect on the level of participation and nature of contributions individuals will make in future teams. However, Wilson (2010) warns of the likelihood of a collective cultural memory being formed that may influence existing team members and be absorbed by newcomers. This is a time when the team has to reflect on collective and individual achievements and how far they have come together. Team members should recognise each other's contributions and give credit where it is due. Leaving any team member feeling that their contribution has not been recognised as adding value may result in resentment, which members may carry forward, making storming proportionately harder to overcome in the future. This observation was made for one of the specialist groups in the current study where one team member left the group filled with resentment and was not willing to work with the same team members in the future.

The socio-cultural approaches, also known as Vygotskian approaches, draw on the Social Development Theory derived from the work of Vygotsky (1978). The theory asserts three major themes: (1) Social interaction, which plays a fundamental role in the process of cognitive development, (2) The concept of the More Knowledgeable Other (MKO), which refers to anyone who has a better understanding with regard to a particular task, concept or process (teacher or peer), and (3) The Zone Of Proximal Development (ZPD), which represents "a transformative

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space where learning and development happen, in collaboration with a more capable other, a peer or teacher" (Brodie & Pournara, p. 41).

There is a significant body of knowledge within the Vygotskian tradition that suggests that social processes during collaborative task execution play a crucial role in the development of metacognitive and self-regulatory abilities (Whitebread et al., 2009). The formats of collaboration often used in the classroom include student-student, student-teacher, student-tutor and student-expert collaborations (Ramaswamy, Harris & Tschirner, 2001). The limitation of Vygotskian approaches to group work is that social interaction in the ZPD promotes self-regulation in the MKO, as opposed to socially shared regulation that occurs by providing the more capable others with opportunities to critically evaluate their thinking and make their thoughts and understanding of scientific concepts explicit (Schraw et al., 2006).

Peer-teaching inherent in Vygotskian approaches is problematic in that those who do the teaching get opportunities to reflect on their ideas and verbalise them. The ones who listen are unfortunately not afforded the same opportunities. It is for this reason, therefore, that the Vygotskian approaches are likely to benefit the MKO more than the one being taught. What compounds the problem is that the role of 'teacher' is often assumed by the more assertive students with perceived academic ability or popularity (Bianchini, 1997). Brodie and Pournara (2005) assert that the problem with those who are already advantaged becoming teachers is that the opportunity to teach adds to their advantage. The two researchers propose that equity in socio-cultural group work approaches can be fostered by affording all learners the opportunity to teach. This solution, however, raises the issue of learner confidence and competence in the subject matter and in the language of learning. Brodie and Pournara (2005) argue that allowing learners with a poor knowledge base to teach may serve to perpetuate misconceptions and ignorance within the team.

Bianchini (1997) explains that the consideration of group work as a quick fix to ensuring equity and excellence is problematic. In her study of the interplay between knowledge construction, equity and context during group work, Bianchini (1997) found that despite using a powerful group work model and carefully crafted group tasks, differences in learner participation and academic achievement remained. An in-depth analysis of videotaped group discussions revealed

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that procedural matters dominated discussions with students of high status (perceived academic ability and popularity) having greater access to the groups' resources and discussions.

In a subsequent study, Alexopoulou and Driver (1997) investigated the impact of gender difference on the level of contribution made by collaborative group members. Their findings have important implications for my study because the groups subjected to in-depth analysis in the current study consisted of different gender compositions. It became important, therefore, to keep in mind that the gender differences could constitute plausible explanations for observed patterns and levels of cognitive regulation at play in the social space.

In describing the literature base that informed their study, Alexopoulou and Driver (1997) share findings by researchers who conducted studies on the influence of gender on social collaboration by students in a similar age group. Males in mixed groups were found to ignore females and direct their explanations to other males. Males were observed to talk more, interrupt more, control the discussion and ignore females, while females had a tendency to ask for more clarification and pose confirmation seeking questions (Aries, cited in Spender, 1980). This observation may be explained by the differences in how males and females perceive their academic abilities, especially in science related fields. Males and females were also found to differ in how they resolved disputes during collaborative group discussions with male students preferring to solve conflict in a relatively straightforward way, and females preferring to end the conversation in a bid to preserve relationships. Females opted for modes of interaction that fostered a sense of 'consensus' (Belenky, Clinchy, Goldberger & Tarule, 1986), employing cooperative verbal strategies, opting for a turn-taking mode of interaction, and being more interested in reaching a 'fair outcome' (Spender, 1980). Males, alternatively, opted for competitive verbal strategies, fighting for dominance and were more interested in establishing the winning argument.

A detailed analysis of the group discussions of secondary physics students working in single-sex pairs and fours yielded similar results in another study by Alexopoulou and Driver (1997). Their findings are better presented in their own words:

> *In accordance with the literature on gender-related modes of interaction, the findings of this study showed that males tended to progress through confrontational discussions whereas females appeared to need to maintain an underlying sense of consensus so as to explore their ideas and*

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> *hence progress. Moreover, whereas regressive discussions among males appeared to be the product of disagreements being perceived as threatening the participants' relative status within the group, among females they seemed to be the product of differences being perceived as threatening a consensual discussion* (Alexopoulou & Driver, 1997, p. 404).

In socio-political approaches, group work is used to critique stereotypes and injustice (Brodie & Pournara, 2005). Bianchini (1997), however, asserts that giving students explicit instruction on how to make the most of group work can make collaboration more beneficial. Tasks in which students have been directly asked to collaboratively look at and critique inequalities in society and how mathematics promotes social justice and injustice (Vithal, 1997) constitute examples of socio-political approaches to group work, and may be used to explicitly raise student awareness about socio-political issues.

A more recent form of group work which is usually used together with other approaches is the situated approach, which draws on the theoretical perspective of situated learning. The theoretical basis for these group work approaches span between socio-cultural and socio-political perspectives. Group work is not only seen as a tool for developing the learner for the immediate need of understanding subject matter, but also for the long term goal of developing learners for the world of work. These approaches have received little attention in terms of research.

The work presented in this section was important for my study because it alerted me to the possible emergence of peer-teaching, conflict, tensions, stereotyping and power relations inherent in group discussions. I believed that these factors had the potential to influence interpersonal cognitive regulation.

Brodie and Pournara (2005) assert that the nature of the task given to learners during group work may make or break successful social interaction. It is important that tasks given in this context must not be routine, requiring algorithmic problem-solving. Struggling with non-routine, novel tasks with the support of peers promotes the construction of new meanings by learners (Brodie & Pournara, 2005). Several non-routine instructional methods have been successfully used to implicitly develop cognitive regulation skills and learning in social contexts. Inquiry-based learning is one such mode of instruction that is particularly used for science instruction.

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2.6.3 Inquiry-based learning as a tool for implicit training in regulation of cognition

Inquiry-based learning has been identified as one of the laboratory instruction styles that can be employed to simultaneously improve science learning and develop metacognitive abilities (Rickey & Stacy, 2000). During authentic inquiry learning (Chinn & Malhotra, 2002), students are expected to work collaboratively with their peers, and explain verbally and in writing the procedure that they followed to solve the problem, which requires reflection, an important aspect of metacognition (Davis, 2003). "Authentic inquiry promotes metacognition and self-regulation because students are better able to monitor their learning and evaluate errors in their thinking or gaps in their conceptual understanding" (Schraw et al., 2006, p. 119).

Cognitive regulation is an important element of scientific inquiry because successful inquiry, which entails formulating hypotheses, designing investigations, interpreting data, and troubleshooting methods, for example, requires a scientist to constantly reflect on and direct his/her thinking towards the desired outcome. Veenman (2012) concurs in saying that most salient features of metacognitive behaviour are depicted in the cognitive processes that the learning of science draws on, such as those involved in reading texts, problem-solving, inquiry learning, and writing. Zohar and Barzilai (2013) note that the development of learners' scientific thinking and inquiry skills continues to be a central and significant focus of metacognition research in science education. This is demonstrated by the number of studies that have focused on the contribution that cognitive regulation makes to developing students' thinking skills and their ability to reason about scientific explanations and evidence.

Inquiry instruction can be characterised into different levels depending on the varying degrees of educator involvement and student independence (Buck, Bretz, & Towns, 2008). The levels of inquiry range from the confirmation laboratory (Level 0), where all of the information is provided to students, to authentic inquiry (Level 3), where the students are responsible for deciding on and formulating the problem, procedures, analysis, communication and conclusions. In guided inquiry, which constitutes Level 1, students are given experimental procedures and are expected to look for patterns in the collected data. During open inquiry (level 2), students are given the leeway to design their own experiments to address some general topic.The unstructured, hypothesis-driven, variable, controlled nature of inquiry learning draws heavily on the important metacognitive features of goal orientation and planning, as compared to other

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laboratory designs (Veenman, 2012). The level of inquiry learning incorporated in the simulated industrial project ranges between the first and second levels in terms of educator involvement and student autonomy.

In addition to promoting metacognitive thinking, inquiry-based activities have been found to greatly elicit meaningful student-student and student-instructor interactions. Krystyniak and Heikkinen (2007) conducted a study with the aim of identifying differences in the nature of student-team and student-instructor verbal interactions during inquiry and non-inquiry laboratory activities. In addition to changing the role of the instructor to facilitator and promoting greater independence on the part of the students, due to the collaborative nature of the inquiry activities, students responsible for particular aspects of the task became confident in their understanding of those parts and took on a more active role in the group discussions. In contrast to peer interactions during inquiry activities, verbal interactions within non-inquiry activities were observed to be of an asymmetric nature with discussions often dominated by one group member.

In another study, Hofstein, Navon, Kipnis and Mamlok-Naaman (2005) found that students in an inquiry group outperformed the control group in their ability to ask more and better questions. The findings of the studies performed by Krystyniak and Heikkinen (2007) and Kipnis and Hofstein (2008) seem to suggest that when planned properly, an inquiry-type laboratory carries the potential to provide students with an opportunity to practice and develop metacognitive skills.

There were three other studies whose findings found relevance in the current study, largely because they employed instruction that combined elements of inquiry and collaborative learning to promote metacognitive activity in science-related fields at university level. These three studies were those of Sandi-Urena et al. (2012) and Khosa and Volet (2014). In the next paragraphs, I discuss briefly the scholars' findings, as well as how these findings informed this study.

Sandi-Urena et al. (2012) conducted a mixed methods study with general chemistry laboratory students in order to determine how effective a cooperative, problem-based project would be in developing problem-solving skills in the targeted group of students. Four participants assigned to work in a team for an entire semester were expected to plan, conduct an experiment and present their findings to the teaching assistant and their peers. During a period of four weeks, the

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teams of students analysed the posed problem, set goals, planned task execution strategies, designed and implemented experiments, learnt the necessary laboratory techniques, discussed and evaluated processes and outcomes, answered guiding planning questions, and submitted individual laboratory reports. During the presentation, session teams were afforded the opportunity to communicate their procedures and findings. The teams of students also defended their decisions and conclusions in response to the questions posed by their teaching assistant and peers. The findings of Sandi-Urena et al. (2012) are relevant to my study because, in concurrence with observations made in the current study, the instructional measures put in place required students to exercise a variety of metacognitive regulatory skills consistent with planning, monitoring and evaluation, with social interaction playing a significant role in reinforcing these metacognitive regulatory processes. Sandi-Urena et al. (2012) found that students who were exposed to cooperative problem-based laboratory instruction showed improved problem-solving skills and increased regulation of cognition despite a lack of explicit instruction on metacognition. Designing a laboratory activity that required cooperative learning provided students with an environment that was conducive to social interaction and reflection (Sandi-Urena et al., 2012).

Khosa and Volet (2014) conducted a study with second year undergraduate students in Veterinary Medicine to examine, amongst other aims, the extent to which groups of students differed in metacognitive regulation during a collaborative learning activity. A theory-based coding scheme was developed for this purpose. Students working in self-selected groups of five or six worked together on a clinical case-based assignment as part of their physiology course. Video recorded discussions of two groups were selected for in-depth analysis. The two groups were selected because their grades in physiology were comparable but the groups were observed to differ markedly in their collective understanding of their case at the end of the group assignment. This was the students' first exposure to working with real-life case material.

The students had to apply primary preclinical knowledge that they had learnt in the course, extract relevant physiology based clinical concepts, and investigate the underlying principles of treatment of the various diseases presented in the case. The first task entailed generating learning objectives for the clinical case, and the second task entailed the construction of a concept map of the clinical case. The discussions of students in the two tasks were transcribed and analysed for

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cognitive activity and metacognitive regulation. Concurrent self- and social regulation was observed in their study. A significant difference was not observed in how often the students engaged in planning, monitoring and evaluation for both tasks. What was noteworthy about this case was the limited amount of planning and evaluation observed for both groups, as well as the non-existent instances of high-level regulation. Similar findings were observed in this study (which is discussed in more detail in Chapters 5, 6, and 7), suggesting that planning and evaluation may constitute the more sophisticated form of metacognitive regulation. The authors explained this observation by citing that the students may have viewed evaluation as the responsibility of the teacher in both tasks and that planning may have not been necessary for task 2.

I found Khosa and Volet's (2014) study to be unique in that beyond characterising students' metacognitive activity into theoretical codes of planning, monitoring and evaluation, the authors went a step further by characterising the observed regulatory efforts in terms of depth of regulation. Although conducted in the veterinary sciences, this study finds relevance in my work because it served to validate the findings obtained through the analysis of group discussions in the chemistry laboratory context. Therefore, the codes and descriptions used by Khosa and Volet (2014) to distinguish between low and high level metacognitive regulation were adapted and used for determining the depth of metacognitive regulation displayed by individuals during specialist and home group discussions in this study. The details of how the codes and descriptions were adapted to the current study will be presented in Chapter 4.

2.7 Conclusions

This chapter has served the purpose of setting the scene for my research and mapping out the theory that underpinned the study. The findings emanating from some of the sections in this chapter have a number of implications for my study. Firstly, the literature suggested that analysing group discussions warranted the use of a framework that defines cognitive regulation from a socialistic rather than an individualistic stance. This requirement necessitated the use of a combination of Iiskala et al.'s (2004) SSMR Theory, as well as Schraw et al. (2006) and Paul Pintrich's (2000) Theories of Individual Cognitive Regulation to inform the formulation of the conceptual and analytical frameworks used in this research.

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Secondly, research on metacognitive regulation inherent in the planning of investigations during inquiry based laboratory activities are a rare and much needed missing aspect of research in the study of metacognitive activity in laboratory contexts (Krystyniak & Heikkinen, 2007). This meant that this study entailed developing and refining a relevant coding scheme to analyse student discourse during collaborative group discussions. Inductive and deductive approaches to analysis were employed for this purpose. Details on the development and refinement of the analytical tools used in this thesis will follow in Chapter 4. The lack of research in this field also meant that the current study carried the potential of making theoretical and methodological contributions to current literature.

Thirdly, reviewing the best practices used for developing the skills of metacognitive regulation served to bring to light the patterns of SSMR as observed by other researchers when measures of metacognitive instruction were put in place. First, using a combination of collaboration and inquiry as an implicit form of metacognitive instruction elicits thinking and the regulation thereof, promotes discussion, and makes metacognition visible. Second, the literature confirmed the manifestation of cognitive regulation in terms of planning, monitoring and evaluation during collaborative group discussions. Third, the observation of concurrent self and social regulation during collaborative learning was confirmed. Lastly, the potential influence of the interplay between knowledge construction, equity, and context during collaborative group discussions on cognitive regulation and learning was highlighted, as well as the different ways that male and female learners prefer to resolve social conflict. More on how these patterns were observed in the current study will follow in Chapters 5 and 6.

Finally, the literature suggests that providing reflective scaffolding by way of context-orientated prompts elicits cognitive regulation, promotes discussion, makes thinking visible, and has beneficial effects on student learning (Papadopoulos et al., 2009). Hence, reflective learning prompts were provided to students for use during the home and specialist group discussions. The detailed description of the contents of these questionnaires is available in the methods chapter and is also presented in the form of a published article (Pilcher et al., 2015).

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CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

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CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

Chapter 2 focused on a review of the relevant literature with regard to previous and current research on metacognition and metacognitive instruction. In this chapter, commonly used research methods and the challenges in identifying metacognitive activity in natural settings are discussed. This chapter further outlines the research paradigm, methodology, design, and the data collection methods that were used in this study. I describe how the pilot study results helped to inform the design and development of the protocols used for the collection and analysis of data in the main study. The chapter concludes with a discussion of the main study, i.e. sampling, data collection, data analysis, as well as measures taken to ensure trustworthy findings and an ethical study. Table 3.1 gives an overview of the research design and methodology followed and discussed in detail in this chapter.

Table 3.1 An outline of the research methodology

Title	Manifestations of metacognitive activity in an upper undergraduate organic chemistry laboratory.
Research questions	**Primary research question**:
	How does metacognitive regulation manifest in students' verbal contributions during the collaborative planning of practical investigations?
	Research Question 1: What aspects of metacognitive regulation manifest as students plan investigations in collaborative learning groups?
	Research question 2: How does metacognitive regulation manifest during specialist group discussions?
	Research question 3: How does metacognitive regulation manifest during home group discussions?
Epistemological paradigm	Constructivism with influences of pragmatism.
Methodological paradigm	Qualitative case study approach.
Research design	Holistic multiple case study (Yin, 2014).
Selection of participants	Purposive convenience sampling:
	Research Question 2: two specialist groups, one consisting of four students and the other of three students.
	Research Question 3: four students (two from each specialist group) displaying varying styles of interaction in terms of metacognitive regulation.
Data collection methods	Systematic online observation (audio recorded and field notes) and retrospective stimulated recall interviews (audio recorded).
Data documentation	Transcripts of selected specialist and home group discussions, interview transcripts and field notes.
Data analysis	General inductive approach (Thomas, 2003).
	Qualitative content analysis (Schreier, 2012).
Ethical considerations	Ethical clearance granted, informed consent and voluntary participation, participant confidentiality, freedom to withdraw participation at any time, researcher as a participant observer.
Quality criteria of the study	Credibility, transferability, confirmability and dependability (Lincoln & Guba, 1985).

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3.2 Research paradigms

Guba and Lincoln (1994) define a paradigm as a set of basic beliefs or assumptions that define for its holder the nature of the world or reality (ontology), the individual's place in it, and the possibilities of relationships that the holder may have with that world and its parts (epistemology). These assumptions represent a particular stance that a researcher takes when choosing a method of inquiry, i.e. research approach. Researchers generally select amongst three research approaches, namely, quantitative, qualitative, and mixed methods. Cresswell (2014) defines research approaches as "plans and the procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation" (p. 3).

Four philosophical worldviews known to influence researchers' choice of research approach are post-positivism, constructivism, transformatory worldviews, and pragmatism. Post-positivism is consistent with quantitative research and is sometimes referred to as 'the scientific method'. The post-positivist research approach begins with a theory and determines whether the collected data supports or refutes that theory (Cresswell, 2014). This process of analysis usually leads to revisions and further testing. Qualitative researchers often take a constructivist worldview, which relies largely on participants' views of the phenomenon being studied. Rather than starting with a predetermined theory, as in the post-positivist approach, the researcher generates or inductively develops a theory or pattern of meaning from the collected data (Cresswell, 2014). A transformatory worldview underpins research with an interest in addressing issues of social justice, discrimination, and oppression. Pragmatists use a combination of research approaches whether quantitative, qualitative or both to achieve a better understanding of the problem. Pragmatism serves as the philosophical underpinning for mixed methods research (Cresswell, 2014).

I followed a more inductive approach to analyse the pilot study data for behaviours that were indicative of social cognitive regulation. Using a coding scheme developed with the help of the pilot study data, I employed a qualitative content analysis to analyse the group discussions for manifestations of metacognitive regulation. An inductive approach was also followed in analysing the data collected through the retrospective individual and group interviews. Therefore, I position my study as qualitative with influences of a pragmatic worldview.

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3.3 Research design

Nieuwenhuis (2007) defines research design as "a plan or strategy which moves from the underlying philosophical assumptions to specifying the selection of respondents, the data-gathering techniques to be used and the data analysis to be done." (p.70). Research designs such as narrative approaches, phenomenology, grounded theory, ethnography and case studies are embedded within the worldviews held or lenses employed by qualitative researchers (Cresswell, 2014). The narrative approach and phenomenology lend themselves to research with a particular focus on studying individuals and their lived experiences. Case studies and grounded theory are popular in research with a primary focus on exploring processes, activities and events. Ethnography, which has its roots in anthropology and sociology, lends itself to research conducted to learn about the shared patterns of behaviour of an intact cultural group within a natural setting (Cresswell, 2014). These five designs are similar in their general process of research in that they employ similar data collection methods, such as interviews, observations, documents, and audio-visual material, although in varying degrees (Cresswell, 2014).

Each research design has its own way of collecting and analysing data and there are advantages as well as disadvantages to using each of them. Due to my particular interest in the manifestations of metacognitive regulation in social contexts, I chose to follow a qualitative case study approach. I chose this approach on the basis that it made provision for an in-depth study of social cognitive regulation in natural settings, it allowed for the use of multiple data collection strategies, as well as the possible use of a theoretical lens for the purposes of data analysis (Cresswell, 2014). In the next section, I provide a detailed description of the case study approach as a research method and explain why it was deemed an appropriate design for this research.

3.3.1 Case study design

The case study approach has been confused in the past with doing 'fieldwork' or participant observation rather than being viewed as a formal research method with its own logic of design (Platt, 1992). In her book dedicated to describing a case study as a research method, Yin (2014) provides a twofold definition of a case study, which presents it as an all-encompassing method that allows for an in-depth investigation of phenomena as they occur in natural settings. She also defines it as a way of triangulating data from multiple sources of evidence, as well as using prior developments of theoretical propositions to guide the subsequent data collection and analysis.

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Case study as a research design has been used in various fields of research such as psychology, sociology, social work, and education. Cases or units of analysis bound by time and activity often constitute a programme, event, activity, process, group or one individual. Yin (2014) argues that situations that warrant a case study as a preferred research design occur when "how" and "why" main research questions are asked, when a researcher has little or no control over behavioural events, and when the researcher studies a contemporary phenomenon in its natural setting.

Figure 3.1 below gives an overview of the four basic case study designs, as delineated by Yin (2014). The author distinguishes between two variants of case study research as single- and multiple-case studies. The difference between the two designs is that with single-case design, the researcher studies a single-case in relation to its contextual conditions. With multiple-case design, the researcher studies and contrasts multiple cases each in their own context. Single- and multiple-case study designs are further divided into holistic (single unit of analysis) and embedded (multiple units of analysis) designs. Holistic single- and multiple-case study designs focus on only one unit of analysis, whereas embedded single- and multiple-case study designs focus on multiple units of analysis.

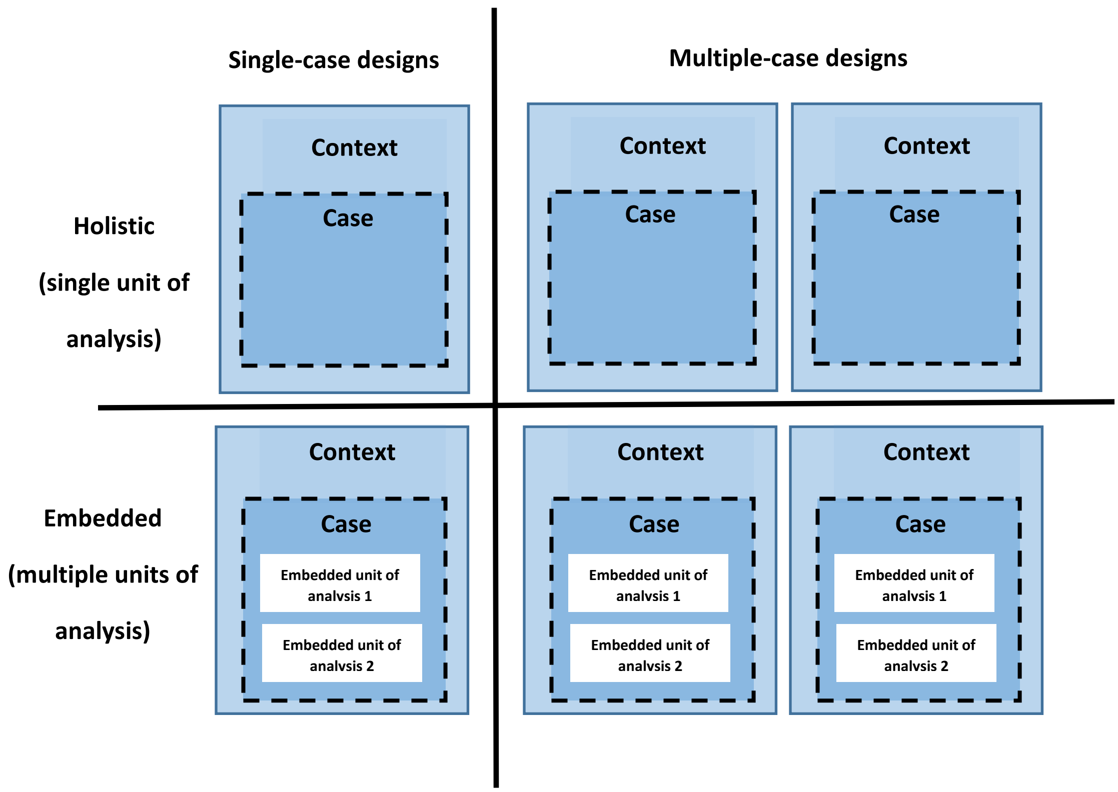

Figure 3.1 Basic types of case study designs (adapted from Yin, 2014)

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The rationale for following one of the four case study designs lies in the research questions guiding the study. It is also very important in case study research to delineate the propositions underpinning the study, as well as the unit of analysis. The primary research question was posed with a particular focus on determining how metacognitive activity manifests in students' group discussions while they plan investigations for an extended laboratory practical activity. The primary focus of my analysis, and therefore my unit of analysis, was the group discussions from which manifestations of metacognitive activity were inferred. The group discussions remained the unit of my analysis regardless of group context, making the holistic multiple-case study design a suitable method of investigation in this study. In the next section, I describe how Yin's (2014) holistic multiple-case study design was adapted for this study.

As stated in Section 3.4 above, each research design has its advantages and disadvantages. Although case study research may overlap with historical studies that follow narrative or phenomenological research designs, the advantages that it has over these designs is a direct observation of the events being studied, as well as complementary sources of evidence. Case study research has been classically considered a 'soft' form of research (Yin, 2014) and has been criticised for arriving at findings that cannot be generalised. However, the requirements of methodological rigour, a thorough literature review, and careful posing of research questions make case study research demanding. The question of generalisation is discussed in more detail in Section 3.9.2 of this chapter.

3.3.2 A multiple-case study of manifestations of metacognitive activity

Yin (2014) asserts that, unlike in experimental designs, the decision to use multiple cases should be based on replication logic, i.e. an additional case should be selected so that it either predicts similar results (literal replication) or it predicts contrasting results for anticipatable reasons (theoretical replication). In the main study, a conscious decision was made to analyse the discussions of two specialist groups (Research Question 2) in anticipation that varying group contexts would result in contrasting manifestations of social regulation. The decision to study how students with varying styles of interaction, for example, assertive vs tentative, regulated cognitive activities in their respective home groups (Research Question 3) was also based on theoretical replication. Acknowledging the potential influence of social context on the regulation

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of cognition led to the proposition that being exposed to different home group contexts could result in the students regulating cognitive activities differently.

Figure 3.2 below shows that although different group contexts were studied for the purposes of answering Research Questions 2 and 3, the unit of analysis remained the same. Assuming varying group contexts, indicators of metacognitive activity (MA) were expected to manifest differently in each case.

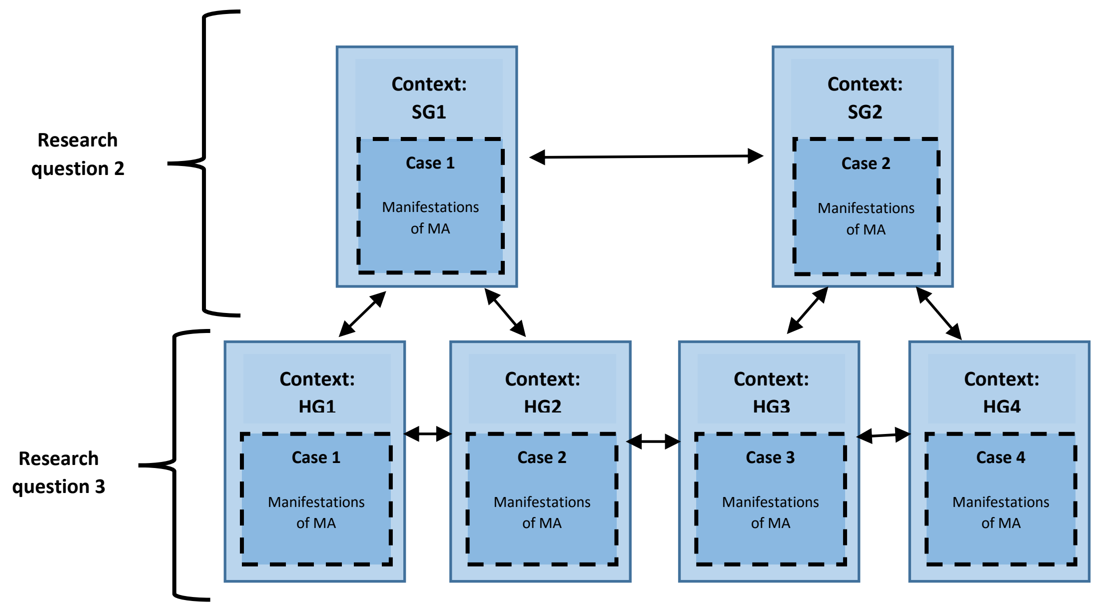

Figure 3.2 Multiple case study method adapted for the main study

Answering Research Question 2 entailed analysing the discussions of both groups for metacognitive activity. Answering Research Question 3 involved analysing the home group discussions of specific individuals for metacognitive activity.

3.4 Context: The simulated industrial project

As explained in Chapter 1 (Section 1.3), the context in which the current study took place was the planning session of the simulated industrial project, an extended laboratory activity combining elements of guided inquiry, collaborative learning, and metacognitive scaffolding. A detailed description of what the laboratory activity entailed is available as a published article attached as Appendix 1.1, but for the sake of brevity it is introduced in the discussion below. Hence, a brief description of each element as it pertains to the current study is provided next.

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3.4.1 Guided inquiry and contextualisation

Only the problem, theory, and condensed experimental procedures were given to students in the simulated industrial project, which is consistent with the definition of guided inquiry as provided by Buck, Bretz and Towns (2008). The level of difficulty was escalated by requiring the specialist groups to engage in discussions and to draw up experimental procedures from the available resources. The communication from these discussions was expected to be rich in instances of social regulation. Requiring the students to collaboratively generate their own detailed experimental procedures saw the students taking ownership and entering the laboratory with confidence, and demonstrating a better understanding of what they were doing and why they were doing what they were doing.

The element of contextualisation embedded into the simulated industrial project also played a significant role in how the students regulated activities during the specialist and home group discussions. The students thus also developed a professional identity. This observation was evident in how they were constantly role playing during group discussions and how they carried themselves during the presentation of their recommendations to the hypothetical company board. Excerpt 3.1 below is an example of the role playing observed in the student discussions.

Excerpt 3.1

528. **Kagiso**: *Ja* (Yes) we assume we have everything this is a company […]

1349. **Kagiso**: *Haa sesi haa. Haa la re disturba ke company ya rona le tlo wisa company. Consultation batho ba nka se tlhole ba tla mo.* (no sister no. You are disturbing us it's our company you are going to destroy our company. Consultation people will no longer come here).

(Turns 528 and 1349, Transcript of *Team Kagiso*'s specialist group discussions, planning session)

3.4.2 Collaborative learning

The task of drawing up procedures for the three routes and experimentally evaluating all three in the laboratory would have been too overwhelming for individual students considering that this was something they were not likely to have experienced before. However, the sharing of activities is known to reduce cognitive processing load, making room for negotiations and co-construction of knowledge (Whitebread, 1999). Based on these considerations, the jigsaw

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learning technique (Aronson, 2000) was used as a group work approach in the simulated industrial project.

3.4.3 Metacognitive scaffolding

Metacognitive scaffolding was incorporated in this research by way of Reflective Learning Strategy Questionnaires (RLSQs) with activity specific prompts introduced before, during and after task execution. The metacognitive prompts were adapted from Schraw's (1998) regulatory checklist, which was designed to facilitate the regulation of cognition before, during and after task performance. The incorporation of RLSQs was expected to greatly increase the likelihood that the students would engage in intra- and inter-individual regulation. The RLSQs used by the students during the simulated industrial project have been provided as Appendices 2.1, 2.2, 2.3 and 2.4.

3.4.4 The planning session of the simulated industrial project

Figure 3.3 gives an overview of the sequence of events and the times allocated for the home and specialist group activities during the planning session.

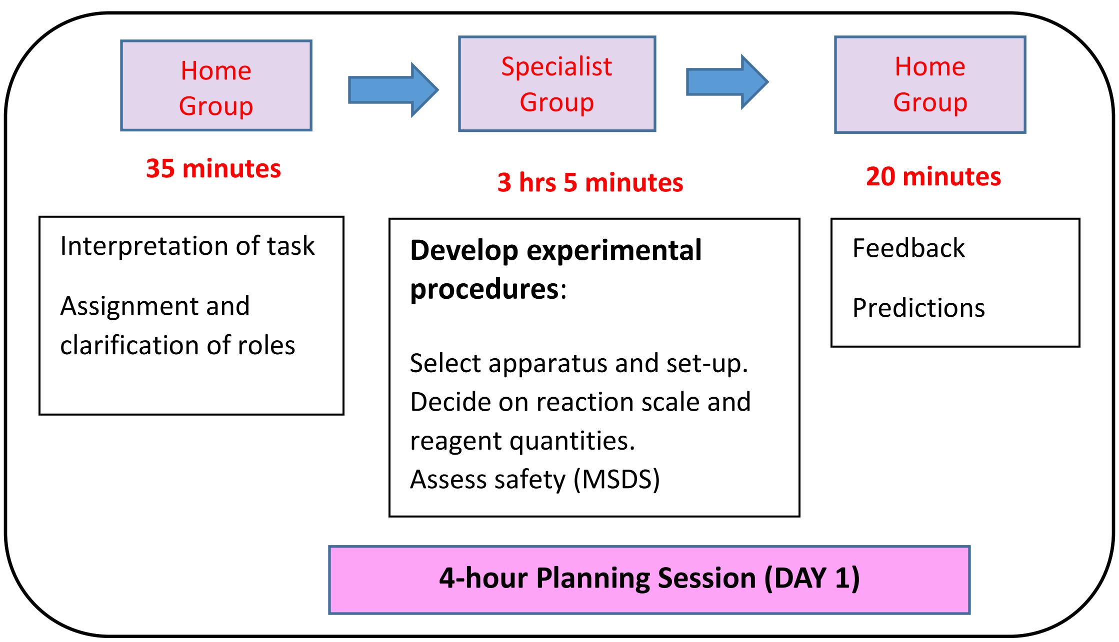

Figure 3.3 Overview of the sequence of events during the planning session

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The planning session was structured to occupy a period of four hours. Upon arrival, the students were placed in predetermined home groups of two to three by the lecturer. The students were given 35 minutes to clarify task requirements and expectations with their peers and the teaching staff. The teaching staff included the lecturer and one teaching assistant. The next three hours were dedicated to specialist group discussions where members of the home groups who had been allocated the same synthetic routes convened into predetermined specialist groups of three or four. The students made use of supplementary reading material at their disposal to extrapolate safety data, glassware, equipment as well as the amounts required to carry out the syntheses in the laboratory. Both the specialist and home group discussions of all consenting students were audio recorded.

3.5 Methodological approaches to identifying metacognitive activity in natural settings

A literature review on the methodologies used to identify metacognitive activity in natural settings assisted me in the process of arriving at the decision to follow a qualitative case study approach. The challenge of identifying metacognitive activities is that these mechanisms often remain covert, taking place inside the heads of the students, making their direct observation difficult. However, researchers have proven with supporting evidence that metacognitive activity can be inferred from its behavioural consequences (Khosa & Volet, 2014; Whitebread et al., 2009). Veenman (2012) warns that the observation of metacognitive activity poses some validity problems as it often relies on self-reports collected through either prospectively or retrospectively administered questionnaires, item-by-item evaluations, or through retrospective interviews. These self-report instruments run the risk of eliciting socially desirable responses and as a result fail to give a true reflection of the cognitive knowledge and regulation that is actually used during task execution (Veenman, 2012).

The methods used to identify metacognitive activity may be divided into two categories, namely, online and offline methods (Veenman, 2007). The methods used during actual task performance, such as systematic observation, think-aloud protocols, and computer log-file registration are referred to as online, while the use of questionnaires and interviews that are administered either prior or retrospective to task performance constitute offline methods. The questions asked in retrospective, offline methods often probe the frequency of strategy use and skill application of a learner (Veenman, 2012). Offline methods rely heavily on self-reports from the students,

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whereas online measures are obtained from judges who are external to the learning process, such as the researcher or instructor. People may report that they will execute certain strategies, but fail to do so or they may give inaccurate recollections of what they actually did during task execution. For these reasons, online methods are preferred over offline methods, or are combined with offline methods in the study of metacognitive activity (Veenman, 2012).

Whitebread et al.'s (2009) study on the metacognitive ability of young children is evidence that systematic online observational methods have the following five advantages: they record what students actually do (rather than what they recall or report that they do); they allow researchers to create links between learners' behaviours and the context; they are crucial for students with poorly developed skills, i.e. children or second language speakers as they do not depend largely on verbal abilities; they allow the recording of verbal and non-verbal behaviours; and they allow the opportunity to record the social processes involved in the development of metacognitive and self-regulatory processes (Azevedo, 2009).

The prospect of recording behaviour as it happens rendered systematic online observation a suitable research method for investigating the manifestations of metacognitive activity in social contexts. The limitation of observation as a data collection tool is that it gives the researcher access to only what is happening at the moment. The researcher does not gain access to what happened before or after the event, or to the cognitive processes of the participants during task performance in the natural setting. Gaining access to what happens in the minds of students while they perform their tasks is intrinsic to the study of metacognitive activity. For this reason, systematic online observation was combined with offline retrospective interviews to allow the researcher to gain access to what the students were thinking at the time of task performance.

3.5.1 Systematic on-line observation

Observations made by human beings are largely unconscious and unsystematic. However, for use as a research tool, observation needs to be systematic and subjected to several quality checks in order to produce trustworthy results (Merriam, 2009). Similar to interviews, observations also vary in terms of structure. The researcher can choose aspects to focus on ahead of time, formulating these aspects into a code sheet. With less structured observations, the researcher allows the focus of observation to emerge and change over time. Hintze, Volpe and Shapiro

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(n.d.) make a distinction between naturalistic and systematic direct observation as the two methods frequently used by psychologists to observe behaviour in classroom settings. The descriptions of naturalistic and systematic direct observations are respectively analogous to the descriptions offered by Merriam (2009) for less structured and structured observations.

With naturalistic observation, the researcher enters the site and makes observations with no predetermined behaviours in mind. With systematic observations, the researcher enters the site with the aim of observing specific behaviours that have been operationally defined *a priori*. A workable definition of the target behaviour should provide a description of the behaviour that clearly defines the parameters of its existence and nonexistence (Hintze et al., n.d.). The researcher should also carefully specify and select the times and places for observation. The focus in the current study was manifestations of metacognitive activity inherent in the collaborative planning of practical investigations. I also focused on delineating the target behaviour, time and place for observation as social regulation during the planning session of the simulated industrial project. Systematic online observation was therefore used in this study.

In the continuum of several stances taken by researchers while observing, I would say that in my observation of the students while they worked in their groups during the planning session, I primarily took on the role of *Observer as participant*. Merriam (2009) describes this stance as peripheral, where the role of the researcher as observer is known by the participants and the researcher's participation in group activities is secondary to the role of information gatherer. In this stance, the researcher can interact closely with members without participating in the core activities of the group (Adler & Adler, 1998). My participation in the session was limited to helping to distribute reading materials and recording devices amongst the groups.

3.5.2 Field notes

It takes a lot of concentration to observe and record in detail what you see. For this reason, the data obtained through observations can be recorded in several ways. What is observed can be captured on-site in the form of field notes or through audio/video recording for off-site detailed analysis. In this study, field notes and audio recordings of group discussions were used to record all observations. Although not used frequently, field notes provided perspective in terms of the context of audio recordings of group discussions. Field notes were used to capture information such as dates, times for each activity, instructors facilitating the activities, how long each activity

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lasted, as well as any deviations from the planned activities. As observer, I also included comments, and the thoughts and insights that emerged as I reflected on what was taking place. Examples of the field notes taken during each planning session are provided as Appendix 3.1 for the pilot study, and Appendix 3.2 for the main study.

3.6 Overview of the research project

The current study spanned a period of three years. The third year organic chemistry course in which the study was conducted is presented in the second semester of each year. A pilot study was conducted in the first year and the main study in the second year. The third year was used to transcribe, analyse data, and write.

Table 3.2 Overview of the research project

Year 1 (2013)	**Year 2 (2014)**	**Year 3 (2015)**
Pilot study	Main study	Transcription and analysis of main study data. Writing.

3.7 Pilot study

3.7.1 Purpose of the pilot study

Preliminary data collection by means of a pilot study was necessary to guide the choice of research design, as well as the design of data collection and analysis protocols for use in the main study. The context in which the pilot study was conducted (described below) was similar to the context in the main study with the exception that teaching assistants were given the role of synthetic route experts who facilitated discussions within the groups.

3.7.2 Participants (pilot study)

The pilot study was conducted in 2013 with a group of consenting third year organic chemistry students (n = 38). Up until 2012, the whole group could fit into one laboratory session, but in 2013 the class size exceeded the capacity of the laboratory, which led to the division of the class into two groups, e.g. Monday group (26 students) and Thursday group (12 students). Students were allocated into groups based on their lecture schedules.

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The Monday planning session of the simulated industrial project consisted of nine home groups and four specialist groups, while the Thursday group had four home groups and three specialist groups. Several audio recording devices were placed randomly to record student discussions as they worked in their home and specialist groups. A semi-structured interview schedule (Appendix 3.3) with 18 items was compiled and used in retrospective individual interviews.

3.7.3 Data collection (pilot study)

Data was collected for both the Monday and Thursday groups. The data collected during the pilot study served as evidence of the rich data that could be collected using the chosen data collection strategies. Through the pilot study, I was able to collect the data, as shown in Table 3.3.

Table 3.3 Complete audio data collected in the pilot study

Forms of data collected	**Monday Group (26 students)**	**Thursday Group (12 students)**	**Total**
Audio recorded home and specialist group discussions	**Home group Z Parts 1 & 2**: 10 mins 9 secs (good sound quality). **Home group O Parts 1 & 2**: 26 mins 9 secs (poor sound quality). **Specialist group MonA**: 2 hours 30 mins (good sound quality). **Specialist group MonB**: 2 hours 28 mins (poor sound quality).	**Home group B Parts 1 & 2**: 34 mins 17 secs (poor sound quality). **Specialist group ThursA**: 2 hours 22 mins (good sound quality). **Specialist group ThursB**: 2 hours 30 mins (poor sound quality).	**7** **(≈ 11 hours)**
Audio recorded interview data	8 interviews (Average 15 mins 20 secs per interviewee).	2 interviews (Average 16 mins 30 secs per interviewee).	**10** **(≈ 2 hours 35 mins)**

A list of all the recordings together with the duration for each audio are available in the Appendices (Appendix 3.4). Examples of the recordings shown in Table 3.3 above are also available on a compact disc provided with this thesis. The number of audio recorders was limited which meant that not all of the groups could be recorded. The available recorders were thus interspersed amongst the home and specialist groups to capture as much audio data as possible.

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However, several technical problems were encountered. Some data was lost due to the malfunctioning of audio recorders, facilitators forgetting to turn the recorders on and off, poor sound quality, and background noise. The majority of the recording devices used were fairly old and captured a lot of background noise, which made it very difficult to distinguish conversations of target groups from those of neighbouring groups. Also, being old models, the recorders did not support the transfer of digital files onto a computer for safe keeping and easy transcription.

For the Monday group, only two home and two specialist group recordings had complete recordings, although of those the recordings of one home and one specialist group were difficult to analyse due to background noise. For the Thursday group, one group and two specialist groups were fully captured, although with poor sound quality in the majority of the recordings, as shown in Table 3.3 above. Of the seven recordings, only three (one home group and one specialist group from Monday and one specialist group from Thursday) were considered to be of fairly good quality with less background noise. A total of 18 students in the Monday group and seven students in the Thursday group agreed to participate in follow-up individual interviews. Of the students who had indicated a willingness to participate in follow-up interviews, eight from the Monday group participated in retrospective interviews, and two from the Thursday group. A high quality audio recording device was used to capture the follow-up interviews to ensure successful retrieval and good quality sound. In total, I had three audio recorded group discussions (roughly five hours of recordings) and ten interviews (roughly two and half hours of recordings) to work with.

3.7.4 Preliminary data analysis and findings (pilot study)

The audio recordings of one specialist group (Specialist group MonA), one home group (Home group Z), and one interview were purposively chosen for transcription and data analysis. The group discussions and interview transcripts have been provided in the CD with additional information. The specialist and home group recordings were chosen on the basis that the quality of recording was good and the majority of what was said could be transcribed and prepared for analysis. Interview audio recording selection was purposive in that the recording selected was that of the most verbal member of the chosen specialist group. All of the discussions were conducted predominantly in English. The specialist group whose audio recording was chosen for analysis was made up of four team members, one Indian female, one black male and two white

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female students. The Indian female's interview was chosen for analysis. The home group consisted of one white male and two white female students.

The specialist and home group discussions were subjected to an in-depth analysis for the purposes of developing a coding scheme for use in the main study, while interview data was used for the purposes of triangulation. The general inductive approach to qualitative data analysis (Thomas, 2003) was used. The general inductive approach is commonly used by researchers in the social sciences to systematically analyse qualitative data with the aim of developing a model or theory (Thomas, 2003). Through inductive analysis, research findings are allowed to emerge from frequent themes inherent in the raw data. The process followed to inductively derive indicators of metacognitive activity from the pilot study data is discussed further in Chapter 4.

A preliminary analysis of data was conducted to also evaluate the success of the chosen data collection methods in elucidating manifestations of metacognitive activity in these contexts. Several lessons were learnt from analysing the pilot study data, which are presented in the next section.

3.7.5 Lessons learnt from analysing pilot study data

A preliminary analysis of the pilot study data enabled me to identify all of the challenges that had to be addressed in the main study. The following observations were made:

- Discussions in the home groups were more about logistics than the actual subject and task matters.
- Specialist group discussions were found to consist of more instances of consensus building, negotiations and social regulation.
- Students could facilitate their own discussions. Allowing students' discussions to proceed without the guidance of a facilitator had the potential of allowing the discussions to be more natural, with more instances that are rich in consensus building and social regulation. A decision was taken to allow students to facilitate their own discussions in the main study.
- Listening to the audio recorded discussions, it became very difficult to identify who was talking at what time as it was the facilitator chairing the discussion who introduced the

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students' names in the beginning of the discussion. Thus I could not get a sense of who was talking by recognising their voices. A decision was therefore taken to have each student introduce themselves prior to engaging in group discussions in the main study.

- The majority of the audio recordings for the Monday and Thursday planning sessions could not be transcribed due to the poor quality of the recorders. The technology in most of the recorders was too old and the files could not be downloaded onto a computer for easy transcription. The old recorders were also not able to isolate the target sound from the surrounding noise. I needed to invest in good quality recorders that could capture group discussions without being affected by noise generated by the surrounding group discussions. A decision was made to purchase good quality recorders designed specifically for capturing group discussions and to use these in the main study.
- Social regulatory contributions were easily identifiable in students who were assertive and more vocal in their verbal contributions.
- The focus of the interview schedule used for the follow-up semi-structured interviews had to be changed as the items mainly probed the students' experiences of activities in the simulated industrial project rather than how they regulated cognitive activities in their learning groups. This format of questioning could have been suitable if the study followed a phenomenological research design. Being a case study, the focus of analysis was the manifestations of social regulation and not students' experiences. A strategy adapted from that used by Anderson, Nashon, and Thomas (2009) was introduced as part of the interviewing procedure. This strategy entailed playing a clip of the audio recorded discussion of the specialist group (critical incident) being interviewed to stimulate recall and reflection about the monitoring and control strategies of the group at the time.
- A coding scheme was developed based on the conceptual framework and findings of the preliminary analysis of the pilot study data (see Chapter 4). This analytical framework was further refined and used to analyse the data in the main study.

3.8 Main study

The data collection for the main study was conducted from July to September 2014. Various data collection instruments were used to gather the data necessary to answer the research questions.

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3.8.1 Participants (main study)

The main study was conducted with a consenting group of third year organic chemistry students (*n* = 39). Although all of the students in the course gave consent to being recorded while working in their groups, only ten agreed to participate in the follow-up interviews. Similar to the 2013 group, the students were divided into two groups, i.e. Monday group (20 students) and Thursday group (19 students). Students were allocated groups based on their lecture schedules. Both the Monday and Thursday planning sessions consisted of seven home groups and six specialist groups. I was present in both sessions as a participant observer. Field notes (Appendix 3.2) were taken during all of the sessions.

3.8.2 Data collection (main study)

Data was collected for both the Monday and Thursday groups. The amount of data collected during the main study is shown in Table 3.4 below.

Table 3.4 Data collected in the main study

Forms of data collected	**Monday Group (20 students)**	**Thursday Group (19 students)**	**Total**
Audio recorded home and specialist group discussions.	**7 home groups Parts 1 & 2:** (average 1 hour per group). **6 specialist groups** (average 3 hours 30 minutes per group).	**7 home groups Part 1 & 2:** (average 1 hour per group). **6 specialist groups** (average 3 hours 30 minutes per group).	**26 (56 hours)**
Audio recorded interview data.	**1 x specialist group** (47 mins 11 secs). **2 x individual** (Ansie: 25 mins 46 secs; Bettie: 14 mins 31 secs).	**1 x specialist group** (32 mins 30 secs). **2 x individual** (Kagiso: 27 mins 28 secs; Leonard: 37 mins 35 secs).	**6 (3 hours 5 mins)**

A list of all the recordings together with the duration for each audio is available in the Appendices (Appendix 3.5). Examples of some of the audio data from the group discussions and interviews have been included in a compact disc that is provided with this thesis.

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3.8.3 Sampling (main study)

Choosing what, where, when and whom to observe or interview constitutes sampling. Most researchers distinguish between probability and nonprobability sampling. Probability sampling is not justifiable in research that does not seek to generalise its findings to a population from which a sample is drawn. For this reason, nonprobability sampling is preferred by qualitative researchers.

The most common form of nonprobability sampling is purposive or purposeful sampling (Merriam, 2009). This form of sampling is suitable for an investigator who needs to select a sample from which much can be learnt about the phenomenon of interest. Because the analysis of the data relied heavily on making inferences from the specialist group discussions, it was necessary to interview the participants to provide confirming or disproving evidence (Miles, Huberman & Saldana, 2014). A selection of cases for in-depth analysis was therefore made on the basis of all of the team members being willing to participate in the follow-up focus group interviews. Two specialist groups, referred to from here on as *Team Kagiso* (3 hours 11 minutes) and *Team Bettie* (3 hours 37 minutes), were purposively chosen for in-depth analysis; each group was named after its team leader. Four students (two from each specialist group), two who were observed to be more vocal in their social regulation and two who seemed tentative in their regulatory efforts, were deliberately chosen for further analysis of their regulatory contributions within the home groups.

Scholars differentiate amongst the different types of purposive sampling (Cresswell, 2007; Miles & Huberman, 1994). Merriam (2009) lists the more common types of purposive sampling as typical, unique, maximum variation, convenience, and snowball sampling. The sample chosen for in-depth analysis in this study constituted a convenience sample. With convenience sampling, the sample is selected based on factors such as time, money, location and availability (Merriam, 2009). The sample in this research was selected as a matter of convenience in that all of the members of each specialist group were the only students who made themselves available for follow-up interviews both as a group and as individuals.

Ideally each home and specialist group had to have equal numbers of students, however, having 19 students in the Thursday group and 20 students in the Monday group made this distribution

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impossible. Some specialist groups consisted of three members, while some were made up of four members. *Team Kagiso* consisted of four members, one female and three males, including Kagiso (after whom the team was named as a consequence of him assuming the role of leader). *Team Kagiso* consisted of Setswana and Zulu speaking Black students. *Team Bettie* consisted of three members who were all Afrikaans speaking White female students.

In light of the previous and current literature reports, it was anticipated that the diversity inherent in the two teams in terms of gender and varying personalities would result in varied patterns of interaction and thus varied patterns of metacognitive regulation. It is important to note that although the medium of instruction during this activity was English, the students were free to carry out group discussions in the language of their choice. The members of *Team Kagiso* carried out their discussions mostly in Setswana, while the conversations in *Team Bettie* were predominantly conducted in Afrikaans.

3.8.4 Systematic online observation

Prior to collecting data through observations, the researcher needs to gain access to the setting in which the phenomenon of interest takes place (Merriam, 2009). In the current study, entry into the research site was gained by seeking permission to conduct research from the head of the chemistry department and all involved instructors of the course. A letter with a detailed explanation of the purpose and period of the study was sent to the Head of Department for approval prior to observations taking place. Bogdan and Biklen (2007) caution researchers not to take what happens in the research site personally, to have someone on site to introduce them, and to be relatively passive and unobtrusive so as to put the participants who are being observed at ease. These two researchers also suggest that establishing a rapport by being friendly and showing interest in the activity also helps the process to go smoothly. In this study, each planning session started with the instructor introducing me as a researcher. The students were also were made aware of the study and my presence through invitation letters (Appendix 3.6) given to them in the previous class. I tried to be as unobtrusive as possible by placing audio recorders at each group's station and sitting at the back of the class before the students worked in their groups.

Consciousness of the audio recorder varied amongst students. Some students, like Kagiso and Amos (*Team Kagiso*) forgot about the recorder judging by the way that they carried on in their

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off-task discussions and how they were often heard apologising for their use of bad language when Reneilwe reprimanded them (see Excerpt 3.2 below). Ansie (*Team Bettie*) and Leonard (*Team Kagiso*) demonstrated their awareness differently; Ansie often spoke softly, while Leonard tried to constantly monitor what he was saying during the discussion (Turn 828, Excerpt 3.2 below), although he seemed to have forgotten about the recorder towards the end of the discussion when he engaged in a verbal confrontation with Kagiso.

Excerpt 3.2

826. **Amos**: *A re neede bodidensity tsa bona ba gafa gaan ** (Kagiso laughs) eh kana ra recordiwa moo.* (We don't need their densities here they can go and **, oh by the way we are being recorded here)

827. **Reneilwe**: Shhh!

828. **Leonard**: *A bone nna ke didimala so nna ka itse tla be ke bolela thata* (That's why I am keeping quiet 'cause I know I would be talking too much)

829. **Amos**: *Ah diM o tla ntshwarela ke mistakenyana* (Oh this madam will forgive me, it's just a minor mistake)

(Turns 826 – 829 Transcript of *Team Kagiso*'s specialist group discussion, planning session)

3.8.5 Stimulated recall interviews

Stimulated recall interviews typically involve the use of audio or video recordings of specific behaviour, which are used to stimulate participants' recall of their thought processes at the time of that behaviour (Calderhead, 1981). The use of stimulated recall as a method for interviewing participants is often attributed to Bloom (1953), who played back recordings of lectures and discussions to university students with the aim of investigating student thought processes in the two learning settings, thus allowing comparisons to be made between lectures and discussions on the basis of the thought processes that each strategy elicited. Subsequent researchers have used stimulated recall interviews to study high school students' metacognition across formal and informal science learning contexts (Anderson et al., 2009). This method of interviewing is based on the assumption that the cues provided through the video or audio recordings will enable participants to 'relive' the episode to the extent of enabling them to make accurate recollections of their thought processes retrospectively. In the current study, stimulating the recall of the students through audio recorded clips of their group discussions assisted greatly in jogging their memories, and it allowed them to relive the experience of working together in their specialist

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groups. While listening to the clips, the students could be heard recalling what was happening at that particular moment.

Excerpt 3.3

31. Ansie: (*listening to the clip*) That's Bettie! (*laughs*). (*in the clip Bettie, is surprised about the four hour waiting time in the experimental procedure*) She actually studied in those four hours (*laughs*).

(Turns 31, Transcript of Ansie's follow up interview)

Researchers wishing to use stimulated recall interviews are advised to consider several factors that may influence the richness and nature of the data obtained through this data collection method (Calderhead, 1981). Firstly, the participants may experience anxiety or embarrassment in listening to themselves, which may influence their recall or the extent to which they are prepared to talk about their thought processes at the time. The problem of anxiety or embarrassment could be overcome by the researcher establishing a rapport with the participants and familiarising the participants with the stimulated recall procedure. In the current study, each interview session began with the researcher putting the participants at ease by asking them to say their name out-loud and establishing a common understanding of the term 'metacognition'. The playing of audio clips was preceded by the researcher saying the following: "*I am going to play a few clips of audio recording which were captured as you were working in your specialist groups. The aim is not to embarrass anyone but to enable you to remember what was said, how it was said and who said it.*" (Appendix 3.7).

Secondly, some thinking has never been verbalised and may not be verbally communicable. Such thinking constitutes tacit thought processes that formed part of the participants' everyday cognitive activities and could thus not be spontaneously verbalised during the stimulated recall interviews. Similarly, metacognitive activity may not be conscious or explicit in many learning situations. Many of the thought processes are highly automated, at least among adults, and these may develop without any conscious reflection, making them difficult to report to others. However, one could argue, as does Calderhead (1981), that the thought process involved in remembering social behaviour is qualitatively different from those involved in remembering

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facts, albeit possibly biased or partial. In support of this argument, Schank and Abelson (1977) make a distinction between *plans* and *scripts*. On the one hand, the cognitive processing of *scripts* is largely automated and occurs when an activity is 'routinised' or overlearned. The processing of *plans*, on the other hand, similar to the regulation of cognition, is more conscious and deliberate and can as a result be easily reported.

Thirdly, how researchers choose to prepare and brief participants in terms of how they should comment may greatly influence the nature of data generated though the stimulated recall interviews. Some researchers prefer to state explicitly which thoughts the participants are expected to recall and comment on in listening to the clip (Anderson et al., 2009; McKay & Marland, 1978), while some prefer to be less explicit about which thoughts to recall (Calderhead, 1979; McIntyre, 1977). Calderhead (1981) cautions that explicit instruction used to prepare participants prior to listening to the clips has to be weighed against the possibilities of imposing or eliciting desirable responses. However, the participants may, alternatively, provide more detailed accounts if they know which thoughts to focus on. In this study, I found that explicitly reminding the participants of the aim of the study and establishing a common understanding of metacognition in the context of learning in a group brought focus and allowed the students to concentrate on recalling thoughts that were relevant to the discussion.

Items in the schedules were changed to probe how the students monitored and controlled their thinking during the group discussions in the planning session. Two schedules were generated, one for the specialist group interviews (Appendix 3.7) and one for the individual interviews (Appendix 3.8). Audio clips or episodes of the group engaging in talk indicative of regulation were selected by the researcher and used during the interviews to stimulate recall. The groups were interviewed separately. Individuals in the groups who were observed to behave differently in terms of how vocal they were during the group discussions were identified in each group and interviewed individually.

3.8.6 Data analysis (main study)

All of the data was organised into folders for safe keeping. All of the recordings of the selected specialist and home group discussions and interviews were transcribed and captured on the *ATLAS.ti* software for data analysis purposes. Data analysis in this research involved using a

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coding scheme and inferring metacognitive activity from the students' verbal communications, making qualitative content analysis the data analysis method of choice.

Qualitative content analysis is a systematic means of describing the meaning of qualitative data (Schreier, 2012). It entails assigning parts of the qualitative data to categories featured in a coding frame or coding scheme. Merriam (2009) argues that content analysis is implicitly used in any inductive qualitative data analysis. Historically, content analysis was viewed as very quantitative in nature, focusing on the frequencies of occurrence of specific messages, e.g. the number of times certain phrases or speech patterns were used (Merriam, 2009). However, in qualitative research, content analysis has been adapted to facilitate the communication of meaning rather than purely relying on its quantitative aspect.

Analysis in qualitative content analysis is perceived as inductive in that while *a priori* categories are used to initially guide the analysis, other categories are allowed to emerge throughout the data analysis process. The identification of meanings and nuances is key to the process of qualitative content analysis (Merriam, 2009). Qualitative content analysis can be applied to interview transcripts, transcripts of focus groups, and textbooks, amongst other resources. Schreier (2012) asserts that qualitative content analysis is a suitable data analysis method for the description of data that warrants some degree of interpretation. Qualitative content analysis is most suitable for research that is concerned with meaning that is less obvious (Schreier, 2012), rendering it suitable for analysing the data in this study for instances of metacognitive activity.

A coding scheme is central to the data analysis process in qualitative content analysis. *A priori* codes inductively derived through the analysis of the pilot study data were used to code the verbal communication that was characteristic of regulatory processes reflected in the main study. However, the coding scheme was also allowed to evolve with new and emerging indicators. For the purposes of this study, the advantages of qualitative content analysis were found to outweigh its disadvantages. Rich data was obtained by transcribing long hours of students' discussions in the home and specialist groups.

It is easy for one to feel overwhelmed by large quantities of qualitative data. Qualitative content analysis helps in this regard because it is different from other qualitative data analysis methods in that instead of aiming to arrive at a comprehensive and holistic view of the data, focus is placed

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on specific aspects of the data. The data is reduced by focusing on specific aspects according to the research questions. In this research, focus was placed on episodes that exemplified elements of regulation of cognition. Statements in these episodes were selected for analysis and coded according to descriptions in the coding scheme. Episodes of meaning-making and peer knowledge construction (cognition) were labelled as non-metacognitive and coded accordingly.

The systematic nature of qualitative content analysis warrants the following of a specific sequence of steps. Schreir (2012) lists the steps for qualitative content analysis as follows: deciding on a research question; selecting material; building a coding frame or scheme; dividing material into units of coding; trying out the coding frame; evaluating and modifying the coding frame; conducting the main analysis; and finally, interpreting and presenting the findings. A total of two specialist group discussions (*Team Kagiso*: 3 hours 11 minutes; *Team Bettie*: 3 hours 37 minutes) and four home groups (2 hours 12 minutes) were transcribed and subjected to in-depth analysis. More on how these steps were followed to analyse the data in the main study is provided in Chapter 4.

3.9 Quality criteria (credibility, transferability, confirmability and dependability)

The researcher has to persuade the target audience that the findings of his or her study are worth paying attention to and that the study was conducted with the utmost rigour, and is of high quality. When coming to data collection and analysis, qualitative as opposed to quantitative researchers are concerned with addressing aspects of trustworthiness. Lincoln and Guba (1985) describe credibility, transferability, dependability, and confirmability as key criteria of trustworthiness.

3.9.1 Credibility

Credibility has been defined as the extent to which findings are congruent with the data presented (Lincoln & Guba, 1985). In qualitative research, human beings are the primary instruments of data analysis and, as a result of their inherent biases, they are unable to capture objective truth (Merriam, 2009). However, qualitative researchers have a number of strategies at their disposal that they can use to increase the credibility of their findings, the most commonly used of which is triangulation. Denzin (1978) distinguishes between four types of triangulation to confirm emerging findings, e.g. using multiple methods of data collection, multiple sources of data, multiple investigators, and multiple theories. The use of multiple data collection methods

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increases credibility in that what a researcher finds through observations may be corroborated by what emerges in the interview data. Using multiple sources of data refers to the comparison of data collected at different times or places. To ensure trustworthy findings in this study, qualitative data was collected using a combination of systematic online observations and stimulated recall interviews. Data from the different sources (field notes, group discussions and interview transcripts) were compared to check if they led to the same conclusions.

Multiple investigator triangulation occurs when multiple investigators analyse the same data. The concept of investigator triangulation, as proposed by Denzin (1978), is consistent with the strategy of triangulating analysts, as suggested by Patton (2002). Two or more researchers independently analyse the same set of qualitative data and compare the findings (Merriam, 2009). In the current study, I employed the multiple investigator strategy to increase the credibility of the findings obtained through my coding scheme. Two rounds of peer debriefing (Lincoln & Guba, 1985) were used to assess the ability of the coding scheme to generate credible findings. Colleagues A and B, who were experienced in qualitative research and had no direct experience with my research, the students, and the instructional context, served as an analytic audience, one during the development of the coding scheme and the other upon completion of the first cycle of coding.

Discussions held daily with Colleague A over the course of one week led to consensus over the formulation and applicability of the definitions of each manifestation of metacognitive regulation, e.g. planning, monitoring, control, and evaluation, as well as indicators that exclusively exemplified each manifestation. During the second round of peer debriefing, Colleague B was given the specialist group discussion transcript, the coding scheme, as well as directions for coding and was asked to act as an independent coder. The results of the second round of peer debriefing are provided in Chapter 4.

3.9.2 Transferability

The concept of transferability in naturalistic inquiry is analogous to external validity in the context of quantitative research. Lincoln and Guba (1985) assert that in comparison to how a quantitative researcher establishes external validity by determining statistical confidence limits, the naturalist inquirer can only provide thick descriptions of the context. This makes it possible for researchers to make judgements about the extent to which the study is transferable.

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3.9.3 Dependability and Confirmability

Dependability and confirmability are synonymous with reliability in quantitative research. Lincoln and Guba (1985) argue that since there can be no validity without reliability and therefore no credibility without dependability, a demonstration of the former should be enough to establish the latter. However, the authors advise researchers to be explicit about how they have established both aspects of trustworthiness in their studies. Dependability and confirmability may be established by using overlapping methods that are similar to the kind of triangulation used to establish credibility. Alternatively, researchers can subject their work, in the form of a data trail, to an inquiry audit.

Similar to how it is used in the business world in the form of fiscal audits, during an inquiry audit, the process and product of inquiry are assessed. Researchers are therefore urged to provide an audit trail, which constitutes a residue of the records stemming from the inquiry. Such records should include raw data, data reduction and analysis products, data reconstruction and synthesis products, process notes, personal notes, as well as instrument development information. A detailed discussion on how the coding scheme and criteria used for data analysis were generated for the current study is provided in Chapter 4 and also serves as a form of an audit trail. In addition, all other material necessary to show examples of the processes and products of the current study have been attached as appendices, and some have been saved in the compact disc provided with this thesis. Furthermore, to eliminate the overall bias that I as the researcher could bring to the study, I constantly reflected on the researcher process and obtained critical evaluation of the research process from my research supervisors and peers.

3.10 Ethical considerations

Before commencement of the pilot and main studies, ethical clearance was obtained from the University of Pretoria's Faculty of Natural and Agricultural Sciences Ethics Committee (Appendix 3.9). None of the participants were minors and therefore the use of consent forms to be signed by parents was not necessary. In both the pilot and main studies, the participants were asked to sign a consent form (Appendix 3.10) signalling their willingness to participate in the study after reading an invitation letter (Appendix 3.6) duly informing them of the objectives of the study.

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3.10.1 Informed consent and voluntary participation

All of the third year organic chemistry students participated in the simulated industrial project as part of their course work. In a contact session prior to the planning session, the students were issued with the invitation letters mentioned above informing them of the study and its intentions, together with task related supplementary documentation. Only the data of those students who gave their consent to participate in the study was analysed and reported. Only those students who volunteered to participate in the follow-up interviews were interviewed. Students were also informed that they could withdraw from participation at any point without consequence.

3.10.2 Privacy and confidentiality

In this report, pseudonyms have been used instead of real names to protect the identities of the students. Pseudonyms will also be used in all future reports related to the current study. The participants were assured complete confidentiality throughout the study.

3.10.3 Handling and storage of data and dissemination of research findings

All of the qualitative data, e.g. the video and audio recordings and transcripts, were handled by the researcher, her assistant(s) and supervisors only. Upon completion of the study, the data will be stored in a safe place and will be destroyed after 15 years. The findings of the study were used to compile the current report, which is submitted to my supervisors and external examiners for examination purposes. The findings will also be published in accredited science education journals and presented at science, mathematics and technology education conference(s). The next chapter presents the data related to the pilot study, as well as the data analysis of the data obtained from the main study.

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CHAPTER 4

DATA ANALYSIS

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CHAPTER 4

DATA ANALYSIS

4.1 Introduction

The coding schemes developed for the purposes of identifying social regulation must be designed in such a way that they are sensitive enough to capture a wide range of manifestations and allow for an analysis that is rigorous enough to generate trustworthy findings (Azevedo, Moos, Johnson & Chauncey, 2010). A variety of analytical tools to examine the manifestations and dynamics of inter-individual regulation in natural classroom settings have been developed over the years (see Kung & Linder, 2007; Vauras & Volet, 2013). In their attempts to develop observational tools for social regulation, researchers have opted for a Grounded Theory approach (Khosa & Volet, 2014; Whitebread et al., 2009).

It became necessary in this study to employ an analysis method that could facilitate the goal of arriving at a rich description of nuances in the observed patterns of social regulation, as displayed by the students in a laboratory context. The approach that I employed to develop a coding scheme was both inductive and deductive in that the indicators of intra- and inter-individual regulation were obtained through a preliminary analysis of the pilot study data. These were then compiled into a coding scheme and subjected to several quality checks by an analytic audience prior to use as an analytic tool in the main study. In this chapter, I also discuss in detail how the quality checks by an analytic audience assisted me to arrive at a more comprehensive coding scheme. This chapter also serves as an audit trail, providing detailed explanations of how the coding scheme was developed and how it was used to analyse the main study's data.

A discussion is included in this chapter of how I drew from existing analytic frameworks to formulate criteria that enabled me to make a distinction between high- and low-level metacognitive regulation. Lastly, I show how my analytic tools relate to my research questions and how they assisted me to analyse the group discussions for manifestations of metacognitive activity. Although all of the chosen specialist and home group discussions were subjected to an in-depth analysis, only excerpts from *Team Kagiso* have been used to illustrate how the coding scheme was used to analyse the group discussions for manifestations of metacognitive activity.

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4.2 Pilot Study

In the pilot study, one audio recorded specialist group discussion, which was 2 hours 30 minutes long, was chosen on the basis that the quality of recording was good and the majority of what was said could be transcribed and prepared for analysis. The specialist group transcript resulted in 71 pages of students' discussions, 1934 turns of talk, including turns by the facilitator and instructor. The specialist group discussions were transcribed verbatim over a period of two weeks by me and prepared for data analysis. The process of developing a coding scheme started off with a partial theory of what constitutes cognitive regulation in collaborative group discussions as planning, monitoring, control, and evaluation, these occurring at the intra- and inter-individual levels.

For the purposes of this study, I subscribe to the definition of coding as the "process of making notations next to bits of data that strike you as potentially relevant for answering your research questions" (Merriam, 2009, p. 178). Verbal expressions indicative of cognitive regulation were inductively determined from analysing the pilot study data. I started the process of data analysis by reading through the transcript in detail to get an overview of the content of the student discussions. Using *open coding*, only those turns by students considered to be regulatory in nature were assigned descriptive codes (Saldana, 2013), for example, statements such as "*No they give you the procedure but then they want you to, like you know how the previous ones we got?*" were assigned the descriptive code "activating prior knowledge". The descriptive codes were assigned to the point of saturation, i.e. to the point where no new nuances emerged. This process constituted the first cycle of coding. Next, the codes reflecting the same form of regulation were combined to reduce redundancy and overlapping. For examples of the pilot study coding, please refer to the CD provided with this thesis.

Recognising that collaborative activity meant that the students would regulate their own learning as well as that of their peers, the indicators of cognitive regulation were further divided into personal and social regulation based on whether the students were regulating their own cognitive activities or those of their fellow team members. In this way, the verbal indicators of cognitive regulation inductively derived from the pilot study data were used to arrive at the more comprehensive analytic framework, which is shown as Table 4.1 below.

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Table 4.1 Coding scheme with indicators of personal and social regulation inductively derived from preliminary analysis of the pilot study data

Planning (Any verbalisation or behaviour related to the selection of procedures (organisational) necessary for performing the task, individually or with others).		**Monitoring** (Any verbalisation or behaviour related to the ongoing on-task assessment of the quality of task performance (of self or others) and the degree to which performance is progressing towards a desired goal).	
Personal Planning	**Social Planning**	**Personal Monitoring**	**Social Monitoring**
Student individually sets or clarifies task demands and expectations, clarifies prior knowledge, sets goals and targets, decides on ways of proceeding with the task, identifies and selects appropriate strategies, seeks and collects necessary resources, budgets time, and organisation of work space.	Student works together with others to set and clarify task demands and expectations, allocates individual roles, negotiates responsibilities, sets goals and targets, decides on ways of proceeding with the task, identifies and selects appropriate strategies, seeks and collects necessary resources, negotiates how and when to carry out tasks, help each other, shares and takes turns independently and budgets time.	Self-commentates, reviews progress on task (keeping track of procedures currently being undertaken and those that have been done so far), rates effort on-task or rates actual performance, checks behaviour or performance, including detection of errors, self-corrects.	Reviews progress on task of team or peer, checks and/or corrects knowledge or understanding of peer or collective knowledge or understanding of team, checks performance of peer or collective performance of group.
Control (Any verbalisation or behaviour related to a change in the way a task had been conducted (by self or others), as a result of cognitive monitoring)		**Evaluation** (Any verbalisation or behaviour related to reviewing task performance and evaluating the quality of performance)	
Personal Control	**Social Control**	**Personal Evaluation**	**Social Evaluation**
Changes strategies as a result of previous monitoring, suggests and uses strategies in order to solve the task more effectively (e.g. optimise experimental procedures or task performance), applies a previously learnt strategy to a new situation, troubleshoots, repeats a strategy in order to check the accuracy of the outcome, seeks help from more knowledgeable peer, uses nonverbal gesture as a strategy to support own cognitive activity, copies from or imitates a model.	Suggests a change of strategies as a result of personal monitoring, uses new strategies to optimise task performance, initiates application of previously learnt strategies, takes initiative to troubleshoot, repeats strategy use to check for accuracy, seeks help from more knowledgeable peer based on team agreement, assists or guides a peer or team as a whole.	Evaluates personal goals in relation to team goals, revises planning as a result of outcome, reviews own knowledge and understanding, explains tasks, evaluates effectiveness of strategies used, rates quality of performance, observes or comments on task progress, tests outcome or effectiveness of a strategy in achieving a goal, evaluates own solution relative to others'.	Evaluates goals of team, reviews knowledge and understanding of team or peer, explains task to team, evaluates strategies used by peer or team, rates quality of team or peer performance, observes or comments on task progress of peer or team, tests outcome or effectiveness of a strategy chosen by peer or team in achieving a goal, evaluate team's or peers' solutions relative to other teams or peers.

4.3 Main Study

I transcribed word for word *Team Kagiso's* specialist group discussion, which was 3 hours 11 minutes long. The sequence of discussions were numbered as turns of talk. A turn began when an individual took the stage in a conversation, and ended when another person took over (Hogan, 1999). *Team Kagiso's* specialist group discussion resulted in 2920 turns of talk including verbal

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contributions by the lecturer, neighbouring students, researchers, and teaching assistants. Students' verbal contributions alone constituted 2618 turns of talk.

The students in *Team Kagiso* carried out their group discussions mostly in Setswana, which was the home language of three of the group members. Although this meant that language would not be a barrier in allowing the students to make their thoughts and thought processes explicit, this resulted in a lot of code switching between English and Setswana. Being well conversant in Setswana, I could translate all conversations into English after transcription. However, to validate the translations, the accuracy of the translated conversations was assessed by forward and back translation of the turns of talk by a colleague who was a first language Setswana speaker. In the event of discrepancies, we discussed these and adjusted the translations accordingly.

In the case of *Team Bettie's* discussions, the students carried out their group discussions mostly in Afrikaans, which was the home language of all three group members. I have a working knowledge of Afrikaans, so I could easily interact with the data in its original form. An experienced transcriber whose first language was Afrikaans transcribed the 3 hours 27 minutes of discussions and translated the turns from Afrikaans into English. *Team Bettie's* specialist group discussion resulted in 1489 turns of talk, including verbal contributions by the lecturer, neighbouring students, researchers, and teaching assistants. The students' verbal contributions alone constituted 1354 turns of talk. The translations were also subjected to a similar process of forward and back translation by the researcher and transcriber to evaluate the extent to which the translations captured the original meaning.

The initial coding scheme was used to perform a preliminary in-depth analysis of *Team Kagiso's* specialist group discussions. However, the coding revealed deficiencies in the coding scheme. In its initial format, the coding scheme did not make a distinction between instances when students regulated thinking, task performance or behaviour. The coding scheme was not sensitive enough to pick up nuances in these manifestations. A review of the literature on self-regulated learning led to the work of Pintrich (2000), which validated the observations that during collaborative learning, the regulation of cognition was not limited to content and task features, but extended to behaviour as well as task performance (Pintrich, 2000). It became necessary, therefore, to

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develop a coding scheme that could distinguish between the regulation of cognition about the chemistry content, the task features, behaviour, and task performance.

Pintrich (2000) speaks about phases and areas of regulation where phases refer to forethought/planning, monitoring, control and evaluation, and areas constitute cognition about the content, task features, behaviour, and task performance. The term ‘phase’ of regulation seemed to suggest that the processes of planning, monitoring, control, and evaluation occurred in stages when in reality, cognitive regulation was an iterative process rather than a progression. To suit my understanding of the nature of cognitive regulation, I opted for use of the term ‘manifestations’ of regulation to refer to the components of regulation, i.e. planning, monitoring, control, and evaluation, thereby indicating that there is no hierarchy or progression between these components in a natural setting. The types of regulation as a distinction between intrapersonal (self) and interpersonal (shared/other) regulation were an additional dimension that was added to the classification system to make the coding scheme more comprehensive.

Using codes that could capture the manifestation, area, and type of regulation allowed for a coding scheme that would be sensitive to the subtle differences that existed in the behaviours that were exemplary of metacognitive regulation. Codes such as [MON_OR_COGN] were developed to specify the manifestation of regulation (monitoring), the type of regulation (*other*-regulation) and area of regulation (cognition). Such a code would be assigned to an instance when a student checked on the understanding of his or her peers. Two additions, COGN(C) and COGN(T), were used to distinguish between the regulation of chemistry related cognition and the regulation of task related cognition, shown as Cognition (C/T) in Table 4.2. The manifestations of regulation were indicated by the following acronyms: planning (PLAN), monitoring (MON), control (CTRL), and evaluation (EVAL). *Other*-regulation and *self*-regulation were indicated by OR and SR respectively. Areas of regulation were indicated as follows: cognition [COGN(C) & COGN(T)], behaviour (BEHAV) and task performance (TASK). Codes were assigned manually and captured electronically through a computer assisted qualitative data analysis (CAQDAS) software, *Atlas.ti* version 7. The refined coding scheme (Table 4.2) was used to code instances of metacognitive regulation in the transcribed specialist group discussions.

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Table 4.2 Coding scheme with indicators of manifestations, types and areas of cognitive regulation

Forethought/Planning	Monitoring
Cognition (C/T): activate relevant prior content, strategy and procedural knowledge (e.g. what knowledge will we need for the task); clarify task instructions and demands towards common understanding of task. **[PLAN_SR_COGN, PLAN_OR_COGN]** [Planning_Self regulation_Cognition, Planning_Other regulation_Cognition]	**Cognition (C/T)**: Check understanding or thinking (own or peers) of instructions, content, procedures, seek validation of thought, seek critique of thinking. **[MON_SR_COGN, MON_OR_COGN]** [Monitoring_Self regulation_Cognition, Monitoring_Other regulation_Cognition]
Behaviour (B): negotiate rules of engagement **[PLAN_SR_BEHAV, PLAN_OR_BEHAV]** [Planning_Self regulation_Behaviour, Planning_Other regulation_Behaviour]	**Behaviour (B)**: check for conducive behaviour (on/off task, what peer is doing), enquire about role(s) expectations, monitor effort on task, monitor efficiency. **[MON_SR_BEHAV, MON_OR_BEHAV]** [Monitoring_Self regulation_Behaviour, Monitoring_Other regulation_Behaviour]
Task performance (T): negotiate roles and responsibilities seek and collect necessary resources in advance, draw up schedule, set goals and targets, select appropriate strategies, negotiate how best to carry out task. **[PLAN_SR_TASK, PLAN_OR_TASK]** [Planning_Self regulation_Task performance, Planning_Other regulation_Task performance]	**Task performance (T)**: check resource requirements, check resource availability, check information availability, check information requirements, check task instructions and requirements e.g. what still needs to be done, check performance of task, check progress on task, monitor time, check progress regarding a specific aspect of task. **[MON_SR_TASK, MON_OR_TASK]** [Monitoring_Self regulation_Task performance, Monitoring_Other regulation_Task performance]
Control	**Evaluation**
Cognition (C/T): correct thinking, explain, seek clarification from More Knowledgeable Other (Vygotsky, 1978), critique thinking, critique suggestion, activate prior knowledge. **[CTRL_SR_COGN, CTRL_OR_COGN]** [Control_Self regulation_Cognition, Control_Other regulation_Cognition]	**Cognition (C/T)**: evaluate understanding, evaluate thinking, **[EVAL_SR_COGN, EVAL_OR_COGN]** [Evaluation_Self regulation_Cognition, Evaluation_Other regulation_Cognition]
Behaviour: draw attention to task at hand, commend for good behavior, demand attention, urge increase in effort, urge increase in speed, urge decrease in speed, urge a pause, urge silence, call to order. **[CTRL_SR_BEHAV, CTRL_OR_BEHAV]** [Control_Self regulation_Behaviour, Control_Other regulation_Behaviour]	**Behaviour**: evaluate behaviour, evaluate attentiveness, evaluate cooperation. **[EVAL_SR_BEHAV, EVAL_OR_BEHAV]** [Evaluation_Self regulation_Behaviour, Evaluation_Other regulation_Behaviour]
Task performance: change strategy/approach to optimise task performance, introduce strategy, point out information required for successful task execution, clarify task expectations, request critique of performance, critique performance, point out what still needs to be done, critique strategy use, put forth way forward, re-reads task instructions, seeks information, seeks resources, caution about time left, draw attention to task instructions, remind of aspect of task to be completed. **[CTRL_SR_TASK, CTRL_OR_TASK]** [Control_Self regulation_Task performance, Control_Other regulation_Task performance]	**Task performance**: evaluate task execution, evaluate progress on task, evaluate level of task completion. **[EVAL_SR_TASK, EVAL_OR_TASK]** [Evaluation_Self regulation_Task performance, Evaluation_Other regulation_Task performance]

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4.4 Establishing trustworthiness for the coding scheme and coding

Two rounds of peer debriefing (Lincoln & Guba, 1985) were used to establish the consistency of the coding scheme and system of coding. Two colleagues who were experienced in qualitative research but had no direct experience with my research served as an analytic audience, one during the development of the coding scheme and the other upon completion of the first cycle of coding. Discussions held daily over a period of one week led to consensus about the definitions of manifestations, types and areas of metacognitive regulation, as well as the verbal behaviours indicative of these aspects of regulation.

During the second round of peer debriefing, another colleague was given an extract of the specialist group discussion transcript, coding scheme, as well as directions for coding, and was asked to act as an independent coder. The level of inter-coder agreement was determined by calculating Cohen's Kappa, a statistic used in similar research to determine inter-rater reliability (Kung & Linder, 2007). Inter-rater reliability is a measure of the level of agreement between two coders. It provides valuable information regarding the effectiveness of an employed coding system. Cohen's kappa normally ranges from 0 to 1. Cohen's kappa values less than 0.40 indicate poor agreement, while kappa between 0.40 and 0.75 are an indication of fair to good agreement. Kappa values above 0.75 indicate strong agreement between coders (Fleiss, 1981).

The colleague coded a portion of student talk consisting of two pages of transcript, which consisted of 26 turns of talk, 14 of which were interpreted as non-metacognitive and 12 as metacognitive. Six out of 12 metacognitive turns were coded the same, which resulted in a Cohen's kappa value of 0.35, indicating a poor level of agreement (Landis & Koch, 1977). Examples of interrater coding have also been provided as Appendix 4.1. Detailed information of how the Cohen's kappa was calculated is also shown in Appendix 4.2.

Most of the disagreements that arose were due to a particular type of statement that was perceived to have dual meaning. Statements such as '*it is this one, right?*' could be interpreted as either a clarification seeking statement (control) or a validation seeking statement (monitoring). After much deliberation, we agreed that depending on the context, all statements in a form of a question ending with the word '*right*' were representative of validation seeking behaviour, and was therefore a monitoring strategy that the students used to get their peers or instructors to

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confirm their thinking. Any other regulatory questions not ending with the word '*right*' were interpreted as information or meaning seeking and were thus exemplary of behaviour associated with control.

Excerpt 4.1 shown below is another example of types of statements for which coding disagreement was encountered. In the excerpt, Amos encourages team members to relax and points out that they have not even finished their reaction mechanisms.

Excerpt 4.1

10. **AMOS**: Relax guys, relax! *Ha ise le fetse le go ira dimechanism mara la…* (You haven't even finished your mechanisms but you…)

(Turn 10 Transcript of *Team Kagiso*'s specialist group discussion).

This turn of talk had been coded as an evaluative statement as EVAL_OR_TASK (Evaluation of task performance, other regulation), interpreting the statement as Amos evaluating his peer's task performance. The independent coder disagreed, citing that Amos' comment implied that the team members were diverting attention to something else when they had not yet finished what they were working on at the time. For the independent coder, it was as if the team members were jumping to the next task before completing the task at hand, so she perceived the statement as demonstrating control of other in connection with the task, and should therefore be coded as CTRL_OR_TASK (Control of task performance, other regulation). Consensus was reached and the coding was changed accordingly. All other similar statements in the transcript were changed according to the independent coder's recommendations. Two conflicting turns remained unchanged after providing motivation for the codes assigned, which resulted in a Cohen's kappa of 0.75, indicating good agreement.

4.5 Data Analysis

Using the modified coding scheme, the transcript of *Team Kagiso's* discussions was recoded in *Atlas ti.* version 7 to incorporate the refined definitions negotiated with the independent coder. Three stages of data analysis were employed to analyse the discussions in the specialist and home groups. The first stage entailed the identification and coding of statements that were indicative of metacognitive regulation (MR statements). The second stage entailed sorting turns

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classified as non-metacognitive (Non-MR Statements) into *Conceptual*, *Digressions*, *Non-substantial*, *Questions/queries*, *Task-related (other)* or *Other* statements. Thirdly, metacognitive statements were further judged for the quality of regulation that they portrayed (Khosa & Volet, 2014).

A rigorous and iterative process was carried out to assign codes to all of the students' turns of talk. Each turn was assigned a code and these were grouped into a total of five families in *Atlas ti*. version 7, i.e. SR & OR Planning, SR & OR Monitoring, SR & OR Control, SR & OR Evaluation, and Non-MR Statements. The five families were generated per team member. Excerpts from *Team Kagiso's* specialist group discussions will now be presented to show how the modified coding scheme was used to analyse the data for manifestations of metacognitive regulation.

4.5.1 Stage 1: Coding for Episodes of Metacognitive Regulation

Kung and Linder (2007) argue that the scarcity of studies that investigate metacognition in natural contexts may be due to the difficulty inherent in classifying statements as cognitive or metacognitive. These two scholars assert that some statements such as *"…I don't think they're right because it was kind of, last time it hadn't really started rolling yet*" are clearly metacognitive, while some such as "*I don't know*" are not. A statement such as the latter may constitute a figure of speech or a student's evaluation of his/her knowledge. The scholars, however, argue that even if the statement may be a figure of speech, it is highly likely that such an expression was triggered by a feeling of doubt as a result of a student evaluating his/her knowledge.

To distinguish between cognitive and metacognitive statements, in the current study, the turns of talk in the form of either questions, assertions, instructions, judgements or suggestions from which planning, monitoring, control or evaluation could be inferred were interpreted as metacognitive. The inclusion or exclusion of statements in this category was dependent on whether the statements exemplified regulation of thinking, behaviour or task performance. The codes assigned to statements identified as metacognitive indicated the manifestation, type, and area of regulation, as well as the sub-codes serving as brief descriptions of the verbalisations, e.g. MON_OR_COGN(C) (*checks peer's understanding about the chemistry content*).

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To simplify the process of coding, each turn of talk was assigned a single code. All turns of talk were coded, none was skipped. Acknowledging the complexity of natural social talk, I accept that some turns of talk can never be clear-cut metacognitive or non-metacognitive. With the focus of my study being on the manifestations of metacognitive activity, statements requiring dual coding as metacognitive and non-metacognitive were coded twice, however, in deciding on the encompassing code for the purposes of quantifying metacognitive turns, priority was given to the regulatory contributions that the statements were making. A good example is the following utterance made by Leonard in the initial stages of the specialist group discussions:

Excerpt 4.2

8. **Leonard**: **Do we have to speak loud or not really?** No, we need a specialist group thing (RLSQ).

The first part of the turn in bold was interpreted as a simple non-regulatory question and the second part as a metacognitive control statement with Leonard alerting his team mates to missing information. In coding the turn was classified as metacognitive.

4.5.1.1 Planning/Forethought

Planning was defined as any verbalisation demonstrating thinking about how individuals intended to go about performing the task. Evidence of planning and forethought was observed in statements such as the ones presented in the excerpts below.

Example PLAN 1: A few minutes into the specialist group discussion Leonard poses this question trying to put forward a strategy to optimise task performance:

Excerpt 4.3

183. LEONARD: How would you like to split it (the task)? Someone does MSDS (Materials Safety Data Sheets), someone does the calculation, someone proposes the apparatus and someone proposes how the actual experiment can be done what do you think?

This statement was coded as: **[PLAN_OR_TASK] (***negotiates roles and responsibilities***).**

Example PLAN 2: In the initial stages of the discussion, Kagiso proposes how the team should go about executing the task of drawing up detailed experimental procedures.

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Excerpt 4.4

175. KAGISO: Okay mmm I say work out, *ankere* (isn't it) we are given the product that we need? So we work out the retrosynthetic route and then work out the forward route from that.

This statement was coded as: **[PLAN_OR_TASK] (***proposes strategy to optimise task performance***).**

Example PLAN 3: In this example Reneilwe verbalises how she plans to optimise her own task performance i.e. by writing the solution on the side, while she waits for one of her peers to finish what he was doing.

Excerpt 4.5

847. RENEILWE: (?) *ko ngwala mo thoko* (I will write it on the side)

This statement was coded as: **[PLAN_SR_TASK] (***proposes strategy to optimise task performance***).**

4.5.1.2 Monitoring

Monitoring was defined as any verbalisation characterised by checking thinking, performance, and behaviour in relation to the task. Individual and peer monitoring manifested mostly as expressions in the form of questions asked with the intention of checking their own or peers' comprehension of task instructions, to seek validation of their own thinking or comprehension by peers or sometimes instructors.

The students sought confirmation of their thinking from their peers and this emerged as the most commonly used monitoring strategy amongst the members of *Team Kagiso*. This was reflected in statements such as the ones provided in the examples below:

Example MON 1: A few minutes into the specialist group discussion the group members are thinking about how to answer the metacognitive prompt "*What information is missing? How will you obtain this information?*" Reneilwe poses a validation seeking question to her team members:

Excerpt 4.6

119. RENEILWE: Okay, how are we gonna obtain it (missing information), (by) research right?

This statement was coded as: **[MON_SR_COGN(T)]** (*seeks validation of thought about task performance*).

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This question was interpreted as a self-regulatory strategy used by Reneilwe to monitor and check with her team members if she was thinking along the right lines in terms what the answer should be.

Example MON 2: Leonard checks if his peers read up on what the desired product is used for. He asks this question to try and bring his point across. This turn was interpreted as other-regulation as Leonard tried to convince his peers that reading up on what the desired product is used for is also crucial information regarding optimal task performance:

Excerpt 4.7

116. LEONARD: okay what is this product used for? What is that for? Did you read it? You didn't read it?

This statement was coded as: **MON_OR_TASK** (*checks peer's task performance*).

Example MON 3: Leonard checks whether peers understand and realise what the prompt (*What will you do in order to compile the detailed experimental procedure for the synthetic route, i.e. distribution of tasks – who will do what?*) asks them to do:

Excerpt 4.8

211. LEONARD: But then that's what they are asking us now, do you realise that? Please would you read it for us? If you don't mind please.

This statement was coded as: **MON_OR_COGN(T)** (checks peer's understanding about task).

4.5.1.3 Control

Control was conceptualised as any verbalisation that is expressed with the intention of changing the way that an individual has been thinking (about task, content, instructions or procedures), and enhancing task performance. Control of individual and peer cognition was observed in instances when individuals attempted to enhance their understanding by seeking clarification from their peers or the lecturer, explaining to their peers to try and change their minds or to correct their peer(s)' thinking, and critiquing their peer(s)' thinking.

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Example CTRL 1: Kagiso and Amos realise that they do not understand something about the solution that they need to use and they ask the lecturer for clarification:

Excerpt 4.9

744. KAGISO: Mm (*agrees*) (?) this doesn't makes sense. Dr P! Dr P! […]

748. AMOS: Eh madam! (*Kagiso laughs*) **[**…]

750. AMOS: Um we don't understand here, (*reads*) the residue was dissolved in dichloromethane and the solution was washed with water. Which solution? The one we (?) stirred overnight or the residue solution?

Turn 750 was coded as: **[CTRL_SR_COGN(C)]** (*seeks clarification from the lecturer*).

Example CTRL 2: Kagiso clarifies the concept of residue in chemical terms to Amos

Excerpt 4.10

735. AMOS: *Ke nako,* twenty four hours *byanong re etsa eng?* (it's time, twenty four hours, what do we do now?) *The residue was dissolved in…residue byang? Residue ke matlakala moes?* (The residue was dissolved…what do they mean residue? Isn't residue rubbish?)

736. KAGISO: No the remainder. When you transfer it.

Turn 736 was coded as: **[CTRL_OR_COGN(C)]** (*clarifies peer's thinking about the chemistry*).

4.5.1.4 Evaluation

Evaluation was defined as any verbalisation that was characterised by evaluative statements or judgements about an individual's behaviour, task performance or thinking. Evaluative statements that exemplified this category were as follows:

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Example EVAL 1: Reneilwe tries to remind Kagiso what a rotary evaporator is and what it looks like, and Kagiso admits to not having any recollection of seeing this instrument. This statement was interpreted as Kagiso's evaluation of his own knowledge or memory.

Excerpt 4.11

1012. RENEILWE*: E e heatang, ke yona e e heatang ba e bitsa (?)* (the one that heats up, the one that heats up they call it (?))

1013. KAGISO: *Oh yes hae nna* I don't remember (Oh yes I don't remember)

Turn 1013 was coded as: **[EVAL_SR_COGN(C)]** (*makes judgement about own memory*).

Example EVAL 2: Reneilwe makes an evaluative statement about her understanding of the logic behind the calculations they have done to determine the amounts of reagents:

Excerpt 4.12

1525. RENEILWE: Now I get it *ne kentse ke re why e ya twice why e seng half we're working back (?)* *(*now I get it I was thinking to myself why it goes twice why not half we're working back*).*

This statement was coded as: **[EVAL_SR_COGN(T)]** (*makes judgement about own understanding of the task*).

Example EVAL 3: In the excerpt below Leonard evaluates Reneilwe's written response to one of the prompts in the specialist group reflective learning strategy questionnaire:

Excerpt 4.13

134. LEONARD: I think it is a bit too summarised [*referring to what peer wrote down as a response to a question in the RLSQ*].

This statement was coded as: **[EVAL_OR_TASK]** (*makes judgement about peer's task performance*).

4.5.1.5 Compilation of data obtained in stage one

The manifestations, types, and areas of regulation identified through coding the specialist group discussion transcripts were used to generate maps of patterns of metacognitive regulation for

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each student in *Team Kagiso* and *Team Bettie* (Appendices 4.3 to 4.9). Descriptive sub-codes were used to demonstrate nuances in the metacognitive statements. Some descriptive sub-codes were unique to individual students and some were common amongst the students. In this way, descriptive sub-codes served as empirical indicators of how metacognitive regulation manifested in each of the team members' verbal contributions.

The profile maps give an overview of the patterns in terms of manifestations, types, and areas of metacognitive regulation, as demonstrated by members of each specialist group. In the maps, I show four manifestations of cognitive regulation, i.e. Planning, Monitoring, Control, and Evaluation. Each manifestation is divided into two types of regulation as *Self-regulation* and *Other-regulation*. Each type of regulation is further divided into four areas of cognitive regulation, which is indicated as cognition about chemistry concepts [COGN(C)], cognition about the task [COGN(T)], behaviour (BEHAV), and task performance (TASK). These profile maps will be referred to in the results chapters. Table 4.3 is an example of one of the profile maps.

4.5.2 Stage 2: Coding of Non-MR Statements

Stage 2 entailed going over the transcript and coding all of the statements that had not been coded as metacognitive statements. This process assisted me to critically evaluate the coding criteria and identify additional statements that met the criteria for metacognitive regulation but were overlooked. Therefore, the statements that were categorised as non-metacognitive in Tables 5.1 and 6.1 (see Chapters 5 and 6) represent turns of talk by the students that I simply could not characterise as exemplifying any of the manifestations of cognitive regulation. Non-metacognitive statements emergent in the peer discussions were labelled as *Conceptual*, *Questions/Queries*, *Non-substantive*, *Digressions*, *Task related other,* and *Other* (Hogan, 1999). Non-regulatory statements in the form of observations, ideas, inferences, and assertions about the task and chemistry were labelled as *Conceptual* statements, e.g. "*Recrystallisation, conical flask and you need a stove to heat."* Simple and direct requests for information were classified as *Questions/Queries*, e.g. '*Anyway, Reneilwe what were you saying*?' *Non-substantive* statements constituted isolated responses or statements that did not contain any substantial and conceptual information such as "*oh yeah*", "*alright okay*", "*oh my gosh*". *Digressions* included off-task talk that had nothing to do with the task or underlying chemistry concepts.

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Table 4.3 Manifestations of Self- and Other-regulation by Kagiso (*Team Kagiso*)

Planning (12)		**Monitoring (82)**	
SR (0)	**OR (12)**	**SR (43)**	**OR (39)**
COGN(C) [PLAN_SR_COGN(C)] **COGN(T) [PLAN_SR_COGN(T)]** **BEHAV [PLAN_SR_BEHAV]** **TASK [PLAN_SR_TASK]**	**COGN(C) [PLAN_OR_COGN(C)]** **COGN(T) [PLAN_OR_COGN(T)]** **BEHAV [PLAN_OR_BEHAV]** **TASK [PLAN_OR_TASK] (12)** negotiates roles and responsibilities (3), negotiates time required in lab (1), proposes strategy for sharing info with peers (1), proposes strategy to optimise task performance (7),	**COGN(C) [MON_SR_COGN(C)] (28)** seeks validation of thought about the chemistry (28) **COGN(T) [MON_SR_COGN(T)] (11)** checks own understanding about the task with peer (3), checks task requirements with peers (1), checks with peers how best to approach task (1), seeks validation of thought about task (6) **BEHAV [MON_SR_BEHAV]** **TASK [MON_SR_TASK] (4)** checks group's progress on task with peer (1), checks own progress on task (1), checks own task performance (1), checks with peers how task should be performed (1)	**COGN(C) [MON_OR_COGN(C)] (4)** checks peer's understanding about the chemistry (4) **COGN(T) [MON_OR_COGN(T)] (4)** checks peer's reasoning about the task (1),checks if peer understands what he is saying (1), checks peer's understanding of task instructions (2) **BEHAV [MON_OR_BEHAV]** **TASK [MON_OR_TASK] (31)** checks peer's performance of task (14), checks peer's progress on task (11), checks peers' progress on task (3), checks progress on task of group (2), checks with lecturer about groups' performance of task (1)

Control (302)		**Evaluation (20)**	
SR (90)	**OR (212)**	**SR (15)**	**OR (5)**
COGN(C) [CTRL_SR_COGN(C)] (66) activates own memory about the chemistry (2), corrects own thinking about the chemistry (6), seeks clarification from lab assistant about the chemistry (5), seeks clarification from lecturer about the chemistry (15), seeks clarification from peer about the chemistry (38) **COGN(T) [CTRL_SR_COGN(T)] (13)** seeks clarification from lecturer about the task (6), seeks clarification from peer about the task (7) **BEHAV [CTRL_SR_BEHAV]** **TASK [CTRL_SR_TASK] (11)** seeks clarification from lecturer about task performance(6), seeks clarification from peer about task performance (5)	**COGN(C) [CTRL_OR_COGN(C)] (149)** activates peer's prior experience (1), activates peer's prior knowledge (1), affirms peer's thinking about the chemistry (12), clarifies peer's thinking about the chemistry (82), corrects peer's thinking about the chemistry (19), critiques peer's thinking about the chemistry (5), draws peer's attention to information given (1), explains the chemistry to peer (13), justifies own thinking about the chemistry (7), questions peer's thinking about the chemistry (7), asks peer to elaborate (1) **COGN(T) [CTRL_OR_COGN(T)] (33)** affirms peer's thinking about the task (2), clarifies own thinking about task to peers (1), clarifies peer's thinking about the task (12), clarifies task to peers (1), corrects peer's thinking about his thinking about the task (2), corrects peer's thinking about task (3), critiques peer's thinking about task performance (3), critiques peer's thinking about task (3), explains task instructions to peer (3), justifies own task performance to peer (1), urges peer to carefully think about task (1), urges peers to consider other factors before making decisions (1) **BEHAV [CTRL_OR_BEHAV] (3)** corrects peer's pronunciation (1), instructs peer to keep quiet (1), urges peer to wait (1), **TASK [CTRL_OR_TASK] (27)** affirms peer's task performance (2), corrects peer's calculations (1), critiques peer's task performance (2), draws peer's attention to given information (2), draws peers' attention to task requirements (2), draws peers' attention to task (4), instructs peer how to perform task (5), point out information as important to peer (1), volunteers approach for task performance (4), urges peer to proceed with task (3), urges peer to allow him time to work on task (1)	**COGN(C) [JUDG_SR_COGN(C)] (12)** makes judgement about own knowledge (8), makes judgement about own memory (2), makes judgement about own understanding of the chemistry concepts(2) **COGN(T) [JUDG_SR_COGN(T)** **BEHAV [JUDG_SR_BEHAV]** **TASK [JUDG_SR_TASK] (3)** makes judgement about correctness of own calculations (1), makes judgement about own completion of task (2)	**COGN(C) [JUDG_OR_COGN(C)]** **COGN(T) [JUDG_OR_COGN(T)]** **BEHAV [JUDG_OR_BEHAV]** **TASK [JUDG_OR_TASK] (5)** makes judgement about group's task completion (3), makes judgement about peer's task performance (2)

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Task related other statements included statements that were clearly task related but were not necessarily regulative, such as students introducing themselves in the beginning of the recording. The *Task related other* category also included statements that were task related but with parts omitted because they were inaudible and could not be transcribed. The category labelled as *Other* included turns of talk that could not be transcribed at all because they were inaudible, as well as turns where nothing was said but sounds were made such as students clearing their throats.

Tables 5.1, 5.2, 6.1 and 6.2 in the next two chapters provide a breakdown of the frequencies of occurrence of the verbal contributions that students made as part of metacognitive and non-metacognitive talk.

4.5.3 Stage 3: coding for quality of metacognitive regulation

As discussed in Chapter 3, fine-grained differences in cognitive regulation were observed by breaking down the manifestations of regulation into low- and high-level metacognitive talk in a study by Khosa and Volet (2014). Low-level social regulation was observed when students reflected on the task by relating the different pieces of information provided in the case file, adding information to group discussions, and seeking information from each other. The qualitative differences in social regulation helped to explain the marked difference in the collective understanding of the case observed in both groups at the end of the assignment.

Combined high-level cognitive and metacognitive processing are most desirable for collaborative group interactions (Volet, Summers, & Thurman, 2009). Conceptually overlapping terms have been used to distinguish the levels or depth of cognitive processing. Terms such as high-level and low-level cognitive processing have been used by researchers such as King (2002). High-level processing is characterised by elaborations, speculations, justifications, inferences, drawing relations, asking thought-provoking questions, and negotiation. Sharing of information, exchanging ideas, clarifying understanding or providing definitions are all described as exemplifying low-level cognitive processing (Volet et al., 2009). Kempler and Linnenbrink (2006) make similar distinctions between surface-level and deeper-level questions with deeper-level questions constituting questions that require more elaborate answers. Hogan (1999) also makes a distinction between deeper and surface socio-cognitive processing. The extent to which students elaborated on and connected ideas, scrutinised and clarified propositions, constructed

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explanations rather than reiterate observations, and substantiated explanations with supporting evidence constituted criteria used to determine depth of processing during a collaborative group exercise. In their research, Volet et al. (2009) and Khosa & Volet (2014) showed that similar distinctions may be observed in terms of the levels of metacognitive regulation processing.

Drawing up criteria to distinguish between the levels of social regulation necessitated me to first consult the literature and formulate clearly how I chose to distinguish between high- and low-level social regulation. Volet et al. (2009) combined the constructs of social regulation and content processing as two continuous dimensions in their proposed theoretical framework for socially-regulated learning (Figure 4.1).

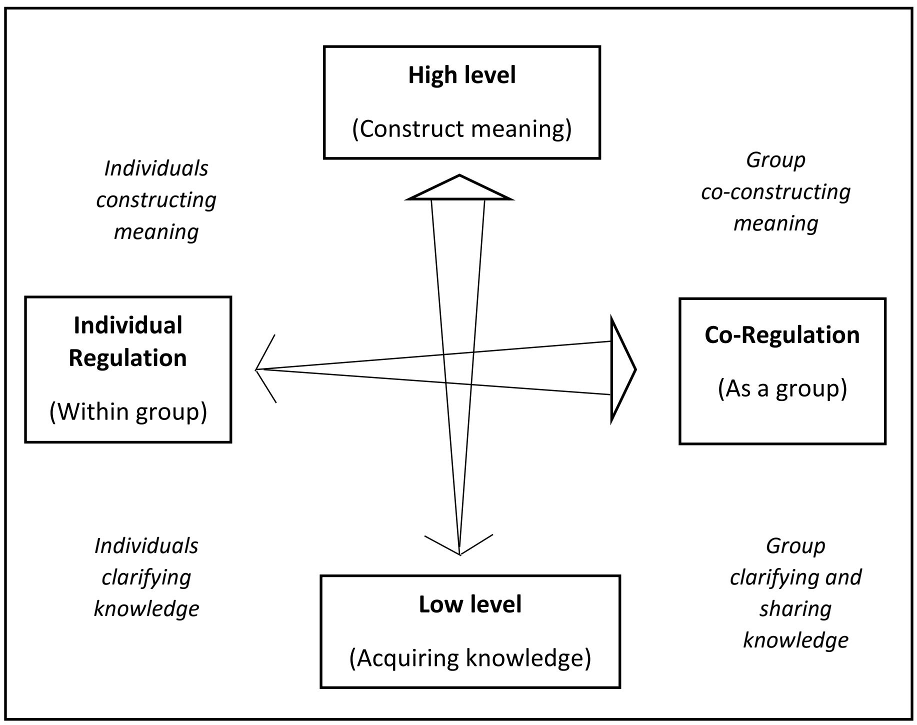

Figure 4.1 Theoretical framework for socially-regulated learning (adapted from Volet et al., 2009)

The intersection of the two dimensions results in four quadrants. Each quadrant is made up of the dominant form of social regulation (individual or group) and level of content processing (low or high). The framework shows that the desired and most effective form of collaboration is represented by a combination of high-level content processing and co-regulation. The use of continuous dimensions finds relevance in the current study because indicators of regulation will

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lie along a continuum between high- and low-level regulation. Some manifestations may not necessarily portray clear-cut high- or low-level regulation, but may more closely reflect more of one level of regulation than the other, making categorisation in high- and low-level regulation possible. In this study, I was interested in the indicators for all four manifestations of metacognitive regulation. Thus, it made logical sense to develop criteria that would delineate and serve as indicators of each manifestation of social regulation, i.e. planning, monitoring, control, and evaluation. Table 4.4 gives a detailed description of what I conceptualised as constituting low- and high-level social regulation for each manifestation of metacognitive regulation.

Table 4.4 Indicators of low- and high-level metacognitive regulation

Level of regulation / **Phase of regulation**	**Low-level (LL)** (characterised by information-seeking behaviour & low order thinking).	**High-level (HL)** (characterised by meaning-seeking behaviour and higher order thinking).
Planning/forethought	Propose how task should be approached or executed without any conceptual justification.	Include conceptual justification for proposed plan.
Monitoring	Checking with the aim of obtaining information and completing task.	Checking with the aim of enhancing conceptual understanding.
Control	Seek information, add/give information to facilitate task completion, stop flow of discussion, critique or question to acquire information.	Seek meaning, volunteer meaning, explore ideas, question or critique with the aim of encouraging deeper thinking and conceptual understanding, reflect on meaning to enhance conceptual understanding.
Evaluation	Make judgements or evaluative statements about thinking, behaviour or task performance.	Include conceptual justification for judgements made.

Low-level regulation was characterised by information-seeking regulatory behaviour and *low-order* thinking. High-level regulation, alternatively, was characterised by meaning-seeking regulatory behaviour and *higher-order* thinking. During planning, the low-level regulation was expected to be observed in instances such as when individuals proposed task execution strategies without offering any conceptual justifications for what they thought could be done by themselves or the group. Checking with the aim of simply acquiring information or validating with no

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demonstrated interest in gaining an understanding exemplified low-level monitoring. High-level monitoring was expected in instances where the individual's monitoring showed concerted efforts to check whether or not he/she understood what was being done.

Indicators of high-level control included seeking meaning, volunteering meaning, exploring ideas, questioning with the aim of encouraging deeper thinking and conceptual understanding, and reflecting on meaning to enhance conceptual understanding. High-level control was expected in instances such as when an individual was not content with a straightforward answer from a peer or instructor and he/she insisted on an explanation for the given answer. The students were expected to offer conceptual justifications for the evaluations that they made in order for these to qualify as high-level regulation. For the easy coding of the already identified metacognitive statements as high- or low-level, the descriptive sub-codes used by Khosa and Volet (2014) were adapted and used as empirical indicators. Table 4.5 shows the descriptions of the codes used as empirical indicators for low- and high-level social regulation, as well as statements taken from *Team Kagiso* as illustrations of exemplary verbal contributions.

High-level regulation was expected in instances when the students sought to establish conceptual understanding by seeking explanation (Seek meaning: SM), volunteering an explanation (Volunteer meaning: VM), providing conceptual justification (CJ), and stimulating thinking (ST). Low-level regulation was expected in instances when the students sought to acquire information (Seek Information: SI), give information (GI), and instigate regulation without offering conceptual justification (noCJ). Therefore, all of the statements judged to demonstrate high-level social regulation were coded as SM, VM, CJ or ST, and all of the statements judged to demonstrate low-level regulation were coded as SI, GI, or noCJ.

Using the criteria outlined in Tables 4.4 and 4.5, I went over the transcripts of the Team Kagiso and Team Bettie's specialist group discussions and classified metacognitive statements as high- or low-level regulation. Evidence of how the low- and high-level planning, monitoring, control, and evaluation manifested in the verbal interactions of each team are presented and discussed in Chapters 5 and 6.

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Table 4.5 Empirical indicators depicting the quality of metacognitive regulation

Low-level metacognitive regulation (LL)	**High-level metacognitive regulation (HL)**
SI: Seek information (**SG Discuss turn 874**: *"What do I what do I give them? What do I keep?*).	**SM: Seek meaning** (**SG Discuss turn 970**: "*…when they say you must filter in something and concentrate in vacuo what do they mean?*").
GI: **Give information** (**SG Discuss turn 809**: *"mm this is your separating funnel"*).	**VM: Volunteer meaning** (**SG Discuss turn 1517**: *"at fifty percent so this means here we need to have twice this"*).
noCJ: **No Conceptual justification** (**SG Discuss turn 2108**: "*It's right*").	**CJ: Conceptual justification** (**SG Discuss turn 516**: *"litmus paper to check the solution if it's around three because we need to check it"*).
	ST: Stimulate thinking (**SG Discuss turn 279**: "*Part two, answer this section after working through the available resources does that make sense?*").

4.6 How the coding scheme and criteria assisted in answering the research questions

Through Research Question 1, I sought to explore the aspects of metacognitive activity inherent in discussions of collaborative learning groups as they plan practical investigations. The theoretical assumptions that underpinned this study were delineated in my conceptual framework, as described in the literature review chapter (Chapter 2). Firstly, metacognitive regulation manifests as instances of planning, monitoring, control, and evaluation. Secondly, the introduction of the element of collaboration amongst peers results in manifestations of metacognitive regulation being observed at the intra-individual level as self-regulation, and at the inter-individual level as other-regulation. The data obtained in this research served to validate these assumptions.

To answer Research Questions 2 and 3, a coding scheme of indicators of cognitive regulation was used to identify and characterise metacognitive statements in terms of manifestation, type, and area of regulation. In addition, using the criteria stipulated in Tables 4.3 and 4.4, metacognitive statements were judged for quality of regulation in terms of low- and high-level regulation. An in-depth analysis resulted in the determination of individual styles of interaction and patterns of metacognitive regulation, as demonstrated by the members in the two specialist

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groups. The home group discussions were also analysed for manifestations of metacognitive activity that was demonstrated by specific individuals in their home groups.

4.7 Chapter summary

The in-depth inductive and deductive analysis of data in the pilot and main study, respectively, assisted greatly in enabling me to identify and characterise instances of social regulation into manifestations, types, and areas of regulation. Furthermore, the evaluation of metacognitive statements in terms of quality of regulation took the depth of analysis to a higher level. In this chapter, I described in detail the processes that I followed to develop and validate a coding scheme and formulate criteria for analysing verbal interactions for manifestations of social regulation. Kagiso's specialist group discussions were used as an example to illustrate how the coding scheme was used. I concluded the chapter by describing how the designated coding scheme and criteria assisted me to answer the research questions.

Chapters 5 and 6 constitute the results chapters, and provide detailed descriptions of the metacognitive activity inferred from discussions in the specialist and home groups of the members of *Team Kagiso* and *Team Bettie*. I acknowledge that a margin of error is built into a coding system, which distinguishes between the different manifestations, types, and areas of regulation. In quantifying the frequencies of occurrence of the manifestations, types, and areas of regulation demonstrated by the students, some frequencies were observed to be very low. To account for limitations in the accuracy of coding the interpretation of differences and similarities of the frequencies of occurrence lower than 2% presented in Chapters 5, 6 and 7, should be handled with caution.

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CHAPTER 5

TEAM KAGISO: PATTERNS OF METACOGNITIVE REGULATION

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CHAPTER 5

TEAM KAGISO: PATTERNS OF METACOGNITIVE REGULATION

"the reason I was so vocal, I felt like we were running out of time and I had to just get everyone to quickly finish."

"I always tried to bring it to their attention but I never actually take a stand to try to call anyone in to order, because then that would effectively mean, I was assuming the leadership position in the group, and that's wrong."

5.1 Introduction

The exploration of metacognitive regulation inherent in the planning of investigations during inquiry based laboratory activities was highlighted as an important and much needed missing aspect of research in the study of metacognitive activity in laboratory contexts (Krystyniak & Heikkinen, 2007). In this chapter, I describe patterns of metacognitive regulation as enacted by a collaborative learning group during the planning session of the simulated industrial project, this group was labelled *Team Kagiso*. The specialist group discussion of *Team Kagiso* was audio recorded and transcribed verbatim. Some of the excerpts drawn from the specialist group discussions and interview data that was used to substantiate the assertions made in this chapter may seem particularly data-rich for the reader. However, I consider the inclusion of data-rich excerpts important for giving the reader an opportunity to read the excerpts in context and to get a well-rounded view of the discussions that led to the observed students' regulatory responses.

As explained in Chapter 4, code switching between English and Setswana was observed for *Team Kagiso*. In the excerpts used, English translations are presented in brackets. The codes SG Discuss, HG Discuss, IND INT and SG INT have been used to respectively indicate the source of data being quoted as Specialist Group discussion, Home Group discussion, Individual Interview, and Specialist Group interview. The data obtained through the follow-up group and individual interviews served the important role of supplementing and validating inferences made from specialist group discussions. The combination of these results helped me to pinpoint aspects of metacognitive regulation that are inherent in a collaborative learning context (Research Question 1), as well as to understand how these aspects of metacognitive regulation manifest during collaborative learning in a chemistry laboratory context (Research Question 2).

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Most studies have looked at academic achievement scores or performance as a measure of the success of metacognition training. In my study, determining the quality of feedback and contributions that the students made towards predicting the best route after working in their specialist groups (Research Question 3) serves as an indication of whether or not the combined implicit (collaborative inquiry-based laboratory design) and explicit (metacognitive prompts) eliciting of metacognitive activity resulted in improved conceptual understanding of the chemistry concepts underlying the simulated industrial project. The data used and findings that emerged to answer this research question for *Team Kagiso* are also presented in this chapter. The chapter begins with a description of the team members, the roles that they assumed and the group dynamics observed through an analysis of their verbal interactions.

5.2 The nature of social interactions and dynamics observed in *Team Kagiso*

Team Kagiso consisted of four members - Kagiso, after whom the group is named, is a Black male with a flamboyant personality, and was the dominant member of the team. Reneilwe is a Black female. Amos and Leonard are Black males. Kagiso, Amos and Reneilwe had a way of relating to each other, using pet names such as *chomie* (friend or chum) and *samma* (belonging to my mother) when referring to each other. It is important to note that these familiar names have deeper meanings in their cultural context, for example, 'chomie' does not only mean friend, but best friend. The use of pet names was observed especially between Kagiso and Reneilwe, however, Leonard was often sidelined. Kagiso and Amos tended to mock him by making rude comments, with Reneilwe often calling everyone to order. Leonard, however, did not take the criticism lying down and was able to fend for himself and stood his ground.

Another dynamic that I observed was Leonard's tendency to bully Reneilwe by making remarks that often made her uncomfortable. In fact, during the follow-up interviews, Reneilwe reported that she had worked with Leonard before and they did not get along (**SG INT Turn 70**). Sometimes foul language was used in confrontations and asterisk symbols (*) were used to denote these in the transcript. These dynamics are brought to the fore because I believe that they shaped the cognitive and metacognitive engagement in this group (see the CD provided with this thesis for a transcript of examples).

During the specialist group discussions, Kagiso emerged as very vocal and confident and he spontaneously assumed a leadership position. This was welcomed by all group members as it

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seemed that they all thought highly of him and trusted his chemistry content knowledge. In deciding how to tackle the task, the group decided to split duties. Kagiso and Amos were responsible for deciding on the types and sizes of glassware to be used, as well as the safety data. Reneilwe and Leonard worked on the calculations of reagents and had to supply Kagiso and Amos with the mass and volume information necessary for decisions regarding suitable glassware to be used. This task did not proceed without its fair share of storming (Wilson, 2010) in the form of tension and conflict. Reneilwe wanted the task of doing calculations to be given to Kagiso because she trusted his analytical skills, but Leonard wanted this task for himself. Eventually, Kagiso gave in and allowed Leonard to do the calculations. This conversation can be seen in Excerpt 5.1 below.

Excerpt 5.1

217 RENEILWE**:** (*Referring to Kagiso*) I will do the MSDS you will do the more calculations I trust you with that.

218 LEONARD: I would have loved to do the calculations but it’s good […]

222 LEONARD: Will do the applications…

224 RENEILWE: Applications (*laughing*) what application?

225 LEONARD: I don’t know, what can I do?

226 RENEILWE: Um (*sighs*) what else is there to do?

227 LEONARD: I would have loved to do the calculations […]

237 RENEILWE: Ah what else is there, the the table okay the one doing calculations is going to work hard to get the molar mass isn’t it?

238 AMOS: [*I make*] mistakes and correct them I am too specialised (*feeling sorry for himself*)

239 KAGISO: Mmm (*agrees*) Leonard will do that

240 LEONARD: What do I do?

241 KAGISO: The mole calculations

242 LEONARD: I would love to do that

243 RENEILWE: And… the mechanism, correct mechanism I think we should […]

247 KAGISO: um Leonard will work on the equivalence and

248 LEONARD: And the mathematical…

(*Turns 217 – 248 Transcript of Specialist group discussion, planning session*)

However as feared by other group members Leonard ended up not rising to the occasion and being too slow. Annoyed, Kagiso had to take over and verify Leonard’s calculations. This interaction was observed in turns 1580 to 1583 in the specialist group discussion transcript of

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Team Kagiso. Elsewhere Kagiso, annoyed again said: **"***but Leonard you honestly took forever to calculate something that shouldn't take this long, gosh!*" (**SG Discuss Turn 1795**). In his defense Leonard responded: *"and so we are not equally gifted I hope you realise that"* **(SG Discuss turn 1796)**. Later on Leonard volunteered to do calculations of costs of reagents and was rejected. This caused him to retract.

Excerpt 5.2

1963. LEONARD:	*Ke dicost ke tla tla ke tlo etsa dicost* (It's the cost I will come and do the costs)
1964. KAGISO:	but are you sure?
1965. LEONARD:	W*a bona dicost ne le nnetse go pointana difingers ke a botsa* (You see the costs you were just pointing fingers, I am asking)
1966. KAGISO:	Are you sure you are not gonna take a decade to do it?
1967. LEONARD:	It's fine maybe *ka* (with my) condition *ya ka* (?)

(*Turns 1963 – 1967 Transcript of Specialist group discussion, planning session*)

Amos was disruptive and often made rude remarks. For example, when asked to list what was missing from the information given in the brief, Amos' reply was "*Everything is missing*". Reneilwe emerged as the conciliator in the group always calling members to order, particularly Amos, and drawing their attention back to the task at hand. She would do this by either reprimanding them or by re-reading the instructions to get them to get back to thinking about the task. This behaviour is shown in Excerpt 5.3 below.

Excerpt 5.3

1213 RENEILWE:	*Guys o ko le iketleng tuu* (guys please stop it) keep your eye on the ball
1214 KAGISO:	The recorder!
1215 AMOS:	Which ball? Which ball?
1216 RENEILWE:	E *re leng mo yona ka* (the one we are busy with)
1217 AMOS:	Which ball?
1218 KAGISO:	No it's off
1219 RENEILWE:	Haaa! No it's not if you press it there
1220 KAGISO:	Mmm!

(*Turns 1213 – 1220 Transcript of Specialist group discussion, planning session)*

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5.3 Nature of talk observed for *Team Kagiso*

The use of qualitative content analysis allowed for the counting of frequencies of occurrence of statements that reflected cognitive and metacognitive activity. Table 5.1 below shows a comparison of the types of statements that the students made in their verbal contributions. The details of how the turns of talk were coded and categorised into the different types of statements were discussed in Chapter 4. The percentage values for each type of statement presented in Table 5.1 were calculated relative to the total verbal contributions for each team member (Kagiso: 1021 turns, Amos: 573 turns, Leonard: 497 turns, and Reneilwe: 527 turns). Calculating percentages of types of statements relative to each student's total turns of talk shows more clearly the distribution of responses per person, and ensures that the percentages are normalised against each team member's style of interaction.

Overall, the group spent a considerable amount of the time (29.1% of turns of talk) trying to sort out the logistical aspects related to the underlying chemistry concepts and the task; this constitutes cognitive activity. Cognitive activity could be observed in Conceptual statements (280 turns), Task related statements (364 turns) as well as in Questions or queries directed at peers, or the lecturer and teaching assistant (117 turns). Kagiso contributed roughly twice as many turns of talk as each of the other group members, 1021 turns of talk compared to 497 turns by Leonard, 573 and 527 turns of talk by Amos and Reneilwe, respectively. Kagiso assumed the role of leader and set out to steer the group in his pursuit to ensure that he left the planning session having acquired a clear understanding of what he needed to do in the laboratory. This was confirmed by what he said during the individual follow-up interview:

Excerpt 5.4

19. Interviewer: Now, what about, as you were doing that (specialist group discussion), what about you yourself, were you also monitoring yourself as well in the process?

20. Kagiso: What I like about the special group is that we were all doing the same thing. So I needed to make everything clear, I needed to understand everything that I had to do on my own, so I made that time, I make sure that I use that time to clear out everything I didn't understand. So I make sure we cover everything as far as getting the MSD, and getting the steps clearly what we need to do, and the calculations and…plus we were given a little time to spend with our specialist group so, when I felt…the reason I was so vocal, I felt like we were running out of time and I had to just get everyone to quickly finish.

(Turn 19 & 20 Transcript of Individual follow-up interview with Kagiso)

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Table 5.1 Frequencies of occurrence of metacognitive and non-metacognitive statements for *Team Kagiso*

		Non-metacognitive Statements							
Names	**Metacognitive Statements**	**Conceptual**	**Digressions***	**Non-Substantial**	**Task related (other)**	**Ques/Query**	**Other**	**Total**	**No. of turns**
Kagiso	**416 (40.7%)**	133 (13.0%)	144 (14.1%)	174 (17.0%)	120 (11.8%)	29 (2.8%)	5 (0.5%)	**605 (59.3%)**	**1021**
Amos	**267 (46.6%)**	47 (8.2%)	95 (16.6%)	39 (6.8%)	81 (14.1%)	40 (7.0%)	4 (0.7%)	**306 (53.4%)**	**573**
Reneilwe	**211 (40.0%)**	33 (6.3%)	105 (20.0%)	54 (10.2%)	94 (17.8%)	27 (5.1%)	3 (0.6%)	**316 (60.0%)**	**527**
Leonard	**238 (48.0%)**	67 (13.5%)	56 (11.3%)	43 (8.7%)	69 (13.9%)	21 (4.2%)	3 (0.6%)	**259 (52.1%)**	**497**
Total	**1132 (43.2%)**	**280 (10.7%)**	**400 (15.3%)**	**310 (11.8%)**	**364 (13.9%)**	**117 (4.5%)**	**15 (0.6%)**	**1486 (56.8%)**	**2618**

*Number does not indicate digressions instigated by the student, but his/her contributions to off-task social talk.

The students in this group also spent a considerable amount of time on off-task social talk (15.3%), labelled as digressions in Table 5.1. It is important to note Leonard's participation in off-task talk (11.3%) as compared to that of his peers. This limited participation in off-task talk could be interpreted as the strategy that he used to circumvent the hostility shown towards him by his team members. This was affirmed by his response during the individual follow-up interview, "*And it turns out that I'm actually quite bossy and I find it useless to be talking if people don't listen. It really defeats the purpose*" (**IND INT Turn 32**). This, however, did not stop him from contributing to talk concerned with the task and the regulation thereof, which is reflected in how often he contributed to the group's co-construction of meaning (Conceptual statements: 13.5%; Task related statements: 13.9%; Questions/queries: 4.2%) and co-regulation of cognitive activity (Metacognitive statements: 47.9%). The comparable frequency of participation in off-task talk observed for Kagiso (14.1%), Amos (16.6%), and Reneilwe (19.9%) is also not surprising and can be attributed to the nature of the social interactions observed between these three.

The verbal exchange that was indicative of metacognitive regulation constituted 43.2% of the turns of talk. In general, all of the students in this team displayed fewer instances of talk that was indicative of metacognitive regulation as compared to non-metacognitive statements. This observation was to be expected given the procedural nature of the task. The focus of the current study warranted a clear demarcation of the turns of talk that displayed metacognitive regulation and turns that were only cognitive but not regulatory in nature. Inclusion into the metacognitive regulation category was dependent on whether the verbal expression instigated a change in

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thinking, task performance or behaviour. This meant excluding all other turns, task-related or not, that were not representative of regulation. Limited instances of metacognitive regulation were also expected because novice learners are generally not metacognitive and reflective by nature (Ertmer & Newby, 1996).

5.4 Frequencies and manifestations of metacognitive regulation

The metacognitive statements were further categorised in terms of manifestations (planning, monitoring, control, and evaluation) and types of regulation (self- or other-regulation). Planning was characterised by any verbalisation that was indicative of forward thinking and talk related to the selection of procedures (organisational) necessary for performing the task. Monitoring was observed in verbalisations that were related to the ongoing on-task assessment of the quality of thinking and the degree to which performance was progressing towards the desired goal. Control included any verbalisation that was expressed to influence thinking, behaviour, and task performance. Evaluation was observed in talk related judgements that were made about thinking about the chemistry or the task, behaviour, as well as the quality of task performance. Self-regulation was observed in instances when individuals regulated their own thinking, behaviour, and task performance, while other-regulation was observed in instances when one team member regulated the thinking, behaviour, and task performance of his/her peers.

Table 5.2 presents a breakdown of the metacognitive regulation into manifestations and types of regulation per team member. The raw counts for each manifestation and type of regulation were normalised against each team member's style of interaction by calculating the percentages relative to each members' total turns of talk. Kagiso contributed the highest and most metacognitive statements (36.7%) relative to his peers. Control as a manifestation of metacognitive regulation comprised 71% of metacognitive talk compared to its counterparts, Planning (4.5%), Monitoring (20.3%), and Evaluation (4.2%).

The breakdown of regulatory statements into manifestations and types of regulation revealed that a greater proportion of regulation occurred when the students tried to regulate each other's thinking about the underlying chemistry concepts, the task features, task performance, and behaviour (other-regulation: 60.9% vs self-regulation: 39.1%). This observation is characteristic of collaborative learning contexts that support social regulation (Whitebread et al., 2009).

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Table 5.2 Breakdown of metacognitive regulation turns of talk into manifestations and types of regulation

Name	Planning (%)			Monitoring (%)			Control (%)			Evaluation (%)			Total MR turns*
	SR	OR	Subtotal	SR	OR	Subtotal	SR	OR	Subtotal	SR	OR	Subtotal	
Kagiso	0	2.9	**2.9**	10.3	9.4	**19.7**	21.6	51.0	**72.6**	3.6	1.2	**4.8**	**416 (36.7%)**
Amos	0	2.6	**2.6**	21.3	6.0	**27.3**	32.2	33.7	**65.9**	1.5	2.6	**4.1**	**267 (23.6%)**
Reneilwe	1.4	7.1	**8.5**	11.4	6.6	**18.0**	22.7	48.8	**71.5**	1.4	0.5	**1.9**	**211 (18.6%)**
Leonard	0	5.9	**5.9**	6.3	9.2	**15.5**	20.6	52.9	**73.5**	2.1	2.9	**5.0**	**238 (21.0%)**
Total raw scores*	**3 (0.3%)**	**48 (4.2%)**	**51 (4.5%)**	**139 (12.3%)**	**91 (8.0%)**	**230 (20.3%)**	**273 (24.1%)**	**531 (46.9%)**	**804 (71.0%)**	**27 (2.4%)**	**20 (1.8%)**	**47 (4.2%)**	**1132**

*** Percentages in brackets: total raw scores normalised against the whole team's total number of metacognitive statements**

Metacognition is covert and is only made visible when students communicate their thoughts. Instances of self-regulation are made overt when think aloud protocols are used to assess metacognitive activity of individual students. The frequencies of occurrence, as indicated in Table 5.2, may indicate fewer manifestations of self-regulation, but this may not be a true reflection of events as other-regulation is often revealed as a result of the covert self-regulation. This assertion is based on the assumption that a student may, after assessing his/her level of understanding, see the need to clarify his or her thinking by seeking an explanation from the lecturer or teaching assistant (self-regulation). As a result, the student may then return to clarify his or her peers' thinking about the same concept after recognising a misconception as reflected in his or her peers' verbal expressions (other-regulation). This act may be executed to ensure that the team members have a common understanding of the underlying chemistry concepts or task. A good example of other-regulation occurring subsequent to self-regulation is demonstrated in the excerpt from *Team Kagiso*'s specialist group discussion, which is shown below.

Excerpt 5.5

743. AMOS: [*Reads from the summarised experimental procedure*] <u>and the solution was washed with water?</u>

744. KAGISO: Mm [*agrees*] (?) this doesn't makes sense. Dr P! Dr P! [*Calls lecturer by name to come over*] […]

749. DIRK: Hallo

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750. AMOS: Um we don't understand here, [*reads from summarised experimental procedure*] the residue was dissolved in dichloromethane and the solution was washed with water. Which solution? The one we (?) stirred overnight or the residue solution?

751. DIRK: This first part is the sample involved up until this part here.

[...]

779. AMOS: *A re ye Kagiso a re bue gore ka mokgwa o daai man a neng a bolela ka teng a re ro rinsang?* (Let's go Kagiso, let's talk about what that guy told you, what are we rinsing?) I am noting it down. Solution (?)

(*Turns 743 – 779 Transcript of Specialist group discussion, Planning session*)

After reading from the condensed experimental procedure, Kagiso realised that he did not understand the instructions in the procedure and sought clarification from the lecturer (turn 744). This was interpreted as a self-regulatory move and coded as '*seeking clarification from lecturer*'. The teaching assistant, Dirk, responded and explained the underlying chemistry concepts to Kagiso. Although Amos posed the question (turn 750), Kagiso was the first one to realise they needed help. The ensuing discussions in turns 751 to 775 were largely between Dirk and Kagiso. Kagiso in turn explained the concepts to Amos, his team member (turns 779 to 798). Instances where Kagiso conveyed and explained to Amos what Dirk had told him were interpreted as other-regulatory and coded as '*clarifies peer's thinking about the chemistry*'.

The classification of interactions as other- or self-regulatory was dependent on whether or not the act of regulation set off a change in the individual or in his or her peers. Higher frequencies of occurrence were observed for self-regulation when compared to other-regulation in instances of monitoring (SR: 12.3% vs OR: 8.0%) and evaluation (SR: 2.4%; OR: 1.8%). This was probably due to the fact that it was in these instances that the students were concerned about checking whether they were on the right track or not by seeking validation of their thinking and by making judgements about their level of understanding. Self-monitoring and self-evaluation were observed in statements such as "*the suggested route is this one right?*" and "*I would honestly not know, I don't know"* respectively. I will now discuss how the different manifestations and types of metacognitive regulation emerged for the team, drawing on the frequencies of occurrence presented in Table 5.2 above. In my discussion of how metacognitive regulation manifested, I will also make reference to Figures 5.1, 5.2, 5.3 and 5.4, which have been included to give an overview of the areas of regulation observed for each manifestation and type of regulation. To

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enable inter-individual comparison, the raw counts for each area of regulation were normalised by calculating the percentages relative to each team member's total metacognitive statements.

5.4.1 Planning

Planning was observed in verbal exchanges that were indicative of forward thinking and in instances when the students engaged in negotiations with regard to aspects of task performance such as strategies for optimum task execution, as well as roles and responsibilities. Planning was not only observed in the beginning of the discussions while students prepared for the task, but also in the course of task execution and toward the end when they still negotiated how to structure information and formulate instructions for the experimental procedures.

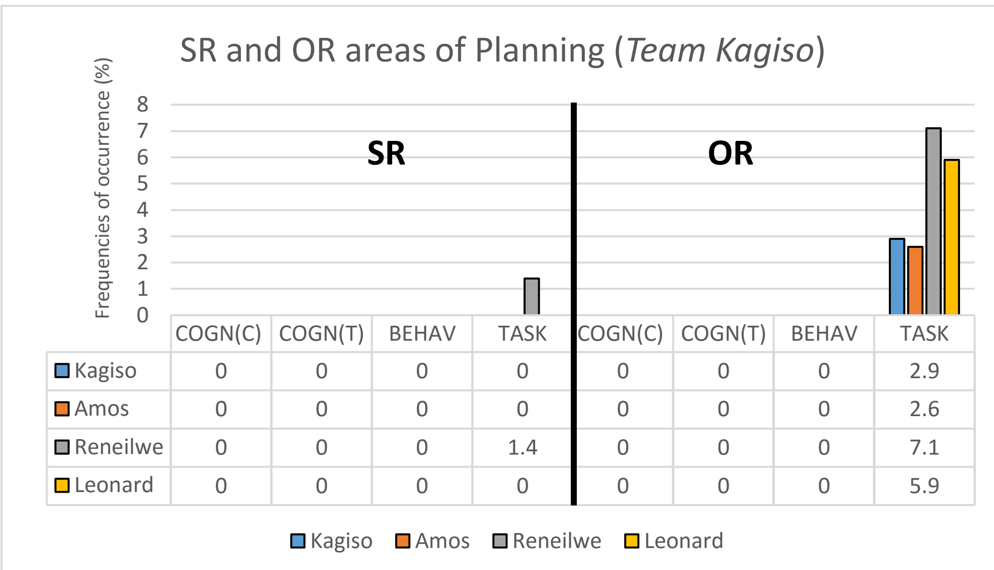

Figure 5.1 Self (SR) and Other (OR) areas of Planning by *Team Kagiso**

*Self-regulation (SR) on the left-hand side and Other-regulation (OR) on the right-hand side.

A look at the results that emerged from *Team Kagiso* (Figure 5.1 and Table 5.2) reveals that very low frequencies of planning were observed for all team members at the social level, and evidence for planning was almost non-existent at the individual level (Kagiso: 2.9%; Amos: 2.6%; Leonard: 5.9%; Reneilwe: 8.5%). The highest frequencies of planning were observed for Reneilwe, who was the only member for whom planning was observed at both the individual and inter-individual levels. Most of what constituted planning in the beginning of the specialist group discussions were negotiations around roles and responsibilities, best approaches to task

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execution, as well as the clarification of task requirements from peers and instructors. These discussions were interpreted as task-related and other-regulatory as peers were observed to influence each other's decision making and thinking about how the task could be approached and the responsibilities allocated. All of the team members participated in this discussion. The planning that the team members engaged in was mostly other-related and all had to do with task performance and not about behaviour or thinking. The only instances of self-regulation with regard to planning were observed for Reneilwe when she sought to establish her role within the group structure and when she verbalised her thoughts on how she planned to perform her part of the task [**SG Discuss Turn 847**: "*…ko ngwala mo thoko (I will write it on the side)"*] and [**SG Discuss Turn 1953**: "*ke ngwala dimolar mass tsa teng le didensity (I am writing the molar masses and densities)"*].

The low frequencies of planning observed for *Team Kagiso* could be explained by the fact that the students had never been expected to engage in planning their laboratory activities before. They were most likely to approach the activity in the same way that they had tackled previous laboratory tasks, e.g. delve straight into the task at hand. This was precisely the reason why the metacognitive prompts by way of Reflective Learning Strategy Questionnaires (RLSQs) were introduced to scaffold metacognitive regulation (Appendices 2.1 to 2.4). The metacognitive prompts asked of the students before working in their specialist groups were employed to encourage the students to engage in planning during task execution, examples of these include: "*What will you do in order to compile the detailed experimental procedure for the synthetic route, i.e. distribution of tasks – who will do what?*" and after working in their specialist groups, "*Based on your derived experimental procedure, how much time and what resources (lab equipment, books etc.) will you need for each step?*" The efforts to scaffold and encourage planning were, however, not met with substantial proportions of talk that were indicative of planning. The students viewed the RLSQ as just another form to complete:

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Excerpt 5.6

11. Interviewer: Were there things that you were wondering about as you were doing that questionnaire in terms of your route, in terms of your understanding? Or again was it just plain and simple just to complete the questionnaire?

12. Kagiso: Just fill it out, we have a task, you have to do…

13. Interviewer: Just do it.

14. Kagiso: You were like, here's more homework (*laughs*), something you didn't like, oh, homework.

(*Turn 11 – 14 Transcript of Individual follow-up interview with Kagiso*)

Listening to the audio recording however, revealed that the RLSQ did serve to structure discussions especially in the beginning of the specialist group discussions. This observation could probably be explained by the fact that the prompts in part 1 of the specialist group RLSQ were presented as introductory material to be completed prior to students being given all the documentation necessary for formulating the experimental procedures for their allocated synthetic route. Kagiso and Reneilwe gave testament to the merits of having the RLSQ as a tool for encouraging thinking, something they professed they would normally not have done:

Excerpt 5.7

44. Interviewer: Now did you as a group, find any value, I mean, in using that questionnaire? Was it helpful in helping you to do the task that you had to do at that point?

45. Reneilwe: I think it did. Like it was forcing us to think.

46. Kagiso: Ja (Yes).

47. Reneilwe: 'Cause we'd have different questions and it would be like, what are they asking? And then, *ja* (yes), eventually you're forcing us to think! actually about what we're doing.

48. Interviewer: Okay, so do you agree that it forced you to think?

49. Kagiso: *Ja* (Yes).

50. Interviewer: Is that something that you couldn't have done…?

51. Kagiso: Normally? No.

52. Interviewer: *Ja* (Yes), normally on a normal basis, had we said…

53. Kagiso: We would have waited to do a step and see what's going on and…

54. Interviewer: To be told?

55. Kagiso: With this one you, you had to kind of think about the outcome of what you had to do before you actually solve…*ja*.

(*Turns 44 – 55 Transcript of follow up group interview with Team Kagiso*)

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At the end of the discussions, the completion of Part 2 of the specialist group RLSQ came up as an afterthought and a mandatory task. It is likely that the students felt that they had obtained all of the necessary information to report back to their home groups. They may also have felt that requiring them to put a proper plan on paper of how much time they would need for each step of their synthetic route was too difficult:

Excerpt 5.8

2840. RENEILWE:	*Nna mara ka gore handwriting ya Amos, handwriting ya Amos ga ke e bone* (because I can't read Amos' handwriting). I forgot to complete the part at the back [*referring to the RLSQ*].
2841. KAGISO:	*Ao nkosi yami!* (oh my lord!) [*sounds annoyed*].
2842. AMOS:	Just tick yes, yes 'cause we have already […]
2862. RENEILWE:	A*nswer this oh no ke moo o tlo choosang le moo. Guys can we do this re tsamayeng tuu?* (answer this oh no this is where we have to choose here. Guys let's can we do this and go please?) [*reads from RLSQ*] Based on your derived experimental procedure how much time, and what resources dadada will you need for each step? […]
2918. KAGISO:	*So ke ngwala* (so I write) day two, three hours. We're ready. *Mara* (But) the lab equipment we didn't write anything about lab equipment.
2919. RENEILWE:	D*i ngwale he* (write them then).
2920. KAGISO:	Are we getting marks for this? [*referring to the RLSQ*] (END 03:11:02).

(*Turns 2840 – 2920 Transcript of Team Kagiso's specialist group discussion, Planning session*)

One would have thought that working in a team could have given the students all the more reason to engage in planning, stages labelled as 'forming' and 'norming' in Bruce Tuckman's team development model (Wilson, 2010). Working in a group was however, a challenge and the students expressed the frustrations they experienced in having to accommodate each other's views and contributions towards a common goal:

Excerpt 5.9

56. Interviewer:	Okay, no, that's fine. Now I just want to know, as you were busy extrapolating procedures, remember you were not given anything, you had to extrapolate it from the resources. Were there any instances where you realised that the collective knowledge, the knowledge of the group, or understanding, was not enough? And, how did you deal with that? I mean, we just listened to a clip at this point. Because it was always about the collective, everybody had to be on board. Can you remember?
57. Kagiso:	Um, honestly I think it was the collective it was enough, it's just we didn't know how to channel it in the sense of we didn't know what was really needed from us. So…because once we understood what was going on, we could provide the answers of what to do and

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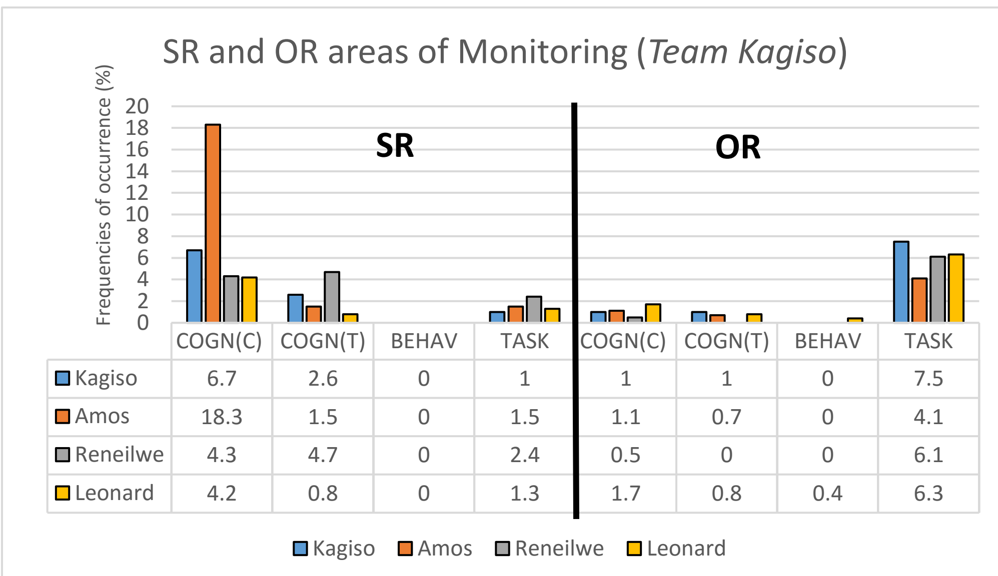
how to go about it. So the problem was maybe not understanding at first go what our task was.

58. Amos: But with us I think the other problem was, we had a lot of ideas because there were four people thinking the same thing, so the other one was saying that this one was wrong, the other one was saying this one is right. It was a lot of ideas from individuals, coming from us, and…

(*Turns 56 – 58 Transcript of follow up group interview with Team Kagiso*)

5.4.2 Monitoring

Monitoring as a metacognitive regulation strategy was observed in turns of talk when the students checked for conducive behaviour necessary for efficient task performance, and when they established their own or their peers' understanding of and thinking about the underlying chemistry concepts [COGN(C)] or task [COGN(T)].



	SR COGN(C)	SR COGN(T)	SR BEHAV	SR TASK	OR COGN(C)	OR COGN(T)	OR BEHAV	OR TASK
Kagiso	6.7	2.6	0	1	1	1	0	7.5
Amos	18.3	1.5	0	1.5	1.1	0.7	0	4.1
Reneilwe	4.3	4.7	0	2.4	0.5	0	0	6.1
Leonard	4.2	0.8	0	1.3	1.7	0.8	0.4	6.3

Figure 5.2 Self (SR) and Other (OR) areas of Monitoring by *Team Kagiso**

*Self-regulation (SR) on the left-hand side and Other-regulation (OR) on the right-hand side.

The members of *Team Kagiso* used monitoring to mostly seek confirmation that they were on the right track in their perceptions of the task [MON_SR_COGN(T)], thinking about the underlying chemistry [MON_SR_COGN(C)], and their task performance [MON_SR_TASK]. Statements such as: "*the suggested route ke (is) this one right*?", "*so what, how do I phrase it? Ah one specialist will…*" and "*We are not going to do the mechanisms right*?" suggested that the constant need for confirmation during the planning session was a strategy that the students used

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to make sure that they kept abreast with the activities in the group. It also indicated that they were attempting to ensure that they completed their parts of the task to the satisfaction of task requirements. What was noteworthy was Amos' high frequencies of self-monitoring (18.3 + 1.5 + 1.5 = 21.3%) and overall monitoring frequencies of occurrence (18.3 + 1.5 + 1.5 + 1.1 + 0.7 + 4.1 = 27.2%) relative to his peers (Table 5.2). However, an in-depth look at the areas of regulation revealed that Amos concentrated most of his self-monitoring efforts in one area of regulation, i.e. on validating his thinking about the underlying chemistry concepts (Figure 5.2). For Kagiso, Amos and Reneilwe's monitoring was observed to be skewed with most instances of regulation directed at the self rather than at the other (Table 5.2).

It is important to note that Leonard was the only team member for whom instances of other-monitoring (1.7 + 0.8 + 0.4 + 6.3 = 9.2%) exceeded instances of self-monitoring (4.2 + 0.8 + 1.3 = 6.3%). An in-depth look at the data showed that these other-regulatory efforts were, in fact, spread across all the areas of regulation (Figure 5.2). This observation constitutes evidence of his prime concern being that of achieving collective progress in the group. Kagiso demonstrated the second highest instances of overall monitoring (Table 5.2). A deeper look at the areas where he applied his efforts towards regulation revealed that the checking of team members' understanding of the task was observed more for Kagiso than his counterparts.

During the follow-up individual interview with Kagiso, he indicated that he wanted to be part of every aspect of the specialist group task to ensure that he left the discussions well-prepared for the laboratory (Excerpt 5.4). This way of thinking is illustrated by the observed high instances of monitoring in the area of team members' task performance (7.5%). It is as if he realised that he had to oversee how the other team members performed the task because their task outcomes would have a direct bearing on his own task performance and outcomes in the laboratory. The monitoring of behaviour did not feature prominently for this team of students. Only one instance of behaviour monitoring was observed when Leonard checked with Kagiso how his behaviour had affected him, "*Okay I am sorry Kagiso, am I coming down hard on you*?" (**SG Discuss Turn 146**).

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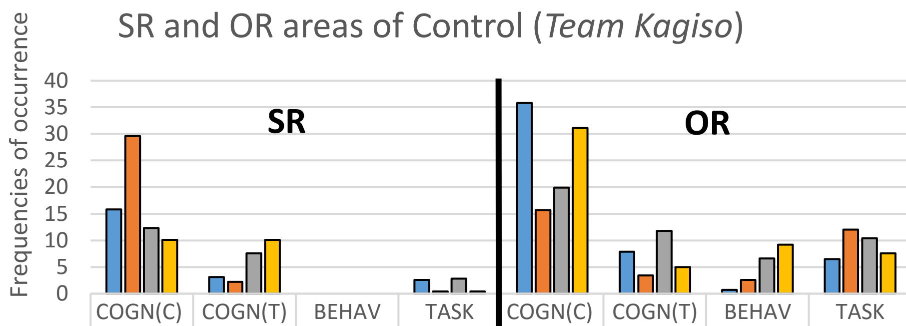
5.4.3 Control

Control was characterised by action verbs such as activate, correct, critique, and clarify. This activity included statements that were uttered in order to influence thinking about the underlying chemistry concepts and the task, as well as to influence behaviour and task performance.



	COGN(C)	COGN(T)	BEHAV	TASK	COGN(C)	COGN(T)	BEHAV	TASK
Kagiso	15.8	3.1	0	2.6	35.8	7.9	0.7	6.5
Amos	29.6	2.2	0	0.4	15.7	3.4	2.6	12.0
Reneilwe	12.3	7.6	0	2.8	19.9	11.8	6.6	10.4
Leonard	10.1	10.1	0	0.4	31.1	5	9.2	7.6

Kagiso Amos Reneilwe Leonard

Figure 5.3Self (SR) and Other (OR) areas of Control by *Team Kagiso**

*Self-regulation (SR) on the left-hand side and Other-regulation (OR) on the right-hand side.

Instances of overall control for Kagiso, Reneilwe and Leonard were comparably high (Table 5.2). Manifestations of control were well-spread across different areas of regulation and more sparsely distributed in self-regulation as compared to other-regulation. Overall, this observation was found amongst all of the members of *Team Kagiso*. However, the highest frequencies of occurrences of self-control were observed for Amos, and most of these occurrences of self-regulation were concentrated in the area of regulating thinking about the underlying chemistry concepts (29.6%). A deeper look at the indicators associated with this area of regulation (Appendix 4.4) revealed that Amos mostly regulated his thinking about the content by seeking clarification from his peers rather than from the instructors, which gives an indication of his heavy reliance on peers, especially Kagiso, as most of his clarification seeking statements were observed to be directed at him. It is also important to note that only Kagiso and Leonard were observed to engage with the lecturer to clarify their understanding of the chemistry concepts (Appendix 4.3 and 4.5). This observation was not surprising for Kagiso as he had taken it upon himself to ensure that he would leave the specialist group discussion having reached the

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objectives of the task. For Leonard, it was all about ensuring a collective understanding of the chemistry and the task. Their ability to engage with the lecturer could also be due to the fact that, compared to their peers, these two students felt confident enough to express their thoughts and have their ideas critiqued by the lecturer.

The highest frequencies of other-control were observed for Kagiso (35.8 + 7.9 + 0.7 + 6.5 = 50.9%) and Leonard (31.1 + 5.0 + 9.2 + 7.6 = 52.9%), and most of these other-regulatory efforts were applied in the area of cognition about the underlying chemistry concepts (Kagiso: 35.8% and Leonard: 31.1%). A look at the finer details in Appendices 4.3 and 4.5 reveals that the two students were comparable in terms of how they clarified their peers' thinking about the chemistry content, activated their peers' prior knowledge, affirmed their peers' thinking about the chemistry, and drew their peers' attention to the given information. These observations gave an indication that each member played a prominent role in regulating the cognitive activities within the team, and that this behaviour may be attributed to the level of confidence in their chemistry content knowledge. The high frequencies of occurrence of regulating cognition about the chemistry content observed for Kagiso (35.8%) and Leonard (31.1%), and the low frequencies of regulation of the same area of cognition displayed by Amos (15.7%) and Reneilwe (19.9%) seemed to suggest that while Kagiso and Leonard offered intellectual leadership to the team, Amos (TASK: 12.0%) and Reneilwe (TASK: 10.4%) focused on the logistical aspects of task performance.

5.4.4 Evaluation

All of the verbalisations characterised by judgements that the individuals made about their thinking, behaviour and task performance, and that of their peers were classified as evaluative. Evaluation was the least prominent manifestation and could possibly be thought of as the most challenging form of regulation for students. Manifestations of evaluations of the self were marked by instances when the students made judgements about their knowledge and understanding of the underlying chemistry concepts, as well as judgements about their own quality of task performance and level of task completion.

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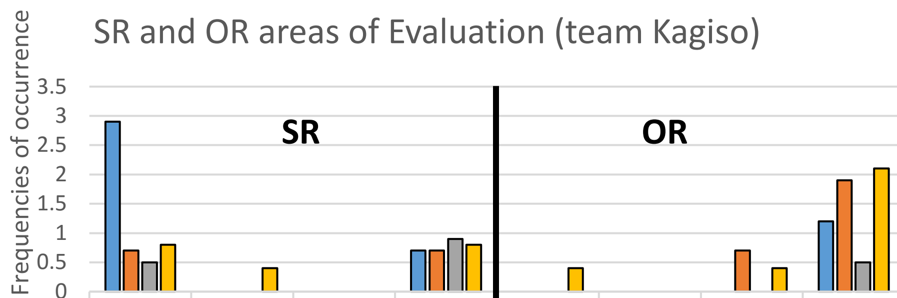
Figure 5.4 Self (SR) and Other (OR) areas of Evaluation by *Team Kagiso**



	COGN(C)	COGN(T)	BEHAV	TASK	COGN(C)	COGN(T)	BEHAV	TASK
Kagiso	2.9	0	0	0.7	0	0	0	1.2
Amos	0.7	0	0	0.7	0	0	0.7	1.9
Reneilwe	0.5	0	0	0.9	0	0	0	0.5
Leonard	0.8	0.4	0	0.8	0.4	0	0.4	2.1

Kagiso Amos Reneilwe Leonard

Figure 5.4Self (SR) and Other (OR) areas of Evaluation by *Team Kagiso**
*Self-regulation (SR) on the left-hand side and Other-regulation (OR) on the right-hand side.

Other-regulation in terms of evaluation was observed in instances when the students made judgements about their peers' task performance and task completion. Kagiso and Leonard demonstrated the highest frequencies of occurrence of overall evaluation compared to Amos and Reneilwe (Table 5.2). However, Kagiso and Leonard differed in how they utilised their regulatory efforts in this manifestation. Kagiso's evaluation lay more towards himself than his peers and most of these self-regulatory efforts were concentrated in the area of cognition about the underlying chemistry concepts. Leonard's evaluations were mostly directed at the other than the self and his combined self- and other-regulatory efforts were spread across areas of cognition about the chemistry, cognition about the task, behaviour, as well as task performance. Evaluations of thinking about the task were observed only for Leonard when he evaluated his own understanding of the task [**SG Discuss Turn 39**: *"(?) I am getting confused"*]. At the individual level, all of the students in this team mostly evaluated their content knowledge or understanding of the underlying chemistry concepts, as well as their task performance. On the social level, all of the students remarked on the level of task completion of their peers and the group as a whole. It is noteworthy that Leonard was the only member who critically evaluated his peers' thinking about the chemistry content.

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An overview of the results provided in Table 5.2 shows that the categories of Evaluation and Planning were comparable in terms of frequencies of occurrence (Evaluation: 4.2%, Planning: 4.5%). This finding is consistent with the findings Khosa and Volet's (2014) study where few instances of planning and non-existent instances of evaluation were observed when they analysed the verbal interactions of undergraduate veterinary science students for inter-individual metacognitive regulation.

In the beginning of the planning session, the students were informed that the lecturers would assess the accuracy of their generated experimental procedures. Whitebread et al. (2009) have asserted that students may not see the need to evaluate their own work due to the anticipated lecturer feedback at the end of the session. This is the most probable explanation for the low frequencies of occurrence of evaluation observed for this team. Zimmerman (1998) indicates that learners who have developed the skill of self-regulation do not avoid self-evaluation and are aware of the importance of evaluating task performance and their understanding in terms of the goals set for the task. Consistent with this assertion is Ertmer and Newby's claim (1996) that the tendency to evaluate own thinking during and after task execution may be what separates a novice and expert learner.

5.5 Depth of metacognitive regulation

Table 5.2 shows that the frequencies of occurrence of monitoring were high for Kagiso and Amos (Kagiso: 19.7%, Amos: 27.3%). However, the quantitative data conceals the fact that Kagiso's utterances reflected a higher level of cognitive processing and meaning seeking behaviour as compared to Amos. The qualitative analysis revealed the differences in the motivation that lay behind the regulation executed amongst the peers. With Kagiso, it emerged very clearly in most of his utterances that what drove the monitoring was the need to establish understanding or meaning [**SG Discuss Turn 202**: "*…Ankere (Isn't it) she is saying that we need to work under the impression that we don't have anything"*], while with Amos, monitoring was mostly executed to get the information necessary for task completion and not necessarily to obtain conceptual understanding [**SG Discuss Turn 2083**: "*It's the same beaker akere (right)?*"]. This was confirmed in the follow-up interview when Amos disclosed that it was only during the laboratory session when he realised what the procedures that they were busy formulating in the planning session really meant in terms of experimental execution. This was so much so that he

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only identified minor mistakes that he had made in the procedures in the laboratory session, mistakes that he could have identified and corrected in the planning had he paid more attention to executing the task with understanding rather than acquiring information for task completion. His poor planning could have cost the group in terms of obtaining the desired chemical compound in the laboratory.

Excerpt 5.10

122. **Amos**: I think when you start doing things, they start making sense and there's some other things, that you see that, 'no, I missed this', I could have done it this way and all that. Because on the planning I think I've missed on reagents and stuff, but I wrote it like you know the drawings and stuff. So I don't think they (team members) saw it (?) but I think they figured it out themselves and stuff, because I think (?) okay, something is missing here, and they added that.

(*Turn 122 Transcript of follow-up interview with Team Kagiso*)

This realisation highlighted the need to probe further and look at the qualitative differences in terms of the depth of metacognitive regulation, as opposed to only looking at the quantitative differences. As discussed in Chapter 4, contextualised sub-codes used by Khosa and Volet (2014) were adapted and used for the purposes of identifying evidence of high- and low-level regulation in metacognitive turns of talk. High-level regulation was observed in instances when the students sought to establish conceptual understanding by seeking explanation (Seek Meaning: SM), volunteering an explanation (Volunteer Meaning: VM), providing conceptual justification (CJ) and stimulating thinking (ST). Low-level regulation was observed in instances when the students sought to acquire information (Seek Information: SI), supply information (Give Information: GI) and instigate regulation without offering conceptual justification (noCJ). The transcript of *Team Kagiso*'s discussion was revisited to classify metacognitive regulation statements as either high- or low-level. The distinction between high- and low-level metacognitive regulation was dependent on whether or not regulation instigated conceptual understanding. Table 5.3 below gives a breakdown of how the students differed in terms of the depth of regulation. For easy comparison, the results are reported for the combined SR and OR instances per person. The values in parentheses are the percentages calculated by dividing the raw scores by each individual's total turns of metacognitive talk.

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Table 5.3 Breakdown of manifestations of regulation according to low-level (LL) and high-level (HL) regulation

Manifestation of MR →	**Planning**			**Monitoring**			**Control**			**Evaluation**			**Total turns**
Depth of MR →	**LL**	**HL**	**Subtotal**	**LL**	**HL**	**Subtotal**	**LL**	**HL**	**Subtotal**	**LL**	**HL**	**Subtotal**	
Kagiso	7	5	**12**	59	23	**82**	199	103	**302**	17	3	**20**	**416**
	(1.7)	(1.2)	**(2.9)**	(14.2)	(5.5)	**(19.7)**	(47.8)	(24.8)	**(72.6)**	(4.1)	(0.7)	**(4.8)**	
Amos	6	1	**7**	65	8	**73**	157	19	**176**	9	2	**11**	**267**
	(2.2)	(0.4)	**(2.6)**	(24.3)	(3.0)	**(27.3)**	(58.8)	(7.1)	**(65.9)**	(3.4)	(0.7)	**(4.1)**	
Reneilwe	16	2	**18**	33	5	**38**	129	22	**151**	3	1	**4**	**211**
	(7.6)	(0.9)	**(8.5)**	(15.6)	(2.4)	**(18.0)**	(61.1)	(10.4)	**(71.5)**	(1.4)	(0.5)	**(1.9)**	
Leonard	8	6	**14**	28	9	**37**	118	57	**175**	7	5	**12**	**238**
	(3.4)	(2.5)	**(5.9)**	(11.8)	(3.8)	**(15.6)**	(49.6)	(23.9)	**(73.5)**	(2.9)	(2.1)	**(5.0)**	
Total	37	14	**51**	185	45	**230**	603	201	**804**	36	11	**47**	**1132**

*** Percentages in brackets: raw scores normalised against each team member's total number of metacognitive statements.**

Low-level regulation was observed in instances when the students sought information, e.g. "*Okay guys what information is missing?*" gave information, e.g. "*Yes you've got two hundred and fifty, you have a one fifty [beaker]*" and offered no conceptual justification for the regulation that they instigated, e.g. "*That's the Celite*". High-level regulation was observed in instances when the students sought meaning, e.g. "*…when they say you must filter in something and concentrate in vacuo, what do they mean by that?*", volunteered meaning, e.g. "*No they mean that's equivalent. This is your starting product*" stimulated thinking, e.g. "*Why don't you have the moles?*" and when they provided conceptual justification for their regulation, e.g. "*Wait hey man you don't have, wait don't write anything, you know why? I don't have density of benzaldehyde, I have mass that needs ten point four grams*". Roughly two-thirds of the talk were classified as low-level in each of the manifestations of regulation as can be seen in the frequency distribution totals per manifestation of regulation. There is a striking agreement between the patterns observed for Kagiso and Leonard on the one hand, and Amos and Reneilwe on the other for the manifestation of control in terms of the depth of their regulatory contributions, with Kagiso and Leonard making significantly more high-level contributions in this manifestation.

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However, in the sophisticated manifestation of evaluation, only Leonard distinguished himself in terms of demonstrating the most instances of high-level regulation.

In the paragraphs that follow, I provide a detailed account of the qualitative differences that were observed per manifestation of regulation. The graphs shown in Figure 5.5 give an overview of the differences that were observed in the depth of metacognitive regulation in *Team Kagiso* in terms of the normalised counts of observations. The percentages of frequency of occurrence for each indicator were calculated by dividing the indicator raw counts by the total number of verbal contributions made by team members in that manifestation. Calculating the percentages normalised the depth of regulation against each team member's style of interaction. It is, however, important to note that the differences as they appear in the graphs in Figure 5.5 are exaggerated because the scales used on the graphs are different. Using the same scale for all of the graphs would render the difference in some of the graphs obscure. Percentages are reported for the combined SR and OR instances per person. The results presented in Figure 5.5 will be discussed below with occasional reference to Table 5.3 and Appendices 4.3, 4.4, 4.5 and 4.6.

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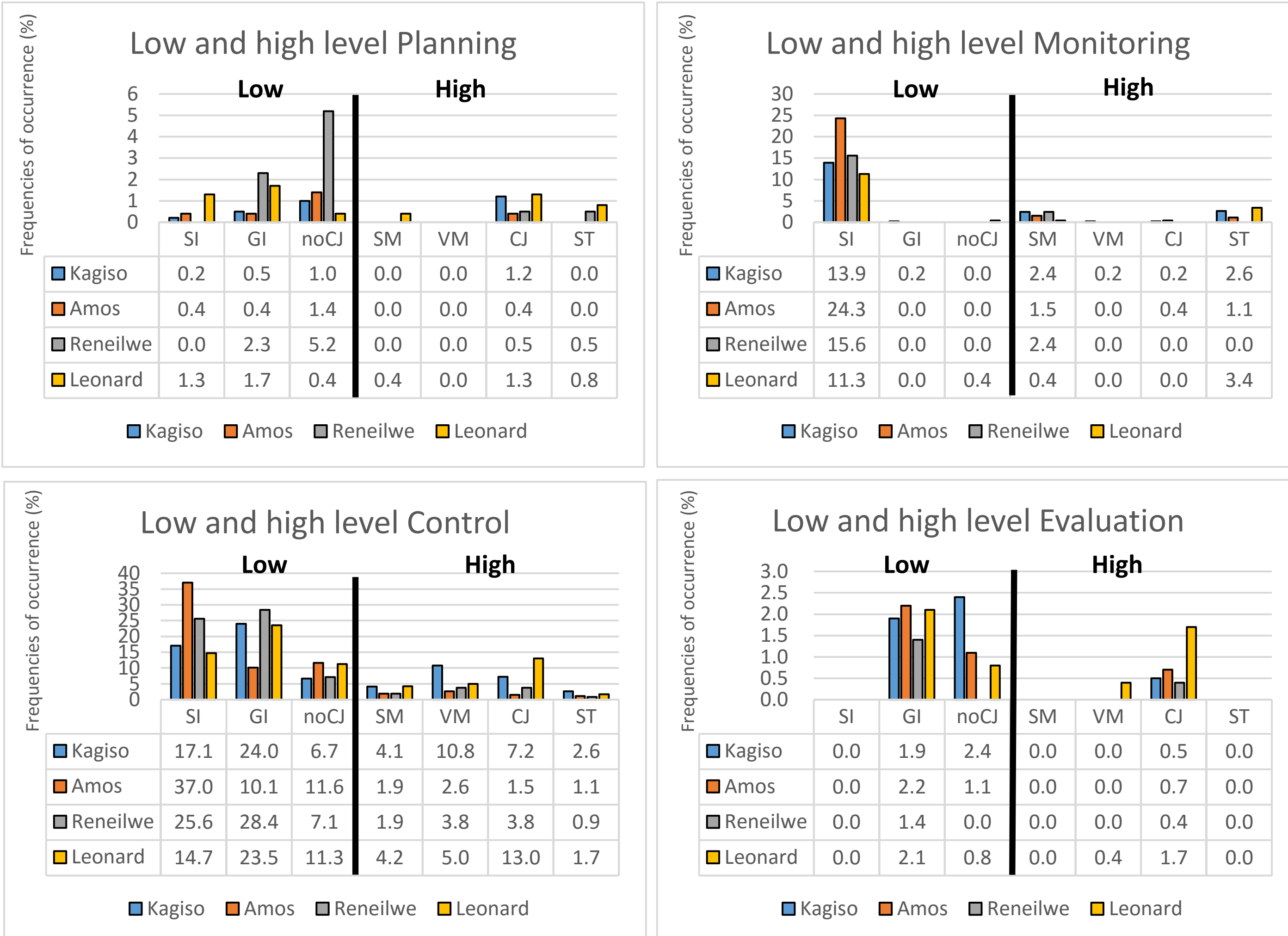

Low and high level Planning

	SI	GI	noCJ	SM	VM	CJ	ST
Kagiso	0.2	0.5	1.0	0.0	0.0	1.2	0.0
Amos	0.4	0.4	1.4	0.0	0.0	0.4	0.0
Reneilwe	0.0	2.3	5.2	0.0	0.0	0.5	0.5
Leonard	1.3	1.7	0.4	0.4	0.0	1.3	0.8

Low and high level Monitoring

	SI	GI	noCJ	SM	VM	CJ	ST
Kagiso	13.9	0.2	0.0	2.4	0.2	0.2	2.6
Amos	24.3	0.0	0.0	1.5	0.0	0.4	1.1
Reneilwe	15.6	0.0	0.0	2.4	0.0	0.0	0.0
Leonard	11.3	0.0	0.4	0.4	0.0	0.0	3.4

Low and high level Control

	SI	GI	noCJ	SM	VM	CJ	ST
Kagiso	17.1	24.0	6.7	4.1	10.8	7.2	2.6
Amos	37.0	10.1	11.6	1.9	2.6	1.5	1.1
Reneilwe	25.6	28.4	7.1	1.9	3.8	3.8	0.9
Leonard	14.7	23.5	11.3	4.2	5.0	13.0	1.7

Low and high level Evaluation

	SI	GI	noCJ	SM	VM	CJ	ST
Kagiso	0.0	1.9	2.4	0.0	0.0	0.5	0.0
Amos	0.0	2.2	1.1	0.0	0.0	0.7	0.0
Reneilwe	0.0	1.4	0.0	0.0	0.0	0.4	0.0
Leonard	0.0	2.1	0.8	0.0	0.4	1.7	0.0

Regulation low-level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification &

Figure 5.5 Breakdown of the depth of metacognitive regulation by normalised counts of empirical indicators

5.5.1 Depth of Planning

Qualitative planning was characterised by low-level discussions consisting of instances of seeking or giving information, offering solutions, and proposing strategies to optimise task performance without providing conceptual justification. As alluded to in Section 5.4.1, the highest frequencies of planning were observed for Reneilwe. However, Table 5.3 and Figure 5.5 show that the majority of Reneilwe's regulatory efforts in the manifestation of planning were low-level, manifesting mostly as regulation executed without accompanied conceptual justification and the giving of information. This is not to say that Reneilwe did not make any

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considerable contribution to the group's planning. Reneilwe did contribute, although not so much towards establishing a conceptual understanding of the task, but rather towards ensuring that the task was done and completed in the given time. This claim is supported by the large proportion of low-level planning (noCJ) shown in Figure 5.5. She contributed the most ideas on how best to optimise task performance, and was vocal about this although without any accompanied justification. This was observed in statements such as:

Excerpt 5.11

1132. RENEILWE**:** *E re ke ngwale density pele* (let me first write the density).

1827. RENEILWE**:** *Kgante e ira ke mang Amos? E ira ke wa feditseng* (who do you suppose should do the cost Amos? The one who's finished first should do the cost).

1073. RENEILWE**:** Can we draw up a table in the mean time? Mm? *ga re draw upe table in the meantime* (let us draw up a table in the meantime).

1103. RENEILWE**:** I want to make the table *pele* (first).

(*Turns 1132, 1827, 1073, 1103 Transcript of Specialist group discussion, planning session*)

For Reneilwe, giving information was observed during the negotiations of roles and responsibilities. A lot of the talk that the students engaged in involved simply giving straight answers to their peers' enquiries without accompanied explanations to enhance understanding. This was observed especially when they engaged in negotiations about responsibilities and task execution strategies.

The second highest frequencies of occurrence of planning were observed for Leonard (Table 5.3). His regulatory efforts in the manifestation of planning were evenly distributed between low- and high-level regulation, and were spread across most of the indicators of regulation. The majority of occurrences of planning observed for Kagiso and Amos exemplified low-level regulation. No observations were made of students volunteering meaning. This could be explained by the nature of the talk that characterised planning. Instances where the students demonstrated forward thinking and when they engaged in talk about logistical aspects of the task were classified as manifestations of planning. However, instances of the students justifying their thinking were necessary to enhance understanding about what the task was all about and why it had to be executed in a particular manner. Overall, low-level metacognitive regulation dominated

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talk related to planning. This was the case for all team members, but was the most prominent for Amos and Reneilwe.

5.5.2 Depth of Monitoring

The largest proportion of monitoring was observed for low-level seeking of information. Low-level monitoring featured prominently in instances when the students looked to their peers and lecturers to validate their thinking about the underlying chemistry concepts and the task (Figure 5.2). Although Amos demonstrated the highest frequencies of monitoring, the majority of his regulatory contributions in this manifestation exemplified low-level regulation. In fact, the majority of monitoring efforts were low-level for all of the members in *Team Kagiso*, with most manifesting being to seek information. There were only a few instances depicting high-level seeking of meaning. Seeking information was observed in instances where the students checked task requirements with their peers, sought validation of thought about the task, checked peers' progress with the task, among other instances.

The low-level regulation observed for Amos was dominated by confirmation seeking statements. Although Kagiso's instances of low-level regulation were exemplary of monitoring by seeking validation or confirmation of thought about the chemistry [COGN(C)], these instances only occurred 28 times (Appendix 4.3), and were not directed at only one member of the team but at all of the team members, as well as instructors. Meanwhile, with Amos, seeking validation of thinking from his peers dominated his low-level monitoring and was observed in 49 statements to be exact (Appendix 4.4). Statements such as, "*But we, that will happen after we cooled it right?", "it's volume x is equals to volume right?", "so this time it's an ice bath right?", "so this thing is not moisture sensitive right?"* were indicative of his constant need for affirmation. He would always ask Kagiso to confirm before he could go ahead and write something down. This could be interpreted as a monitoring strategy or perhaps a reflection that he did not trust in his own knowledge, or a tendency to avoid thinking about anything. It may also be indicative of a heavy reliance on Kagiso to provide answers without him giving it some thought first. In fact, Kagiso realised and pointed this out to him:

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Excerpt 5.12

1150. **KAGISO**: I like how you just write when I say things, no! it's not correct [*laughs*] [*referring to Amos*] […]

1155. **AMOS**: *O bua dilo tse byana nka se kwale byang jo! Ke tlhaloganyo soo seo!* (saying those kinds of things that's why I write! That makes sense!)

(*Turns 1150 & 1155 Transcript of Specialist group discussion, planning session*)

The highest frequencies of stimulating thinking were observed for Leonard followed by Kagiso. Statements such as, *"…and you are sure that trans cinnamate is a solid?"* (**SG Discuss Turn 1879**), *"Fine! Mara (but) does my point come across?"* (**SG Discuss Turn 2419**), as well as turn 1964 in Excerpt 5.13 below, demonstrate Kagiso's attempts to enhance the conceptual understanding of his peers by urging them to think deeply and assess their understanding of the underlying chemistry or the task:

Excerpt 5.13

279. KAGISO: Part two, answer this section after working through the available resources does that make sense?

1963. LEONARD: *Ke dicost ke tla tla ke tlo etsa dicost* (it's the cost I will come and do the costs)

1964. KAGISO: But are you sure?

(Turn 279 and Turns 1963 - 1964 *Transcript of Specialist Group Discussion, planning session)*

Another good example of high-level monitoring by way of stimulating thinking was demonstrated by Leonard in the beginning of task execution when team members were still negotiating meaning around the task:

Excerpt 5.14

68. RENEILWE: [*reads from RLSQ*] <u>upon completion of this task return to the home groups and present the information.</u> So this is what we answer before. [*reads from RLSQ*] <u>What information</u>, oh! <u>after reading this what information is missing? how will we obtain it? What will you do in order to compile the synthetic route?</u> […]

75. KAGISO: It says "<u>what information is missing? How will you obtain this information?</u>"

76. RENEILWE & LEONARD: Okay.

77. KAGISO: Google it [*instructs peer*].

78. AMOS: Sure Kagiso (?) reference resources.

79. RENEILWE: Obviously the quantities, everything the quantities, apparatus is missing.

80. AMOS: But *akere* (isn't it) we know we have to get at least a product of 2 grams so we just work from there, backwards.

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81. LEONARD:	No no no that's, if you want to work backwards it means that you have to have the efficiency of every single step [*emphasising by hitting the table with pen*].
82. AMOS:	No they say at least 2 grams.
83. LEONARD:	*Ja* (Yes) but then…
84. RENEILWE:	Okay guys what information is missing?
85. LEONARD:	If you need at least 2 grams then you need the efficiency of every single step [*emphasising again*].
86. AMOS:	No you.
87. KAGISO:	Noted, noted.

88. RENEILWE & KAGISO: What information is missing?

89. LEONARD:	What is missing is the experimental procedure…
90. KAGISO:	Which will be provided so I don't think we can say that
91. LEONARD:	But they say that…
92. RENEILWE:	No we can.
93. LEONARD:	But this is before we know that there is gonna be [information given to us]
94. KAGISO:	(?) the question.
95. LEONARD:	But this is before.
96. KAGISO:	Yes.
97. LEONARD:	Okay, the experimental procedure is not provided and as well and what ca… do they just want that to be experime[nt], or in the lab or you have to design the experimental process of how you do it or you don't have to worry about that?
98. AMOS:	That, that [interrupting].
99. RENEILWE:	Mmm? *Enge?* (what?)
100. LEONARD:	The experimental procedure is not given ah, right? and as well the efficiency of the of the routes proposed is not given. Do you get that?

(*Turns 68 to 100 Transcript of Specialist group discussion, planning session*)

The discussion started with Reneilwe reading from the RLSQ and indicating to team members the first question that they needed to tackle, which paraphrased is, "*having read the brief, what information is missing?"* Leonard tried to sway peers from opting for a simplistic way of thinking about the task by asking questions that urged them to think deeper before writing down the answer. However, he was met with much opposition from his team members. This high-level regulation demonstrated by Leonard was motivated by his need to do things right, he felt

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accountable to the group. He stated during the follow-up interview that he wanted to make sure that what he produced would be useful to everyone in the group:

Excerpt 5.15

28. Leonard: Yes, yes, I did it and it was done right. The thing is it has to be done right. There's nothing wrong with letting myself down but I shouldn't let the whole team down.

29. Interviewer: That's true. The whole accountability issue as well.

30. Leonard: So I have to make sure that I've done well and done right and the second person can read them, because if I could read them it doesn't help they can't read it. Because it's also meant to be a group, not my thing, it's not about my thing, it's always about me, in if it's a group work thing.

(*Turns 28 to 30 Transcript of follow up individual interview with Leonard*)

He was not satisfied with just scratching the surface, he would have liked the team to focus and think deeply about what they were doing:

Excerpt 5.16

46. Leonard: What I would say is that some of them were too short-sighted. And some of them, if we raised an issue, for example, I showed them Google, was it used for, because then that would give us an idea with the purification process and what kind of thing. They don't think too deep into the matter being raised. They tend to stick to what they have as opposed to actually open their heads, open their minds, and listen to any new idea. The problem is, I don't know, they have too much of a closed mind. Many of them or all of them have too much of a closed mind to actually listen to someone else. Perhaps if it's something on paper and it's written, perhaps then they will read and listen.

(*Taken from Transcript of follow up individual interview with Leonard*)

5.5.3 Depth of Control

As can be seen in Figure 5.5 and Table 5.2, this category has the largest number of responses that populate all of the manifestations and types of metacognitive regulation. The comparably high frequencies of regulation in the manifestation of control were observed for Kagiso (72.6%), Leonard (73.5%) and Reneilwe (71.5%), with the majority of control efforts exemplifying low-level regulation. However, the largest gap between frequencies of low-level and high-level regulation was observed for Reneilwe (50.7%) and Amos (51.7%), with low-level control constituting the dominant form of regulation for both. Amos' regulatory efforts were characterised largely by low-level seeking of information and suggestions and objections without conceptual justification with minor appearances of high-level regulation. Leonard, Kagiso and

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Reneilwe's low-level regulatory efforts were characterised largely by the giving of information, an indicator that featured seldom for Amos.

It is important to note for this manifestation the high frequency of giving of information for Kagiso and seeking of information for Amos. Listening to the audio recorded group discussions revealed that the interaction between Kagiso and Amos placed the two students at opposite ends to each other in terms of control, with Kagiso taking the role of the supplier of information and Amos as the seeker of information. It is also important to note that much of the give and take engagement presented in the graph (Figure 5.5) actually occurred between these two members of the team since they were allocated the same aspect of the task. This engagement is, however, not beneficial or desired as it disadvantaged the one and benefited the other. Kagiso, who emerged as the more knowledgeable one offering intellectual leadership to the group, failed to enhance his fellow team members' conceptual understanding by simply providing straightforward answers to facilitate rapid task completion.

Leonard had the highest frequencies of offering conceptual justification and seeking meaning, while Kagiso had the highest frequencies of volunteering meaning and stimulating thinking. Kagiso demonstrated high-level regulation in the type of engagement he had when he consulted with the instructors. This was observed in his verbal exchange with the lecturer, where he engaged in a lengthy discussion to try and understand what the instruction, "filtering and concentrating a solution *in vacuo"* meant:

Excerpt 5.17

970. KAGISO:	I, I have a question while you are here, when they say you must filter in something and concentrate in vacuo what do they mean by that?
971. LECTURER:	A rotary evaporator
972. KAGISO:	Oh!
973. LECTURER:	Vacuo means vacuum.
974. KAGISO:	oh!
975. LECTURER:	So a rotary evaporator works under vacuum.
976. KAGISO:	oh! And how do you concentrate your solution? […]
978. LECTURER:	Remember using a rotary evaporator in second year?
979. KAGISO:	It's a while back when I did.
980. LECTURER:	It's a while back?

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981. KAGISO: Yes.

982. LECTURER: You put it on and you heat it.

983. KAGISO: Yes.

984. LECTURER: And […]

986. LECTURER: You have a vacuum.

987. KAGISO: Mm [*agrees*].

988. LECTURER: And it cools the vapours from heating up the system and then condense it remember?

989. KAGISO: Yes, and they collect in a…

990. LECTURER: (?)

991. KAGISO: Yes, now we want the stuff that collected?

992. LECTURER: No, you don't want the stuff that's come off, that's your solvent.

993. KAGISO: Yes.

994. LECTURER: That you remove.

995. KAGISO: Oh, we want the stuff that's remaining!

996. LECTURER: The stuff that's remaining

997. KAGISO: It is actually my product, yes.

998. LECTURER: That's your concentrate, the stuff that's been concentrated by removing the solvent.

999. KAGISO: Removing the solvent, okay.

1000. LECTURER: Thanks.

(*Turns 970 to 1000 Transcript of Specialist group discussion, planning session*)

As mentioned before, it is important to note that for this manifestation of regulation, instances of the students seeking clarification from the lecturer were observed for only Kagiso and Leonard (Appendices 4.3 and 4.5 respectively). Kagiso also consulted with the laboratory assistant. I cannot help but wonder if it was a lack of confidence in their content knowledge that prevented the other members from consulting with the lecturer or their submission to the leadership role spontaneously assumed by Kagiso.

5.5.4 Depth of evaluation

Overall, low-level indicators of regulation dominated the talk in the evaluation category with only conceptual justification featuring as a high-level indicator for all members of the team. The majority of low-level regulatory efforts were characterised by the giving of information and statements without conceptual justification. Comparatively high frequencies of occurrence of

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conceptual justification were observed for Leonard, for example, when he made a judgement about the accuracy of his calculations, he based it on the fact that he made sure to keep all the digits and not round off early in his calculations "*mine are accurate 'cause I have been keeping all the digits*". Low-level evaluation was observed for Kagiso, who tended to make judgements about his peers' task performance or the group's level of task completion without providing conceptual justification. Also noteworthy is the low-level giving of information for this manifestation by Reneilwe. All of the verbal contributions from Reneilwe were interpreted as low-level giving of information, which constituted instances where she gave updates in terms of her own progress on the task, as well as that of the team (**SG Discuss Turn 2509**: *"[reads from the RLSQ] <u>for your assigned route you will need to be aware of the hazards,</u> yes we are done*").

The one thing that stood out about Kagiso in this manifestation of regulation was his ability to admit when he did not know something. He displayed a sense of metacognitive knowledge about what he knew and what he did not know. He had the highest frequencies of making judgements about his knowledge and understanding (Appendix 4.3), which is reflected in the excerpts below:

Excerpt 5.18

1282. LECTURER:	Okay so it's ruled out so what else is gonna govern what fac… whether you gonna use gravity or vacuum?
1283. KAGISO:	No I don't, no I am not [sure].

And

Excerpt 5.19

743. AMOS:	[*Reads from the summarised experimental procedure*] <u>and the solution was washed with water?</u>
744. KAGISO:	Mm [*agrees*] (?) this doesn't makes sense. Dr P! Dr P! [*calls lecturer by name to come over*].

This quality may have assisted him to take initiative and gain more from his engagement with the lecturer, teaching assistant, and his peers by asking the right questions. The lack of evaluation, as observed for members of *Team Kagiso,* is a trait of novice learners who "rarely reflect on their performance and seldom evaluate or adjust their cognitive functioning to meet changing task demands or to correct unsuccessful task performances" (Ertmer & Newby, 1996, p. 6).

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5.6 Patterns of metacognitive regulation for individual team members

Quantitative and qualitative differences and similarities were observed for patterns of self- and other-regulation amongst the members of *Team Kagiso*. Each team member was observed to display a unique style of interaction in terms of how they regulated cognitive activities in the specialist group. The quantitative and qualitative results, depicted respectively in Figures 5.1 – 5.5 and Appendices 4.3, 4.4, 4.5 and 4.6, accurately reflected the styles of interaction displayed by each student during the specialist group discussions.

5.6.1 Kagiso's style of interaction

Kagiso was assertive in his regulatory contributions and excelled more in enhancing his conceptual understanding by utilising self-regulatory strategies than his peers through other-regulation. He used the peer engagement and instructor support to regulate his own cognitive processes and enhance his conceptual understanding. He admitted this in two instances, in Excerpt 5.4, shown as part of Section 5.3 above, and Excerpt 5.20 shown below.

Excerpt 5.20

29. Interviewer: So it would be that you figure things out better by taking control, by being in every aspect of the project.

30. Kagiso: Yes, so it was almost as if I was doing an individual thing, and people were helping me, so things that I couldn't do right away that's how I chose to delegate. So it was reassuring myself that yes, you understand and keeping in check what I needed to do on my own. So I was thinking about, okay, as a group we need to finish this, but when I get in the prac, I need to follow up on what me and Amos were doing, which incorporated the MSD, incorporated the calculations from Leonard…so I think, *ja* (yes), if that answers your question.

(*Turns 29 to 30 Transcript of follow up individual interview with Kagiso*)

Kagiso's beliefs about group work also emerged in his responses during the interview, and were demonstrated in turn 30. To him, it was "*as if I was doing an individual thing, and people were helping me*". It was every one working on their own, but towards a common goal. For instance, Leonard working quietly on the calculations made Kagiso very uneasy as he felt that he was not in control of the most crucial element of the experiment. He preferred to do the calculations himself. Delegating and trusting a peer with the most crucial part of the task turned out to be a very difficult thing for him to do. The students had previously worked individually and planned on their own, so this was new and uncomfortable, especially for someone like Kagiso.

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Excerpt 5.21

22. Kagiso: Mostly I was thinking about the calculations. So… and Leonard was not talking a lot, and I wanted to make sure that the amount that we're gonna weigh out, because I think that's crucial. Because we had a given mass that we had to get at the end of the practical. So now I was worried about that because I had preferred that I do the calculation, but he objected, he wanted to do the calculations, so I let him do it, but I was also just double-checking what he was doing. So in that sense, I was thinking about what someone else was doing, which I don't think was right actually. Because we had…after we fought about me doing the calculation, you doing it, we delegated the job to him. So I should have maybe trusted him to just do it, and focus on me and Amos doing the procedures. Ja (yes), but we needed those values, the volumes, there was a time where we were asking him about the volumes and he was not there, and I felt I could have done it quicker. So it was…

(*Turns 22 Transcript of follow up individual interview with Kagiso*)

For Kagiso, a group can never function without a leader, which is why he decided to take the lead when no one else rose to the occasion, "*Like if you're working in a group, and there is no leader, no one that we say, you are in charge of doing this, someone has to come forth and do it, because without that things just don't work out, in my personal opinion*" (**IND INT Turn 28**). As a result, he dominated the discussion, achieving the highest number of turns of talk relative to his peers. He clearly misunderstood the aim of collaborative work. This could explain his tendency to only give information (low-level regulation) as opposed to clarifying his peers' thinking by stimulating their thinking, volunteering meaning, and by offering conceptual justifications (Figure 5.5). It was as if he operated on the motto: *every man for himself, God for us all*. All he cared about was coming out of the planning session having a good understanding of what he needed to do in the lab. Evidence of this was the observation that the frequencies of occurrence of his self-regulation were higher than other-regulation for both the manifestations of monitoring and evaluation (Table 5.2). A similar observation was made for Amos where instances of self-regulation were higher than other-regulation in the manifestation of monitoring.

5.6.2 Amos' style of interaction

Amos was disruptive and seemed as though he did not see the point of planning. Amos' constant off-task talk distracted the group from meaningful discussions. He was also more concerned about quick completion of the task rather than about spending time on probing deeper and seeking meaning (Figure 5.5). The statement below is one of many where Amos demonstrated this disposition.

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Excerpt 5.22

1541. AMOS: What more do we have to do *mfana ka (my son)? Re fetse tuu nna a ke rate tlhakatlhakano* (let's finish please, I don't like confusion).

(*Turn 1541 Transcript of Specialist group discussion, planning session*)

Amos admitted to not being much of a thinker, but rather being more technical. He understood the concepts better when he enacted them. Kagiso attested to the fact that Amos was always ahead of everyone in the laboratory. This trait or learning style preference could explain why he fared better (i.e. finished quicker and got the highest yield of product) in the laboratory than in the planning session. He even admitted that this was the very first practical that he had planned and prepared for and one he would always remember in detail.

Excerpt 5.23

122 **Amos**: *Re* think when you start doing things, they start making sense and there's some other things, that you see that, 'no, I missed this', I could have done it this way and all that.

125 **Amos**: 'Cause as I said, I think that was the only practical I can remember. It just stuck in my mind because we had to plan it ourselves. And the rest, agh…(*all burst out laughing*).

(*Turns 122 & 125 Transcript of follow up interview with Team Kagiso*)

Amos sought a lot of validation, especially in terms of his understanding of the underlying chemistry concepts (Figure 5.2). His style of interaction was characterised by low-level seeking of information and failing to offer conceptual justification for his statements (Figure 5.5). He used the opportunity for engagement to take advantage of his peers' work and achieve his personal goals. In fact, Table 5.2 shows that Amos was the only member for whom the frequencies of occurrence for self- and other-regulation were comparable. Amos justified his constant need for confirmation as a monitoring strategy rather than a lack of confidence.

5.6.3 Reneilwe's style of interaction

The majority of Reneilwe's verbal contributions were characterised by low-level seeking and giving of information and statements without conceptual justification, although she occasionally demonstrated high-level regulation by seeking and volunteering meaning (Figure 5.5). The highest instances of task performance related planning (Figure 5.1), although mostly low-level (Figure 5.5), were observed for Reneilwe, suggesting that she was mostly concerned about achieving organisation and focus in the team. However, low occurrences of monitoring, clarifying, and evaluating her peers' thinking about the chemistry (Figures 5.1, 5.3, 5.4) seemed

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to suggest that she was not the strongest team member in terms of content knowledge. Although she did not seem to have contributed much in terms of her peers' understanding of the chemistry, she mediated relations amongst the team members and kept organisational matters in check.

5.6.4 Leonard's style of interaction

Overall, Leonard showed attributes of a seasoned reflective and metacognitive learner who took responsibility for himself as well as the team. He used the engagement with instructors and his peers to not only enhance his understanding, but also that of his team members. He was curious and tenacious, dissatisfied with only scratching the surface, but rather constantly urging and challenging the group to think deeper by asking thought-provoking questions (Excerpt 5.14). Regardless of the resistance and opposition from his team mates, Leonard managed to contribute high-level regulation related to all the four manifestations of cognitive regulation (Figure 5.5). His regulatory actions were driven by his belief that priority should be given to doing things right as opposed to rushing the process, which achieves rapid task completion but with mediocre outcomes, (**IND INT Turn 28**: *"The thing is it has to be done right. There's nothing wrong with letting myself down but I shouldn't let the whole team down"*). He displayed a sense of accountability in that he felt that working in a group meant that he should never let his team down. He felt accountable for his team's success. However, he regulated in subtle ways to avoid giving the impression of taking on the role of leadership or imposing his ideas on the team. This style of interaction was observed in the beginning of the specialist group discussion while the team members were negotiating task execution strategies and the allocation of roles:

Excerpt 5.24

183. LEONARD:	How would you like to split it? Someone does MSDS, someone does the calculation, someone proposes the apparatus and someone proposes how the actual experiment can be done what do you think?
184. KAGISO:	That makes sense.
185. LEONARD:	So we all do equal work.
186. KAGISO:	Yes, but then for the person *o irang* (who does) *dicalculations* (the calculations) they need to know the proposed mechanism to work out *ka di* (with the) reagent.
187. LEONARD:	But then we work, we gonna share information.
[...]	
213. KAGISO:	Okay, so it is a group of four so we have to divide…
214. LEONARD:	Yes, we have to divide, yes.
215. AMOS:	Are you dividing the work now?
217. RENEILWE:	I will do the MSDS you will do the more calculations, I trust you with that [*addressing Kagiso*].

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218. LEONARD: I would have loved to do the calculations, but it's good.

(*Turns 183 to 218 Transcript of Specialist group discussion, planning session*)

Leonard did not believe in dictating terms, which explains his style of interaction. Very often, he was observed to offer suggestions and allow individuals some latitude to accept or reject them. One can say that he enjoyed operating behind the scenes.

Excerpt 5.25

50. Leonard: I always tried to bring it to their attention but I never actually take a stand to try to call anyone in to order, because then that would effectively mean I was assuming the leadership position in the group, and that's wrong. And that's one thing I don't want to do. People should rather be led, or it used to be led, as opposed to someone arising from the masses and calling themselves a leader, or actually dictating or delegating any certain jobs or actually trying to pretend, or actually raise an image that he or she knows better than the rest of the masses assembled there in that group. So I would say that's not the kind of position I ever want to assume, whether I know better or not, I always take a down position and I be part of the masses as opposed to be someone who stands out in that mass.

(*Turns 50 Transcript of follow up interview with Leonard*)

Leonard's philosophy about group work (captured in Excerpt 5.26 below) was that in a group you must trust that the individuals are capable of completing the tasks allocated to them. He believed that people have to be given space to figure things out on their own without constant monitoring. Judgement should only be passed when the final product is presented, but not during the process.

Excerpt 5.26

26. Leonard: […] but sometimes when something is not allocated to be your task you have to let go and let other people do that task that they will do, and since they are in your group and they are more than capable, as much as you are perhaps, or I don't know whether they are more capable than you are or not, that's another matter altogether. […] I'd like to work with people when they give you a task and they trust you to with it, they don't follow up too much, only have to follow up when the time is right, when you have to produce. Only then can you be judged, you shouldn't be judged while doing the process, because then you will still feel as an individual that these people don't trust me, why did I even get this task in the first place, is this a test, or do they really think I'm capable of doing this, otherwise they shouldn't even entitled you, or was it actually embarked that you should do the task in the first place. Because it sounds like it's a joke really, they give you something and don't trust that you'll really deliver […]

(*Turns 26 Transcript of follow up interview with team Leonard*)

Leonard's philosophy about team work was echoed in his words, "*It's not about my thing, it's always about me, if it's a group work thing*" (**IND INT Turn 30**). Leonard believed that in a group, one needs to account for the actions and decisions that one makes (**IND INT Turn 40**:

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"*Yes, if it's not for you only then you have to explain*"). It was not surprising that he was the only team member with frequencies of other-regulation higher than self-regulation in the manifestation of monitoring, the manifestation used mostly by his peers for self-regulatory purposes. He also demonstrated the highest frequencies of other-regulation in the manifestation of control (Table 5.2). Leonard admitted that his thinking was influenced largely by feelings. He found it hard to think and regulate his thinking when he did not feel well. He needed a supportive environment to function optimally. He found the group not very receptive to his ideas, which made regulation difficult.

5.6.5 Summary

From the follow-up interviews there was a sense of the beliefs students held about group work and this could explain the patterns of regulation observed, e.g. that students felt they were helping each other by just supplying or seeking information and not opting to rather offer explanations or ask questions that could stimulate thinking and elicit conceptual understanding. Kagiso was assertive in his regulatory contributions using the platform of collaborative group engagement to achieve his personal goals of conceptual understanding. Amos was assertive but mostly dependent in his regulatory contributions. He solicited and used the support made available through collaborative engagement to achieve rapid task completion. Leonard was tentative in his regulatory contributions. He demonstrated this style of engagement by making suggestions and raising objections but being careful not to impose his ideas on his peers. He also showed selflessness in that he constantly urged his peers to think deeper by asking the 'hard' questions. It seems as if his ultimate goal was that of collective conceptual understanding rather than rushed task completion. Reneilwe's interests on the other hand, seemed to lie between establishing collaboration and focus amongst peers in order to facilitate task completion, but her constant need for validation resulted in her relying heavily on her team members.

Having established the styles of interactions and patterns of metacognitive activity displayed by members in *Team Kagiso* I was interested in whether operating within new social contexts, i.e. home groups, the same styles of interaction in terms of cognitive regulation would be observed (research question 3). Next, I discuss how research question three was answered.

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5.7 How individual students regulated cognitive activities in subsequent home group discussions

Research question 3: *How does metacognitive regulation manifest during home group discussions?*

Through Research Question 3, I sought to determine whether the individuals followed the same styles of interaction when regulating activities in the subsequent home group discussions. I could not help but wonder how the whole exercise of participating in the specialist group activities prepared individuals to make meaningful regulatory contributions back in their home groups. For this purpose, I chose two individuals from each of the specialist groups in my sample and analysed their home group discussions. I also conducted follow-up individual interviews with these students to augment my findings. Judging from the observations of the specialist group discussions, I decided to choose one individual who seemed to be outspoken and, as a result, took on the leadership role, as well as an individual who showed signs of regulation but in subtle ways. For *Team Kagiso,* Leonard emerged to be the soft spoken one while Kagiso emerged as vocal in his contributions. In this section, I only report on the observations made from the analysis of the discussions from Kagiso and Leonard's home groups.

5.7.1 Background information on what constituted home group discussions

The students working in home groups were each allocated a different synthetic route to the desired compound, namely routes A, B, and C. The three routes were carefully selected to ensure that the prediction and ultimate decision regarding the best route would not be a straight-forward exercise as there was no clear 'best' route. During the planning session in the specialist groups, each home group member was afforded an opportunity to work out a detailed experimental procedure for their route together with members from other home groups who had been allocated the same route. Returning from these lengthy specialist group discussions, each route specialist was expected to give feedback to his/her fellow home group members so that the group could obtain a holistic view of what each route entailed. The students were given 20 minutes to engage in these retrospective home group discussions. Having observed in the pilot study that the students did not put much effort into these retrospective home group discussions, in the final study, the students were expected to draw from their newly-gained knowledge regarding their routes and make a prediction of which route would turn out to be the best considering the criteria

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of cost, technical challenge, and environmental impact (Appendix 2.2: Part 2 of Home group RLSQ). Making this prediction forced them to critically evaluate each other's routes in terms of the evidence presented by each specialist.

5.7.2 Analysis of the contributions made by Kagiso and Leonard in their respective home groups

Kagiso and Leonard were interesting cases in that although one was more outspoken than the other, both demonstrated the greatest frequencies of high-level regulation in the categories of planning, monitoring, and control in contrast to their peers (Table 5.3), but were motivated differently, one to serve his own needs while the other focused on the needs of the group. To answer Research Question 3, I will first foreground the dynamics in terms of social interactions observed in Kagiso and Leonard's respective home groups because I believe that the new social context also played a role in how these two students regulated cognitive activities. Excerpts from the home group discussions presented in context have been included as supporting evidence of the assertions made.

5.7.2.1 Dynamics and social interactions in Kagiso's home group

Ideally, each home group had to consist of three members to facilitate the making of a well-rounded decision based on the evaluations of the three synthetic routes to the target organic compound. However, the total number of students resulted in some home groups only consisting of two members as opposed to the ideal three. This was the case for Kagiso's home group.

Kagiso's home group consisted of only two members. Kagiso worked with Siyanda (female, Black). Kagiso was allocated Route C, while Siyanda worked on Route B. They addressed each other as 'friend' and this seemed to suggest that they knew each other. No tension was picked up in their conversation. Although Kagiso steered activities in the group, this arrangement seemed to work well for the two students. Siyanda came across as disorganised. She admitted that all of her information was scattered (turn 29 in excerpt below) and found it hard to find what she needed to assist in the group's decision making:

Excerpt 5.27

28. **Kagiso**: How many moles of that did you have? The mass.

29. **Siyanda**: (?) everything is just everywhere. Seventeen eighty-one.

(Turns 28 – 29 Transcript of Kagiso's home group discussion)

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As a result of coming from his specialist group discussions well-prepared, Kagiso easily assumed the leadership role in the home group. He ended up explaining the work to Siyanda and calculating the costs of reagents for her in order for them to decide which amongst their two routes was the cheapest. This decision was preceded by Kagiso first doing the calculations, which is an exercise that Siyanda had to have completed in her specialist group. Kagiso was well organised and he understood the task, i.e. what he was doing and why he was doing it. This was demonstrated in the many occasions when he pointed to the resources that the group could consult to guide them in making the prediction. At first, it was the use of the safety data sheets the group could use to determine the route with reagents most harmful to the environment. Secondly, he reminded Siyanda that they had been given a sheet with the twelve principles of green chemistry that they could consult:

Excerpt 5.28

91. **Siyanda**: In order to know if the solvents we are using are environmentally friendly or not?
92. **Kagiso**: *Ja* (yes). You need your MSD.
93. **Siyanda**: *Nna phela* (we) we have not even done that.
94. **Kagiso**: You don't have a MSD?
95. **Siyanda**: We haven't done the MSD, did you guys do it?

(Turns 91 – 95 Transcript of Kagiso's home group discussion)

Another dynamic observed in terms of social interactions in this home group was Kagiso reverting to consulting with a member of another group to get more information and check his reasoning when he realised that he would not get this form of monitoring from Siyanda as a result of her unpreparedness.

5.7.2.2 Dynamics and social interactions in Leonard's home group

Leonard worked with Matt (male, White) and Eksteen (male, White). Leonard was a specialist for Route C, Matt for Route A and Eksteen for Route B. All of the members of Leonard's home group were actively involved in the discussion, although Eksteen's contribution could be regarded as sporadic. No tension was picked up in their conversation, and they seemed to work well together. Although there was no tension, there were instances of argumentation that facilitated decision making. No one team member dominated the discussion or tried to impose his decisions on the others. Matt took on the leadership role by initiating the discussion and

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pointing out to team members when it was time to move on to the next item. Eksteen emerged as the unprepared one, although he did not show signs of being disorganised and not knowing what was happening like Siyanda in Kagiso's home group. Only Leonard and Matt had come prepared having worked out the costs of reagents for their routes. Eksteen had not and he had to be allowed time to calculate while Matt and Leonard moved on to other aspects of the home group task.

5.7.2.3 How Kagiso and Leonard contributed in their respective home group discussions

Table 5.4 gives an overview of the types of verbal contributions made by Kagiso and Leonard in their respective home groups. The same system that was followed for coding the specialist group discussions described in Chapter 4 was used to categorise Kagiso and Leonard's home group verbal contributions into metacognitive and non-metacognitive statements. The percentage values for each type of statement presented in Table 5.4 were calculated relative to the total number of verbal contributions for each student (Kagiso: 79 turns and Leonard: 106 turns).

Table 5.4 Comparison between Kagiso and Leonard's home group verbal contributions

Name	Metacognitive statements	Non-metacognitive statements							Total no. of turns
		Conceptual	Digression	Non-Substantial	Task related (other)	Ques/Query	Other	Total	
Kagiso	**45 (57.0%)**	9 (11.4%)	2 (2.5%)	3 (3.8%)	15 (19.0%)	3 (3.8%)	2 (2.5%)	**34 (43.0)**	**79**
Leonard	**54 (50.9%)**	15 (14.2%)	9 (8.5%)	5 (4.7%)	11 (10.3%)	12 (11.3%)	0	**52 (49.1%)**	**106**

The verbal contributions that were interpreted as metacognitive indicate that both Kagiso and Leonard equally contributed in terms of regulating cognitive activities in their respective home groups. Looking at the two members' specialist group contributions in Table 5.1 (Kagiso: 40.7% and Leonard: 43.0%), it is clear that the proportion of metacognitive statements as compared to non-metacognitive increased for both Kagiso and Leonard, but more for Kagiso than for Leonard. A comparison of the manifestations and types of regulatory contributions made by Kagiso and Leonard in their specialist group (Table 5.2) and respective home groups (Table 5.5) reveals an overall increase in other-regulation (Kagiso: 64.5 vs 91.0 and Leonard: 70.9 vs 81.6) and a decrease in self-regulation (Kagiso: 35.5 vs 8.9 and Leonard: 29.0 vs 18.6) for both, particularly in the manifestations of control and monitoring.

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Table 5.5 Comparison between Kagiso and Leonard's home group regulatory contributions in terms of manifestations and types of regulation

Name	Planning			Monitoring			Control			Evaluation			Total
	SR	OR	Subtotal	SR	OR	Subtotal	SR	OR	Subtotal	SR	OR	Subtotal	turns
Kagiso	-	-	**-**	3 (6.7%)	11 (24.4%)	**14 (31.1%)**	1 (2.2%)	29 (64.4%)	**30 (66.7%)**	-	1 (2.2%)	**1 (2.2%)**	**45**
Leonard	-	1 (1.9%)	**1 (1.9%)**	1 (1.9%)	5 (9.3%)	**6 (11.1%)**	7 (13.0%)	38 (70.4%)	**45 (83.3%)**	2 (3.7%)	-	**2 (3.7%)**	**54**

However, an in-depth look at the quality of each of the two individual's contributions (Table 5.6 below) in terms of high-level and low-level regulation reveals a difference in the depth of regulatory efforts. The results in Table 5.6 are the percentages obtained by dividing counts of high- and low-level regulatory statements in each manifestation of regulation by the total number of each individual's metacognitive statements. The percentages are reported for the combined SR and OR instances per person.

Table 5.6 Comparison between Kagiso and Leonard's home group regulatory contributions in terms of depth of regulation

Name	Planning (%)			Monitoring (%)			Control (%)			Evaluation (%)			Total
	LL	HL	Subtotal	LL	HL	Subtotal	LL	HL	Subtotal	LL	HL	Subtotal	turns
Kagiso	0	0	**0**	24.4	2.4	**26.8**	48.8	21.9	**70.7**	2.4	0	**2.4**	**45**
Leonard	2.3	0	**2.3**	6.8	4.5	**11.3**	43.2	43.2	**86.4**	0	0	**0**	**54**

Only 24.3% (2.4 + 21.9) of Kagiso's regulatory contributions constituted high-level regulation, while 47.7% (4.5 + 43.2) of Leonard's regulatory efforts were pitched at a higher level. This trend is different from the one observed for the two students in the specialist group where they both contributed comparable amounts of high-level regulation (Kagiso: 32.2% and Leonard: 32.3%). When compared to the level of regulation demonstrated by Leonard in the specialist group, an increase in the occurrence of high-level regulation and a decrease in low-level regulation is observed in the home group. The opposite is true for Kagiso. This observation may be explained by the nurturing and supportive environment that Leonard found himself in while operating in the home group. For Kagiso this finding provides further evidence for his self-serving objectives, because he had ample opportunity to convey his understanding to Siyanda but chose not to do so.

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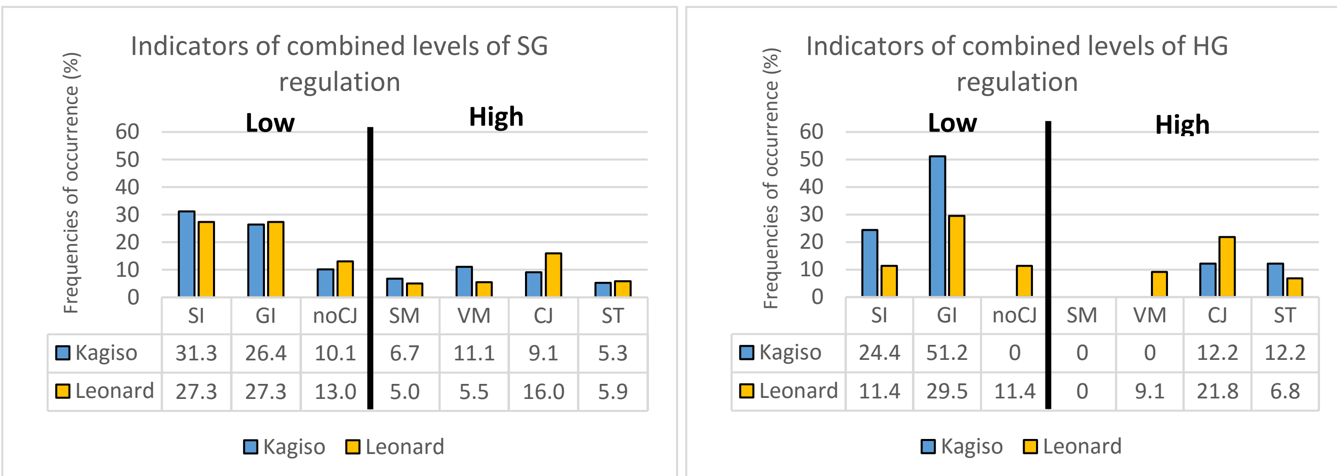
A look at the prominence of manifestations, types, and levels of regulation assisted me to determine whether the styles of interaction observed for Kagiso and Leonard, identified respectively as assertive and tentative in the specialist group, emerged in their interactions with their peers in the home groups. An in-depth look at how the two students differed in terms of the empirical indicators of low- and high-level regulation uncovered the specific actions that each individual followed to regulate activities in the specialist and home groups. The percentages for each of the indicators were calculated against each student's total number of verbal contributions and graphs drawn to present the differences for combined manifestations and types of regulation (Figure 5.6).



Regulation low level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 5.6 Comparison of Kagiso and Leonard's depth of regulation in the specialist group and their respective home groups (HG)

Compared to their specialist group contributions, fewer frequencies of seeking information were observed in the home groups, and frequencies of seeking meaning were non-existent for both Kagiso and Leonard. This could be explained by the fact that the two entered the home group negotiations with a clear understanding of the underlying chemistry concepts, as well as what the task entailed. No occurrences of volunteering meaning were observed for Kagiso. The majority of his verbal contributions in the specialist group were dominated by the seeking and giving of information (SG: 31.3 + 26.4 = 57.7% and HG: 24.4 + 51.2 = 75.6%). This observation constitutes a recurring theme for Kagiso's style of interaction in the specialist group discussions.

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The home group members were more receptive to his regulatory efforts, which made it easier for him to volunteer meaning, share information, and offer more conceptual justifications for his suggestions and objections. In the next sections, I will describe the depth of regulatory contributions observed for Kagiso and Leonard with reference to examples of talk drawn from their home group discussions.

5.7.2.4 Depth of regulatory contributions by Kagiso

An in-depth analysis of Kagiso's metacognitive turns revealed that the majority of regulation he made were characterised by low-level giving of information and seeking of information rather than promoting collective conceptual understanding of the group. High-level monitoring was observed when Kagiso checked his fellow team members' understanding of the chemistry [**HG Discuss Turn 72**: *"Went away, ja (yes). But you can always recover a product, hey?"*]. Although he did not ask a lot of thought-provoking questions, Kagiso demonstrated high-level regulation when he urged Siyanda to think more critically by pointing out the need to consult the given resources, as well as the resources that they had generated in their specialist groups:

Excerpt 5.29

90. **Kagiso**: And then in terms of environment, we have *amacriterias* (criteria) here…remember it is better to prevent waste than to clean up waste. This is what we need to know. Twelve principles of green chemistry this is what we need to know.

(*Turn 90 Transcript of Kagiso's home group discussion*)

This observation could be explained by the fact that active participation in the specialist group enabled Kagiso to enter the home group discussion with a broadened level of understanding of the task and underlying chemistry concepts. High-level control was also observed when Kagiso asked a thought-provoking question to urge Siyanda to think deeply before making a decision regarding the best route (**HG Discuss Turn 120**: *"But is it environmentally friendly?"*). Other than that, the majority of Kagiso's regulatory efforts could be described as low-level and self-serving. An in-depth analysis revealed a recurring style of interaction in how Kagiso carried himself in the specialist and home groups. Kagiso was once again driven to serve his own needs rather than Siyanda's, similar to his conduct in the specialist group. Rather than coach Siyanda in the debate on the best route, he took over and performed the calculation for her and in one

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instance, he looked to a female student from another group, labeled "Woman", to validate his thinking.

Excerpt 5.30

132. **Woman**: They separate least, and then we chose the best route would be C because it's most cost effective and the least challenging, so then you just (?) environmentally (?) too. Because A is not, because it's Grignard reagents. And B we use a lot of dichloromethane they have a lot of halogenating a lot of colour (?) waste.

133. **Kagiso**: We also have that. We also have that on C.

134. **Siyanda**: So shall we choose C?

135. **Kagiso**: Where's our routes? Proposed routes. This is our (?)

136. **Woman**: See, and we have azides. We have an azide.

137. **Kagiso**: We have a…yes, (?), what's this? We have pyridine. This is similar. Do you guys have a dichloromethane?

138. **Woman**: No. *Ja* (yes), we do use dichloromethane but we don't use…sulfonic or whatever that is. We chose that.

139. **Kagiso**: Well then B is not environmentally friendly.

(Turns 132 – 139 Transcript of Kagiso's home group discussion)

An in-depth look at the discussion that Kagiso and Siyanda engaged in when comparing their two routes in terms of technical difficulty revealed that, compared to Siyanda, Kagiso had a deeper understanding of the procedures in his route. In reality, Route B was technically challenging considering the period of time required for refluxing. This information may have been missed by Siyanda alone or her whole specialist group. Siyanda wasted time completing tasks that she could have prepared in her specialist group. The discussion between Siyanda and Kagiso was overall asymmetrical, with Kagiso emerging as the more knowledgeable one (MKO) who directed the cognitive and metacognitive activities of the group. The lack of preparedness and confidence on Siyanda's part put her on the receiving end of the interaction as she did not question anything that Kagiso put forward, but accepted it. This home group was dysfunctional and dominated by Kagiso. Productive co-regulation was not apparent, with group dynamics only partially compensating for deficiencies in Siyanda's preparation and conceptual understanding.

5.7.2.5 Depth of regulatory contributions by Leonard

Although he did not take on a leadership role, Leonard was involved in the regulation of cognition in the home group discussion. He demonstrated this in the many occasions when he openly shared his thoughts and raised objections to his peers' suggestions. The majority of

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Leonard's regulation could be characterised as high-level provision of conceptual justification in the manifestations of monitoring and control. He made concerted efforts to ensure that his team members understood his reasons for making objections and suggestions. Apart from offering conceptual justification, high-level monitoring was also observed when Leonard checked his peers' understanding of the goal of the home group task (**HG Discuss Turn 240**: *"What do you think? So that's the goal?"*). Another indication of high-level control, which featured prominently next to providing conceptual justification in the control manifestation, was volunteering of meaning (8.9%). Volunteering of meaning was observed when Leonard tried to ensure that his team mates understood the idea behind the task:

Excerpt 5.31

238. **Leonard**: The idea is can we think logically as scientists and can we actually gather information that is given and we see that, do we have the ability to see that more is needed and what more is actually needed and where can you find out more. And when we actually have the experience of what to do in the lab, and can we really make it in the lab and if it's possible.

(*Turn 238 Transcript of Leonard's home group discussion*)

Leonard was not happy with superficial reasoning and thus asked thought provoking questions to get his peers to think more critically about each route before making a prediction. Instances of Leonard stimulating his peers' thinking were observed on several occasions. On one occasion, Leonard pointed out that the experiments requiring dry conditions might be something to take into account. Matt did not see this aspect as a technical difficulty as, according to him, it only entailed putting in drying tubes and drying the glassware ahead of time:

Excerpt 5.32

131. **Matt**: Okay, what we had to do is obviously create a Grignard, which is quite easy.

132. **Leonar**d: But, but then the anhydrous conditions …

133. **Matt**: *Ja* (yes), they're not that bad, 'cause we just put drying tubes on.

(*Turns 131 – 133 Transcript of Leonard's home group discussion*)

On another occasion, Matt wanted to conclude that Leonard's route was the cheapest, but Leonard was not satisfied and suggested that they wait for Eksteen to first submit his cost before

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making a decision. To save time, Matt asked Eksteen to find out from his fellow specialist group members what the cost was. This is shown in the excerpt below.

Excerpt 5.33

147. Matt: Okay, that route, I think yours is the cheapest, I think.

148. Leonard: *Ja* (yes). *Ja* (yes), but then he has to submit his.

149. Matt: *Ja* (yes). Do you want to ask someone in your group quickly what that cost was?

150. Eksteen: *Ja* (yes).

(*Turns 147 – 150 Transcript of Leonard's home group discussion*)

Although low-level giving of information featured prominently in Leonard's regulation, his giving of information was mainly observed to be used to ensure not only that the task was completed, but that it was done correctly.

Excerpt 5.34

24. **Matt**: No, but we have to know what the costs were.

25. **Leonard**: But at the end end end (*laughs*). And the efficiency of every step, right. Because remember, you don't get a hundred percent yield, do you get it? As the efficiency of every step that we're going to be doing there […]

28. **Matt**: Bubbling your hydrogen there…

29. **Leonar**d: Oh, and that's quite a safety issue. We should say something, feasibility and practicality.

(*Turns 24 – 29 Transcript of Leonard's home group discussion*)

Overall, Leonard's efforts towards regulation could be classified as high-level and altruistic. In their interactions, Leonard's home group was very democratic, collaborative and supportive of a member who came in less prepared. The supportive nature in the style of interaction was observed when group members restructured tasks to allow Eksteen to catch up. Leonard suggested that they first need to assist Eksteen with his calculation of the cost of reagents to facilitate decision making. Eksteen reported that he still needed to get all of the necessary amounts. Leonard then suggested that they deal with the costs later. Matt suggested that they move on to look at the technically challenging route.

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Excerpt 5.35

120. **Leonard**: Oh, he didn't calculate his (*referring to Eksteen*), let's calculate his because then the whole thing is incomplete.

121. **Matt**: Do you have your amounts that you need?

122. **Leonard**: Is that just per, this is just for two grams that you produce in the lab?

123. **Matt**: *Ja* (yes). Is yours also per two grams?

124. **Leonard**: *Ja* (yes).

125. **Eksteen**: Okay, most…

126. **Leonard**: Okay, we just gonna receive that one.

127. **Matt**: The least technically challenging.

(*Turns 120 – 127 Transcript of Leonard's home group discussion*)

Collaboration was democratic in that most of the decisions were negotiated amongst the team members as opposed to one team member calling the shots. This group also spent a considerable amount of time debating and arguing which route was environmentally friendly. The interaction between the members in Leonard's home group was truly collaborative and respectful. This group was functional and productive compared to Kagiso's home group. Leonard's altruistic style of interaction worked much better in this functional group than in the dysfunctional specialist group.

5.8 Concluding remarks

Regulation in the specialist group discussions of *Team Kagiso* was observed to manifest mostly in the form of monitoring and control, with few manifestations of planning and evaluation. The differentiation of manifestations of regulation in terms of types and areas of regulation revealed that the majority of regulation was other-regulatory and much emphasis was placed on regulating thinking about the underlying chemistry concepts and the task. This observation could be attributed to the nature of the task, requiring knowledge of chemistry content and experimental techniques. An in-depth analysis of the depth of regulation by members of this team revealed that the majority of regulation was characterised by low-level giving and seeking of information. The low-level depth of regulation seemed to be a strategic decision to facilitate task completion given

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the time constraints that the students were working under. These patterns of regulation were observed to recur in the two home groups that were subjected to further analysis.

The time constraint of only having 20 minutes to engage in home group discussions did not make things any easier for both home groups. Coming in prepared assisted both Leonard and Kagiso to actively participate in their home group discussions. Alexopoulou and Driver (1996) find that students' progress or regression in physics reasoning seems to be related to the forms of argument construction and types of social interaction when students work in groups. Progress in reasoning and the regulation thereof was found to be dependent on the extent to which team members evaluated their own and their peers' assertions instead of simply presenting or accepting these views. Their willingness to be open about thinking and to raise objections was found to be more important than equal participation towards achieving collective conceptual understanding (Alexopoulou & Driver, 1996). Willingness to be open about their thinking and to raise disagreements facilitated the process of prediction making, as demonstrated by all of the members in Leonard's team. The tendency to simply present own findings and accept others' findings without questioning was observed in Siyanda's contributions. Leonard's group demonstrated a high level of metacognitive activity in that they not only evaluated their own routes in terms of the stipulated criteria, but they evaluated their peers' routes as well, and corrected each other's understanding of the underlying chemistry concepts. I found these observations to be consistent with the findings of Alexopoulou and Driver (1996) where progressive discussions were characterised by peers questioning and evaluating each other's suggestions. Siyanda's unpreparedness made it possible for Kagiso to revert back to his style of interaction, i.e. to pursue his own goals and serve his own needs. The social context in Leonard's home group proved to be a more conducive environment to his altruistic style of interaction, enabling him to make a substantial contribution in terms of regulating cognitive activities in the team.

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CHAPTER 6

TEAM BETTIE: PATTERNS OF METACOGNITIVE REGULATION

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CHAPTER 6

TEAM BETTIE: PATTERNS OF METACOGNITIVE REGULATION

"I just…especially when marks are involved, I prefer doing stuff myself. I don't like relying on someone else to do something […] I wanted to, at least when we start I wanted to know exactly what was happening, […] And I just trust myself more […]"

"*I didn't talk much but that doesn't mean that I didn't think. So I…I'm thinking constantly but I have difficulty in expressing myself*"

6.1 Introduction

In this chapter, I describe *Team Bettie's* patterns of metacognitive regulation, as enacted during the planning session of the simulated industrial project. Similar to *Team Kagiso*, the specialist group discussion of *Team Bettie* was audio recorded, transcribed verbatim, and translated into English. The inferences made about patterns of metacognitive activity for each team member presented in this chapter have been substantiated by the data drawn from the specialist and home group discussions, as well as from the follow-up individual and group interviews. The data for this team was analysed similarly to *Team Kagiso*'s to facilitate the answering of Research Questions 1, 2 and 3.

The home group discussions of two members of *Team Bettie* were analysed in order to determine the quality of regulatory contributions that each of the students made in their respective home group discussions (Research Question 3). The data and findings that emerged to answer Sub-Research Question 3 for *Team Bettie* are also presented in this chapter. The chapter begins with a portrait of the team members, the roles that they assumed, and the group dynamics observed through the analysis of verbal interactions.

6.2 The nature of social interactions and dynamics observed in *Team Bettie*

Unique patterns of social interaction were also observed to influence the nature and depth of metacognitive regulation for this group. It is for this reason that I begin by first foregrounding the group dynamics that I observed to facilitate the manifestations of metacognitive activity. The members of *Team Bettie* did not use pet names to address each other, and discussions were fairly formal compared to *Team Kagiso*. Their verbal interactions were observed to be civil, with no

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apparent tensions or confrontations between members. Through the follow-up group interview, I established that Bettie, after whom the group was named, and Lynette were friends and study partners outside of class time, which was not obvious from the transcript.

Ansie, alternatively, was not used to working in a group (**IND INT Turn 12:** "I'm not really used to working in a group. I love individual work. But…*ja* (yes), I found it…it's productive, it's quicker to solve a problem when you have more brains. Problem-solving."). Although it was her first time working in a group with the two girls, Ansie reported the experience as a pleasant one as the two team members made her feel comfortable and accommodated her personality.

Ansie was an introvert, but came across as being very reflective **(IND INT Turn 43**: "I didn't talk much, but that doesn't mean that I didn't think. So I…I'm thinking constantly but I have difficulty in expressing myself"), often regulating her team members' task performance and thinking, although in subtle ways (turn 647 below).

Excerpt 6.1

644. **Bettie**: Is it millimole or millilitre?

645. **Ansie**: *Nee, dis millimole* (no, it's millimole).

646. **Bettie**: Millimole? Okay.

647. **Ansie**: *Hierdie een is dan twintig percent mole, so is jy seker? Onthou daardie is in millimole en hierdie is twintig mole percent?* (This one is then 20% mole, so are you sure? Remember that one is in millimole and this one is 20 mole percent?)

(*Turns 644 – 647 Transcript of Specialist group discussion, planning session*)

In her own way, Ansie provided intellectual leadership to the team by asking the team members hard questions and urging them to think harder and verify their contributions (**SG Discuss Turn 898**: "Are you just gonna say fourty-four?"*;* **Turn 344**: "Um…What do you mean now?"*;* **Turn 447**: "Yes, but separated with what?"). Ansie's regulation was welcomed by the other two members of the group.

Bettie came across as being an extrovert. She appeared to be a fast learner, however, this disposition made it difficult for her to operate in a group as she was often asked by her team members to pause and clarify what she was doing and thinking. She expressed in an interview that she likes to take charge and make sure that she knows what is going on, especially when marks are involved:

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Excerpt 6.2

16. **Bettie**: I just…especially when marks are involved, I prefer doing stuff myself. I don't like relying on someone else to do something […] I wanted to, at least when we start, I wanted to know exactly what was happening, […] And I just trust myself more […]

(Turn 16 Transcript of follow-up individual interview with Bettie)

Bettie verbalised her thoughts a lot: "I think out loud and, ja. Even when I'm studying I'll sit and talk to myself […] okay, yes, I've got it, and they always laugh at me, it's very funny" (**SG INT Turn 70)** and she explained that this was a strategy that she used to self-regulate. She expressed in the follow-up interview that she used this strategy to also bounce her ideas off her peers, thus allowing her peers to assess whether or not she was on the right track:

Excerpt 6.3

28. **Bettie**: Where if you…or if I, if I speak about it, or talk about it, or explain to someone else, I get the feeling of it, I get the understanding, and then you keep thinking, okay, but this part is a bit not clear, so then you discuss that. I just find that I understand it better so then for long term you remember it for much longer, than just for the test.

(*Turn 28 Transcript of follow-up individual interview with Bettie*)

As a result of her being outspoken and preferring to do things herself, Bettie spontaneously took it upon herself to steer the group activities and be the group leader.

Lynette came across as not being very confident in her chemistry knowledge, which was reflected in how often she asked her team members to validate her thinking before she could proceed with a task. Bettie and Ansie were at times too fast for Lynette, who frequently implored them to wait so that she could catch up. Turn 187 below is just one of many examples where Lynette asked her team members to slow down.

Excerpt 6.4

185. **Ansie**: *Ja, by stap 1* (yes, at step 1).

186. **Bettie**: *So dan gaan jy daai millimol moet gaan verdubbel verdubbel vir stap 1* (so then you will need to double that millimol for step 1) Okay.

187. **Lynette**: Okay, *Wag, wag, wag. Hoe het julle die millimol gekry?* (Wait, wait, wait. How did you get the millimoles?)

188. **Ansie**: *Jy maal met 12 gra…(*You multiply by 12 grams)

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189. **Lynette**: *Oh ja, oh ja, van die twaalf gram* (Oh yes, oh yes, by twelve gram).

(*Turns 185 – 189 Transcript of Specialist group discussion, planning session*)

Lynette and Bettie confirmed this observation during the follow-up group interview:

Excerpt 6.5

93. **Lynette**: *Ja* (yes), it was again the thing, like I take longer to process something and Bettie was like on the third separation and I'm still on the first, so I'm like, just wait, let me just catch on!

94. **Interviewer**: Okay, but eventually you caught on, you could see what was happening.

95. **Lynette**: *Ja* (yes). What was nice with our group is that one person didn't do everything and waited for the others. We worked ahead, and they actually waited for me just to process what's going on.

96. **Bettie**: *Ja* (yes), every time she told us, no, okay, wait, I'm not there, then we'll go back and let's discuss it first, get everyone on the same page and then move on.

(*Turns 93 – 96 Transcript of follow-up group interview with Team Bettie*)

The members in this group decided to use a different task execution strategy from the one employed by *Team Kagiso*. Instead of delegating different parts of the task to team members, the members of *Team Bettie* decided to work together one step at a time on all aspects of the task. This meant that putting together the effort of three would enable quick task execution and would ensure that each member left the specialist group discussion with a clear understanding of each aspect, and was independent of fellow team members (turn 98 and 101).

Excerpt 6.6

97. **Interviewer**: Okay, so your strategy, because groups…people decided on different strategies, it was not like some just do calculation, some do MSDS, you all did everything together?

98. **Lynette**: *Ja* (yes). Because then only one person is going to understand the calculations and the other people were just going to write it down.

99. **Bettie**: Exactly.

100. **Lynette**: So what's the point of that?

101. **Bettie**: And then especially with us, it helped in the sense that, because none of us got a product the first day and we needed that product to go further the next week, and because none of us got, they gave us a different amount the next week that they've made. So then we had to adjust our calculations accordingly. So if one did the calculations, the rest wouldn't have been able to adjust it to that. So, and also, everyone needs to understand what's going on so it doesn't help one knows calculations and one knows the safety. Everyone needs to know the safety of all the chemicals. So to us, it just made sense that everybody did everything and just did it quicker because we were three instead of just one.

(*Turns 97 – 101 Transcript of follow-up group interview with Team Bettie*)

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In hindsight, the team saw the benefits of having chosen to do everything together. Forced to recalculate the amounts of their reactants based on their new amounts of starting reactant, each team member could adjust their calculations on their own without having to rely on one team member to do so (turn 101). Overall, the interactions in the specialist group were supportive and collaborative. One observation unique to this group was how often they consulted with the teaching assistant (Diana) throughout their specialist group discussions. I labelled this form of talk off-group talk. Off-group talk constituted any verbal exchange observed between students and individuals other than their team members, e.g. lecturer or students from neighbouring groups. The highest instances of off-group engagement were observed between the members of *Team Bettie* and Diana and constituted 71 turns of talk. It was almost as though Diana became the fourth member of the team. The students in this team asked questions and Diana happily supplied information without prompting for deeper thought. Excerpt 6.7 below is an example of the type of interaction observed between members of *Team Bettie* and Diana:

Excerpt 6.7

296. Lynette:	We get zero point two. So how do we get it to zero point eight? (*pause*).
297. Diana:	We obviously need to then decrease your amount of ether that you were then using. Because how did you calculate this and that?
298. Bettie:	*Ja* (Yes), we said the millimoles of our limiting reagent divided by the volume…the two ether volumes that we're adding.
299. Lynette:	Just to make sure, they say these two are fifty percent yield that we should expect, and this one is a hundred percent. So we times to this mole or this one?
300. Diana:	Well, *ja* (yes), you must just work backwards so…
301. Bettie:	*Ja, ja*, (Yes, yes) but …
302. Diana:	*Ja* (Yes), the moles of this, or whatever you get of this is fifty percent of then what you get of that, which is therefore fifty percent of what you get of this. So you then know how much of this you would need, working backwards.
303. Bettie:	Oh! Okay, so, okay, *ja* (yes), so went directly from there to here.

(*Turns 296 – 303 Transcript of Specialist group discussion, planning session*)

In the next sections, I will present the quantitative and qualitative data as evidence that corroborates the inferences that I made about patterns of metacognitive regulation for the members of *Team Bettie*.

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6.3 Nature of talk observed for *Team Bettie*

Using the criteria stipulated in Chapter 4, each team member's verbal contributions were coded as metacognitive (planning, monitoring, control, evaluation) or non-metacognitive (conceptual, digression, non-substantial, task-related other, question/query, other). Table 6.1 gives an overview of how frequently each type of utterance was identified for each member of *Team Bettie*. It is important to note that the percentage values in brackets for each type of statement in Table 6.1 were calculated relative to the total verbal contributions for each team member, showing clearly the distribution of responses per team member and normalising the percentages against each member's style of interaction.

Table 6.1 Frequencies of occurrence of metacognitive and non-metacognitive statements for *Team Bettie*

Names	Metacognitive Statements	Non-metacognitive Statements							No. of turns
		Conceptual	Digressions	Non-Substantial	Task-related (other)	Ques/Query	Other	Total	
Bettie	**399 (66.0%)**	75 (12.4%)	21 (3.5%)	39 (6.4%)	60 (9.9%)	11 (1.8%)	-	**206 (34.0%)**	**605**
Ansie	**226 (63.5%)**	34 (9.6%)	24 (6.7%)	15 (4.2%)	45 (12.6%)	9 (2.5%)	3 (0.8%)	**130 (36.5%)**	**356**
Lynette	**255 (64.9%)**	46 (11.7%)	28 (7.1%)	18 (4.6%)	33 (8.4%)	10 (2.5%)	3 (0.8%)	**138 (35.1%)**	**393**
Total	**880 (65.0%)**	**155 (11.4%)**	**73 (5.4%)**	**72 (5.3%)**	**138 (10.2%)**	**30 (2.2%)**	**6 (0.4%)**	**474 (35.0%)**	**1354**

Bettie's verbal contributions were almost twice as much as that of all of her peers, i.e. 605 turns of talk compared to 356 turns for Ansie and 393 turns of talk for Lynette. This is not surprising as she assumed the leadership role and steered the groups' activities. Overall, the team spent a considerable amount of time on verbal exchange indicative of metacognitive regulation (65.0%), as compared to non-metacognitive talk (35.0%). However if turns of talk by Diana had been included, the percentage difference between metacognitive and non-metacognitive talk could have been much lower. This observation is the opposite of what emerged for *Team Kagiso*, where 43.2% of the contributions were metacognitive statements, and 56.8% non-metacognitive. All of the students in this team generally displayed comparable instances of talk indicative of metacognitive regulation (Bettie: 66.0%, Ansie: 63.5%, Lynette: 64.9%). Talk concerned with sorting out the logistical aspects of the task and underlying chemistry concepts was observed in statements categorised as conceptual (11.4%), task related other (10.2%), and question/query (2.2%). Generally, this team spent the majority of non-metacognitive talk (23.8% of total talk)

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clarifying the logistical aspects of the task (Task-related other and Queries) and underlying chemistry concepts (Conceptual).

The group spent significantly less time engaging in off-task social talk (5.4%) as compared to the members of *Team Kagiso* (15.3%). The members of *Team Bettie* equally participated in off-task talk, with Lynette instigating most of the off-task conversations. One member would instigate the conversation and the other team members would reply. The off-task social talk, however, was often short, with one member of the team regulating task performance by drawing the team's attention back to the task at hand. The excerpt below is an example of such instances where Bettie made a statement (Turn 694) to draw Ansie and Lynette back to the task when they engaged in off-task talk.

Excerpt 6.8

686. **Lynette**: *Is hy nuut hier?* (Is he new here?)

687. **Ansie**: *Ja, hy's 'n eerste jaar med.* (Yes, he's a first year med.)

688. **Lynette**: *Dis cool. Eerste jaar? Maar Biochemie of Honeurs?* (That's cool. First year? But Biochemistry or Honours?)

689. **Ansie**: *Nee chemie* (No, chemistry)

690. **Lynette**: *Ja maar BSc of…?* (Yes but BSc or…?)

691. **Ansie**: BSc

692. **Lynette**: *Dis cool. Is dit lekker?* (That's cool, is it nice?)

693. **Ansie**: *Ja* (Yes)

694. **Bettie**: Okay, *een punt drie drie is sy density.* (Okay, one point three three is it's density.)

695. **Ansie**: *Vir wat is dit?* (Yes what is that for?)

(*Turns 686 – 695 Transcript of Specialist group discussion, planning session*)

Metacognitive statements were further divided according to manifestations and types of regulation. The results of this differentiation follow next.

6.4 Frequencies of occurrence of metacognitive regulation

Statements that were interpreted as metacognitive were further categorised by manifestation (planning, monitoring, control or evaluation) and type (self or other) of metacognitive regulation (Table 6.2 below). Self-regulation was observed when the participants regulated their own thinking, task performance, and behaviour. Other-regulation was observed when the team

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members regulated each other's thinking, task performance, and behaviour. Percentage values were calculated by dividing the raw counts of occurrence by the total number of verbal contributions per team member.

Table 6.2 Breakdown of metacognitive regulation turns of talk into manifestations and types of regulation

Name	Planning (%)			Monitoring (%)			Control (%)			Evaluation (%)			Total MR turns*
	SR	**OR**	**Subtotal**	**SR**	**OR**	**Subtotal**	**SR**	**OR**	**Subtotal**	**SR**	**OR**	**Subtotal**	
Bettie	0.3	2.5	**2.8**	4.8	3.8	**8.6**	24.8	58.6	**83.4**	3.8	1.5	**5.3**	**399 (45.3%)**
Ansie	0	2.7	**2.7**	4.0	8.8	**12.8**	28.3	53.1	**81.4**	1.8	1.3	**3.1**	**226 (25.7%)**
Lynette	0.8	2.4	**3.2**	18.4	7.8	**26.2**	31.4	33.7	**65.1**	3.5	2.0	**5.5**	**255 (29.0%)**
Total raw scores*	**3 (0.3%)**	**22 (2.5%)**	**25 (2.8%)**	**75 (8.5%)**	**55 (6.3%)**	**130 (14.8%)**	**243 (27.6%)**	**440 (50.0%)**	**683 (77.6%)**	**28 (3.2%)**	**14 (1.6%)**	**42 (4.8%)**	**880**

*** Percentages in brackets: total raw scores normalised against the whole team's total number of metacognitive statements.**

The bigger picture shows that manifestations of control emerged as the most prominent form of regulation in terms of general frequencies of occurrence, with monitoring, planning, and evaluation featuring less often. The breakdown of verbal contributions into types of metacognitive regulation shows that half of the regulatory talk consisted of verbal contributions that were targeted at controlling fellow team members' thinking about cognitive activities (other-Control: 50.0%). Overall, other-regulation emerged as the more prominent type of regulation compared to self-regulation (Other-regulation: 60.4% vs Self-regulation: 39.6%). This may be explained by the fact that during collaborative learning, students' thinking is more easily revealed when they regulate their peers than when they regulate themselves. Instances where self-regulation occurred more than other-regulation were observed when the students monitored (SR: 8.5% vs OR: 6.3%) and evaluated (SR: 3.2% vs OR: 1.6%) cognitive activities.

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In total, Table 6.2 shows that for *Team Bettie*, regulatory behaviour was observed across all the manifestations and almost all the types of regulation. I will now discuss the different manifestations and types of metacognitive regulation that were observed for the team, drawing on the frequencies of occurrence as presented in Table 6.2 above. In my discussions of how metacognitive activity manifested, I will also make reference to Figures 6.1, 6.2, 6.3 and 6.4, which have been included to give an overview of the areas of regulation observed for each manifestation and type of regulation. To enable inter-individual comparison, raw counts for each area of regulation were normalised by calculating the percentages relative to each team member's total metacognitive statements. Occasional reference will also be made to the profile maps of each student's regulatory patterns (Appendices 4.7, 4.8, and 4.9). The profile maps provide an overview of the contextualised indicators of metacognitive regulation that were inferred from each team member's verbal contributions.

6.4.1 Planning

Planning was observed in verbal exchanges that were indicative of forward thinking, and in instances when the students engaged in negotiations with regard to aspects of task performance, such as strategies for optimum task execution, as well as roles and responsibilities.

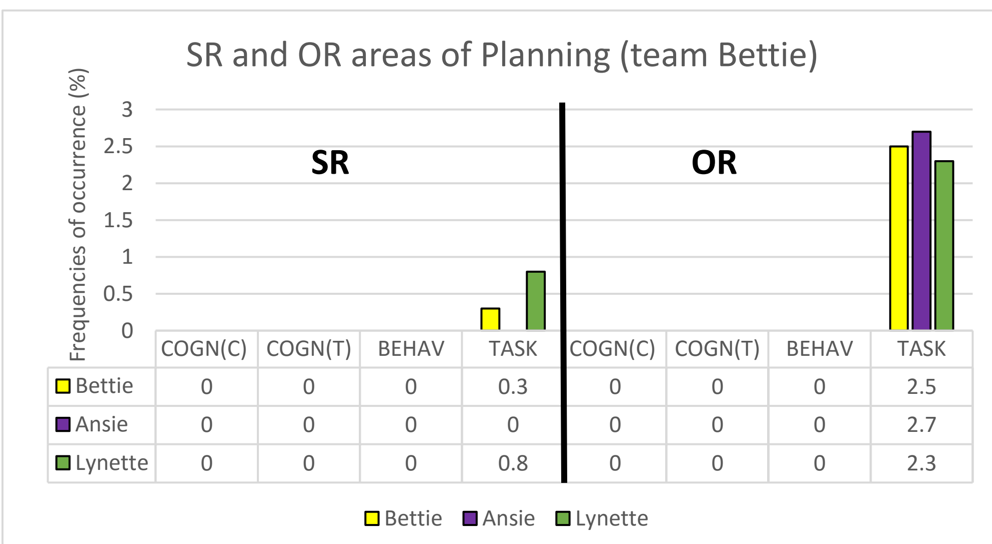

Figure 6.1 Self (SR) and Other (OR) areas of Planning by *Team Bettie**

*Self-regulation (SR) on the **left-hand side** and Other-regulation (OR) on the **right-hand side.**

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Generally, very few instances of planning were observed in *Team Bettie*'s verbal interactions. Isolated instances of planning were observed when the members discussed how best to approach and execute the specialist group task, and when they identified and anticipated aspects for future consideration. For all of the team members, planning did not feature as prominently as the other manifestations of metacognitive regulation (Bettie: 2.8%; Ansie: 2.7%; Lynette: 3.1%). The prevalence of Ansie and Bettie's total regulatory contributions in terms of planning were comparable, with Ansie making no contributions at the intra-personal level. Figure 6.1 also shows that Bettie and Lynette's regulatory efforts at the individual level were only directed at personal task performance. For Lynette, intra-individual level planning was observed in instances when she expressed how she planned to perform the task [**SG Discuss Turn 1001**: "*Jinne ek gaan hierdie goetjies moet netjies oorskryf (*jeez, I will have to write these things over very neatly*)"*]. With Bettie, intra-individual planning was observed when she thought out loud and expressed how she planned to utilise the waiting period in the laboratory [**SG Discuss Turn 155**: *"Ek kan net sowel net hierheen kom en hier werk vir vier ure* (I can just as well just come here and work here for four hours)].

Planning manifested mostly at the social level when members put forward ideas regarding strategies that could optimise the team's task performance. I interpreted these verbalisations as inter-individual planning because it was in these instances of talk that the students were observed to influence each other's decisions about how best to perform the task:

Excerpt 6.9

498. Bettie: *Ja, ja, ek gaan hom, ja. Ons moet net eers hierdie uitsorteer en dan die procedures uitwerk, dan kan ons dit sommer saam doen en soos die equipment en alles. (*Yes, yes, I'm going to, yes. We must just sort this out first and then work out the procedures, then we can do this together, like the equipment and all that).

(*Turn 498 Transcript of Specialist group discussion, planning session*)

The various ways in which Ansie regulated the team's task performance with regard to planning was noteworthy. A look at the profile map of Ansie's regulatory patterns (Appendix 4.8) shows that her regulation of the team's task performance also included instances where she demonstrated some forethought, particularly when she pointed out important aspects for the team to consider in the future [**SG Discuss Turn 135**: *"Ons gaan die, die suurheid van die goed moet*

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*meet (*We will need to measure the acidity of the stuff*)"*] and when she urged the team to plan ahead [**SG Discuss Turn 1087**: *"Ons moet vra oor daai later (*We must ask about that later*)"*].

An in-depth analysis of the team's discussion showed that the team members started off their discussions by spending a lot of the time trying to sort out the reaction mechanism of their synthetic route instead of planning their task. This was done with the help of the laboratory assistant, Diana. The team completely ignored the RLSQ, which was meant to facilitate the talk around planning their task, and instead focused on their unfinished reaction mechanisms. This discussion was observed in turns 8 to 76 of the specialist group discussions (available in the CD with additional information). It was only after the lecturer announced that he expected them to have already gone over Part 1 of their RLSQ that they realised that they were lagging behind. For this team, it seemed that the role of the RLSQ was not clear. This was confirmed by Bettie and Lynette's responses during the follow-up group interview. When asked about the role that the RLSQ played in eliciting planning, Bettie had to be reminded what the RLSQ was all about, and Lynette highlighted the abbreviated journal article as the more useful tool:

Excerpt 6.10

102. **Interviewer**:	[…] Did you find any help at all, any value in that questionnaire, the specialist group one?
103. **Bettie**:	I need to remember what it said (*laughs*).
104. **Lynette**:	I think it actually made you think about the practicals, what still needs to be done to actually get what you want. And then when you…because we didn't…they'd said, okay, we're going to do this and this, and we didn't know, okay, how are we going to know what amount we're going to use with the first step. What are we going to do? But once we got the journal, and we worked through it, I actually knew exactly what was going to happen in that six hours every day. And then after that, *ja* (yes), it was so much easier to just know that we just had to do this.

(*Turns 102 – 104 Transcript of follow-up group interview with Team Bettie*)

I suspect that the team members rushed through the RLSQ not only due to time constraints, but also because the RLSQ forced them to think hard and invest time in planning before using the given resources. Instead, the students were eager to skip this step and delve straight into the journal article procedures. Lynette and Ansie expressed their frustration with this part of the task (turns 118 and 119). Bettie could not see the point of the whole exercise as she felt that reading the journal article would facilitate the planning much better than trying to first answer the prompts in the RLSQ (turn 120). This could be explained by the fact that it was the first time in

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the course that students were required to put their thoughts on paper, thus requiring them to plan before executing a task. A further look at the group's discussion showed that going over the questions listed in the RLSQ brought back the focus in the team's discussions, which forced them to regroup and think about the best way to answer the questions.

Excerpt 6.11

77. **Lecturer**: Okay everyone. Alright. Has everyone had a chance to finish that part one of the Part 1 of the Questionnaire? Okay. I suggest you quickly finish it now 5 minutes and then I am going to hand out the next set of the notes and we will go from there.

78. **Ansie**: *Wat moet ons invul?* (What must we fill in?) […]

[*Pause & paging*]

85. **Bettie**: [*Reads from RLSQ*] <u>what information is missing</u>. *Baie* (lots) Okay so what information is missing?

86. **Lynette**: For instance, *daai wat ons, hierdie daai' met mekaar bind, behalwe die dele van die mechanism. Ons kan so sê, part of the mechanism is unclear. Vestaan jy wat ek bedoel?* (if you bind these together except the parts of the mechanism. So we can say that the part of the mechanism is unclear. Do you understand what I am saying?)

87. **Bettie**: *Ja* (yes).

88. **Bettie**: *Ja, ek verstaan wat jy bedoel. Daai hele lys van goed oh ja, dan kan ons sê: "referring to the price list* (Oh yes, I understand what you are saying. That whole list of stuff, oh yes, then we can say: "referring to the price list") […]

[*Filling in questionnaire*]

102. **Bettie**: [*Reads RLSQ*] <u>what will you do in order to compile the detailed experimental procedure?</u>

103. **Lynette**: Okay, *is dit nog 'n vraag wat jy wil vra? soos iets wat jy voel missing is?* (is this another question that you would like to ask? Like something you feel is missing?)

104. **Ansie**: *Nee, dis maar net, ja dit beteken net hoe 'n mens dit gebruik en hoe en wanneer* (no it's just, yes it only means how someone should use it and how and when) […]

107. **Bettie**: *Hoe wil julle die 'planning' doen?* (How would you like to do the planning?) […]

110. **Lynette**: *Dis die Mind map ding ek dink* (I think it is the Mind Map thing). *Lees maar die joernaal en doen 'n mind map van dit* (Read the journal and do a mind map of it).

111. **Ansie**: *Ja* (yes).

117. **Lecturer**: Okay, has everybody got their latest handouts, with the experimentals? [*pause*] Cool!

118. **Lynette**: *Ek weet nie rerig wat ek daar gaan skryf nie* (I don't really know what I am going to write there) [*referring to RLSQ*].

119. **Ansie**: *Ja, ek weet nog nie regtig wat die task is nie* (yes, I don't really know what the tasks is about).

120. **Bettie**: Exactly. *Ek wil net soos die journal artikels lees dat ons die regte planning en 'n list kry*. (I just want to read the journal so that we can do the right planning and make a list).

(*Turns 77 – 120 Transcript of Specialist group discussion, planning session*)

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Most of what constituted planning in the beginning of the specialist group discussions of *Team Bettie* was talk around clarifying the prompts in the RLSQ, and formulating what to write in response to the prompts. However, the students in *Team Bettie* demonstrated some forward thinking in that they always visualised and anticipated what the experiment would look like in practice while working on the detailed experimental procedure for their synthetic route.

Excerpt 6.12

73. **Interviewer**: So you were aware of your thoughts as you (?), and you were constantly monitoring whether everybody's on the same…

74. **Bettie**: *Ja, ja* (yes, yes). We were also thinking, like, at this step, how…we were trying to think how we were going to be in the lab so that we can relate, okay. It doesn't help if we say one thing and in the lab it's completely different. How's it going to be? Okay, and we were trying to think, okay, we're going to have a beaker now, I can imagine it and say, okay, we're going to take this. So that when we go into the lab it's much, much easier to follow.

(*Turns 73 – 74 Transcript of follow up group interview with Team Bettie)*

6.4.2 Monitoring

All of the verbalisations that were characteristic of checking own or peer thinking, behavior, and task performance were interpreted as monitoring. Statements such as "It is not supposed to mix, otherwise you won't be able to get that product. Do you understand?" and "Let me just make sure. So this is one equivalent, so you multiplied it with those two of this?" were interpreted as a form of monitoring that the students used to make sure that they and their peers were on the right track in terms of their thinking, behaviour, and task performance. Team members demonstrated self- and other-monitoring in all of the areas of regulation except for behaviour. The data in Table 6.2 shows that Lynette was once again the team member with the most contributions in terms of monitoring. The data also shows that the majority of her regulatory contributions in terms of monitoring were individualistic. A deeper look at Figure 6.2 shows that the majority of her self-regulation efforts were directed at monitoring her thinking about the underlying chemistry concepts.

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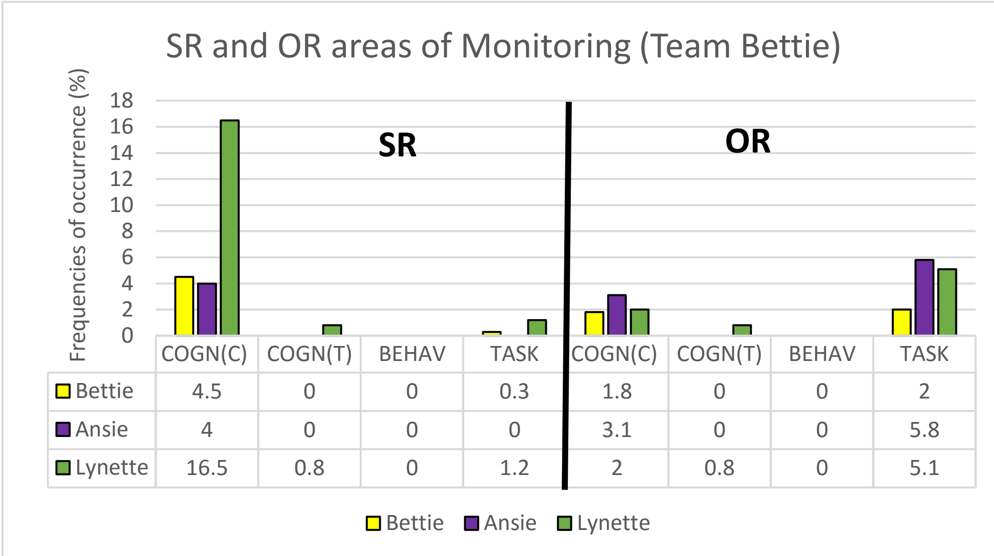

Figure 6.2 *Team Bettie's* SR and OR areas of Monitoring*

*Self-regulation (SR) on the **left-hand side** and Other-regulation (OR) on the **right-hand side**

An even deeper look into her regulation profile map (Appendix 4.9) shows that she achieved this form of self-monitoring by mostly seeking the affirmation of her thinking from her peers, the teaching assistant, and sometimes the lecturer. This form of self-monitoring observed for Lynette was inferred from statements such as [**SG Discuss Turn 1039**: *"Ja. Um, gravity filter and rotary evaporate né? (*Yes. Um, gravity filter and rotary evaporate right?*)"*]. A look at the regulation profile maps of Bettie and Ansie (Appendices 4.7 and 4.8) shows that seeking confirmation of thought was the strategy most commonly used by team members to monitor their thinking at the intra-individual level.

Instances of checking own thinking about the task were inferred from only two turns of talk uttered by Lynette when she sought validation from one of her peers regarding her thinking about task expectations [**SG Discuss Turn 1014**: *"Ons moet half drie klaar wees né? (*We need to be finished by two thirty right?*)"*] and [**Turn 1353:** *"Nou moet ons hierdie goed gaan was, ne? (*Now we must go and wash these things, right?*)"*]. Efforts to check own task performance were observed only for Bettie and Lynette. These efforts of self-monitoring were observed in statements such as [**SG Discuss Turn 1142**: *"So die bottom layer? (*So the bottom layer?*). Hoekom het ek hom as die top layer? (*Why do I have it as the top layer?*)"*], when the team

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members were thinking out loud while they went over and double checked the correctness of their completed tasks.

Ansie had the second highest percentage of occurrences of overall monitoring, and was also the only team member for whom other-monitoring was observed to have occurred more than self-monitoring (SR: 4.0% vs OR: 8.8%). A look at the areas that she regulated at the social level shows that she demonstrated the highest instances of monitoring both the team's thinking about the underlying chemistry concepts, as well as task performance. A further look into her regulatory patterns in terms of monitoring (Appendix 4.8) reveals the various means of regulation utilised by Ansie to monitor the team's cognitive activities. This evidence seems to suggest that beyond monitoring her own cognitive activities, Ansie made concerted efforts to ensure that her fellow team members were on the right track in terms of thinking and task performance.

Although fewer, all of the other team members also demonstrated instances of monitoring the team's thinking about the underlying chemistry concepts, as well as task performance, with Lynette also demonstrating some monitoring of her fellow team members' thinking about the task (Excerpt 6.11 above).

6.4.3 Control

Control constituted the most common form of verbalised regulation observed for this specialist group (77.6%). All verbalisations that were judged to have been uttered to influence the team's cognitive activities were interpreted as regulatory efforts of control. Figure 6.3 shows that overall, regulatory behaviours associated with control were spread across different areas of inter-individual regulation, and were more sparsely distributed across the areas of intrapersonal regulation. It is important to note that this is the only time that the students of this group were observed to regulate behaviour. This observation may be attributed to the fact that operating in a functional group context did not require much regulation of behaviour. This form of regulation was observed especially with Lynette when she urged her team members to wait so that she could catch up (Appendix 4.9).

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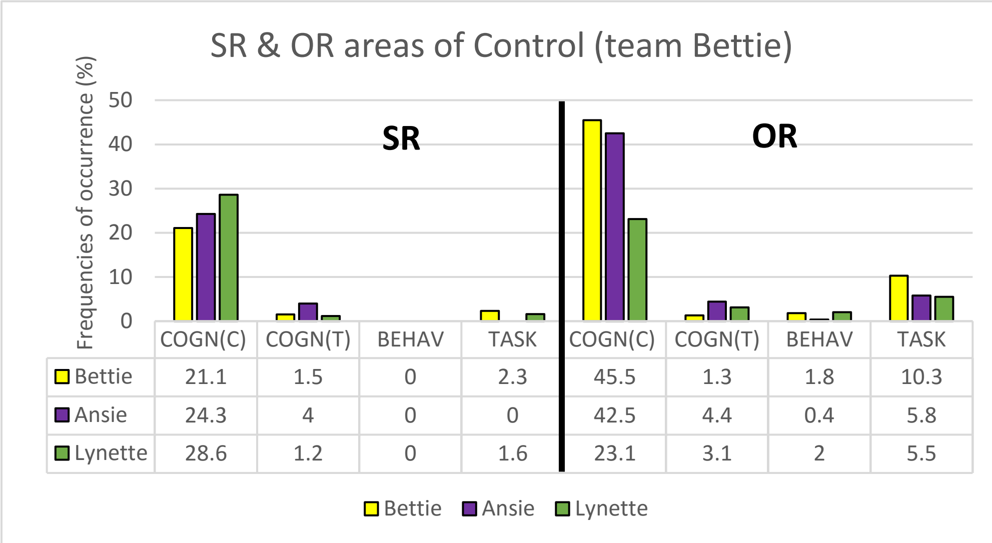

	COGN(C)	COGN(T)	BEHAV	TASK	COGN(C)	COGN(T)	BEHAV	TASK
Bettie	21.1	1.5	0	2.3	45.5	1.3	1.8	10.3
Ansie	24.3	4	0	0	42.5	4.4	0.4	5.8
Lynette	28.6	1.2	0	1.6	23.1	3.1	2	5.5

Figure 6.3 *Team Bettie's* SR and OR areas of Control*

*Self-regulation (SR) on the **left-hand side** and Other-regulation (OR) on the **right-hand side.**

Table 6.2 shows that the prevalence of frequencies of overall regulation in terms of control were highest for Bettie and Ansie (83.4% and 81.4%, respectively) and lower for Lynette (65.1%). A deeper look at the nature of contributions made by Ansie and Bettie shows that the majority of their regulation in terms of control was other-regulatory, with Lynette's regulatory contributions spread almost evenly between self and other regulation. However, an in-depth look at the areas where team members applied their efforts towards regulation in Figure 6.3 reveals that the majority of self-regulation in terms of control were observed when the team members regulated their thinking about the underlying chemistry concepts. The same observation was made for regulation at the social level. Looking at the finer details provided in the regulation profile maps of the team members (Appendices 4.7, 4.8, 4.9), it became clear that the most prominent manifestations of control as a strategy for self-regulating thinking about the chemistry was when the individual students sought clarification from their peers, teaching assistant or lecturer:

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Excerpt 6.13

407. **Ansie**: *Ja, so daardie gaan ons nie nou kan uitwerk nie. Ja, ek wil net vra oor hierdie stap, want ek is nie seker wat gaan aan nie, wat is die punt van hierdie stap?* (Yes, so we aren't going to be able to calculate that now. Yes, I just want to ask about this step, because I'm not sure what's going on, what's the point of this step?)

(*Turn 407 Transcript of Specialist group discussion, planning session*)

Other-regulation of thinking about the underlying chemistry concepts was mostly observed in instances when team members clarified or corrected their peers' thinking about the content [**SG Discuss Turn 208**: *"Nee, want dan gaan dit mos dubbel daardie wees (*No, because then that will then be double that one*)"*].

Instances of members consulting with the teaching assistant were observed for all members of the team. However, it was only Bettie who was observed to have instigated consultations with the lecturer. This could be explained by the fact that the other two team members may have felt more comfortable consulting with the each other or the laboratory assistant. The teaching assistant fell in the same age group as the team members, and may have been perceived as less intimidating than the lecturer. The most prevalent occurrence of self-regulation in terms of control was observed in the area of cognition about the underlying chemistry concepts for Lynette (28.6%). Judging by the number of turns of talk (Appendix 4.9), Lynette relied more heavily on her team mates to clarify her thinking about the underlying chemistry concepts. She confirmed in the follow-up group interview that she liked to process things and then ask when she did not understand.

The highest frequencies of other-regulation in relation to control were observed for Bettie, with most of the regulation manifesting when she regulated her team members' thinking about the underlying chemistry concepts (45.4%). Ansie demonstrated the second highest incidences of regulating cognition about the underlying chemistry concepts (42.5%), while Lynette had the least instances of regulating cognition about the chemistry (23.1%). The data seems to suggest that Ansie and Bettie played a prominent role in regulating the team's cognitive activities and thus provided intellectual leadership in terms of regulating the team's thinking about the underlying chemistry content. An in-depth look at the finer details (Appendix 4.8) shows that Ansie's most prominent contributions in this area of regulation manifested when she clarified,

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affirmed, corrected and questioned her peers' thinking about the chemistry. It is important to note that questioning peers' thinking was only observed in Ansie's utterances. In Bettie's case, the most prominent manifestations in this area of regulation were observed when she clarified, affirmed, and corrected her peers' thinking about the chemistry, as well as when she justified her own thinking about the chemistry to her peers (Appendix 4.7). The only form of other-regulation in this area that occurred most frequently for Lynette was observed in instances when she clarified her peers' thinking about the chemistry.

High frequencies of other-regulation by Bettie in the area of task performance, relative to her peers, deserves a mention (10.3%). The frequency of occurrence of Bettie regulating her team's task performance may be indicative of the leadership role that she assumed.

6.4.4 Evaluation

Evaluation as a regulatory strategy was observed in instances when the students expressed their views about the level or quality of their cognitive activities, as well as that of their peers. For this team, statements such as, "We got to that point. So we don't know how to do this last part", "Listen, I think the volumes are far out" and "I just don't understand this instruction" were interpreted to be evaluative in nature.

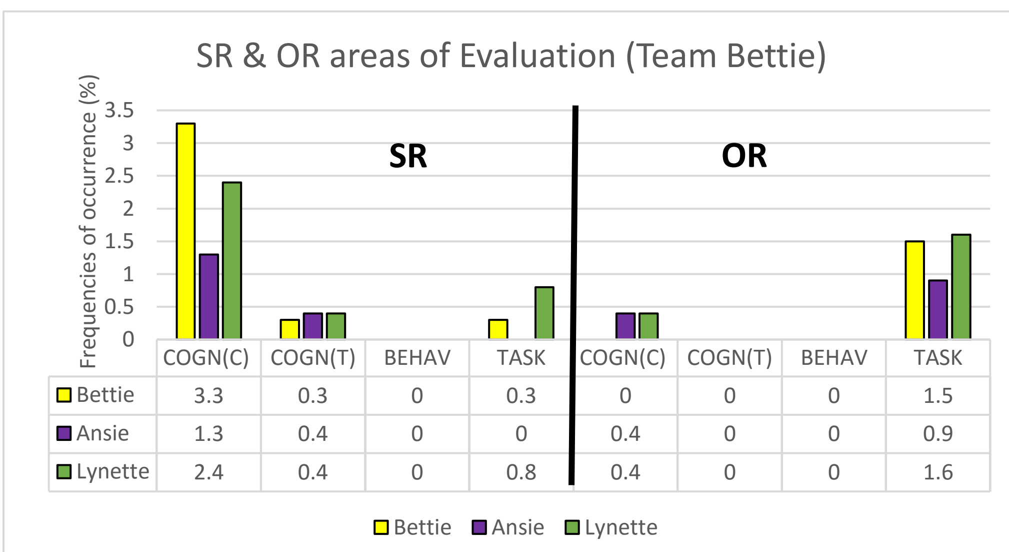

Figure 6.4 *Team Bettie's* SR and OR areas of Evaluation*

*Self-regulation (SR) on the **left-hand side** and Other-regulation (OR) on the **right-hand side.**

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Instances of evaluation did not feature prominently in the manifestations of regulation observed for this specialist group. Indicators of regulation in the form of evaluation were distributed across most of the areas of cognitive regulation, except for behaviour and social cognition about the task. Figure 6.4 shows that, in terms of evaluation, self-regulation was mostly observed when the students evaluated and made judgements about their own understanding of the underlying chemistry concepts [**SG Discuss Turn 281**: *"Ja, oh okay, ek verstaan wat jy bedoel (*yes, oh okay, I understand what you mean*)"*] and **[SG Discuss Turn 400**: *"Ja, maar ek sou ook so gesê het, want nou maak dit baie meer sin (*That's what I would also have said, because now it makes much more sense*)"*]. The prevalence of instances of self-evaluation in this area of regulation seems to suggest that all of the members of *Team Bettie* were able to judge their level of understanding of the chemistry [**SG Discuss Turn 681**: *"Ek verstaan nie net nie hierdie instruction nie (*I just don't understand this instruction*)"*]. This form of introspection may have been instrumental in encouraging the students to identify areas where they were lacking and needed assistance. Isolated incidences where an individual evaluated the team's understanding of the chemistry were observed for Lynette and Ansie.

Overall, planning (2.8%) and evaluation (4.8%) did not feature prominently as compared to monitoring (14.8%) and control (77.6%) for *Team Bettie*. This finding is consistent with the findings of *Team Kagiso* and other related research (Khosa & Volet, 2014; Molenaar & Chiu, 2014) where students' metacognitive activity was found to consist mostly of monitoring and control efforts rather than planning and evaluation. This observation supports Ertmer and Newby's (1996) assertion that novice learners lack advanced metacognitive skills such as reflection, planning, and evaluation.

6.5 Depth of metacognitive regulation

A comparison of the frequencies of instances of regulation showed that Lynette had the highest instances of monitoring, planning, and evaluation (Table 6.2) as compared to Ansie and Bettie. However, the frequencies of occurrence conceal the fact that although Lynette may have demonstrated more instances of regulation than her peers in these categories, her planning, monitoring, and evaluation may not have constituted a higher quality in terms of depth of cognitive regulation as compared to her peers. A further analysis of the team members' metacognitive statements revealed differences in terms of depth of metacognitive regulation.

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Table 6.3 below gives a breakdown of how the students differed in terms of depth of regulation. For easy comparison, the results are reported for the combined SR and OR instances per person. The values in parentheses are the percentages calculated by dividing the raw scores by each individual's total turns of metacognitive talk.

Table 6.3 Breakdown of manifestations of regulation according to low-level (LL) and high-level (HL) regulation

Manifestation of MR →	**Planning**			**Monitoring**			**Control**			**Evaluation**			**Total turns**
Depth of MR →	**LL**	**HL**	**Subtotal**	LL	HL	**Subtotal**	**LL**	**HL**	**Subtotal**	**LL**	**HL**	**Subtotal**	
Bettie	6	5	**11**	23	11	**34**	262	71	**333**	20	1	**21**	**399**
	(1.5)	(1.3)	**(2.8)**	(5.8)	(2.8)	**(8.6)**	(65.7)	(17.8)	**(83.5)**	(5.0)	(0.3)	**(5.3)**	
Ansie	6		**6**	27	2	**29**	153	31	**184**	6	1	**7**	**226**
	(2.7)	-	**(2.7)**	(11.9)	(0.9)	**(12.8)**	(67.7)	(13.7)	**(81.4)**	(2.7)	(0.4)	**(3.1)**	
Lynette	5	3	**8**	58	9	**67**	145	21	**166**	13	1	**14**	**255**
	(2.0)	(1.2)	**(3.2)**	(22.7)	(3.5)	**(26.2)**	(56.9)	(8.2)	**(65.1)**	(5.1)	(0.4)	**(5.5)**	
Total	17	8	**25**	108	22	**130**	560	123	**683**	39	3	**42**	**880**

*** Percentages in brackets: raw scores normalised against each team member's total number of metacognitive statements.**

As explained in Chapter 4, low-level regulation was observed in instances when the students sought and supplied information without providing the necessary justification to promote carrying out the task with understanding. High-level regulation, alternately, was characterised by instances when the students sought meaning, offered explanations, and justified their regulatory efforts in a bid to enhance their own understanding and that of the team. The majority of talk was classified as low-level, as can be seen in the frequency distribution totals per manifestation of regulation. Compared to the other members, the most occurrences of high-level regulation were observed for Bettie in the manifestation of planning and control. Lynette had the highest instances of low-level monitoring.

A detailed account of the qualitative differences that were observed per manifestation of regulation are provided in the paragraphs that follow. The graphs shown in Figure 6.5 give an overview of the differences that were observed in terms of empirical indicators of the depth of metacognitive regulation demonstrated by each member of *Team Bettie*. For a fair comparison, the raw counts of occurrence of each indicator were normalised by dividing the counts by the total number of the students' contributions in each manifestation of regulation. It is, however, important to note that the differences as they appear in the graphs in Figure 6.5 are exaggerated

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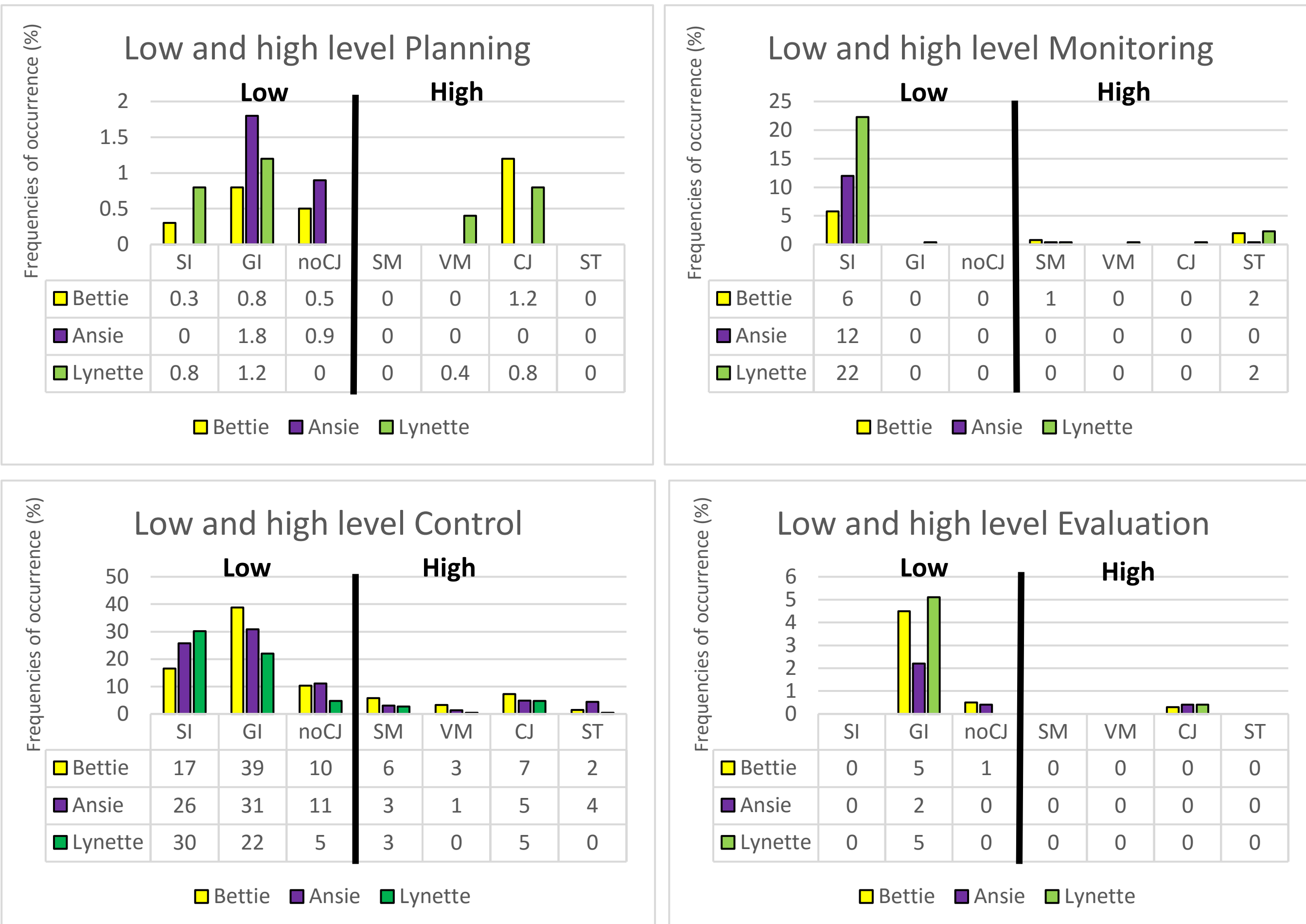
because the scales used on the graphs are different. Using the same scale for all of the graphs would render the difference in some of the graphs obscure. The percentages are reported for the combined SR and OR instances per person. The results presented in Figure 6.5 will be discussed with occasional reference to Table 6.3 and Appendices 4.7, 4.8, and 4.9.



Low and high level Planning

	SI	GI	noCJ	SM	VM	CJ	ST
Bettie	0.3	0.8	0.5	0	0	1.2	0
Ansie	0	1.8	0.9	0	0	0	0
Lynette	0.8	1.2	0	0	0.4	0.8	0

Low and high level Monitoring

	SI	GI	noCJ	SM	VM	CJ	ST
Bettie	6	0	0	1	0	0	2
Ansie	12	0	0	0	0	0	0
Lynette	22	0	0	0	0	0	2

Low and high level Control

	SI	GI	noCJ	SM	VM	CJ	ST
Bettie	17	39	10	6	3	7	2
Ansie	26	31	11	3	1	5	4
Lynette	30	22	5	3	0	5	0

Low and high level Evaluation

	SI	GI	noCJ	SM	VM	CJ	ST
Bettie	0	5	1	0	0	0	0
Ansie	0	2	0	0	0	0	0
Lynette	0	5	0	0	0	0	0

Regulation low-level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 6.5 Breakdown of the depth of metacognitive regulation by normalised counts of empirical indicators

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6.5.1 Depth of Planning

In terms of planning, a lot of the talk that the students engaged in involved them giving straightforward answers to their peers without accompanying explanations to enhance the team's collective understanding. Most of what constituted discussions in the initial stages were negotiations about task execution strategies, and clarifications of the mechanism of the allocated synthetic route. As explained in Section 6.4.1, the students in *Team Bettie* spent a considerable amount of time engaging with the teaching assistant (Diana), seeking answers rather than conceptual understanding. This observation is illustrated in the excerpt below:

Excerpt 6.14

12. **Ansie**: *Ek het gaan probeer om 'n enolate te maak, maar jy kan ... (?)millilitre mos nie 'n enolate is nie (?) wat ek dink nie dis reg nie want wat ek gedoen het* (I tried to make an enolate… but you can … millilitre it's not an enolate right (?) what I am thinking it's not right (?) cause I don't think it is right what I have done).

13. **Bettie**: *Waar kom al hierdie goed vandaan.., waar…HCl?* (Where does all this stuff come from... where…HCl?)

14. **Lynette & Ansie**: *Ja, HCl en daardie…* (Yes HCl and this …) […]

18. **Lynette**: *Kan ons dalk vir Diana vra om ons bietjie te help met die mechanism?* (Can we possibly ask Diana to help us a bit with the mechanism?)

19. **Bettie**: *Ja* (yes).

20. **Bettie**: Can you maybe help us just with the mechanism? [*Asking teaching assistant Diana*]

21. **Diana**: Mm [*agrees*].

22. **Lynette**: Because we got to a point and then we don't know how to go from there … [*turning pages*].

(*Turns 12 to 22 Transcript of Specialist group discussion, planning session*)

Table 6.2 and Figure 6.1 show that the highest percentage contributions of overall planning were observed for Lynette. However, the data in Table 6.3 and Figure 6.5 indicate that the majority of these regulatory efforts were, in fact, low-level, manifesting mostly as seeking or giving of information without accompanying conceptual justification. In terms of planning, instances of low-level seeking of information were observed in statements such as: [**SG Discuss Turn 497**: (*"Kan ons puntsgewys skryf soos stap een en dan die hoeveelhede? (*Can we write this down point by point? Like step one and then the amounts?*)"*]. Instances of simply giving a straightforward response were observed in statements such as: "*Jinne ek gaan hierdie goetjies*

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*moet netjies oor skryf (*you guys, I will have to write these things over very neatly*)"* (**SG Discuss Turn 1001**). Isolated instances of high-level regulation were mostly observed when Lynette regulated her team members' planning by providing conceptual justification [**SG Discuss Turn 499**: *"Ja want ons moet apparatus daar insit, totale en presies, dalk soos die hele ding sommer oorskryf* (yes, because we must insert the apparatus in there, the totals and precise, perhaps we must rewrite the whole thing)*"*] and volunteering meaning, [**SG Discuss Turn 109**: *"Dis die Mind map ding ek dink* (I think it is the Mind Map thing). *Lees maar die joernaal en doen 'n mind map van dit* (read the journal and do a mind map of it)*"*].

Bettie and Ansie's relative contributions to planning were comparable, although all of Ansie's planning exemplified low-level regulation, and Bettie's regulatory contributions were spread across low and high-level regulation. Figure 6.5 shows that Bettie and Lynette distinguished themselves by making the most contributions of providing conceptual justification for thier regulation in terms of planning. Excerpt 6.15 below is one of the instances where Bettie was observed to provide conceptual justification for objecting to her peer's suggestion:

Excerpt 6.15

125. Lynette:	*Ja* (yes). *Een ekwivalent is mos gelyk aan 1ml né?* (One equivalent is equal to 1 mL right?)
126. Bettie:	*Nee, nie te sê nie* (no, not necessarily).
127. Ansie:	*Dit hang af van…* (it depends on…) (?)
128. Bettie:	*Jy gaan, ons gaan van heel van die einde moet begin werk en terugwerk want jy soek 2 gram. Dan gaan jy al die pad van onder af begin werk.* (We have to start right at the end and work backwards, because you need 2 grams. Then you will start working all the way from the bottom).

(*Turns 125 to 128 Transcript of Team Bettie's specialist group discussion, planning session*)

Although without further elaborations, and mostly tentatively, Ansie was verbal about how the team could better execute the task, and also made suggestions in terms of clarifying task requirements. Ansie's regulatory efforts at planning were observed in statements such as: "*Ons moet vra oor daai later* (We must ask about that later)*"* (**SG Discuss Turn 1087**), as well as *"Ek dink ons gaan 'n beaker dan moet gebruik* (I think we will have to use a beaker then)*"* (**SG Discuss Turn 949**).

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6.5.2 Depth of Monitoring

The depth of monitoring was mostly characterised by low-level seeking of information for all of the members of *Team Bettie*. Lynette emerged as the team member with the highest relative contribution of monitoring (Table 6.3). However, a deeper look at the data showed that the majority of her monitoring contributions were directed at the self, and exemplified low-level regulation. She was the member with the most instances of monitoring, but also the member with the most instances of low-level self-monitoring. Low-level self-monitoring was observed mostly when Lynette sought her peers' validation of her thinking about the underlying chemistry concepts (Figure 6.2 above). Statements such as: *"Stem jy saam? Wat is dit?* (Do you agree? What is it?)*"* (**SG Discuss Turn 1268**) and *"Ek wil net gou seker maak, die eerste separation is jou aqueous met jou hydrocinnamic acid, okay? Dan vat jy nou jou aqueous met daardie HCl…ag, ether, okay dan is die organic is drie keer die natrium nê? (*I just quickly want to make sure, the first separation is your aqueous with your hydrocinnamic acid, okay? Then you take your aqueous with that HCl…no, ether, okay then the organic is three times the sodium, right?)*"* (**SG Discuss Turn 574**) serve as examples of the many instances where she was observed to seek affirmation. Lynette demonstrated isolated instances of high-level monitoring when she questioned her peers' thinking about the chemistry. Statements such as: "*Nee, weet jy wat dink ek? Ek dink hierdie persentasie is millilitre. (?) nul punt een drie milliliter. Wat dink jy?* (No, do you know what I think? I think this percentage is millilitres. (?) zero point one three millilitres. What do you think?)" (**SG Discuss Turn 1083**) were interpreted as instances of stimulating thinking where Lynette prompted her peers to think harder.

Although she demonstrated the lowest instances of high-level regulation, the finer details show that most of what constituted Ansie's low-level monitoring was to the benefit of the team rather than herself, i.e. mostly other regulatory. A look at her regulation profile map (Appendix 4.8) shows that she achieved other regulation by seeking information on peers' thinking about the chemistry and checking peers' task performance.

The data shows that, relative to her peers, Bettie demonstrated the highest high-level regulation in terms of seeking meaning. However, a closer look at the details shows that the majority of those meaning seeking episodes of monitoring were actually directed at herself as she verbalised her thinking in the process of trying to establish an understanding of the underlying chemistry

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concepts. The meaning seeking behaviour displayed by Bettie as she was thinking out loud was observed in verbalisations such as, "*Oh, okay. So altwee daardie verloor hulle H's en vorm dubbelbinding* (Oh, okay. So both of them lose their H's and form a double bond)" (**SG Discuss Turn 59**) and "It's a salt solution. It's usually sodium chloride, okay sodium chloride" (**SG Discuss Turn 758**).

6.5.3 Depth of Control

Figure 6.3 shows that the members of *Team Bettie* mostly regulated their thinking about the underlying chemistry concepts. Table 6.3 and Figure 6.5 show that these observed regulatory contributions manifesting as control were predominantly low-level, and were characterised by seeking information, giving information, and statements without conceptual justification. The data in Tables 6.2 and 6.3 show that the highest percentage contributions of control were observed for Bettie (83.4%) and for Ansie (81.4%), with the majority of the regulatory verbal behaviours constituting low-level other regulation. The highest frequencies of high-level regulation were observed for Bettie when she volunteered meaning, sought meaning, and offered conceptual justification for her suggestions and objections. A closer look, however, shows that the majority of the meaning seeking control behaviour observed for Bettie was self rather than other regulatory. Bettie displayed high-level meaning seeking behaviour when she consulted with the instructors [**SG Discuss Turn 397**: *"Ja, ja, dit maak sin ek wil net weet, ja dit maak sin maar ek wil net weet, hoekom sit hulle daardie 2ml daar* (yes, yes, it makes sense, I just want to know, yes, it makes sense but I just want to know why they put that 2ml there)*"*]. She used the opportunity for consultation and social interaction to clarify her own understanding more than that of the team. Ansie distinguished herself with the most percentage contributions of stimulating thinking, while Lynette had the second highest percentage in terms of seeking meaning and providing conceptual justification.

Bettie's high frequencies of giving information and Lynette's high percentage contributions of seeking information are also noteworthy. A similar pattern of regulation placing one member on the receiving end and another as the supplier of information was observed between Kagiso and Amos in Chapter 5. A look at the transcripts shows that much of the give and take engagement observed in the graph (Figure 6.5) actually occurred between Bettie and Lynette, as was the case between Kagiso and Amos. This engagement is, however, not beneficial or desired, to say the

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least, as it disadvantaged the one and benefited the other. Between the two members, Bettie was the more knowledgeable student, but she failed to enhance her fellow team members' conceptual understanding by simply providing straightforward answers to facilitate rapid task completion.

6.5.4 Depth of Evaluation

Figure 6.4 above showed that the members of *Team Bettie* mostly evaluated their thinking on the underlying chemistry concepts and the task at the individual level, and their thinking on the chemistry and task performance at the inter-individual level. However, a look at the finer details in Figure 6.5 reveals that the evaluation portrayed by members of this team was mostly characterised by low-level giving of information, statements without conceptual justification, as well as a limited amount of high-level provision of conceptual justification. No instances of seeking meaning, volunteering meaning, and stimulating thinking were observed in any of the team members' regulatory contributions. This observation could be due to evaluation being mainly about making evaluative judgements rather than acquiring information or establishing meaning.

The giving of information that featured prominently in each of the team members' verbal contributions was characterised by team members simply expressing their views of their own or the team's thinking about the chemistry, the task or task performance. Evaluative statements such as: *"*We got to that point. So we don't know how to do this last part.*"* (**SG Discuss Turn 23**) and *"Luister ek dink die nommers is erg ver* (listen, I think these numbers are far out)*"* (**SG Discuss Turn 341**) were interpreted to be regulatory in nature because they seemed to have been uttered with the aim of influencing the flow of events. However, these statements were categorised as low-level as they were observed to constitute simple reports of the *status quo*, expressed without further justification to promote carrying out the task with understanding.

Isolated instances of high-level evaluation were observed when team members made evaluative statements accompanied by conceptual justification [**SG Discuss Turn 910**: *"Jy sien dis nou waar ek deurmekaar is, want hulle sê jy moet daai eerste ding by die magnesium gooi* (you see, this is where I get confused because they say that you must add that first thing to the magnesium)*"*]. Even though it was at a lower level, the finer details in Bettie's regulation profile map (Appendix 4.7) show that, relative to her peers, Bettie was the team member with the highest frequency contributions of evaluating her own understanding of the underlying chemistry

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concepts. Being knowledgeable and vocal about what she understood and did not understand demonstrated a level of metacognitive knowledge on Bettie's part. This quality may have assisted her to ask the right questions and, as a result, make the most out of her engagement with the instructors and her peers. Excerpt 6.16 below is one of many examples of Bettie engaging with the teaching assistant and identifying what she still needed clarity on.

Excerpt 6.16

1096. Diana: Well…what is your density of ether? Will it be at the bottom or at the top?

1097. Bettie: The ether will be on top but then you take the aqueous layer from that and then wash the aqueous layer with ether.

1098. Diana: Before ether…

1099. Bettie: We know if it's washed with ether, we know the ether layer will be on top. But now before we even get this aqueous layer, I'm not sure where…

(*Turns 1096 to 1099 Transcript of Specialist group discussion, planning session*)

6.6 Patterns of metacognitive regulation for individual team members

Quantitative and qualitative differences and similarities were observed for patterns of self- and other-regulation amongst the members of *Team Bettie*. Each team member was observed to display a unique style of interaction in terms of how they regulated cognitive activities in the specialist group. The quantitative and qualitative results, depicted respectively in Figures 6.1 – 6.5 and Appendices 4.7, 4.8 and 4.9, accurately reflected the styles of interaction displayed by each student during the specialist group discussions.

6.6.1 Bettie's style of interaction

Bettie was outspoken and confident. She thought on her feet and was often asked by her peers to slow down and repeat herself. During the specialist group discussions, she was observed to steer the group activities and take initiative in terms of engaging with her peers and instructors. In an interview with her, she revealed that she trusted herself more, and in her own words "…especially when marks are involved, I prefer doing stuff myself. I don't like relying on someone else to do something*"* (**IND Int Turn 16**). I believe that the decision not to delegate parts of the task to specific individuals within the specialist group worked better for Bettie as it allowed her to contribute to each and every aspect of the task and leave the discussions knowing exactly what she had to do in the laboratory [**IND Int Turn 12**: *"*I had more questions for the

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specialised group, to find out what I specifically had to do."]. It was no surprise to see in Table 6.1 that she had the most turns of talk during the specialist group discussions [605 turns of talk (45%)], the majority of which were metacognitive. Her regulatory verbal contributions manifested largely as control when she influenced the team's thinking about the chemistry and task performance. However, the comparisons in Tables 6.3 and Figure 6.5 revealed that the majority of her regulation was low-level and did not add much to the collective conceptual understanding of the team. In her engagement with her peers, she was mostly observed to give straightforward answers (GI: 44.1%). This style of interaction was observed in verbal contributions such as the one shown in the excerpt below.

Excerpt 6.17

738. Lynette:	*Oh, hierso is daai methyl carbonate, daai. So basies na hierdie stap is dit hierdie produk?* (Oh, here is that methyl carbonate. So basically after this step then it becomes this product?)
739. Bettie:	*Ja, dan separate* (yes, then separate).

(*Turns 738 to 739 Transcript of Specialist group discussion, planning session*)

In an interview with her, she revealed that she thought aloud a lot, and that this was a strategy she used to monitor and regulate her thinking during group discussions:

Excerpt 6.18

23. Interviewer:	And how did you find working in the specialist or in a group?
24. Bettie:	It was much, much better because, I mean, you always…we've seen as well that as an individual you always miss something, every single time. And somebody maybe understands something different because we all have different subjects, that kind of thing. So it's just better to also not even check yourself but just to make sure…you know, it gives yourself more confidence to know that everybody agrees with you […]
27. Interviewer:	And then this kind of thinking, you mentioned in our interviews, that you are the kind of person who feels better to bounce things…that the best way for you to understand something is if you bounce it off somebody else. Why do you find this kind of thinking or this kind of learning better? Thinking about you yourself.
28. Bettie:	[…] Where if you…or if I, if I speak about it, or talk about it, or explain to someone else, I get the feeling of it, I get the understanding, and then you keep thinking, okay, but this part is a bit not clear, so then you discuss that. I just find that I understand it better so then for long term you remember it for much longer than just for the test.

(*Turns 23 to 28 Transcript of follow-up individual interview with Bettie*)

To Bettie, engagement provided an opportunity to bounce ideas off her peers and instructors to enhance her understanding and to validate her thinking. When asked about her experience in

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working in a group, Bettie made no mention of group work being a tool for clarifying fellow team members' understanding; it was all about the validation of her own understanding. Although she recognised that interaction and collaboration was a key aspect of the specialist group task [**IND Int Turn 10**: *"*Basically you don't have just visual like working but you have interaction as well, like help from other people."], Bettie used the platform of engagement provided through collaboration to serve her personal goal of understanding exactly what she was supposed to do in the laboratory.

6.6.2 Ansie's style of interaction

Ansie was quiet and introverted. Although she believed that the opportunity for engagement offered through group work assisted in solving problems quicker, she preferred to work on her own. She made the least verbal contributions during the specialist group discussions (356 turns of talk: 26.3% of group total). However, she reported that just because she was quiet, her silence did not mean that she was not thinking:

Excerpt 6.19

33. Ansie:	I didn't say a lot (*listening to the audio clip of specialist group discussion*).
34. Interviewer:	*Ja!* (Yes!) (*Ansie & interviewer laugh*). So you realise that.
35. Ansie:	Yes, yes, yes. But um… […]
42. Interviewer:	You said already that you realise you didn't talk much.
43. Ansie:	I didn't talk much but that doesn't mean that I didn't think. So I…I'm thinking constantly but I have difficulty in expressing myself, and *ja* (yes)…I think that's a good thing, I'm getting better at that, I'm a tutor now, and that learns me how to express myself better. So, *ja* (yes)…I think sometimes I'm scared, so I don't always have the confidence that this is right and is it right, is it not right, but I have to get past that, because if it's right, it's right. […]
45. Ansie:	So it doesn't sound, listening to the clips as if I contributed.

(*Turns 33 to 45 Transcript of follow-up individual interview with Ansie*)

An in-depth analysis of the team members' regulatory contributions revealed that Ansie actively participated in the team's discussions and contributed towards regulating the activities in her team, although in a very subtle and tentative manner. The data in Tables 6.1 and 6.2 showed that not only were the majority of her verbal contributions regulatory, but she had the highest frequency of overall other-monitoring (OR: 8.8%) of the team's cognitive activities. The

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comparison in Figure 6.2 showed that Ansie mostly monitored her peers' thinking about the underlying chemistry concepts and the team's task performance. In terms of control, Figure 6.3 showed that her regulatory contributions at the social level were spread across all the areas of regulation, with most of her inter-individual control manifesting when she regulated the team's thinking about chemistry concepts. A deeper look at the quality of her regulatory contributions in terms of depth of regulation in control showed that Ansie's regulatory contributions ranged across all of the indicators of low- and high-level regulation. She mostly gave conceptual justification for her suggestions and objections, and demonstrated the highest instances of stimulating thinking within the team. Excerpts 6.20 and 6.21 below are some of the many examples that portray Ansie as someone who was not satisfied with just a simple answer, but rather as someone who urged her peers to think harder:

Excerpt 6.20

889. Bettie:	Okay, *een punt twee equivalent* (one point two equivalent).
890. Ansie:	*Maar ons moet nou eers ether…dit meng met ether, hoeveel omtrent?* (But we must first ether… mix this with ether, approximately how much?)
891. Bettie:	*Ek sê agt en twintig mls* (I say twenty eight mls).
892. Ansie:	*Hoekom?* (Why?)
893. Bettie:	*Nee, nee, wag* (no, no, wait) [*all speaking at once*].

(*Turns 889 to 893 Transcript of Team Bettie's specialist group discussion, planning session*)

Excerpt 6.21

447. Bettie:	Oh! *Weet jy wat, ek dink hierdie crushed ice is om te help separate, want dit sê* (you know what, I think the crushed ice is to help separate, because it says) <u>resulting mixture is separated and the ….</u>
448. Ansie:	Yes but separated with what?
449. Bettie:	And the aqueous layer was washed.
450. Ansie:	*Ja, wat is die twee layers wat vorm want ons gaan die density moet kry?* (Yes, what are the two layers that form because we're going to have to find the densities?)

(*Turns 447 to 450 Transcript of Specialist group discussion, planning session*)

Overall, Ansie came across as very reflective and as someone who appreciated the RSLQs. She felt that using them gave the team direction and that it constantly encouraged her to think about what she was doing (**IND Int Turn 6**: "Yes, the questionnaires, where it constantly made me think of what am I doing now in each step and what did I do that was the previous prac. And I

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really thought that that helped. Is that then the metacognition you're…*"*). The data suggests that Ansie not only regulated her own cognitive activities, but she contributed to the collective conceptual understanding of the team.

6.6.3 Lynette's style of interaction

Lynette came across as not very strong academically as compared to her fellow team members, and she often sought affirmation of her thinking. She was often left behind and requested her peers to slow down so that she could catch up. She was the team member with the second highest frequencies of occurrence in terms of overall verbal contributions (393 turns of talk: 29%). A look at the data revealed that she had the highest instances of verbal contributions that exemplified overall planning, monitoring, and evaluation. However, a deeper look at the data showed that the majority of these regulatory contributions were low-level and self-regulatory, particularly in monitoring and evaluation.

In terms of monitoring, Lynette was observed to use the opportunity for social regulation to mostly seek validation from her peers of her thinking about the underlying chemistry concepts (Appendix 4.9 and Figure 6.5). She demonstrated the least instances of regulation in terms of controlling cognitive activities within the team. The majority of her regulatory contributions manifesting as control were characterised by seeking information to enhance her own conceptual understanding. A deeper look at the nature of the questions that she asked when seeking clarification revealed that these were more to acquire information [**SG Discuss Turn 113**: "*Nee maar wag, wat is die aqueous layer daar?* (No but wait, what is the aqueous layer there?)"], than for establishing meaning. Generally, what can be said about Lynette's style of interaction, as observed in her engagement during the specialist group discussions, is that she used the platform of collaboration to clarify and validate her own thinking. This assertion was confirmed by what she said during the follow-up group interview as a response to a question on how she experienced working in a group. What she said in Excerpt 6.22 below revealed the belief she held about the purpose of group work. For Lynette, group work was a tool that she used to clarify her thinking. She acknowledged its role in enabling quick task completion.

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Excerpt 6.22

15. Interviewer:	What sticks in your mind from your experience when you were working in a group, how did you experience it? […]
17. Lynette:	Also what happened was, some of the stuff that I didn't understand, Bettie would like explain it to me, then I would understand it better. So it's like she said, yes, some people show you something that you didn't know. And it's easier because it's also quicker than just sitting on your own and trying to figure out what is going on here.

(*Turns 15 to 17 Transcript of follow-up group interview with Team Bettie*)

6.6.4 Summary

From analysing the data, I could actually get a sense of how the students felt that they were helping each other by simply supplying or seeking information, and not opting to rather offer explanations or ask questions that could stimulate thinking and elicit conceptual understanding. Bettie and Lynette exhibited the attributes of egocentric metacognition in that both used the platform of collaborative group engagement to achieve personal conceptual understanding. They solicited and used the support made available through collaborative engagement for their own personal gain. Ansie displayed attributes of altruistic metacognition. She demonstrated selflessness when she constantly urged her peers to think deeper by asking the 'hard' questions. The context in *Team Bettie*'s specialist group engagement was observed to be supportive, catering to the team members who were insecure, as well as those who were unhappy with only scratching the surface.

A similar process was implemented for members of *Team Bettie* as was followed for *Team Kagiso* to establish the impact of new social contexts on individuals' styles of interaction in terms of cognitive regulation. Next, I discuss how Sub-Research Question 3 was answered for *Team Bettie*.

6.7 How individual students regulated cognitive activities in their respective home group discussions

Research question 3: *How does metacognitive regulation manifest during home group discussions?*

Through Research Question 3, I sought to determine whether individuals followed the same styles of interaction when regulating activities in their home group discussions. For this purpose, I chose two individuals from each of the specialist groups in my sample, and analysed their home

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group discussions. I also conducted follow-up individual interviews with these students to validate my findings. Judging from the analysis of the specialist group discussions, I decided to choose one individual who seemed to be very vocal in their regulatory contributions, as well as an individual who showed signs of regulation, but in subtle ways. For *Team Bettie*, Ansie emerged as the soft-spoken one, while Bettie emerged as the vocal one.

6.7.1 Analysis of the contributions made by Bettie and Ansie in their respective home groups

Bettie and Ansie were interesting cases in that despite their varied styles of interaction, both contributed significantly in terms of regulating cognitive activities within the specialist team, although they were motivated differently as one was prone to serving her own needs, while the other focused more on the needs of the group. Firstly, I foregrounded the dynamics in terms of the social interactions observed in Bettie and Ansie's respective home groups because I believe that the new social contexts played a role in how the two students were observed to regulate activities. Excerpts from the home group discussions have been included as supporting evidence of the assertions made.

6.7.1.1 Dynamics and social interactions in Bettie's home group

Bettie worked with Monde (Black female) and Simon (Black male). Bettie worked on Route A, Monde on Route B, while Simon was a specialist on Route C. Bettie was observed to steer activities in the group, and entered the home group discussions prepared and displaying a good understanding of what her route entailed. The same could not be said for her fellow home group members. Monde seemed disorganised, and both she and Simon had not yet calculated the costs of reagents for their routes. Simon attributed this failure to the task execution strategy used by his specialist group, citing that people were allocated different aspects of the task and some did not fulfill their duties, such as making all the necessary calculations (see excerpt 6.23 below). In order for the group to make a prediction in terms of cost, Bettie had to first assist both of her peers and show them how to calculate the costs of reagents. Bettie was quick to make suggestions to optimise task performance, which the other two easily accepted.

Excerpt 6.23

5. Bettie: Okay, so…so did you guys break up the costs of your…?

6. Monde: No, we didn't (?) that out.

7. Bettie: You know what, you can work it out from here. I worked out mine.

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8. Monde:	From where?
9. Bettie:	Sorry, my (?). There.
10. Monde:	Oh my gosh, (?) we didn't see that.
11. Simon:	Where?
12. Monde:	Oh, look at that. Oh, then you can sort it out for us…
13. Bettie:	*Ja* (yes).
14. Monde:	(?)
15. Bettie:	(?) You can't count that, though. Like you have to say, okay because that's four-fifty, so you have to say like, okay, how much, but I'm only using five grams.
16. Simon:	Okay, (?) because we assigned one person to the stuff and then we didn't finish. We did finish but then (?) now, so (?) with the costs.

(*Turn 5 to 16 Transcript of Bettie's home group discussion*)

6.7.1.2 Dynamics and social interactions in Ansie's home group

Due to a technical error, the recording of Ansie's home group discussions subsequent to the specialist group activities was found to be too incomplete for analysis. Only seven turns of student talk were captured. However, an analysis of the home group discussions prior to specialist group work (130 turns of student talk) gave an indication of Ansie's style of interaction in a different group context. In the first part of the home group activity, the students were given an opportunity to go over the brief and clarify task requirements. Ansie worked with two White female students, Anita, and Mona. Anita worked on Route B and Mona was responsible for Route C. Anita was the most vocal team member, and she spontaneously took on the leadership role. Ansie did not speak much, but instances of regulation could be inferred from most of her verbal contributions. Although knowledgeable, Ansie was never observed to impose her ideas and suggestions on her team members. Similar to her mode of interaction in the specialist group, she was subtle in her regulatory efforts. Anita and Ansie contributed a lot in terms of clarifying task demands about the underlying chemistry concepts. Mona was observed to often seek guidance and affirmation from her peers.

6.7.1.3 How Bettie and Ansie contributed in their respective home group discussions

Table 6.4 gives an overview of the types of verbal contributions made by Bettie and Ansie in their respective home groups. The same system followed for coding the specialist group discussions, as described in Chapter 4, was used to categorise Bettie and Ansie's home group

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verbal contributions into metacognitive and non-metacognitive statements. The percentage values for each type of statement presented in Table 6.4 below were calculated relative to the total number of verbal contributions for each student (Bettie: 163 turns and Ansie: 27 turns).

Table 6.4 Comparison between Bettie and Ansie's home group verbal contributions

Name	**Metacognitive statements**	**Non-metacognitive statements**							**Total no. of turns**
		Conceptual	**Digression**	**Non-Substantial**	**Task related (other)**	**Ques/Query**	**Other**	**Total**	
Bettie	**95 (58.3%)**	24 (14.7%)	9 (5.5%)	8 (4.9%)	20 (12.3%)	5 (3.1%)	2 (1.2%)	**68 (41.7%)**	**163**
Ansie	**16 (59.3%)**	-	1 (3.7%)	-	8 (29.6%)	2 (7.4%)	-	**11 (40.7%)**	**27**

The verbal contributions that were interpreted as metacognitive indicate that both Bettie and Ansie equally contributed in terms of regulating cognitive activities in their respective home groups. Looking at the two members' specialist group contributions in Table 6.1 (Bettie: 66.0% and Ansie: 63.5%), it is clear that the proportion of metacognitive statements as compared to non-metacognitive decreased for both Bettie and Ansie. a comparison of the manifestations and types of regulatory contributions made by Bettie and Ansie in their specialist group (Table 6.2) and respective home groups (Table 6.5) revealed an overall increase in other-regulation (Bettie: 66.4% vs 90.5% and Ansie: 65.9% vs 87.5%) and a decrease in self-regulation (Bettie: 33.7% vs 9.6% and Ansie: 34.1% vs 12.5%) for both, particularly in manifestations of control and monitoring. These observations could be explained by the fact that the two students had a clear understanding of what the task required and were, as a result, able to regulate team members' cognitive activities in addition to their own.

Table 6.5 Comparison between Bettie and Ansie's home group regulatory contributions in terms of manifestations and types of regulation

Manifestations of MR →	**Planning**			**Monitoring**			**Control**			**Evaluation**			**Total turns**
Types of MR →	**SR**	**OR**	**Subtotal**	**SR**	**OR**	**Subtotal**	**SR**	**OR**	**Subtotal**	**SR**	**OR**	**Subtotal**	
Bettie	1 (1.1%)	16 (16.8%)	**17 (17.9%)**	-	8 (8.4%)	**8 (8.4%)**	3 (3.2%)	62 (65.3%)	**65 (68.5%)**	5 (5.3%)	-	**5 (5.3%)**	**95**
Ansie	-	-	**-**	2 (12.5%)	-	**2 (12.5%)**	-	14 (87.5%)	**14 (87.5%)**	-	-	**-**	**16**

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However, an in-depth look at the quality of each of the two individual's contributions (Table 6.6 below) in terms of high-level and low-level regulation reveals a difference in the depth of regulatory efforts. The results in Table 6.6 are percentages obtained by dividing the raw counts of high- and low-level regulatory statements by the total number of each individual's metacognitive statements pertaining to each manifestation of regulation. The percentages are reported for the combined SR and OR instances per person.

Table 6.6 Comparison between Bettie and Ansie's home group regulatory contributions in terms of depth of metacognitive regulation

Manifestations of MR →	**Planning**			**Monitoring**			**Control**			**Evaluation**			**Total turns**
Depth of MR →	**LL**	**HL**	**Subtotal**	**LL**	**HL**	**Subtotal**	**LL**	**HL**	**Subtotal**	**LL**	**HL**	**Subtotal**	
Bettie	15 (15.8%)	2 (2.1%)	**17 (17.9%)**	7 (7.4%)	1 (1.1%)	**8 (8.5%)**	54 (56.8%)	11 (11.6%)	**65 (68.4%)**	4 (4.2%)	1 (1.1%)	**5 (5.3%)**	**95**
Ansie	0	0	**0**	2 (12.5%)	0	**2 (12.5%)**	12 (75.0%)	2 (12.5%)	**14 (87.5%)**	0	0	**0**	**16**

Similar to the depth of regulation demonstrated by Bettie and Ansie during the specialist group discussions, the majority of regulatory contributions in their respective home groups constituted low-level regulation, particularly pertaining to manifestations of control. Both group contexts were supportive and receptive of Bettie and Ansie's regulatory contributions, which probably explains the recurring theme in terms of their styles of interaction and regulation. An in-depth look at how the two students differed in terms of the empirical indicators of low- and high-level regulation uncovered the specific actions that each individual followed to regulate activities in the specialist and home groups. Percentages for each of the indicators were calculated against each student's total number of verbal contributions and graphs drawn to present the differences for combined manifestations and types of regulation (Figure 6.6).

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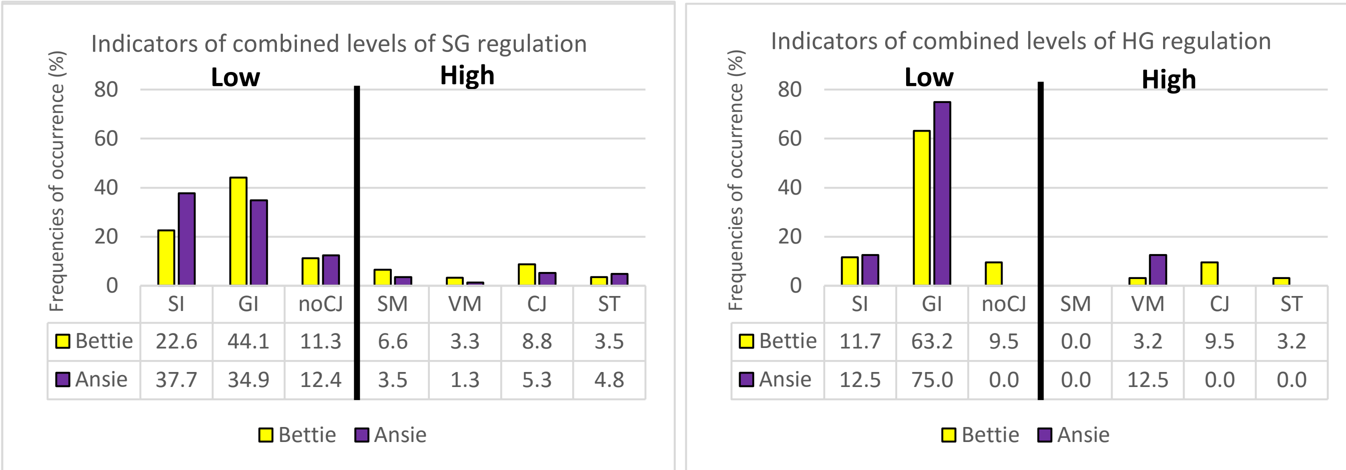

Regulation low level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 6.6 Comparison of Bettie and Ansie’s depth of regulation in the specialist group (SG) and in their respective home groups (HG)

The bigger picture shows that in their respective home groups, Bettie and Ansie’s regulatory contributions were mostly characterised by seeking and giving information, which is similar to the observation made for the two in the specialist group. There were subtle differences in the types of high-level contributions made, i.e. Bettie provided conceptual justification (CJ) and stimulated thinking (ST), whereas Ansie was more likely to volunteer meaning (VM). In the next sections, I will now describe the depth of regulation demonstrated by Ansie and Bettie, with supporting evidence in the form of excerpts of talk drawn from their respective home group discussions.

6.7.1.4 Depth of regulatory contributions by Bettie

Manifestations of planning, monitoring, control, and evaluation were observed in Bettie’s home group verbal contributions. An in-depth look at these manifestations revealed that the majority of her regulation was characterised by low-level giving and seeking of information rather than promoting the conceptual understanding of the team. Similarly to her style of engagement in the specialist group (Figure 6.5), Bettie was once again driven to serve her own needs, as witnessed in her spontaneous assumption of the leadership role. Bettie’s regulatory contributions in terms of planning, monitoring, and evaluating her home group’s cognitive activities were mostly characterised by low-level giving of information; the majority of her monitoring was characterised by the seeking of information. Bettie was observed to mostly offer straightforward

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answers to her peer's clarification seeking questions rather than additional conceptual justifications to enhance understanding. Instances of Bettie's monitoring constituted simple requests for information about her peers' progress with the task (**HG Discuss Turn 225**: "Are you managing?"). Only one instance of high-level monitoring was observed when Bettie stimulated thinking by challenging her peer to critically evaluate his calculations (**HG Discuss Turn 159**: "Are you sure your calculation is right?"). Coming into the home group with incomplete information placed Monde and Simon on the receiving end. The engagement in the group was asymmetric, with Bettie steering activities and dictating terms.

6.7.1.5 Depth of regulatory contributions by Ansie

In the home group, Ansie's regulation manifested largely as self-monitoring (12.5%) and other-control (87.5%). Self-monitoring was observed when Ansie checked with her peers in a bid to clarify task requirements (**HG Discuss Turn 139**: "So we don't have to do this now?") and how best to perform the task (**HG Discuss Turn 43**: "So must we talk through every question?"). These self-regulatory efforts were perceived to be low-level as they represented straightforward requests for information rather than seeking meaning. The majority of manifestations of monitoring for Ansie in the specialist group were, however, other-regulatory and focused on regulating her peers' thinking about the chemistry concepts and the task (Figure 6.2). The difference in how she monitored activities in the home and specialist groups could be because the subject under discussion in the home group was mainly about clarifying task features prior to working in the specialist groups; and the subject of the specialist group talk provided scope for in-depth discussions around the allocated route's underlying chemistry concepts and experimental procedures. A common recurring theme in how Ansie demonstrated monitoring during specialist and home group discussions is the prevalence of self-monitoring by seeking information (SG: 12.0% and HG: 12.5%).

An in-depth look at the areas where Ansie concentrated her efforts of regulation revealed that all her manifestations of control in the home group were other-regulatory and were mostly observed when she regulated her peers' thinking about the underlying chemistry concepts by either affirming (**HG Discuss Turn 80**: "Yes, and then you can protonate…") or clarifying their thinking (**HG Discuss Turn 50**: "There's conversion of the carboxylic acids here"). An even deeper look at Ansie's control statements revealed that most of her regulation in terms of controlling cognitive activities within the team were characterised by low-level giving of

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information. Instances of high-level regulation were observed when she explained her thinking to her team members in order to enhance collective conceptual understanding of the underlying chemistry concepts. Statements such as “Yes, but I know that on, I think it was slide nine of B1, they said that on behalf of carboxylic acids can’t form enolates easily” were interpreted as high-level as they were observed to enhance understanding rather than offer a straightforward answer to a question. A similar pattern of engagement in terms of regulation of cognitive activities was observed for Ansie in the specialist group. The majority of her regulation manifesting as control were other-regulatory (Table 6.2) and were mostly focussed on regulating her team members’ thinking about the underlying chemistry concepts (Figure 6.3) by providing them with the necessary information (Figure 6.5). Overall, Ansie’s depth of regulation in the home group was low-level but tentative and altruistic.

6.8 Concluding remarks

The bulk of talk in the specialist and home groups was metacognitive. The presence of metacognitive talk served as evidence that the regulation of cognition traditionally reported from an individualistic stance can be observed in social contexts. Regulation in the specialist group discussions of *Team Bettie* was observed to manifest mostly in the form of monitoring and control, with a few manifestations of planning and evaluation. The differentiation of manifestations of regulation in terms of types and areas of regulation revealed that the majority of regulation was other-regulatory and much emphasis was placed on regulating thinking about the underlying chemistry concepts and the task. This observation could be explained by the fact that generating detailed experimental procedures for their allocated synthetic route was heavily dependent on the student’s knowledge of the subject matter and experimental techniques. An in-depth analysis of the depth of regulation demonstrated by the members of *Team Bettie* revealed that the majority of regulation was characterised by low-level giving and seeking of information. It was interesting to see how the students thought they were empowering one another by simply giving straightforward answers instead of offering conceptual justifications and asking thought provoking questions that would enhance the collective conceptual understanding of the team. This pattern of regulation was a recurring theme in the two home groups that were subjected to further analysis.

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Bettie found herself in a dysfunctional home group with two of the members coming in unprepared. This group context served her well and allowed her to be in charge and push her own agenda without any opposition. Ansie was once again observed to be tentative in her regulation and shying away from taking on the leadership role or imposing her ideas. Again, the social context compensated for Ansie's style of interaction by having Anita as the vocal member of the team. Coming in prepared assisted Ansie and Bettie to be active participants in their respective home groups. The tendency to simply present their own findings and accept others' findings without questioning was observed in Bettie and Ansie's home group members. Bettie used this platform to push her own agenda, while Ansie saw this as an opportunity to bring her fellow team members up to speed on what the task entailed. The social context in Ansie's home group accommodated her personality and style of engagement, enabling her to make a considerable contribution in terms of regulating cognitive activities in the team without her taking on a leadership role.

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CHAPTER 7

CROSS-CASE ANALYSIS OF MANIFESTATIONS OF METACOGNITIVE ACTIVITY

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CHAPTER 7

CROSS-CASE ANALYSIS OF MANIFESTATIONS OF METACOGNITIVE ACTIVITY

7.1 Introduction

The process followed for developing the coding scheme described in Chapter 4 resulted in a comprehensive analytical framework, which enabled the identification and differentiation of metacognitive activity by manifestation, type, area, and depth of regulation. Tables 5.2 and 6.2 showed the differentiation of regulation by manifestation and type of regulation, while the graphs of SR and OR planning, monitoring, control, and evaluation (Figures 5.1 – 5.4 & 6.1 – 6.4) clearly showed the areas where the students applied their regulatory efforts. The regulation profile maps (Appendices 4.3 to 4.9) allowed for an even deeper analysis of the various ways that the students regulated cognitive activities, while the criteria generated for depth of regulation enabled a distinction to be made in terms of the quality of regulatory efforts as driving personal or collective gains.

This chapter provides an overview of the findings that emerged from a cross-case analysis of the two specialist groups in response to Research Question 2. These findings are followed by a comparison of how the specific individuals chosen from the two specialist groups regulated cognitive activities in their respective home groups (Research Question 3).

A relationship was observed to exist between the individual's styles of interaction, social context, personal goals, and the nature of regulatory efforts. Before providing an overview of how the students showed differences and similarities in regulating cognitive activities within their specialist and home groups, I first foregrounded the social dynamics in terms of their styles of interaction in the respective social contexts.

7.2 Social dynamics in the specialist and home groups

The social contexts in *Team Kagiso* and *Team Bettie* were different. The context in *Team Bettie*'s specialist group was observed to be supportive, catering to team members who were insecure (Lynette), as well as those who were dissatisfied with simply scratching the surface (Ansie). The opposite was true for the social context in *Team Kagiso*. The social context in *Team Kagiso* was harsh to say the least, especially for Leonard, who was often ostracised for raising conflicting views and, as a result, left the team feeling discouraged. The social context in *Team Kagiso*

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confirmed Bianchini's (1997) assertion that using a powerful group work model, like the jigsaw cooperative learning technique in the case of the simulated industrial project, does not always guarantee collaboration and equity. Competitive verbal strategies, fighting for dominance, and establishing a winning argument, as reported by Spender (1980), were observed for males during the group discussions in interactions between Kagiso, Amos and Leonard. Kagiso and Amos often attacked Leonard, who also stood his ground. The social context made it difficult for Leonard to make regulatory contributions. The opposite was true for Leonard's male-only home group. Although it only consisted of males, Leonard's home group was supportive and accommodating of Leonard's style of interaction. However, the difference in the two social contexts may have been due to the cooperative nature (assignment of roles) of the home group activities; as members did not hold equal status of expertise for all the routes and thus had to rely on each other in all matters pertaining to each specific route.

Each of the students was unique in how they interacted with their peers and how they regulated cognitive activities within their teams. Some students like, Ansie and Leonard, were observed to be tentative in their regulatory approach, opting not to take on the leadership role but to play their part behind the scenes. Their style of engagement was to make suggestions and objections while at the same time being very careful not to impose their ideas on their fellow team members. Bettie and Kagiso were observed to be assertive in their approach, probably due to their extroverted personalities and their perceived academic ability, which was justified considering the overall final practical scores of 75% and 72% obtained by Kagiso and Bettie, respectively, which was in the upper 40% of the class. These two students seemed very confident in their subject matter knowledge. They also had the most occurrences of consultation with the lecturer compared to their team mates. Reneilwe, Amos and Lynette appeared insecure, constantly requiring validation from their peers. This seemed to stem from a lack of confidence in their own subject matter knowledge. The low-level giving of information demonstrated by Kagiso suited Amos very well as he could simply get information from Kagiso without first making the effort of figuring things out for himself and making intellectual contributions to the conceptual understanding of the group. The two specialist groups were similar in that both had an extroverted team leader (Bettie and Kagiso), members who were not satisfied with only scratching the surface (Ansie and Leonard), as well as members who constantly needed affirmation (Reneilwe and Lynette). However, *Team Kagiso* also had to deal with Amos, who

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was often disruptive, sponging off his fellow team members, and who tended to deviate from task-related talk.

In terms of personal goals, the social context in the specialist and home groups supported Kagiso and Bettie, allowing the two students to steer activities and to achieve their personal goals of leaving the group discussions with a clear understanding of what they needed to do in the laboratory (Excerpts 5.4 and 6.3). Having their team members coming in unprepared into the home groups made it even easier for Kagiso and Bettie to take on the leadership role and steer activities in this context. Leonard, who was not happy with scratching the surface, and who wanted to use the opportunity for engagement to produce a quality product was shut down in his specialist group, although he later on found support and validation in his home group.

On the one hand, the choice of task execution strategy of *Team Kagiso* did not make things any easier, although it turned out to benefit the team in the long term. Choosing to delegate aspects of the task to different team members resulted in the team being stuck longer in the storming stage of group formation (Tuckman, 1965) while trying to negotiate roles and responsibilities. The members of *Team Bettie,* on the other hand, chose to work one step at a time on all aspects of the task, avoiding spending time engaged in discussions around roles and responsibility. The members of *Team Bettie* did, however, spend a lot of time trying to get the teaching assistant to help them with their task.

7.3 Manifestations of metacognitive activity during specialist group discussions

As much as the strength of collaboration lies in the cognitive conflict it elicits, its limitation also lies in the interpersonal conflict it creates (Alexopoulou & Driver, 1996). Collaborative approaches to group work encourage cognitive conflict and view the notion of disagreements between group members as a means of enabling knowledge construction (Brodie & Pournara, 2005). The premise that the resolution of conflicting views transforms thinking and leads to conceptual growth draws on the Piagetian, Radical Constructivist and Social Constructivist theories about how knowledge is constructed. Alexopoulou and Driver (1996) observe that productive engagement during collaborative group discussions seems to depend on the raising of objections, the willingness to enter into negotiations and to confront the implications of interpersonal conflict.

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My anticipation that the social context and cognitive conflict inherent in collaborative group work could have the potential to affect regulation was validated by the differences in the frequencies of occurrence of metacognitive regulation (MR) compared to non-metacognitive regulation (non-MR) statements. Fewer confrontations and competitive verbal exchanges saw *Team Bettie* emerging as the team with more instances of metacognitive rather than non-metacognitive regulation talk, as compared to *Team Kagiso* (Tables 5.1 and 6.1 - *Team Bettie*: 65.0% vs *Team Kagiso*: 43.2%). More than 60% of talk by members of *Team Bettie* was indicative of MR, while almost 60% of talk by *Team Kagiso* was dominated by non-MR statements, 15.3% of which was off-task social talk.

Next, I compare how metacognitive regulation manifested in the specialist groups, presenting as supporting evidence graphs of the students' regulatory patterns as given in Chapters 5 and 6, reproduced now as figures 7.1, 7.2, 7.3 and 7.4 below. For easy comparison, each figure consists of a combination of the graphs showing manifestations and depth of regulation (for combined self- and other-regulation). The frequencies of occurrence on the y-axis of each graph were calculated relative to the total verbal contributions of each team member showing clearly the distribution of responses per team member and normalising the percentages against each member's style of interaction. The x-axis in the top set of graphs represents the areas of regulation, and the x-axis in the bottom pair represents the indicators of low- and high-level regulation. Although the graphs clearly show the differences that were observed in terms of the regulatory patterns displayed by the members of each specialist group, the reader is advised to keep in mind that the differences are highly exaggerated in the case of planning and evaluation by the different scales used in each of the displays. To account for limitations in the accuracy of coding, an interpretation of the differences and similarities of frequencies of occurrence lower than 2%, such as in the case of manifestations of planning and evaluation, should be analysed with caution.

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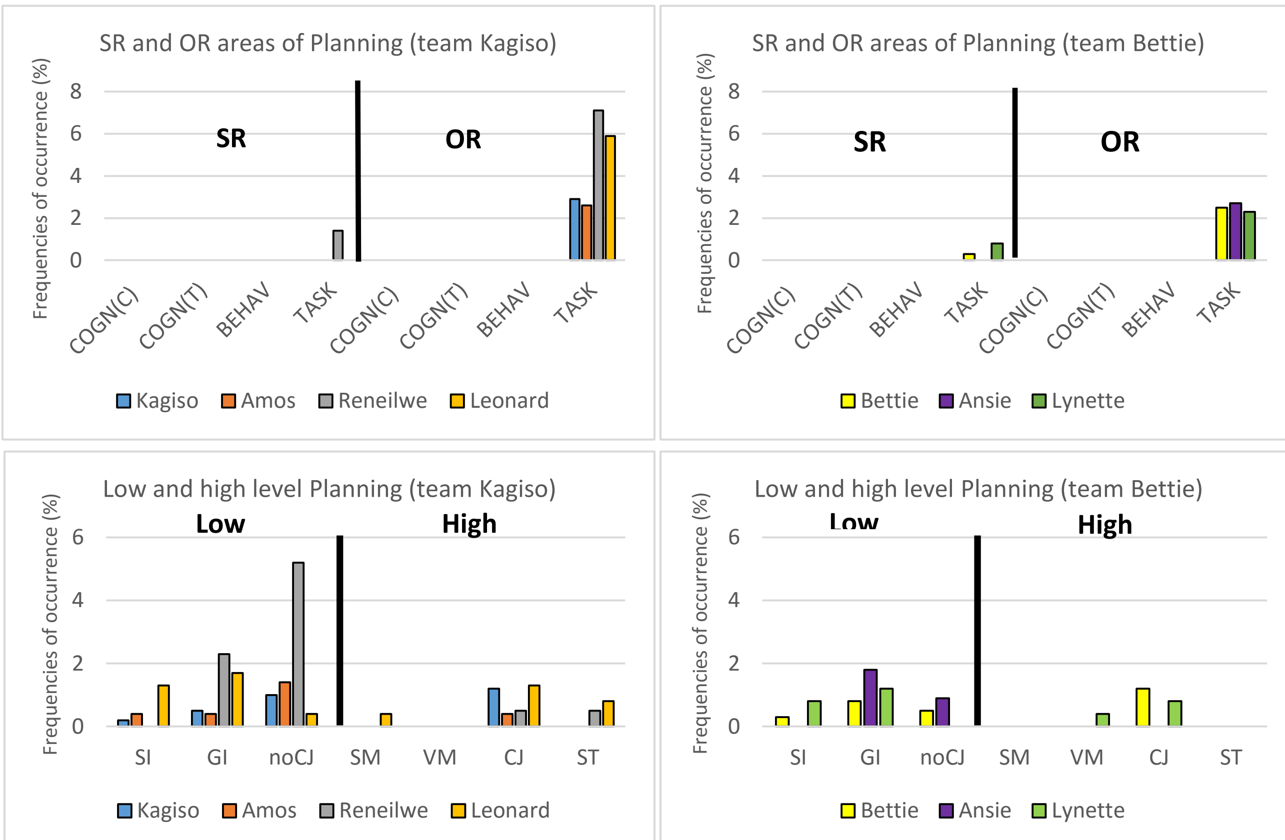
7.3.1 Planning

Overall, low-level metacognitive regulation dominated the talk that was related to planning for both teams. Figure 7.1 below shows the similarities and differences in how both teams demonstrated planning during their specialist group discussions.



COGN(C): thinking about the chemistry**; COGN(T):** thinking about the task**; BEHAV:** behaviour**; TASK:** task performance

Regulation low level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 7.1 Cross-case comparison of manifestations of planning

Very few instances of planning were observed for both teams. The bigger picture shows that the planning that both teams engaged in was mostly other-related, all of which had to do with regulating task performance, and was not about behaviour or thinking. Isolated instances of high-level planning manifested as volunteering of meaning and the offering of conceptual justification for *Team Bettie;* and as seeking meaning, offering conceptual justification and stimulating

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thinking for *Team Kagiso*. Planning that manifested as the inter-individual regulation of task performance and regulatory efforts made without conceptual justification were observed mostly for members of *Team Kagiso*, particularly Reneilwe. This occurred when she sought to establish her role within the group structure and when she verbalised her thoughts on how she planned to perform her part of the task.

An in-depth look at the group discussions revealed that for *Team Kagiso*, most of what constituted the talk related to planning, especially in the beginning of the specialist group discussions, were negotiations around roles and responsibilities, the best approaches to task execution, as well as clarification of task requirements with peers and instructors. Instead of engaging in planning related talk, the members of *Team Bettie* spent time in the initial stages of the specialist group activities trying to sort out the reaction mechanisms of their synthetic route with the help of the teaching assistant, Diana. The team completely ignored the RLSQ, which was meant to facilitate the talk around planning, and instead focused on their unfinished reaction mechanisms. Both teams could not wait to delve into the resources provided and work on generating their detailed experimental procedures.

7.3.2 Monitoring

Figure 7.2 gives an overview of how both teams demonstrated monitoring during their specialist group discussions. The similarities in terms of patterns of monitoring between the two specialist groups are striking. This was evidenced by the dominance of intra-individual regulation of thinking about the underlying chemistry concepts, followed by task performance-related other-regulation as a secondary feature. Amos in *Team Kagiso* and Lynette in *Team Bettie* demonstrated the highest frequencies of self-monitoring related to their thinking about the underlying chemistry concepts. However, an in-depth look revealed that the majority of self-monitoring observed for these two students constituted low-level seeking of information and validation, particularly from their peers. Lynette’s constant need for validation emerged in her interview report as having been driven by a lack of confidence and preferred style of learning.

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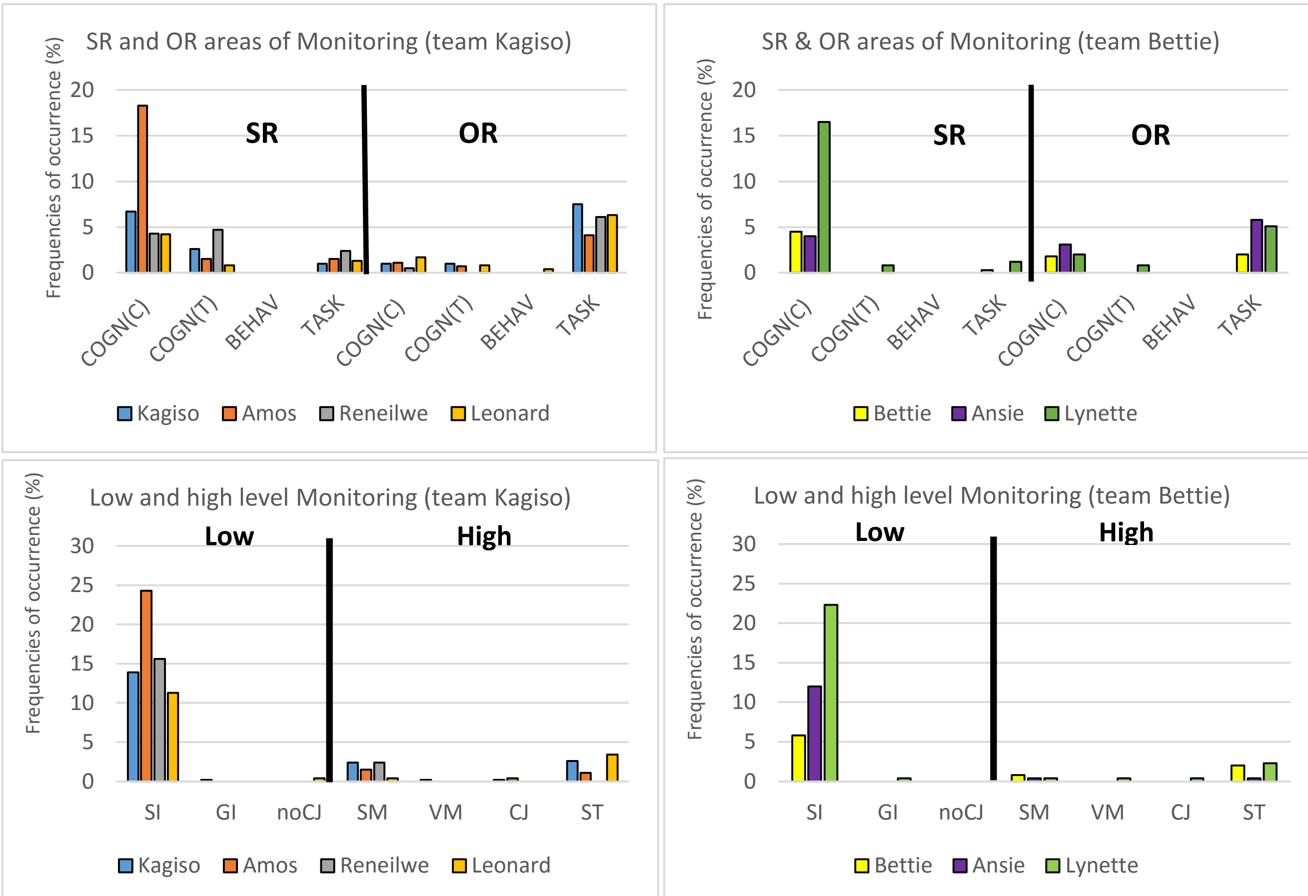

COGN(C): thinking about the chemistry**; COGN(T):** thinking about the task**; BEHAV:** behaviour**; TASK:** task performance

Regulation low level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 7.2 Cross-case comparison of manifestations of monitoring

Amos, alternatively, was observed to seek validation to simply acquire information and avoid thinking about the task or figuring things out on his own. This behaviour backfired in the laboratory when Amos noticed a mistake he had made in the procedures that he drew up as part of his allocated specialist group task and distributed to his team members, a mistake which he could have identified and corrected had he paid more attention to monitoring his task execution rather than pursuing rushed task completion. Fortunately, his team members identified the flaw

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in time and corrected it. Amos' poor planning nearly cost the group in terms of obtaining the desired chemical compound in the laboratory. An in-depth look revealed that the majority of both teams' regulatory efforts were low-level, characterised by the seeking of information. The students mostly posed questions requiring straightforward answers, such as "*do you have the volume there?* " (**SG Discuss Turn 2739**) to check on the progress of their team mates. The other differences in terms of manifestations and depth of monitoring between the two groups were minor.

7.3.3 Control

Control constituted the major form of regulation. Figure 7.3 is an overview of how both teams demonstrated regulation that was related to control. The frequencies of occurrence in the graphs of Figure 7.3 below, which seem low at first glance, are in actual fact quite high in comparison to the frequencies in the graphs for planning (Figure 7.1) and evaluation (Figure 7.4). This is because of the different scales used in the y-axes of these graphs. The high frequencies of occurrence observed for manifestations of control imply that meaning can be attached with confidence to the differences and similarities that were observed for this manifestation.

The cross-case comparison shown by the top pair of graphs in Figure 7.3 above reveals a similar picture in terms of the areas and types of regulation that were demonstrated by the two groups, with control of intra- and inter-individual thinking about chemical concepts dominating the picture. An in-depth look shows that the majority of regulatory efforts by both teams were other-regulatory and low-level. The most prominent difference was that members of *Team Kagiso* had to control a great deal for conducive behaviour in a bid to diffuse the negative interpersonal conflict observed during the specialist group discussions. As a consequence of their group dynamics, *Team Kagiso* also demonstrated more control of intra- and inter-individual thinking about task performance than *Team Bettie*.

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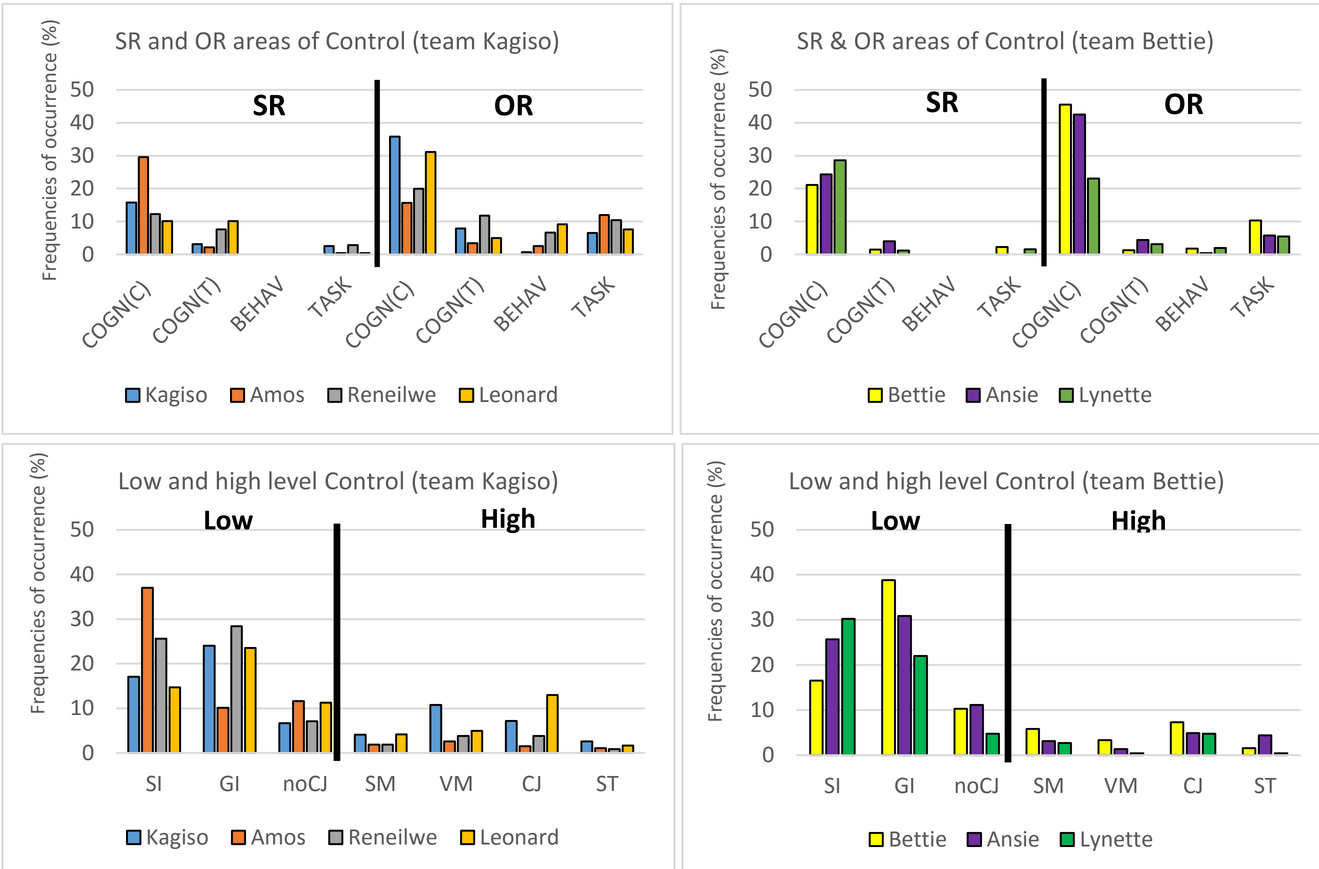

COGN(C): thinking about the chemistry**; COGN(T):** thinking about the task**; BEHAV:** behaviour**; TASK:** task performance

Regulation low level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 7.3 Cross-case comparison of manifestations of control

The highest frequencies of controlling for correct thinking about the subject matter at the intra-individual level were observed for Amos in *Team Kagiso* and Lynette in *Team Kagiso*. Similar to the patterns of self-regulation observed for manifestations of monitoring for these two students, the majority of their regulatory efforts were characterised by low-level seeking of information. In terms of inter-individual control, Kagiso, Leonard, Bettie, and Ansie had the highest frequencies of occurrence of controlling for correct thinking about the underlying chemistry concepts. However, an in-depth look revealed that these students influenced their peers' thinking by mostly

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giving information, occasionally volunteering meaning, and offering conceptual justification for their suggestions and objections. The frequencies of occurrence of low-level seeking of information by some members, and the giving of information by others seemed to explain the nature of engagement observed in both teams. The fact that Amos in *Team Kagiso* and Lynette in *Team Bettie* relied on their team members for information and validation, and that their team mates easily gave information, was clearly indicated by the high frequencies of low-level giving of information.

The members of *Team Kagiso* demonstrated proportionally more intra-individual regulation of own thinking about the task features than members of *Team Bettie*. An in-depth look revealed that most of these occurrences observed for self-regulation of thinking by members of *Team Kagiso* were characterised by members seeking clarification about the task, while members of *Team Bettie* mostly sought clarification about the chemistry. The demonstration of intra-individual regulation of thinking about chemistry was observed in the many instances when members of *Team Bettie* consulted with the teaching assistant. Reneilwe in *Team Kagiso* distinguished herself by being the team member with the highest frequency of regulating her team's thinking about the task. A look at the depth of these regulatory efforts revealed that, although without conceptual justification, Reneilwe often corrected and critiqued her peers' thinking about the task. She achieved this form of regulation by often reminding and correcting her peers regarding the task requirements and demands.

The relatively high level of volunteering meaning observed for Kagiso, and the high level of conceptual justification observed for Leonard (bottom pair of graphs) are observations that were not made for any member in *Team Bettie*. This is surprising considering the interpersonal conflict experienced by members of *Team Kagiso*. These observations lead me to believe that despite the fact that *Team Kagiso* had to deal with interpersonal conflict that was negative, they also had to deal with cognitive conflict, which challenged them to reach deeper levels in their metacognitive regulation. *Team Bettie*, alternatively, seemed to want to avoid conflict at all costs, thereby foregoing the benefit that cognitive conflict could bring.

Overall, *Team Kagiso* had fewer frequencies of occurrence of inter-individual regulation of thinking about the chemistry than *Team Bettie*, but more occurrences of inter-individual regulation of thinking about the task features and behaviour. These observations seem to suggest

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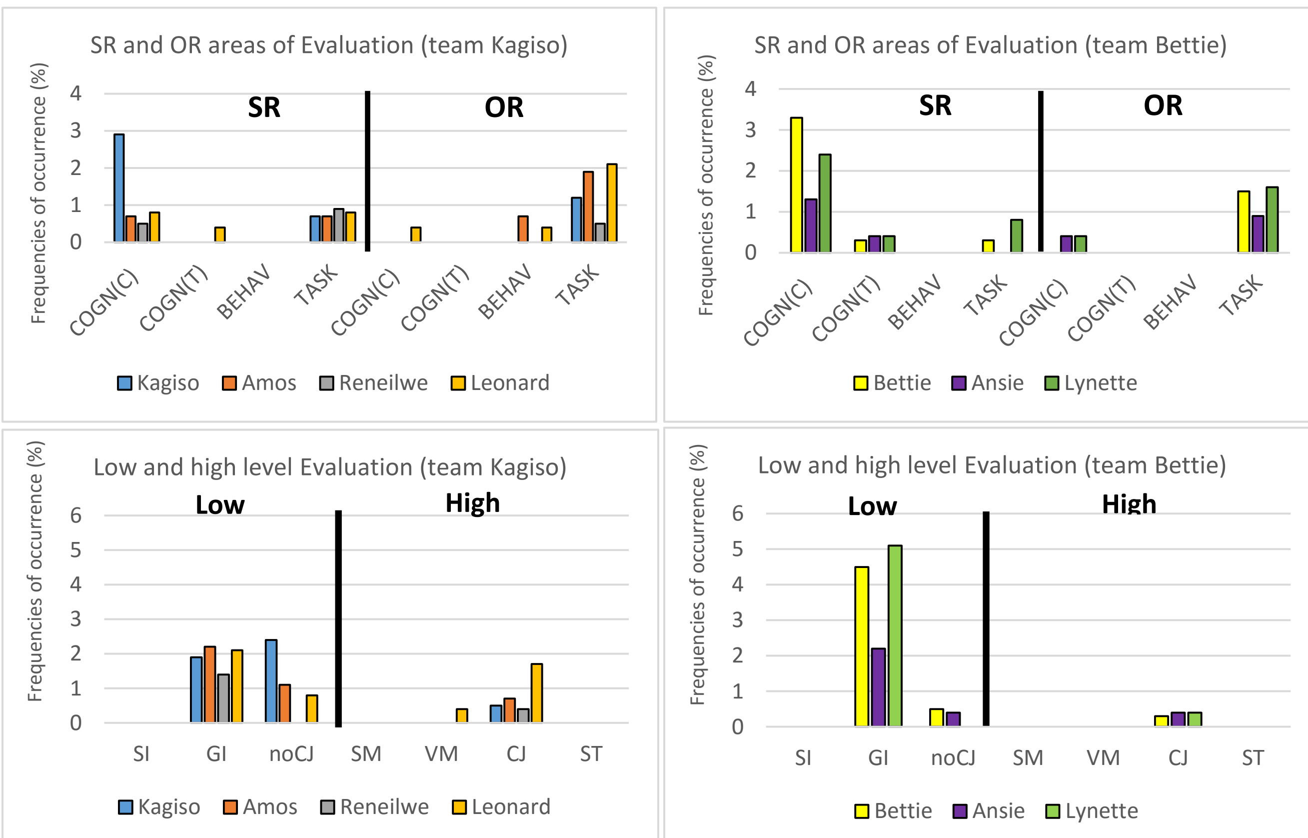
that while *Team Bettie* concentrated on regulating thinking in relation to the chemistry content, the metacognitive talk in *Team Kagiso* was mostly focused on the regulation of the logistical aspects of the task and controlling for conducive behaviour.

7.3.4 Evaluation

Figure 7.4 shows that, similar to the manifestations of planning, low frequencies of the occurrence of high-level evaluation were observed in the two specialist groups' verbal interactions.

Figure 7.4 Cross-case comparison of manifestations of evaluation



COGN(C): thinking about the chemistry**; COGN(T):** thinking about the task**; BEHAV:** behaviour**; TASK:** task performance

Regulation low level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 7.4 Cross-case comparison of manifestations of evaluation

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In contrast to the graphs of control in Figure 7.3 above, the differences and similarities in the frequencies of evaluation are quite small and warrant caution in interpretation. The most prevalent forms of regulation for both teams were observed in the intra-individual evaluation of thinking about the chemistry content and the inter-individual evaluation of task performance. Bettie, Lynette and Kagiso mostly evaluated their own thinking about the chemistry. Statements such as "*I would honestly not know, I don't know*" (**SG Discuss Turn 1253**) were characterised as low-level giving of information, and they mostly constituted evaluative statements made by the students about their memory or comprehension of the content or the task. Discrimination in terms of the depth of evaluation shows that the majority of evaluative statements made by members of both groups were mostly characterised by low-level giving of information, especially for *Team Bettie*, with isolated evidence of objections and suggestions made without conceptual justification. Despite being low by comparison to other manifestations of metacognitive regulation, the relatively high contribution of conceptual justification from Leonard in *Team Kagiso* is worth noting.

An overview of the general trends emanating from the cross-case comparison of the two specialist groups, presented as Table 7.1, is provided next. Only those patterns that emerged in both groups are listed to facilitate a comparison between the two groups in terms of the predominant similarities between them. Control was the major form of regulation followed by monitoring. Table 7.1 shows that the metacognitive talk in the specialist group discussions was dominated by low-level social regulation, which mostly focused on the regulation of thinking about the chemistry content and task performance. The one distinguishing feature of regulation that stood out clearly was the necessity for members of *Team Kagiso* to regulate behaviour in order to diffuse social conflict. Both teams seemed to slip easily into the monitoring and control modes, as compared to planning and evaluation.

Overall, more commonalities than differences were observed in how the students in both specialist groups regulated activities within their teams, which is interesting considering the social and individual differences observed in both. In the next section, I will discuss the similarities and differences in terms of how individual students regulated activities in their respective home groups.

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Table 7.1 Overview of patterns of regulation emanating from cross-case analysis of specialist group discussions

Manifestation of regulation	Type and area of regulation	Depth of regulation
Planning	• Other-regulation of task performance [PLAN_OR_TASK].	Low-level giving of information (GI).
Monitoring	• Self-regulation of thinking about the chemistry content [MON_SR_COGN(C)]. • Other-regulation of task performance [MON_OR_TASK].	Low-level seeking of information (SI).
Control	• Self-regulation of thinking about the chemistry content [CTRL_SR_COGN(C)]. • Other-regulation of thinking about the chemistry content [CTRL_OR_COGN(C)]. • Other-regulation of task performance [CTRL_OR_TASK].	Low-level seeking of information (SI) and giving of information (GI).
Evaluation	• Self-regulation of thinking about the chemistry content [EVAL_SR_COGN(C)]. • Other-regulation of task performance [EVAL_OR_TASK].	Low-level giving of information (GI).

7.4 Manifestations of metacognitive activity during home group discussions

To answer Research Question 3, two students who were observed to differ in how they regulated activities in their specialist groups were selected per team for further analysis of their regulatory contributions in the subsequent home group discussions. To allow for an in-depth analysis, a decision was made to focus only on two students per specialist group who were observed to be different in their regulatory approach. Bettie and Kagiso were chosen because they were similar in their assertiveness, while Ansie and Leonard tended to be tentative in their regulatory contributions. Back in their home groups, the members were responsible for giving feedback to their peers pertaining to their synthetic routes. Information regarding the cost, technical challenge and environmental impact of each route was vital in enabling the students to make a prediction of which route would turn out to be the best. Entering the home group discussions

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prepared was therefore key in enabling the students to actively participate and make meaningful contributions.

7.4.1 Patterns in terms of the students' styles of interaction in the home groups

The styles of interaction observed for all four of the students in the specialist groups were observed to persist in their respective home groups. When he realised that he was not getting any meaningful engagement from Siyanda, who came into the home group discussion unprepared, Kagiso consulted with a student from another home group to facilitate his own personal goals. Bettie dominated the discussions in her home group and even took it upon herself to steer activities within the team, citing in an interview that when marks are at stake, she trusts herself more than her peers. Once again, the two students used the platform of engagement to pursue their own goals rather than bring their fellow team members on board. Anita dominated the discussion in Ansie's home group, however, this did not stop Ansie from asking thought provoking questions and urging her team mates to justify their thinking. Although Matt took the leadership role in Leonard's home group, Leonard flourished in his home group. Leonard was able to openly share his suggestions and objections with his peers in the new social context where the members were receptive of his regulatory efforts and guidance.

7.4.2 Comparison of the four students in terms of manifestations and types of regulation

In contrast to Bettie, Leonard and Kagiso, the regulatory patterns for Ansie were extrapolated from the home group discussions prior to the specialist group discussions as explained in Section 6.7.1.2. Frequencies of occurrence of 50% and higher as shown in Tables 5.4 and 6.4 (Kagiso: 57.%; Leonard: 50.9%; Bettie: 58.3%; Ansie: 59.3%) for verbal contributions that were interpreted as metacognitive indicate that all four students contributed in terms of regulating cognitive activities in their respective home groups. However, looking at the two teams' specialist group contributions in Table 5.1 (Kagiso: 40.7% and Leonard: 43.0%) and Table 6.1 (Bettie: 66.0% and Ansie: 63.5%), it is clear that the proportion of metacognitive statements as compared to non-metacognitive increased for Kagiso and Leonard, but decreased for Bettie and Ansie. The increase observed for Kagiso may be due to the fact that his home group consisted of only him and Siyanda, and he was observed to regulate and dominate discussions more as a result of Siyanda coming in unprepared. The increase in regulatory statements observed for Leonard may be attributed to the supportive and nurturing context in his home group, which made it easy for him to engage and regulate more than he did in his specialist group.

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The discussions in Ansie's home group were dominated by Anita, and the fact that Ansie was an introvert did not help, which explains the low prevalence of verbal contributions on Ansie's part. The discussions of the students in their home groups prior to engaging in the specialist group activities were more cooperative in nature, focused more on logistical aspects of the task than the chemistry, and did not lend themselves well to opportunities for negotiations and cognitive conflict. The focus of these discussions may explain the low prevalence of metacognitive statements in Ansie's home group verbal contributions. The members in Bettie's home group all came in unprepared. The decrease in occurrence of regulatory efforts in this home group could be explained by the fact that group engagement was limited by members not being at the same level in terms of their preparation, which led to Bettie taking over the work to ensure timeous task completion.

Commonalities in how the four students regulated activities in their home groups were observed. A comparison of the manifestations and types of regulatory contributions made by Kagiso, Leonard, Bettie and Ansie in their specialist groups (Tables 5.2 and 6.2) and respective home groups (Table 7.2 below, a combination of Tables 5.5 and 6.5) revealed an overall increase in other-regulation (Kagiso: 64.5 vs 91.0; Leonard: 70.9 vs 81.6; Bettie: 66.4% vs 90.5% and Ansie: 65.9% vs 87.5%). It also showed a decrease in self-regulation (Kagiso: 35.5 vs 8.9; Leonard: 29.0 vs 18.6; Bettie: 33.7% vs 9.6% and Ansie: 34.1% vs 12.5%), particularly in the manifestations of control and monitoring. These observations may be explained by the fact that all four students entered their home group discussions well-prepared and having a clear understanding of what each of their synthetic routes entailed, which enabled them to perform home group tasks and regulate activities within their teams. No tension was picked up on in any of the home groups, except for unequal engagement, which was as a result of some members coming in unprepared.

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Table 7.2 Comparison between Kagiso, Leonard, Bettie and Ansie's home group regulatory contributions in terms of manifestations and types of regulation

Manifestations of MR →	Planning			Monitoring			Control			Evaluation			Total turns
Types of MR →	SR	OR	Subtotal	SR	OR	Subtotal	SR	OR	Subtotal	SR	OR	Subtotal	
Kagiso	-	-	-	3 (6.7%)	11 (24.4%)	**14 (31.1%)**	1 (2.2%)	29 (64.4%)	**30 (66.7%)**	-	1 (2.2%)	**1 (2.2%)**	**45**
Leonard	-	1 (1.9%)	**1 (1.9%)**	1 (1.9%)	5 (9.3%)	**6 (11.1%)**	7 (13.0%)	38 (70.4%)	**45 (83.3%)**	2 (3.7%)	-	**2 (3.7%)**	**54**
Bettie	1 (1.1%)	16 (16.8%)	**17 (17.9%)**	-	8 (8.4%)	**8 (8.4%)**	3 (3.2%)	62 (65.3%)	**65 (68.5%)**	5 (5.3%)	-	**5 (5.3%)**	**95**
Ansie	-	-	-	2 (12.5%)	-	**2 (12.5%)**	-	14 (87.5%)	**14 (87.5%)**	-	-	-	**16**

7.4.3 Comparison of the four students in terms of depth of regulation

An in-depth look at the quality of each of the four students' contributions (Table 7.3 below, combination of Tables 5.6 and 6.6) in terms of high-level and low-level regulation revealed a difference in the depth of regulatory efforts. The results in Table 7.3 comprise percentages that were obtained by dividing the raw counts of high- and low-level regulatory statements by the total number of each individual's metacognitive statements pertaining to each manifestation of regulation. Percentages are reported for the combined SR and OR instances per person.

Table 7.3 Comparison between Kagiso, Leonard, Bettie and Ansie's home group regulatory contributions in terms of depth of regulation

Manifestations of MR →	Planning (%)			Monitoring (%)			Control (%)			Evaluation (%)			Total turns
Depth of MR →	LL	HL	Subtotal	LL	HL	Subtotal	LL	HL	Subtotal	LL	HL	Subtotal	
Kagiso	0	0	**0**	24.4	2.4	**26.8**	48.8	21.9	**70.7**	2.4	0	**2.4**	**45**
Leonard	2.3	0	**2.3**	6.8	4.5	**11.3**	43.2	43.2	**86.4**	0	0	**0**	**54**
Bettie	15.8	2.1	**7.9**	7.4	1.1	**8.5**	56.8	11.6	**68.4**	4.2	1.1	**5.3**	**95**
Ansie	0	0	**0**	12.5	0	**12.5**	75.0	12.5	**87.5**	0	0	**0**	**16**

When compared to the level of regulation demonstrated by Leonard from Table 5.3 on page 118 (**HL**: 2.5 + 3.8 + 23.9 + 2.1 = **32.3%**; **LL**: 3.4 + 11.8 + 49.6 + 6.2 = **67.7%**) in the specialist group, an increase in the occurrence of high-level regulation (4.5 + 43.2 = **47.7%**) and a decrease in low-level regulation (2.3 + 6.8 + 43.2 = **52.3%**) was observed in the home group. This observation may be explained by the nurturing and supportive environment that Leonard

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found himself in while operating in the home group and the gains that he made from the cognitive challenges that he experienced in his specialist group. The opposite was true for Kagiso, who reverted back to his specialist group style of engagement by mostly making low-level regulatory contributions.

All of the members of Leonard's home group were actively involved in the discussion. No one team member dominated the discussion or tried to impose his decisions on the others. Matt took on the leadership role by initiating the discussion and pointing out to team members when it was time to move on to the next item. Eksteen emerged as the unprepared student. Only Leonard and Matt had come prepared, having worked out the costs of reagents for their routes. Eksteen had not and was then allowed time to calculate while Matt and Leonard moved on to other aspects of the home group task. The supportive nature in the style of interaction was observed when group members restructured tasks to allow Eksteen to catch up. Collaboration was democratic in that most of the decisions were negotiated amongst the team members as opposed to one team member calling the shots.

Similar to the depth of regulation demonstrated by Bettie (**HL**: 22 %; **LL**: 78%) and Ansie (**HL**: 15%; **LL**: 85%) during the specialist group discussions (Table 6.3), the majority of regulatory contributions in their respective home groups constituted low-level regulation, particularly pertaining to manifestations of control. Both of their home group contexts were supportive and receptive of Ansie and Bettie's regulatory contributions, which could explain a recurring theme in terms of their styles of engagement and regulation. To summarise, the only one for whom a shift in quality of regulation was observed between specialist group and home group contexts was Leonard who made more high-level contributions in a supportive social environment than in one where he experienced adversity.

An in-depth look at how the four students differed in terms of the empirical indicators of low- and high-level regulation uncovered the specific actions that each individual followed to regulate activities in their home groups. The percentages for each of the indicators were calculated against each student's total number of verbal contributions and graphs drawn to present the differences for combined manifestations and types of regulation (Figure 7.5 below, combination of Figures 5.6 and 6.6).

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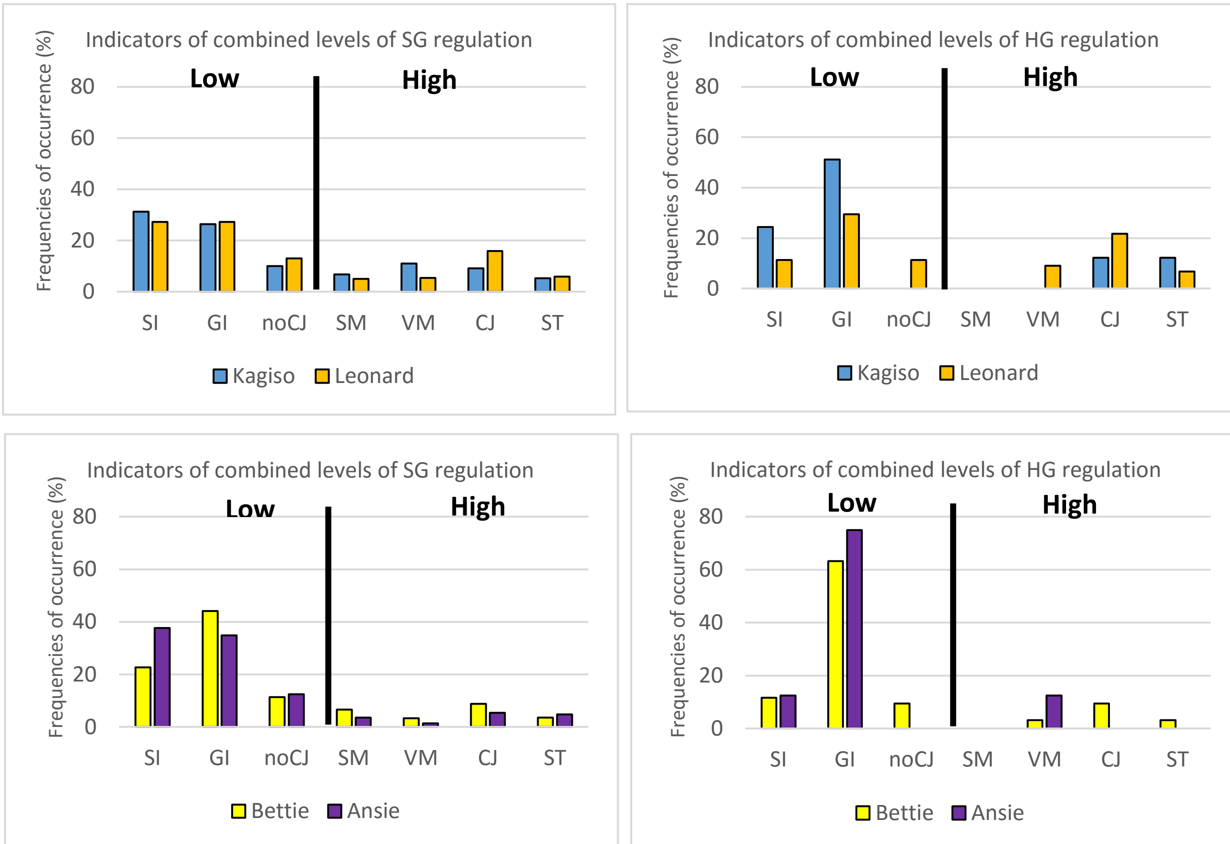

Regulation low level (Left-hand side): SI – Seek Information, GI – Give Information & noCJ – no Conceptual Justification
Regulation high-level (Right-hand side): SM – Seek Meaning, VM – Volunteer Meaning, CJ – Conceptual Justification & ST – Stimulate Thinking

Figure 7.5 Comparison of Kagiso, Leonard, Bettie and Ansie's indicators of depth of regulation in their specialist (SG) and home groups (HG)

Overall, subtle differences were observed in the indicators of high- and low-level regulatory contributions made by the four students in their home groups. The bigger picture shows that the tendency of all the students to regulate by giving information recurred and, in fact, increased in their regulation of home group activities, particularly for Kagiso, Bettie and Ansie. The frequencies of occurrences of low-level seeking of information decreased for all four students, particularly for Leonard, Ansie and Bettie. The decrease observed in the frequencies of seeking information could be due to the fact that coming in prepared meant that these students did not need to consult further. Only Leonard and Bettie continued to make suggestions and objections without conceptual justification. Another commonality observed amongst the four students was the absence of high-level seeking of meaning in their home groups. Frequencies of high-level

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regulation by volunteering meaning persisted for Leonard and increased for Ansie. Similarities were observed in terms of how Kagiso, Bettie, and mostly Leonard continued to offer conceptual justification for their regulatory efforts and stimulate the thinking of their peers. In total, the majority of the regulatory contributions made by the four students in their home groups were characterised by other-regulation mostly manifesting as low-level giving of information, which may have been as a result of all of them entering the home group discussions well prepared. However, the patterns for Kagiso and Leonard show that while they were evenly matched in the specialist group in terms of regulatory contributions there is a clear shift for Leonard towards more high-level contributions in the home group.

7.5 Chapter summary

As mentioned in Chapter 3 (Section 3.3.2), the decision to investigate two specialist groups instead of one was based on a replication logic (Yin, 2014), i.e. an additional case was selected in anticipation that varying group contexts would result in contrasting manifestations of social regulation (theoretical replication). However, similar patterns in terms of manifestation, type, and area of regulation were observed for both groups, regardless of the social context. Subtle differences in terms of the depth of regulation were observed which were largely attributed to the team members' styles of engagement.

The decision to study how students with varying styles of interaction regulated cognitive activities in their respective home groups was also based on the notion of theoretical replication (Yin, 2014). Acknowledging the potential influence of social contexts on the regulation of cognition led to the proposition that being exposed to different home group contexts would also result in the students regulating cognitive activities differently. In terms of the regulatory contributions made by the individual students in their respective home groups, their styles of engagement and patterns of regulation persisted. Ansie and Leonard did not take on a leadership role, but remained reflective and tentative in their regulatory contributions. The only difference is that Leonard made more regulatory contributions and he also demonstrated a clear shift toward high-level contributions in the home group where the context was supportive and receptive.

Kagiso and Bettie remained assertive in their regulatory contributions and still felt the need to steer activities to ensure the achievement of their personal goals. Occurrences of regulation were observed more as manifestations of monitoring and control and less as planning and evaluation.

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As a whole, low-level, other-regulation dominated metacognitive statements were made by the students in both specialist groups. These observations were also made for the home group discussions, which seems to suggest that the lack of planning, evaluation, and deeper regulation may be due to the level of academic maturity of the students, who were only in their senior undergraduate year when the study was conducted. I would argue that in addition to the developmental stage of these students, the lack of planning and evaluation could also be attributed to the fact that they had not been exposed to inquiry-based laboratory assignments before. The students were unaware of the importance of planning and evaluation while preparing for the practical execution of the assignment. Perhaps they were also strategic in trying to get the task completed within the set time limit, which would encourage them to carry out low-level exchanges rather than high level meaning making.

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CHAPTER 8

DISCUSSION AND IMPLICATIONS

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CHAPTER 8

DISCUSSION AND IMPLICATIONS

8.1 Introduction

The cognitive and metacognitive aspects of self-regulated learning have been historically conceptualised as individual processes. My findings confirm the view of contemporary researchers (Grau & Whitebread, 2012; Vauras et al., 2003) that cognitive and metacognitive aspects in individual contexts manifest similarly in social contexts, particularly in natural collaborative learning contexts.

A review of the literature has revealed a growing interest in research that focuses on the social aspect of metacognition. It has also emerged that little attention has been given to the social nature of metacognitive regulation in the collaborative planning of chemistry practical investigations, which is a much needed missing aspect of research on metacognition in laboratory contexts (Krystyniak & Heikkinen, 2007). The present study was carried out with the aim of adding to this area of research by identifying and characterising manifestations of metacognitive activity, particularly cognitive regulation, in groups of students in a simulated industrial project during the planning of organic chemistry practical investigations. To this end, an analytic framework was developed and validated to allow for fine-grained coding that interrogated not only the manifestations of metacognitive regulation at play, but the type of regulation, i.e. *self* or *other*, as well as the areas where the students applied their efforts towards regulation.

A multiple case study of purposively selected specialist and home group discussions was deemed suitable for an in-depth study of metacognitive activity that manifested in the collaborative planning of practical investigations. In Chapters 5, 6 and 7, I described in detail how metacognitive activity was observed to manifest in the selected group verbalisations. My discussion of how these observations helped to answer my research questions begins with a recapitulation of the research questions and the aim of the study, followed by a critical reflection on the research process and the findings. A reflection on the study from a methodological point of view is provided next. I conclude the chapter by providing a brief description of the answers

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to my research questions, as well as the implications for practice, and recommendations for future research.

8.2 Recapitulation of purpose and research questions

This study was carried out to identify and characterise the metacognitive activity, particularly the social cognitive regulation that manifests in group discussions. This was done based on the assumption that the collaborative planning of chemistry practical investigations in the simulated industrial project would encourage students to enter into negotiations, making their thinking visible. For this purpose, collaborative specialist and home group discussions were captured and analysed for manifestations of metacognitive activity. This research was guided by the following primary and secondary research questions:

Primaryresearch question: How does metacognitive regulation manifest in students' verbal contributions during the collaborative planning of practical investigations?

Secondary research questions

Research Question 1: What aspects of metacognitive regulation manifest as students plan investigations in collaborative learning groups?

Research Question 2: How does metacognitive regulation manifest during specialist group discussions?

Research Question 3: How does metacognitive regulation manifest during home group discussions?

Through Research Question 1, I set out to investigate which aspects or components of metacognitive regulation manifest as students engage in the collaborative planning of chemistry practical investigations. Research Question 2 aimed to determine how two specialist groups regulated activities while working together to generate detailed experimental procedures for their allocated synthetic routes. To answer Research Question 3, two students who were observed to differ in how they regulated activities in their specialist groups were selected per team for further analysis of their regulatory contributions in the subsequent home group discussions. This decision was helpful in determining the role that specialist group engagement and regulation played in preparing these students to contribute in the subsequent home group discussions. The transcribed audio recordings of these discussions and the follow-up group and individual

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interviews served as useful information from which the manifestations of metacognitive activity, particularly intra- and inter-individual regulation, could be inferred. A critical reflection on the research process and findings of the study is provided in the next section.

8.3 Critical reflection on the research process and findings

My reflection starts with a discussion of the processes that I followed, and the challenges that I experienced in capturing and analysing the verbal discussions for manifestations of metacognitive activity. Further on, I also discuss how individual dispositions and personal goals were observed to facilitate or constrain social regulation.

8.3.1 Coding scheme development

I set off to determine how metacognitive activity, particularly social regulation, manifests during the collaborative planning of organic chemistry practical investigations. The research process started with the development and validation of a coding scheme. The work of Pintrich (2000) greatly contributed in assisting me to arrive at a more comprehensive coding scheme (shown in Chapter 4 as Table 4.2) to identify and characterise manifestations of metacognitive activity in this context. Pintrich (2000) describes the components of planning, monitoring, control, and evaluation in terms of the phases that students go through to regulate their cognitive activities as they carry out tasks. The term ‘phase’ of regulation used in Pintrich’s (2000) theoretical model to refer to the components of cognitive regulation seemed to suggest that the processes of planning, monitoring, control, and evaluation occurs in stages, when in reality, cognitive regulation is an iterative process rather than a progression. To suit my understanding of the nature of cognitive regulation, I opted to use the term ‘manifestations’ of regulation to refer to the components of regulation, i.e. planning, monitoring, control, and evaluation, thereby indicating that no hierarchy or progression between these components were found in the natural setting that I studied.

Being an internal mechanism, metacognition is generally inferred from students’ verbal and non-verbal behaviours. In my study, I focused only on the manifestations of metacognitive activity emerging from the students’ verbal expressions. For this purpose, I had to reconceptualise the definitions of the different components of cognitive regulation to be consistent with the focus of the current study. Planning was thus inferred from any verbalisation demonstrating forward-thinking and how individuals intended to go about performing the task. Monitoring was defined as any verbalisation characterised by the checking of thinking, performance or behaviour in

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relation to the task. Control was conceptualised as any verbalisation expressed to influence thinking, task performance or behaviour. Lastly, evaluation was inferred from any verbalisation that was characterised by evaluative statements or judgements made about thinking, task performance or behaviour.

A preliminary data analysis highlighted the need for further distinction in terms of the types of regulation (self- and other-regulation), and areas of regulation (thinking, behaviour, and task performance). Self-regulation was inferred from statements that were made to influence the student's own thinking, task performance or behaviour. Other-regulation was inferred from statements directed at influencing the thinking, task performance or behaviour of a fellow team member or the group as a whole. Using codes that could capture the manifestation, area, and type of regulation allowed for a coding scheme that was comprehensive enough to identify and classify the subtle differences that existed in the manifestations of metacognitive activity observed in the group discussions. A similar classification system was successfully used by Grau and Whitebread (2012) to identify aspects of social regulation demonstrated by young children in collaborative science activities. Although using different terminologies, the coding scheme similarly enabled a distinction to be made in terms of regulation processes (manifestations), social intentionality (type), and direction of the activity (areas).

8.3.2 Data collection

The process of data collection posed multiple challenges. Initially, my interest was in specialist group discussions as the primary source of data largely because the specialist group activities met the requirements for a collaborative group work approach, i.e. shared expertise and cognitive demands of the learning task (King, 1998). Having realised the impact of group context on the patterns of regulation from reviewing the literature, I felt the need to determine how individual students regulated activities in different social contexts.

I had the option of analysing the students' home group regulatory contributions before or after the specialist group discussions. The home group discussion preceding the specialist group discussions were more introductory in nature, allowing the students to clarify task demands, roles and expectations. Having engaged with the task for three hours at most to generate detailed experimental procedures for their routes in the specialist groups, the students in the subsequent home group discussions were expected to make predictions about which route would be best

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considering the criteria of cost, technical difficulty, and environmental impact. I chose to analyse the home group discussions subsequent to the specialist group discussions because the task of making predictions required students to enter into negotiations, resulting in more instances of cognitive conflict and social regulation.

Due to time constraints, a decision was made to focus only on two students per specialist group who were observed to be different in their regulatory approach. Bettie and Kagiso were chosen because they were similar in their assertiveness, while Ansie and Leonard tended to be tentative in their regulatory contributions. Preparing the home group discussions of the four students for analysis, I realised that, due to a technical error, not all of Ansie's subsequent home group discussions were captured. To allow for a cross-case comparison, Ansie's regulatory contributions were inferred from her home group discussions carried out prior to the specialist group activities. Although limited in terms of the time spent on discussions related to the subject matter, the analysis gave an indication of Ansie's style of interaction in a different group context. My recommendation to those wishing to conduct a similar study in future is that to avoid intrusions by constantly checking if the recorder is functioning, it would be worthwhile to use an additional recorder for each group to serve as a backup.

Transcribing group discussions was not easy, especially during episodes of turns of talk where members spoke over each other or when they were not sufficiently audible. Transcription required listening over and over again to audio clips where the students spoke at the same time in order to capture each student's remarks. The strategy to have each team member introduce themselves at the start of the recording helped me to recognise each student's voice while listening to the recording. Another challenge experienced in relation to preparing the data for analysis was the language used by the students during the group discussions. Although the medium of instruction during the simulated industrial project was English, the students were free to carry out group discussions in a language of their choice. The members of *Team Kagiso* carried out their discussions mostly in Setswana, while the members of *Team Bettie* used mostly Afrikaans. Although this meant that language would not be a barrier in allowing the students to articulate their thoughts, it resulted in frequent code switching between English and the students' primary language. The benefits of conducting group discussions in a primary language as well as English have been reported (Rollnick & Rutherford, 1996). In addition to ensuring accurate

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transcription, forward and back translation was necessary to check for omissions and the correctness of the translations.

Being Setswana speaking, and a Black South African who understands township lingo, worked in my favour. I could relate to the language and cultural dynamics that I observed in *Team Kagiso*. I also understood that words such as '*chomie*' held deeper meanings. I was, however, limited in terms of understanding the language dynamics and cultural relations of the members of *Team Bettie*, who were all White Afrikaans speaking females. The consequences of not being able to relate to the cultural relations and language dynamics meant that I was limited in my interpretation of certain verbal behaviours, and at times, I could not identify minor errors that were made and overlooked in the transcription and translation of their discussions. One of my supervisors, whose primary language is Afrikaans, greatly assisted in this regard.

8.3.3 Data analysis

In analysing the main study data for manifestations of social regulation, qualitative content analysis was preferred over linguistic discourse analysis, largely because the development and refinement of a coding scheme is central to the approach. In contrast to linguistic discourse analysis, qualitative content analysis allowed me to focus more on the content of the students' verbalisations and less on the organisational structure of language.

Three stages of data analysis were employed to analyse the discussions in the specialist and home groups. The first stage entailed the identification and coding of statements that were indicative of metacognitive regulation (MR statements). The second stage entailed sorting turns classified as non-metacognitive (Non-MR Statements) into Conceptual, Digressions, Non-substantial, Questions/queries, Task-related (other) or *Other* statements. The last category, labelled 'Other', included turns of talk that could not be transcribed because they were inaudible, as well as turns where nothing was said, but an expression such as someone clearing their throat was made. Thirdly, metacognitive statements were further judged for the depth of regulation that they portrayed (Khosa & Volet, 2014). The second stage was important as it assisted me to critically evaluate my coding criteria and identify additional statements that met the criteria for metacognitive regulation, but were overlooked in the first stage of analysis.

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The scarcity of studies that investigate metacognition in natural contexts is attributed to the difficulty inherent in classifying statements as cognitive or metacognitive (Kung & Linder, 2007). In the current study, the inclusion or exclusion of statements into the metacognitive category was dependent on whether the statements were made to influence thinking, behaviour, or task performance. The labels used to code the statements that were identified as metacognitive indicated the manifestation (planning, monitoring, control or evaluation), type (self- or other-regulation), and area of regulation (thinking, task performance or behaviour). Sub-codes in parentheses were added to serve as descriptors of the regulatory behaviour depicted by the verbalisations, for example, the label or code MON_OR_COGN(C) (checks peer's understanding of the chemistry) was assigned when an individual was observed to check his/her peers' thinking about the underlying chemistry concepts.

Disagreement also arose over statements that clearly indicated a regulatory contribution, but were perceived to have dual meaning (control or monitoring), such as '*it is this one, right?*' These disagreements were resolved by revisiting the context in which they were made and engaging in further discussion with the independent coder. The process of coding resulted in 43.2% of statements in *Team Kagiso* and 65% of the statements in *Team Bettie* being classified as metacognitive. Further analysis involved classifying metacognitive statements in terms of manifestation, type, and area of regulation.

8.3.4 Manifestations of metacognitive activity

A combination of contextual and social factors was observed to influence the engagement and social regulation during the specialist and home group discussions.

8.3.4.1 Social dynamics in specialist and home groups

The different social dynamics in terms of equity that were observed in the home and specialist groups may be explained by the fact that in the home groups, each individual received status as a specialist in their own route, while in the specialist groups, the members had equal status as specialists of the same route. Consistent with similar research (Alexopoulou & Driver, 1997), males and females were observed to assume role stereotypes in their engagement, with males taking on a competitive stance and females employing a cooperative verbal approach. Conflict inherent in collaborative group work dynamics was observed to only be beneficial when it was

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not perceived as a personal attack, but rather as an opportunity to engage in negotiations that could lead to transformed thinking.

The presence of interpersonal and cognitive conflict inherent in collaborative learning contexts made instances of other-regulation more easily identifiable. Based on literature reports (Brodie & Pournara, 2005; Vauras et al., 2003), peer-teaching was expected to occur in the cooperative home group discussions, with democratic negotiations expected to dominate discussions in the specialist groups. However, a lot of peer-teaching that is consistent with the Vygotskian (1978) group work approach, often serving the personal goals of the one more knowledgeable other, was observed to dominate both the specialist and home group discussions, with the exception of Leonard's home group.

As reported in the literature (Bianchini, 1977), students who spontaneously emerged as leaders (Kagiso, Bettie and Anita in Ansie's home group) were assertive and possessed perceived academic ability. These students seemed to believe that their knowledge base allowed them spare capacity to regulate group activities in addition to their own. It is surprising how students seemed to think that they were adding value by giving information rather than offering explanations to promote conceptual understanding. The truth is, those who took on a leadership role and dominated discussions, such as Kagiso and Bettie, were the ones who were afforded the opportunity to clarify their thoughts and organise their explanations in a way that made sense to those on the receiving end. This type of engagement was observed to be asymmetrical and not mutually beneficial. Brodie and Pournara (2005) concur, citing that the problem with those who are already advantaged becoming teachers is that the opportunity to teach only adds to their advantage. The two researchers propose that equity in socio-cultural group work approaches can be fostered by affording all the learners the opportunity to teach. This solution, however, raises the issue of learner confidence and competence in the subject matter and in the language of learning. Brodie and Pournara (2005) argue that allowing learners with a poor knowledge base a similar opportunity may serve to perpetuate misconceptions within the team.

8.3.4.2 Observed patterns in terms of manifestations of regulation

Instances of regulation were observed to manifest mostly as control and monitoring, with only a few instances of planning and evaluation (Tables 5.2, 5.5, 6.2 and 6.5). This observation was made in all of the analyses of the specialist and home group discussions, suggesting planning and

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evaluation to constitute the more sophisticated forms of regulation. The students seemed to easily slip into the monitoring and control modes rather than planning and evaluating cognitive activities. Although the Reflective Learning Questionnaires (RLSQs) in Appendices 2.1 to 2.4 were given to the students to support them in achieving higher level regulation while performing their tasks in the specialist and home group discussions, these efforts were not met with substantial evidence of talk that was indicative of planning and evaluation. The students viewed the RLSQs as just another task to complete, and often completed the reflective prompts without giving much thought to their responses. They often asked the question "*is this for marks?*" when it came to completing the prompts in the RLSQs.

In both groups, the students were observed to engage less in planning and evaluation, regardless of varying social contexts. This observation seems to suggest that the difficulty that students experienced in planning and evaluating their thoughts is more a developmental rather than a contextual issue. All of the participants were senior undergraduate students who were exposed to inquiry-based learning for the first time. Metacognition has been reported to be a late developing skill, with planning and evaluation constituting the more sophisticated and rare forms of cognitive regulation, mostly displayed by expert learners (Ertmer & Newby, 1996).

8.3.4.3 Observed patterns in terms of types of regulation

Social regulation in the specialist and home groups manifested mostly as other-regulatory. Although, not explicitly investigated in the current study, instances were observed of shared regulation included as a third mode of regulation in Iiskala, Vauras and Lehtinen (2004)'s SSMR framework. My findings confirmed these researchers' assertions that the regulation of joint activity in collaborative tasks cannot only be reduced to self- and other-regulation. When one team member masters a key element of the task but the others do not, a momentary unequal situation arises requiring the more capable other to take on the role of a teacher(peer-teaching). Such instances can best be described as other-regulation. However, shared regulation is observed when team members together master the key elements and engage in egalitarian and complementary regulation of the task.

To make a significant contribution towards successful task completion, the specialists had to return to their home groups with expert knowledge of all of the aspects pertaining to their synthetic routes. The members who came in unprepared resulted in asymmetrical engagement in

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Kagiso and Bettie's home groups, making it easy for the two students to take on the role of teacher. This unequal situation was not conducive to shared regulation, as described by Vauras et al. (2003), resulting in regulation manifesting mostly as other-regulation. In the home groups, instances of shared regulation were observed between the team members who came in prepared from their specialist groups, e.g. Leonard and Matt in Leonard's home group, as well as Ansie and Anita in Ansie's home group. In terms of the specialist groups, shared regulation occurred between the students who seemed to be at the same level in terms of their understanding of the underlying chemistry concepts. Shared regulation in *Team Kagiso* was observed between Kagiso and Leonard, although it was constrained to a large extent by the social conflict between them. In *Team Bettie*, shared regulation was observed to occur between Ansie and Bettie.

8.3.4.4 Observed patterns in terms of areas of regulation

In terms of areas of regulation, the students mostly regulated their thinking about the underlying chemistry content [COGN(C)], as well as task performance [TASK]. These patterns were observed for both the specialist and home groups. The targeted areas of regulation could be due to the content-dependent nature of the task. The participation, regulation, and successful completion of the task depended heavily on the chemistry knowledge base of the students. The regulation of behaviour was not observed much, and was non-existent in some cases. Groups that experienced less social conflict, such as *Team Bettie*, did not have to regulate for behaviour as much as those experiencing social conflict, such as *Team Kagiso*.

8.3.4.5 Observed patterns in terms of depth of regulation

As explained in Chapters 5 and 6, a comparison of the frequencies of manifestations of regulation (Tables 5.2 and 6.2) was found to conceal the fact that some of these regulatory contributions were not able to foster critical thinking and the implementation of the task with understanding. Depth of regulation was judged by how the regulatory contributions fostered critical thinking and conceptual understanding of the individual or the group. A further differentiation of team members' metacognitive statements into low- and high-level regulation revealed that the students mostly made low-level regulatory contributions in the home and specialist groups, confirming the findings of several other researchers (see Grau & Whitebread, 2012; Khosa & Volet, 2014).

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Regulatory contributions in the specialist and home groups were mostly low level. Possible reasons for the prevalence of the low-level regulation observed in the group discussions are that the chemistry content required for successful task completion was fairly complex and the students probably felt the pressure of having to complete the whole task in one sitting, leaving them with less capacity to engage more deeply. The students had probably not engaged in group work using a jigsaw design before, where they carried significant individual responsibility in their home groups through the quality of their contributions. In fact, during the interviews, the students expressed frustration at not knowing how to incorporate the influx of ideas coming from the different team members. They were used to planning investigations on their own.

8.3.5 Possible explanations for observed patterns of social regulation

In their study, Alexopoulou and Driver (1996) found that the manner in which peers interacted depended mostly on the participants' individual dispositions and personal goals.

8.3.5.1 Individual dispositions and personal goals

Three personal styles of engagement, assertive, tentative and dependent, were observed to influence how individuals regulated activities in their groups. The first style, demonstrated by Bettie and Kagiso, seemed to be driven by a need to achieve personal conceptual goals or rapid task completion. The second type of engagement, observed in Ansie and Leonard, seemed to be driven by a need to establish an understanding of the task. The third one, demonstrated by Amos, Reneilwe and Lynette, seemed to be driven by a lack of confidence, characterised by a constant need for validation. In both cases, the extroverts were assertive in their regulatory approach, and the introverts were tentative. Both the personal characteristics (of being an extrovert or an introvert) and the personal style of regulation (assertive or tentative) transcended group context.

Low-level other regulation was observed to have a crippling effect on members who struggled with the task and the subject matter. In this regard, peers with a better understanding, such as Kagiso and Bettie, missed out on opportunities to empower their teams as they preferred to focus on their personal conceptual goals. Ansie and Leonard were tentative and reflective in their regulation, pushing for deeper thinking and conceptual understanding. Such engagement compensated to some extent for the low-level regulation demonstrated by team leaders in both the specialist groups. This disposition demonstrated by Ansie and Leonard seems to have been a consequence of their personalities rather than the social contexts they found themselves in as it

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transcended group context. I gathered from interviewing Ansie and Leonard that this disposition not only benefited their fellow team members, but prepared the two students to enter the laboratory session with confidence.

Ansie and Leonard showed that one does not have to be assertive to make significant regulatory contributions towards successful task completion. In terms of verbal contributions, the introverted Ansie and Leonard contributed less to the discussions of the specialist groups than the extroverted Bettie and Kagiso (see Tables 5.1 and 6.1), but they gained enough from these discussions to be able to make a really meaningful contribution to their home groups afterwards. Even though their focus seemed to have been on the collective, this did not come at the expense of personal conceptual gain. This observation serves as evidence that cognitive regulation is covert and the extent of manifestation is not necessarily indicative of the extent of learning gain.

Specialist group activities were put in place to enable each specialist to leave the planning session with a clear understanding of what needed to be done once they had to execute the task in the laboratory. The nature of regulation hampered the achievement of this learning outcome for some students, and facilitated achievement for others. Students, such as Amos, interacted and regulated on a low level to obtain answers quickly to avoid figuring things out on their own, which backfired in the first laboratory session. Kagiso and Bettie engaged and regulated the group activities to achieve their personal goals of leaving the discussions with a clear understanding. For the students who did not have their team members' best interests at heart, the aim was to complete the task. They lost sight of the purpose of group work, which transcends task completion and rather signified by the joining of forces to achieve a quality learning product, i.e. experimental procedures detailed enough to facilitate the implementation of laboratory experiments with understanding.

8.3.5.2 Cognitive conflict

The success of collaboration lies in the cognitive conflict that it creates. Despite all of the social challenges observed in *Team Kagiso*, the social conflict that appeared to be a potential threat to progressive discussion did not hamper task completion. In fact, both Leonard and Kagiso left the specialist group more prepared than some of their home group members. It was almost as though social conflict was necessary to facilitate negotiations and deeper thinking. Social conflict in *Team Kagiso* did, however, hamper the frequency of regulation, particularly for a member who

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was ostracised, for example, Leonard decided to limit his engagement in the specialist group. There is no telling how much he could have contributed cognitively and metacognitively had he been given an opportunity to do so. It is likely that the measure of the contribution that he could have made in this group context should be judged by his engagement in the home group where the context was more supportive and egalitarian.

Social conflict emerged occasionally in *Team Bettie*'s specialist group discussion, however, conflict did not lead to one member being attacked and deciding to retract. Ansie was observed to often defuse disagreements between Bettie and Lynette. With *Team Kagiso* experiencing more social conflict and yet being able to achieve more frequencies of deeper regulation and task completion, it can be argued that the diffusion of conflict in a bid to build consensus and preserve the relationships by members of *Team Bettie* may have robbed them of an opportunity to develop deeper conceptual understanding.

8.3.5.3 Lack of preparation

The home group discussions subsequent to the specialist group activities required individuals to enter these negotiations having completed their specialist tasks. Coming in unprepared rendered individuals, such as Siyanda in Kagiso's home group and Eksteen in Leonard's home group, passive and unable to contest their fellow team mates' suggestions. Unequal playing fields in terms of the level of preparation were not conducive to engagement and regulation in this context. In the case of Kagiso and Siyanda, regulation was mostly asymmetrical to the extent where Kagiso felt the need to consult externally to facilitate task completion. Bettie, alternatively, did not trust her team mates to compile the final presentation, citing that when marks are involved, she trusts herself more than others. In terms of Leonard's home group, the context was egalitarian, collaborative and supportive of a member who came in less prepared. The supportive nature in the style of interaction was observed when group members restructured tasks to allow Eksteen to catch up.

Subject matter knowledge and preparation were necessary to make cognitive and metacognitive contributions in this content dependent task. Before they were told with which mechanism they would work, the students were given the reaction mechanisms in a previous contact session and thus had plenty of time to do research on what each route entailed in terms of the chemistry and experimental techniques. It was clear that Ansie studied this information before the planning

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session so that she was prepared for the initial home group discussion prior to the students convening in their specialist groups. The transcript of this discussion demonstrated how coming into the planning session prepared assisted Ansie to raise objections and suggestions during these discussions.

Ideally, productive social regulation should be observed to fluctuate among most of the manifestations, types, and areas of regulation. However, my findings seem to suggest that neither of the specialist groups did much planning or evaluation and also did not cover all of the areas of regulation, yet members of both teams seemed better prepared than others when they engaged in the subsequent home group discussions. So, despite an uneven fluctuation between manifestations, types, and areas of regulation, the students still managed to complete their tasks and emerged better prepared for the subsequent home group discussions. My findings also seem to suggest that cognitive conflict that is managed constructively is essential for deeper levels of cognitive and metacognitive engagement and learning gain.

8.4 Methodological findings

A case study approach allowed for the use of a small sample, a variety of data collection strategies, as well as an in-depth study of the phenomenon in a natural context. A combination of systematic online observations and stimulated recall interviews proved useful in illuminating manifestations of metacognitive activity during the collaborative planning of practical investigations.

8.4.1 Systematic on-line observation

An initial poor agreement between the coders (*Cohen's Kappa* = 0.35) highlighted a fine line that exists between behaviours that are indicative of monitoring and control. In fact, several researchers do not distinguish between these two behaviours and simply present them collectively as monitoring (Khosa & Volet, 2014; Molenaar & Chiu, 2014). Clear distinctions between behaviours associated with each of the manifestations of metacognitive regulation remain a methodological challenge in this area of research. This challenge may be explained by the fact that evidence of metacognitive activity is largely dependent on the subjective inferences made by researchers from verbal and non-verbal behaviours. A high level of inference, however,

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poses a challenge to reliability (Whitebread et al., 2009) and creates difficulties in researchers and independent coders reaching a consensus on the behaviours that indicate each manifestation of regulation between, which is a cause for concern.

A solution proposed by Whitebread et al. (2009) is for researchers to include in their analysis only those behaviours for which absolute agreement is reached. In addressing this challenge, I demonstrated in Chapter 4 how establishing clear definitions and demarcations during the development stage of analytical frameworks can introduce more rigour and facilitate the achievement of acceptable levels of inter-coder agreement. The resolution of disagreements through discussion resulted in a final inter-coder reliability of 0.75, which is acceptable and comparable in terms of the level of agreement to the 0.85 achieved by Grau and Whitebread (2012).

8.4.2 Stimulated recall interviews

The interview data assisted me greatly in validating the findings that emerged from the systematic observations. Stimulating the recall of the students through the audio recorded clips of their group discussions also assisted in jogging their memories and allowing them to relive the experience of working together in their specialist groups. This method of data collection required that I first listen to the recorded group discussions in order to select clips that clearly demonstrated instances when they engaged in negotiations and social regulation. Anderson et al. (2009) refers to these episodes of talk as *critical incidents*. Alternatively, and similar to the process followed by Anderson et al. (2009), students could be asked to identify episodes that they regarded as portraying their regulation of cognitive activities.

8.5 Conclusions and recommendations

This study was an attempt to answer the following research questions:

Research question 1: What aspects of metacognitive regulation manifest as students plan investigations in collaborative learning groups?

Research question 2: How does metacognitive regulation manifest during specialist group discussions?

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Research question 3: How does metacognitive regulation manifest during home group discussions?

In answering Research Question 1, I showed that in a social context, cognitive regulation was observed to consist of layers. Regulatory efforts towards planning, monitoring, control, and evaluation fluctuated among self-, other- and shared regulation, constituting the first layer of social regulation and confirming the findings of contemporary researchers (e.g. Vauras et al., 2003). A deeper look revealed another layer, the areas of regulation. The nature of the task required the students to not only monitor thinking about the task features, but also thinking about the underlying chemistry concepts, conducive behaviour, as well as task performance. Self- or other-regulatory efforts were observed to be applied across different areas, and were sometimes concentrated on specific areas. An even deeper look revealed that regulatory efforts differed in terms of how they promoted collective or personal learning gains. This differentiation led to distinctions being made between varying styles of interaction or patterns of regulation as demonstrated by individual students within each team.

In answering Research Questions 2 and 3, I have shown (in Chapters 5, 6, and 7) how patterns of social regulation and styles of interaction transcended the group context by mostly manifesting as low-level, inter-individual monitoring, and control. I have also shown how the students concentrated most of their regulatory efforts on monitoring and controlling thinking about the underlying chemistry concepts and task performance. Instances of self-regulation manifested mostly as monitoring and control of thinking about the chemistry, characterised by low-level seeking of information. Students may have resorted to low-level contributions as a strategic decision to facilitate the quick completion of the task.

An interrelation between social context, individual dispositions, and personal goals was observed to influence the level and depth of cognitive and metacognitive activity in the specialist and home groups. Social conflict saw members like Leonard deciding to retract and limit their engagement, while low-level peer teaching saw weaker students being at the receiving end and relying heavily on their team mates. Through the low-level giving of information, those assuming the role of teacher or more knowledgeable other were afforded the opportunity to

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regulate their thoughts and organise their explanations in a way that would make sense to those on the receiving end.

Coming in prepared was important for active participation and regulation in the home groups. Students who entered the subsequent home group discussions unprepared were too busy trying to complete their incomplete specialist tasks to regulate activities, making it easy for students like Kagiso and Bettie to revert to their specialist group styles of interaction. The social context in Leonard's home group was supportive of a member who came in less prepared, while the context in Kagiso's home group only partially compensated for deficiencies in a fellow team member's preparation and conceptual understanding. These observations seem to confirm Bianchini's (1997) assertions that using a powerful group work model and carefully crafted group tasks does not guarantee equal participation and academic achievement.

8.6 Implications for teaching and learning

Self-regulation was conceptualised as the regulation of own thinking, task performance, and behaviour. Other-regulation, conceptualised as the regulation of peers' thinking, task performance and behaviour, had implications of asymmetrical peer-teaching inherent in Vygotskian group work approaches. In all of the groups, those who assumed the role of the teacher were the assertive students with perceived academic ability, confirming literature reports (Bianchini, 1997). Peer teaching, accompanied by low-level other-regulation, had a crippling effect on those on the receiving end as it promoted spoon feeding and dependence by simply providing information rather than stimulating thinking. Accompanied by high-level other-regulation, peer-teaching could have been facilitative and empowering by providing conceptual justification and posing thought-provoking questions to stimulate thinking, but this did not happen to any significant extent.

It seems that a concerted effort must be made to teach students how to make the most of group work. Bianchini (1997) concurs, asserting that giving students explicit instruction on how to make the most of group work can make collaboration more beneficial. Tasks in which students have been directly asked to collaboratively analyse and critique inequalities in society (Vithal, 1997) constitute examples of socio-political approaches to group work that could be used to explicitly raise student awareness and teach them how to deal with the conflict, tensions,

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stereotyping, and power relations inherent in group work. My coding scheme opens a way for these types of interventions.

Expecting students to work collaboratively to generate their own experimental procedures elicited discussion, providing opportunities for them to reflect on their thinking, organise their explanations and arguments in a way that would make sense to their peers, and make their thoughts explicit. Collaboration also meant that the task was shared, reducing the cognitive processing load and making room for negotiations and meaning making. Requiring students to generate their own detailed experimental procedures saw the students taking ownership and entering the laboratory with confidence and a better understanding of what they were doing and why they were doing it. The element of contextualisation embedded into the simulated industrial project also played a significant role in how the students regulated activities during the specialist and home group discussions.

The students felt better prepared for the laboratory having actively participated in planning their own investigations. Amos reported that this was the first practical he had ever planned and as a result, would always remember it in detail. Dedicating four sessions to an extended activity, i.e. one day for planning, two days in the laboratory, and a day for presentations allowed time for students to engage, reflect, regroup and carry out investigations with understanding.

Engaging with the prompts in the RLSQs made group discussions more structured and made student thinking visible. The students acknowledged the aim of the RLSQs as a measure that was put in place to encourage them to monitor and regulate their thinking while performing the tasks. However, knowing that the completion of these prompts would not contribute to their laboratory scores resulted in students engaging less with the prompts and delving straight into the tasks at hand. When strategically incorporated into classroom or laboratory activities, RLSQs could be instrumental in scaffolding metacognitive activity and assisting students to carry out laboratory tasks with understanding. Prompting could be gradually introduced until it becomes a norm, and having it contribute towards laboratory scores could be incentive enough to develop a reflective approach.

Finally, Azevedo (2009) asserts that focusing and understanding how metacognitive activity plays out can be instrumental in enhancing the design of learning environments that contain the

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necessary instructional support to accommodate and develop metacognitive skills. My findings highlighted aspects such as the nature of the task, the group work approach, and sufficient time as important factors to consider in the design of learning environments that seek to support the development of metacognitive skills. Evidence of manifestations of individual and social regulation was found in the discussions of students during the completion of tasks in a chemistry laboratory activity, incorporating elements of contextualisation, guided inquiry, collaborative learning, as well as metacognitive scaffolding. Peer interaction during the specialist group discussions and subsequent home group discussions was found to be more collaborative in nature because students had to work together and make important decisions regarding experimental procedures in the specialist groups, and make predictions in the home groups. Having shared expertise and equal access to information in the specialist group discussions, and coming in well-prepared in the subsequent home group discussions enabled students to raise objections and make propositions. However, having to collaboratively make these decisions within a limited space of time may have resulted in students resorting to low-level regulatory contributions as a strategic decision to complete their tasks on time. These findings seem to suggest that in learning environments that are structured to support the development of metacognitive skills in laboratory, contexts need to be allocated enough time to allow students to engage in higher level regulation and meaning making.

8.7 Recommendations for future research

The patterns of regulation observed for the two specialist groups were very similar in terms of the manifestations, types, and areas of regulation [Manifestations: Monitoring, Control; Type: OR; Areas: COGN(C), COGN(T)]. Small differences were observed, such as the fact that regulation of behaviour occurred mostly in *Team Kagiso*, and that *Team Kagiso* demonstrated more self-evaluation of task performance than *Team Bettie* (see Fig 5.4 and 6.4). However, overall, the patterns of regulation were similar. This raises the question of whether these patterns are indicative of the nature of the task or the level of maturity and experience of the students, or both. These observations warrant further research.

Requiring the students to participate in the planning of their own laboratory investigations promoted the carrying out of experiments with understanding, and encouraged less reliance on instructor support during the laboratory sessions. I noted in my field notes how on the first day of

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laboratory work, the students entered the laboratory and went straight to their stations and started working without first consulting with the instructors, an observation seldom made in undergraduate laboratories. Although it was beyond the scope of the current study, during the interviews the students reported that monitoring extended into the laboratory sessions where they constantly visited each other's stations to check their peers' progress and to seek confirmation that they were on the right track. Future research could look into the influence of collaborative planning of own practical investigations on cognitive and metacognitive activity during the carrying out of investigations in the laboratory. A similar study was carried out by Krystyniak and Heikkinen (2007), although with a focus on comparing the nature of student-student and student-instructor verbal interactions during inquiry and non-inquiry laboratories.

8.8 Limitations of the study

The context of my study was the manifestations of metacognitive activity during the collaborative planning of practical investigations as part of an extended laboratory activity, combining elements of contextualisation, guided inquiry, collaborative learning and metacognitive scaffolding. The findings of this study are therefore likely to be restricted to peer interactions that are conducted in similar laboratory contexts. Being a multiple case study of how two teams and four students regulated cognitive activities in their specialist and home groups, respectively, the aim was not to arrive at generalisable findings. The study aimed to provide, with supportive evidence, rich descriptions of the manifestations of regulation as well as factors observed to influence these manifestations during the collaborative planning of chemistry practical investigations. Brief descriptions of the context in which the study took place have been provided in Chapters 1 and 3, and by way of a published article (Appendix 1.1) to enable future researchers to make judgements about the transferability of the findings.

In contrast to the manifestations of monitoring and control, frequencies of occurrences of planning and evaluation were very low and as such, interpretations of similarities and differences must be made with caution. Due to time constraints, not all of the specialists were studied for the nature of the regulatory contributions that they made in the subsequent home group discussions. While the decision to focus only on two students per specialist group (assertive vs tentative) allowed for an in-depth analysis of the influence of style of engagement and group context on social regulation, it would have been interesting to determine the nature of the home group

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contributions made by students like Amos, Reneilwe and Lynette, who were observed to be dependent in their regulatory approach. This is a limitation of the current study, which suggests a direction for further research.

Losing data due to equipment malfunction meant that Ansie's regulatory contributions in the subsequent home group discussions could only be extrapolated from her contributions in the home group discussions preceding the specialist group activities. The lack of data in this regard made comparison difficult and time did not allow for new comparisons to be made using the available data from other students or groups. Determining in advance which students to focus on was difficult as this decision relied on the willingness of the students to participate in follow-up individual and group interviews. Although the students were asked to indicate their willingness to participate in interviews in the first session, most of them initially declined and only changed their minds at the end of the simulated industrial project. In future, it would be advisable to start data collection with specific groups in mind so that great care can be taken to ensure the full capturing of their data.

8.9 Contribution of the study

The focus of my study was metacognitive regulation in the planning of a guided inquiry practical investigation, a much needed missing aspect of research in the study of metacognition in laboratory contexts (Krystyniak & Heikkinen, 2007). Although some research has been conducted in relation to regulation when collaborative learning groups discuss science concepts at primary school level (Grau & Whitebread, 2012), my findings should enhance the understanding of the regulatory processes of upper undergraduate students during the collaborative planning of chemistry practical investigations. Looking back at the contributions that this study was envisaged to make, as anticipated in Chapter one, Section 1.10.1, I believe that this study has made important theoretical and methodological contributions to the growing body of knowledge in the field of research on metacognition in science education.

Firstly, the coding scheme proved to be both conceptually and methodologically useful in that it allowed for fine-grained coding. This system of coding interrogated not only the manifestations of metacognitive regulation at play, but also allowed an in-depth look at the type of regulation, i.e. *self* or *other*, as well as the areas where students applied their efforts of regulation (cognition, behaviour, and task performance). A further distinction was made in terms of depth of regulation

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as high and low-level. Except for the work of Grau and Whitebread (2012) no other study has captured all the four aspects, i.e. manifestation, type, area and depth, in a coding system. Using data that emerged from using the analytical framework, profile maps of patterns of regulation were generated for each student, facilitating easy comparison of how the students were similar or different in their regulation of activities (Appendices 4.3 to 4.9). This way of representing data is also a new contribution to the field. I set out to establish a coding scheme to characterise manifestations of metacognitive activity but in doing so I managed to provide a finer theoretical elucidation of the social nature of metacognitive activity.

Secondly, my major finding was that in group work metacognitive activity is mostly other-regulatory and low-level, manifesting mostly as control and monitoring, with far fewer instances of planning and evaluation. The obvious next step is to identify instructional strategies specifically to develop the skills of planning, evaluation and high-level engagement in social contexts. The RLSQs developed for the purposes of this study was my attempt at encouraging this development but future studies could look into the better use of metacognitive reflective prompts as methods of intervention in social contexts. The question remains, how does one promote the skills of planning and evaluation in social contexts?

Thirdly, by determining frequencies of occurrence for each aspect of regulation an emerging hierarchy in terms of the level of difficulty was established. The findings seemed to suggest that aspects with higher frequencies of occurrence such as monitoring, control and low-level regulation are easier to enact while planning, evaluation and high-level regulation are more challenging. The students also concentrated most of their regulatory efforts on thinking about the chemistry content. Future studies could look into the relationship of these findings to the nature of the task and the students' level of academic maturity.

Fourthly, while previous studies have focused on how group metacognitive activity improves with time (Grau and Whitebread, 2012) no other study has looked into how individuals' patterns of regulation transfer to new social contexts. In the present study the overall and individual patterns of cognitive regulation (manifestation, type, area and depth) were found to be transferrable to new social contexts. This finding generated the hypothesis that patterns of cognitive regulation are dependent on the nature of the task and the level of academic maturity and not on social context. This hypothesis could be tested in future studies.

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Finally, consistent with the findings of Alexopoulou and Driver (1996) in the context of cognitive activity in social contexts, individual patterns of social regulation were also found to be linked to individual dispositions and personal goals. The extroverts took on a leadership role, were assertive in their regulatory efforts, and were driven to pursue their own conceptual goals. The introverts contributed less to the discussions of the specialist groups than the extroverts in both cases, but gained enough from the discussions to be able to make a meaningful contribution to their home groups afterwards. Even though their focus seemed to have been on the collective, this did not come at the expense of personal gain. These observations constitute new findings and seem to suggest that cognitive regulation is covert and the extent of manifestation is not necessarily indicative of the extent of learning gain. Both the personal characteristics (of being an extrovert or an introvert) and the personal style of regulation (assertive vs tentative) seem to have been transferable and not group dependent.

So what was my study all about? My study entailed devising of a coding scheme which later developed into a theoretical framework. I showed that students who react or interact one way in one social context react in the same way in another social context. Finally I showed that students need to be taught how to engage deeper in order to make the most of group work and achieve the desired goals of collective conceptual understanding and learning gain.

8.10 Autobiographical reflection

Looking back I realise what a daunting task it is to try and capture naturally occurring talk and characterise it in terms of manifestations, types and areas of regulation. Such an analysis is time consuming as it should preferably be completed in one go to ensure consistency in coding. The process of research requires one to be continuously open to the idea that theory is not fixed but evolves with more knowledge acquisition. In this journey I had opportunities to engage in long and thought-provoking discussions with some of the best researchers in my field during conferences and academic visits I undertook. I had to constantly think about what I was doing and why I was doing it. In studying about how metacognitive activity manifests I was also engaged in the process of regulating my own thinking. Even in the process of writing I had to constantly monitor and clarify my thinking and organise my explanations and arguments in a way that would make sense to the reader. This thesis is a product of that process of structuring and restructuring my thinking.

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Conducting this study has been an invaluable learning experience. I have learnt that the process of research is messy. For example, in attempting to infer indicators of metacognitive regulation from student talk, code and characterise these indicators according to manifestation, type and areas of regulation, I learnt the valuable lesson that naturally occurring talk does not fit neatly into categories. My research journey was thus frustrating and sometimes tedious and yet immensely rewarding and exhilarating at times. As I delved more and more into the literature I found that my knowledge of the field expanded and assisted me to speak and write with authority. With my masters research project I felt like I did not reach a point where I owned the project, I was still caught up in conforming to what was expected of me. I believe through this project I was able to determine my limitations and strengths as a researcher. The time I spent on the project, immersing myself in the data and constantly engaging in deep thought enabled me to own the project, I found my voice.

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APPENDICES

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Appendix 1.1

Published article: An Inquiry-Based Practical Curriculum for Organic Chemistry as Preparation for Industry and Postgraduate Research

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Appendices 2.1, 2.2, 2.3 and 2.4
Reflective Learning Strategy Questionnaires (RLSQs) used in the simulated industrial project

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Appendix 2.1: Pre-lab individual RLSQ

Reflective Learning Strategy Questionnaire

1. Pre-lab: Individual

1. **Planning:** *At this stage the task is to* ***individually*** *analyse and interpret the brief. Read the brief and answer the following questions.*

Name and Surname:

Student Number: **Date:**

1.1 What do you understand about the task? (i.e. What is the task all about?)

1.2 How does this task relate to the chemistry that you already know?

1.3 What do you still need clarity on? (i.e. What questions do you have?, What information is still missing?), How will you obtain this information?

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Appendix 2.2: Home group RLSQ

Reflective Learning Strategy Questionnaire

2. Planning Session: Home group

2. Planning: *At this stage the task is to clarify with members of your **home group**, objectives as well as contributions expected from each member.*

Student Numbers: **Date:** ______________

PART I: Answer this section **before** working in your specialist groups.

2.1 What do you understand about the task? (i.e. What is the task all about?)

2.2 How does this task relate to the chemistry that you already know?

2.3 What do you still need clarity on? (i.e. What questions do you have? What information is missing?) How will you obtain this information?

PART II: Answer this section **after** you have worked in your specialist groups.

2.4 As a home group, what is your prediction in terms of the final decision, i.e. the best route, considering the criteria of cost, environmental impact and technical challenge? Please make a tick (✓) to indicate your prediction.

Most environmentally friendly route	Route A		Route B		Route C	
Most cost effective route	Route A		Route B		Route C	
Least technically challenging route	Route A		Route B		Route C	
Best route	Route A		Route B		Route C	

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Appendix 2.2: Home group RLSQ

2.5 What will you do in order to compile the brief executive summary and presentation, i.e. time frames, member contributions? (You may present your planning in any format in the box below, e.g. concept map, mind map, bulleted list etc.)

2.6 What are your goals for this task?

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Appendix 2.3: Specialist group RLSQ

Reflective Learning Strategy Questionnaire

3. Planning Session: Specialist group

3. Planning: *At this stage the task is to, as a **specialist group**, collate relevant information and prepare a detailed experimental procedure for the allocated synthetic route.*

Student Numbers: **Date:** ______________

The task:

Each student in this group takes on the role of a specialist with regard to the allocated synthetic route. As specialists, each of you must leave this part of the session knowing all there is to know about the route and how it should be carried out in the laboratory. Each specialist has a responsibility to present accurate information to their home groups. Your home groups rely on each of you to present quality feedback which is a product of proper planning and execution. To make a specialist contribution, you will have to work as a team to make sense of the synthetic route, to develop the experimental procedures and make informed decisions regarding quantities, safety measures and experimental techniques using resources at your disposal. Upon completion of this task, return to the home groups and present the information.

PART I: Answer this section **before** working with the available resources.

3.1 What information is missing? How will you obtain this information?

3.2 What will you do in order to compile the detailed experimental procedure for the synthetic route, i.e. distribution of tasks – who will do what? (You may present your planning in any format, e.g. concept map, mind map, bulleted list etc.)

PART II: Answer this section **after** having worked through the available resources.

3.3 Based on your derived experimental procedure, how much time and what resources (lab equipment, books etc.) will you need for each step?

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Appendix 2.4: Post-lab Day 1 Individual RLSQ

Reflective Learning Strategy Questionnaire

4. Post-"wet lab" Day 1: Individual

4. Monitoring and Evaluation: *At this stage the task is to monitor and evaluate your understanding and progress after you have carried out the first part of the experiment on "wet lab" day 1. Please complete and submit at the beginning of "wet-lab" day 2.*

Name & Surname: ________________________ **Student Number:**_______________

Home group: _______________ **Date:** ______________

Specialist group: ______________

4.1 Which synthetic route are you working on?

4.2 How much of the synthesis did you complete today?

4.3 Do you have a clear understanding of what you have done and what you still have to do? Please elaborate.

4.4 Did you manage to accomplish what you set out to accomplish for today's session? (*circle* **YES** *or* **NO**) **YES** **NO**

Please elaborate:

4.5 What worked?

4.6 What did not work?

4.7 If you could repeat today's work, would you do things differently in terms of, for example, experimental techniques used, experimental procedure, time management, organisation, glassware etc.?
(*circle* **YES** *or* **NO**)

	YES	NO

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Appendix 2.4: Post-lab Day 1 Individual RLSQ

4.8 What changes will you make (if any)?

4.9 To what extent have you reached your goals in terms of the contribution you have to make towards your home group's presentation?

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Appendices 3.1
Pilot study field notes

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Appendix 3.1: Pilot study field notes

→ Questionnaires will be used as/part of Prac activity as from 2014.
19 Aug 2013 } 5 recorders
3-Estelle, 1-Mari, 1-Kgadi
CMY 384 (10H30 → 15H00) + Ipad + BlackB

- Lynne presenting instead of Darren
- Assistants → Not as scribes
  - Dominique → Route B 56 → B2 (4 students)
  - Bonolo → Route C 56 x 2 < C1, C2
  - Ramaube → Route A 56 x 2 < A1, A2
  - Mohammed → Route B 56 → B1 (5 students)
- → Ask stud. to write Group name @ top of sp. questionnaire.

Number of students: 26
- Home groups: 8 of 3 students each, (9) → predetermined 1 of 2 students

- Specialist groups x 6
  - 2 x A < A1, A2
  - 2 x B < B1, B2
  - 2 x C < C1, C2

* Placed recorders upright to get clearer (sound) communication.

* After Lynne's intro, I asked to introduce myself – ask if anyone objects to being recorded = None objected
- Students were also req to speak up
* 26 Individual Pre-lab Questionnaires submitted in the beginning.
  - 14 = Yes to interviews
  - 8 = No to interviews
  - 4 = not indicated.

To determine effectiveness/ depth of understanding.
* Current Hons – 2013, 2012 Third yrs
* Current 3rd years – 2013, 2014 Hons.

- How much can you recall from your third year pracs? → Give qualitative comparison between 2012 (now Hons) 3rd years who used traditional approach and 2013 3rd yrs (2014 Hons) who followed an enquiry based approach. → Memory retention influenced by instructional approach.

Challenges for transcription → Some groups → Simultaneous speaking but discussing different aspects of the work e.g. 2 students talking logistics & 2 students talking calculations.

- Benefit of Jigsaw puzzle strategy, students placed out of their comfort zones i.e. work with different people & not necessarily those they are friends with.

- Introductory paragraph recorded by researcher or assistant & recorded left recording each time.

15 Aug 2013 CMY 384 (11H30 – 16H00)
(7 record) 3 - Estelle, 1-Marié, 1 Kgadi, 1 ipad, 1 phone
Number of students ⇒ 12 students +1 ipad. Estelle.
Presenting: Darren
Assistants – as scribes + time keepers
- Bonolo
- Winnie
- Ramaube
- Kgadi

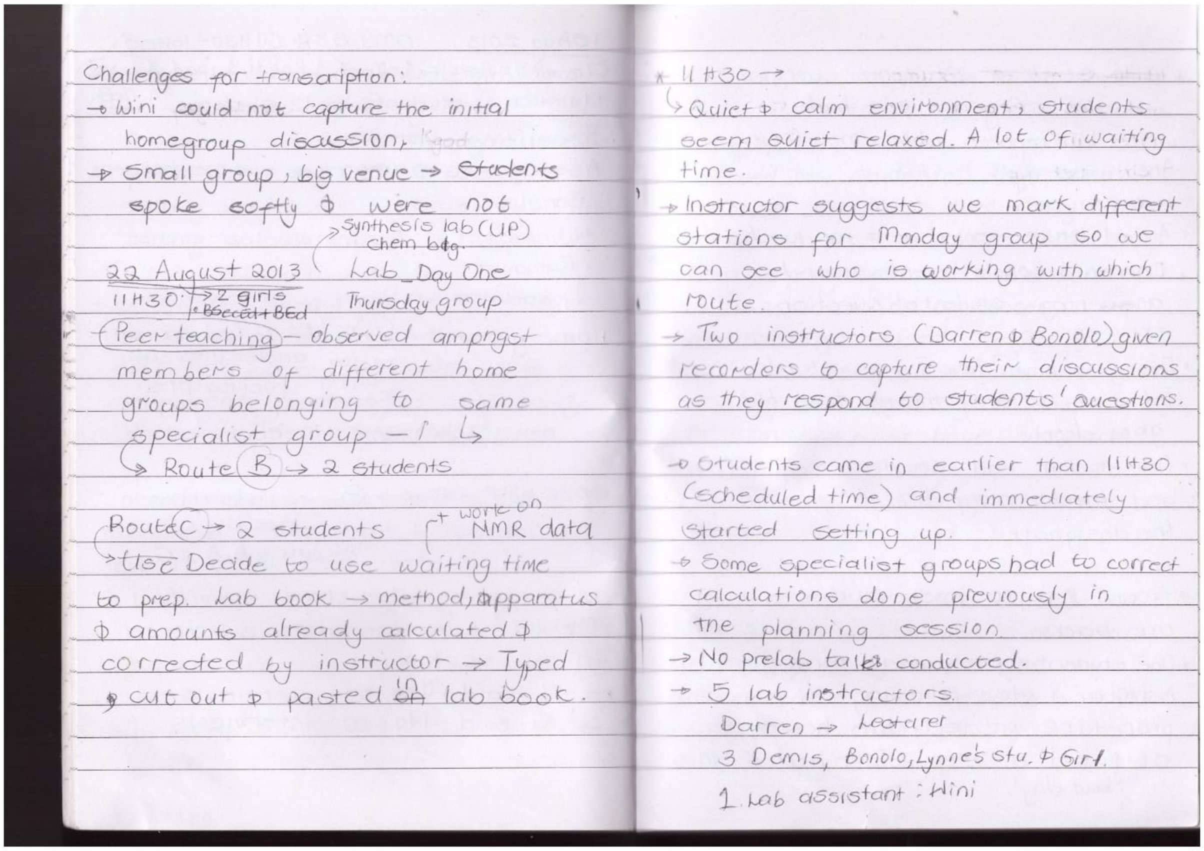
Home groups → (4)] Each had one of assistants as facilitators.
- delta
- alpha
- gamma

3 students in each

Specialist Group → 3 → 4 students in each
Routes A, B, & C.

12 students submitted Individual Pre-lab Questionnaires submitted in the beginning:
→ 7 said Yes to interviews
→ 5 said No to interviews.

Appendix 3.1: Pilot study field notes


Challenges for transcription:
→ Wini could not capture the initial homegroup discussion,
→ Small group, big venue → Students spoke softly & were not

22 August 2013
11H30 → 2 girls • BSc(Ed)+BEd
Lab_Day One → Synthesis lab (UP) chem bdg.
Thursday group

(Peer teaching) – observed amongst members of different home groups belonging to same specialist group
→ Route (B) → 2 students

Route (C) → 2 students + work on NMR data
→ Decide to use waiting time to prep. Lab book → method, apparatus & amounts already calculated & corrected by instructor → Typed & cut out & pasted in lab book.

* 11H30 →
→ Quiet & calm environment; students seem quiet relaxed. A lot of waiting time.
→ Instructor suggests we mark different stations for Monday group so we can see who is working with which route.
→ Two instructors (Darren & Bonolo) given recorders to capture their discussions as they respond to students' questions.

→ Students came in earlier than 11H30 (scheduled time) and immediately started setting up.
→ Some specialist groups had to correct calculations done previously in the planning session.
→ No prelab talks conducted.
→ 5 lab instructors.
Darren → Lecturer
3 Demis, Bonolo, Lynne's stu. & Girl.
1. Lab assistant: Wini

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Appendix 3.2
Main study field notes

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Appendix 3.2: Main study field notes

Monday Group   CMY 384 Prac
11 August 2014
Starting: 10H30 → 14H30

7 home groups
6 specialist groups
Facilitating: Darren & Dominique

10-30 → for few minutes home groups
11H30 — 14H30 – Specialist groups

*Home groups – not much activity
Specialist groups – ~~Disc~~ More discussing observed.

C1] Specialist group – ~~##~~ struggling

Consider → A1 & B1 + C1

Suggestion – Dom → Each specialist come with own rough work → procedure

A1 → Pedra's group
3 Girls – W, I, B
1 Guy – W
} (1) Conversation R

B1 → 3 student
WM
2 × WF
} fast + strong group (2) — Conversation Recorder

C1 → 3 students
2 BM
1 BF
} W Group. (3) → Iphone + mp3 player

B2 → 1 WM
1 BM
1 BF
} Landman (4) Olympus

A2 → 3WF } (5) Ipad

C2 → 1 BM
1 WM
1 WF
1 BF
} (6) Olympus

Darren → Bell Recorder
13 H53 → still specialist groups.

14h02 – Darren announces, stud have 15 mins before going into their home groups. Students are prompted to complete part 2 of the Specialist group RLSQs.
14h20 – students still in specialist groups
Group B1 still asking Darren – question
→ Still looking still relaxed
→ Very few left for lunch, some ate as they worked.

	In-lab Rec	Interv.
1. Rood	N	N
2. Mzimela	N	N
3. Nsingwane	N	N
4. Molwantoa	(Y)	N
5. Landman	N	N
6. EGAMBARAM	N	N
7. MOORE	(Y)	(Y)
8. MUSHOMBA	N	(Y)
9. MYBURGH	(Y)	N
10. PEDRA	(Y)	(Y)
11. KRIEL	N	(Y)
12. GULIWE	(Y)	N
13. MKHIZE	—	—
14. STEYTLER	(Y)	(Y)
15. MAKHATHENG	(Y)	(Y)
16. KRUGER	N	N
17. NAUDE'	N	M
17/19	7/19	8/19

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Appendix 3.2: Main study field notes

Present : Kgadi, MP, Lynne (facilitator)

Date 14 August 2014
Cmy 384 Thursday group Planning Session
11H30
7 Home groups

2 members → 2 groups
3 members → 5 groups
7 groups

NB! Interview previous year's students
→ How project better prepared them for honours pracs

→ Lynne encourages students to quickly complete HG RLSQ Part 1 as time is running out.
→
Sigma.
→ Lynne – leads them through RLSQ different from Darren on Monday

* i.e. Stop – Read through with students & allow them to discuss
* Home groups – more vocal than Monday's group.

Recorders used
mp3 player
Conversation Recorders x2
Ipad
iphone
Olympus recorders x2

12h05 – Specialist Groups
– Student given RLSQs together with ~~C2~~ Resources all at once. When answering part 1 of Specialist group RLSQ the lecturer urges them not to ~~use~~ make use of the resou
De

Description of Groups (Specialist)

B1 { 2 BF, 1 WF
B2 { 2 BF, 1 wm
C1 { 2 Bm, 1 wm } *
A2 { 1 Bm, 1 wm, 1 BF } (*)
C2 { 3 Bm, 1 BF } * { Look out for Actively involved
A1 { 2 BF, 1 wm

14H00 member of C1 → refer → C2
* Students – google info on their phones
N ↳ A2
↳ worked individually – 14h09
14h13 – Lecturer encourages stude. to take 5 minutes break.
→
Specialist groups → C1 & C2 – comparing notes 14h16 → Only these 2 groups
'about 2 students go out.

Str
14h44 → Lecturer announces that there's only 15 mins left for specialist group work
→ C2 – (Klaas) asks lecturer to confirm calculations.
– Lecturer – happy with their calculations.

Received: 19 Pre-lab Individual RLSQs

15h15 → Student regroup, Home group discussion

03h35 – Lecturer announces – 3 mins left.
Lynne explains assessment outcomes & give additional hints on work in lab & in team
– Reiterates referring to notes – how to write Lab notes

TLC as a tool for reaction monitoring

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Appendix 3.3
Pilot study interview schedule

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Appendix 3.3: Pilot study individual interview schedule

This is Kgadi Mathabathe. Today is the ______________ (date) it is now _____________(time). I am interviewing students about their experiences of the inquiry lab activity.

1. What is your name?
2. It has been three weeks since your organic chemistry pracs how much of the last practical activity do you remember?
3. With which home group were you working?
4. With which synthetic route were you working?
5. Did you find any value in the planning sessions?
6. Did the planning sessions better prepare you for the lab?
7. Did you leave the planning session knowing what to do next?
8. How did you experience working in home and specialist groups?
9. Did the group work help at all at enabling you to understand the work much better?
10. If asked to explain the prac to someone else could you explain it?
11. What did you like most about the activity as it was planned, i.e. four sessions – questionnaires, planning, lab and presentation sessions?
12. What did you not like most about the activity as it was planned?
13. Did it make a difference in enhancing your understanding what you were doing and why?
14. Did use of the questionnaires assist at all?
15. Did it make any difference in enhancing the quality of your report?
16. How different was it from the lab activities you have experienced previously?
17. What aspects of the lab activity do you think need changing and how?
18. Thinking of your previous lab experiences, did this activity achieve the goals of making you learn more and carry out your laboratory activities with understanding?

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Appendix 3.4

Pilot study list and duration of recordings

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Appendix 3.4 Pilot study recordings (2013)

Monday planning session (19 August 2013)

1. HG Z Part 2	00:9:48 (good)
2. HG Z Part 1	00:00: 21 (good)
3. SG MonA	2:30:00 (good)
4. HG O Part 1	00:00:46 & 00:4:54 (poor)
5. HG O Part 2	00:10:29 (poor)
6. SG MonB	2:28:09 (poor)

Thursday planning session (15 August 2013)

1. HG Delta after	00:17:19 (Good)
2. SG K	00:6:54 (Good but incomplete)
3. SG ThursA	2:22:10 (Good)
4. HG W Part 2	00:18:43 (Good)
5. HG B Part 2	00:14:15 (poor)
6. HG B Part 1	00:20:02 (poor)
7. HG X Parts 1 & 2	00:17:32 (poor and incomplete)
8. SG ThursB	2:30:37 (poor)
9. SG Thurs other	00:16:09 (poor and incomplete)

Pilot Interviews

1. Student Ay	00:16:17
2. Student Car	00:15:38
3. Student Christ	00:13:11
4. Student Clar	00:19:27
5. Student Kat	00:13:12
6. Student Leti	00:20:06
7. Student Marol	00:13:41
8. Student Nont	00:14:15
9. Student Rob	00:21:18
10. Student Siph	00:10:16

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Appendix 3.5

Main study list and duration of recordings

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Appendix 3.5 Main study Recordings (2014)

Monday planning session

HG Alpha before (26:11)

HG Alpha after (28:58)

HG Kappa before (34:02)

HG Kappa after (18:54)

HG Beta (29:55)

HG Delta before (22:39)

HG Delta after (22:03)

HG Epsilon before (25:25) – Ansie HG

HG Epsilon after (0:38)

HG Gamma before (25:28) – Bettie HG

HG Gamma after (45:26)

HG Pi before (20:30)

HG Pi after

SG A1 (3:16:09)

SG A2 (50:00, 50:00, 50:00, 50:00, 17:49) – *Team Bettie*

SG B1 (3:20:25)

SG B2 (3:12:19)

SG C1 (1:48:09)

SG C2 (26:11 – 3:39:05)

Thursday planning session

HG Iota before (26:21)

HG Iota after (31:15)

HG Lambda before (24:48)

HG Lambda after (30:31)

HG Omega before (25:57)

HG Omega after (29:56)

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Appendix 3.5 Main study Recordings (2014)

HG Omikron before (21:18, 0:29)

HG Omikron after (21:36)

HG Sigma before (26:25) – Leonard HG

HG Sigma after (30:49)

HG Theta before (26:22)

HG Theta after (27:58)

HG Zeta before (34:16) – Kagiso HG

HG Zeta after (30:31)

SG A1 (3:12:42)

SG B1 (3:15:17)

SG B2 (3:12:24)

SG C1 (3:12:09)

SG C2 (3:11:02) *Team Kagiso*

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Appendix 3.6

Invitation letters given to students prior to data collection

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Appendix 3.6 Letter of invitation

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Faculty of Natural and Agricultural Sciences

Department of Science, Mathematics and Technology Education

Groenkloof campus

Pretoria 0002

Republic of South Africa

Tel: +27 12 420 2758

Fax: +27 12 420 5621

Kgadi.mathabathe@up.ac.za

Dear student,

You are invited to participate in a research pilot project entitled: "**Exploring metacognitive activity in an inquiry third year organic chemistry laboratory**".

Through this study we wish to determine:

What aspects of metacognition (regulation of cognition) as indicators of metacognitive ability can be inferred from students' reflections, discussions and behaviour when an inquiry based laboratory activity with embedded reflection prompts is used during third year organic chemistry laboratory training?

As part of the study we would like to observe you as you carry out the laboratory task following an inquiry-based approach. We wish to observe you as you plan for the task, execute the task and present your findings. While carrying out the task you will be requested to answer a few questions that will prompt you to think about your thinking, task tackling strategies and understanding. This data will be used for analysis only if you have granted permission. This data will assist us as we attempt to answer the above question.

The results of this study will be published in scientific journals and presented in conferences. Findings of such a study also have the potential of informing the design of better and more engaging third year organic chemistry laboratory activities for future use.

Should you decide to participate, **the following terms will apply**:

1. Real names will not be used in any report(s); instead pseudonyms (fictitious names and codes) will be used in all spoken and written records and reports.
2. Your responses will be treated in a confidential manner and will only be accessed by you (the participant) and the researchers.
3. Nothing that you say or write in relation to the study will be revealed to other persons in a manner that will reveal your true identity.
4. Participation in this pilot project is voluntary; you have the right to withdraw at any point of the study, for any reason, and without any prejudice, and the information collected and records and reports written will be discarded.
5. At your request, the summary of the findings will be made available to you.
6. No direct benefits will be given to you.

If you agree to these terms and are willing to participate please sign the consent form attached to this invitation letter. To enrich the data, additional data collection by way of voice recordings of student-student and student-instructor interactions during laboratory sessions and 45 minutes individual interviews may be necessary, please indicate in the consent form whether you would be willing to be voice recorded while working in the laboratory and interviewed at the end of the laboratory activity.

If you have any questions or concerns about your participation in the study, please feel free to contact the researchers at the given contact details.

Yours truly,

Mrs Kgadi Mathabathe

23/05/2014

Signature of researcher **Date**

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Appendices 3.7
Specialist group interview schedule

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Appendices 3.7 Specialist group interview schedule

This is Kgadi Mathabathe. Today is the ______________ (date) it is now _____________(time). I am interviewing members of Specialist group _______________ about their experiences of metacognition as it pertains to a collaborative inquiry lab.

(*I will pose these questions and prompt each member of the group to respond to gather varying responses if any*)

1. Can each of you please say your names out loud?
2. As you might recall my research focuses on metacognition in a chemistry lab.

   Could you please explain what your understanding of metacognition is as a group? I would like to check if we are on the same page in terms of our understanding of the construct. (**My definition**: awareness of one's thoughts and the ability to monitor and control these thoughts during task execution – all this of course as an attempt of achieving successful task execution)

   In General:

   As a group and in light of how metacognition has just been explained to you, what key things stick in your minds from your experience of working as a group? (or How did you experience working in a group?)

   In Planning:

   I am going to play a few clips of audio recording which were captured as you were working in your specialist groups. The aim is not to embarrass anyone but to enable you to remember what was said, how it was said and who said it. (Researcher determined critical incidents)
3. How do you find the task of listening to yourselves and reflecting on what was said?
4. What are you learning about your own thinking from hearing yourselves?
5. Do you notice anything that demonstrates the metacognition of the group in these clips?

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Appendices 3.7 Specialist group interview schedule

6. Have you ever thought about this type of thinking before?
7. As you were busy extrapolating experimental procedures from available resources for your allocated route, were there any instances when you realised that the collective knowledge (or the knowledge of the group) and or understanding was inadequate? How did you deal with that?
8. Was there ever a situation when you realised that the group or some members of the group were not on track? How did you deal with that?
9. As part of the industrial project you were expected to complete the Specialist group RLSQ before and after working on the details of your allocated route. As a group, did you find any value in the RLSQ? If so, in what way?

In the Lab

10. As members of the same specialist group did you consult with each other in the lab? What were you talking about? What kinds of questions were you asking yourselves?
11. Why did you ask yourselves these questions?
12. Why did you use that kind of interaction i.e. consulting and thinking together with your specialist team members regarding the experiment?
13. Other than working together in the planning session and in the laboratory, did your work as a specialist group extend beyond the scheduled lab sessions? If so how?

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Appendices 3.8
Individual interview schedule

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Appendix 3.8 Individual interview schedule

This is Kgadi Mathabathe. Today is the _____________ (date) it is now ____________(time). I am interviewing students about their experiences of metacognition as it pertains to a collaborative inquiry lab.

1. What is your name?
2. It has been three weeks since your organic chemistry pracs how much of the last practical activity do you remember?
3. With which home group were you working?
4. With which synthetic route were you working?
5. As you might recall my research focuses on metacognition in a chemistry lab.
6. Could you please explain what metacognition is in your own words? I would like to check if we are on the same page in terms of our understanding of the construct. (**My definition**: awareness of one's thoughts and the ability to monitor and control these thoughts during task execution)
7. The industrial project i.e. your last practical investigation incorporated the following elements:
    - Four days dedicated to a single project (planning session, 2 days in the lab, presentations' session)
    - Extrapolating safety, apparatus and reagents data from a condensed experimental procedure
    - Working in home groups
    - Working in specialist groups
    - Being accountable to your home group members with regard to a particular synthetic route
    - Use of Reflective Learning Strategy Questionnaires (RLSQs)
    - Compiling an executive summary as a team
    - Collaborative presentation of results

    Could you please select the elements that you feel helped you to execute the task better and explain your choice.

    Now, can you rank the elements you have selected in terms of which developed your metacognitive ability of monitoring and regulating your thinking the most.

8. As part of the industrial project you were expected to complete four questionnaires, the Pre-lab, Home group, Specialist group and Post-lab Day 1 RLSQs. Did you find any value in the RLSQs? If so, in what way?

In the Planning session:

How did you monitor and control your thinking during the home group and the specialist group activities? *(I plan to use this question as an overarching question, the questions that follow will be asked as a follow up to student's response if necessary)*

During homegroup activity:

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Appendix 3.8 Individual interview schedule

9. Were you asking yourself questions or talking to yourself as you were working in your home group?
10. What were you talking about? What kinds of questions were you asking yourself?
11. Why did you ask yourself these questions?
12. Why did you use that kind of thinking?

During specialist group activity:

13. Were you asking yourself questions or talking to yourself as you were working in your specialist group?
14. What were you talking about? What kinds of questions were you asking yourself?
15. Why did you ask yourself these questions?
16. Why did you use that kind of thinking?

In the Lab:

How did you monitor and control your thinking as you were conducting your experiment in the lab?

17. Were you asking yourself questions or talking to yourself as you were conducting your experiment in the lab?
18. What were you talking about? What kinds of questions were you asking yourself?
19. Why did you ask yourself these questions?
20. Why did you use that kind of thinking?
21. Beyond the planning session on day one, who did you consult with more often, members of your home group or members of your specialist group?
22. What were you talking about? What kinds of questions were you asking?
23. Why did you ask these questions?
24. In the lab, did you consult with the lecturer or tutors? How often did you deem it necessary to ask questions? What kinds of questions were you asking?

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Appendices 3.9
Proof of ethics approval

Appendix 3.9 Ethics approval

UNIVERSITEIT VAN PRETORIA
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ETHICS COMMITTEE
Faculty of Natural and Agricultural Sciences

01 August 2013
Prof M Potgieter
Department of Chemistry
University of Pretoria
Pretoria
0002

Dear Prof Potgieter

EC130709-071: Exploring metacognitive activity in a third year guided-enquiry organic chemistry laboratory

This protocol conforms to the requirements of the NAS Ethics Committee.

Kind regards

Prof NH Casey
Chairman: Ethics Committee

Agriculture Building 10-20
University of Pretoria
Private bag X20, Hatfield 0028
Republic of South Africa

Tel: 012 420 4107
Fax: 012 420 3290

ethics.nas@up.ac.za

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Appendices 3.10
Letter of informed consent

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Appendix 3.10 Letter of informed consent

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Faculty of Natural and Agricultural Sciences

CONSENT FORM

I, ____ understand that:

1. The purpose of this study is to capture and analyse student discourse, written reflections and in-laboratory activities for manifestations of natural-in-action metacognition or metacognitive activity during a cooperative inquiry based third year organic chemistry laboratory activity with embedded reflection prompts.

2. Audio and video recording will be used to capture all activities.

3. As part of this study I will have to participate in more than one activity, i.e. planning for the laboratory experiment, carry out the laboratory experiment, write a laboratory report and present findings to peers, work with my peers in cooperative learning groups to complete the task and complete questions that will encourage me to think about my thinking and understanding while carrying out the task.

4. Any personal information about me that is collected during the study will be held in the strictest confidence and will not form part of my permanent record at the university.

5. I am not waiving any human or legal rights by agreeing to participate in this study.

6. My participation in this study is completely voluntary and I may withdraw participation if I decide to do so any time during the study.

I verify, by signing below, that I have read and understand the conditions listed above.

Signature : ____

Date : _________________________

<u>PLEASE COMPLETE FIELDS ON THE NEXT PAGE</u>

<u>IN-LAB VOICE RECORDING</u>

To capture your thoughts as you work in the laboratory you may be asked as part of a pre-selected home group to have a recorder with you at all times while you work in the laboratory. Please indicate below with a tick in the appropriate box, whether or not you would be willing to be voice recorded while you work in the laboratory.

Yes	
No	

<u>PARTICIPATION IN INTERVIEWS</u>

To enrich the data, collection of additional data by way of interviews may be necessary. Please indicate below with a tick in the appropriate box, whether or not you would be willing to be interviewed at the end of the laboratory activity.

Yes	

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Appendices 4.1
Examples of interrater coding comments

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Appendices 4.1 Examples of interrater coding comments

Interrater coding: Independent coder and researcher comments

Independent coder comments in Red

Researcher response highlighted in yellow

1. RENEILWE: Specialist group ah.. C-2, Reneilwe [*introduces herself*] Rene introduces herself
2. KAGISO: Kagiso [*introduces himself*] Kagiso introduces himself
3. LEONARD: Leonard! *[introduces himself*] Leonard introduces himself
4. AMOS: Amos [*introduces himself*] Amos introduces himself
5. RENEILWE: *O e stopile kae chomie mo ne*? (where did you stop it my friend is it here?) Rene asks a question…[I am not sure what the question was about therefore not coded]
6. KAGISO: *Ja* (Yes) Kagiso responded to Rene's question with a yes [not coded for same reason as in 5 above]
7. RENEILWE: oh we continue on okay what do I have to do? They didn't give us… Kagiso's yes clarifies for Rene what she had asked about in 5 above. Rene then confirms that they can continue and asks another question: *What do I have to do*? Seeking clarification??She then makes an incomplete statement: *They didn't give us* .. [CTRL-SR-T] I agree
8. LEONARD: do we have to speak loud or not really? No we need a specialist group thing. Leonard asks if they should speak louder [maybe in connection with the audio-recording that needed to take place-seeks clarification (ctrl)] He answers himself: No and points out that they need what he referred to as 'a specialist group thing' [Leonard has seen that something is missing that the group needs-seeks validation in connection with the task at hand (mon)-CTRL-MON-R-T. I agree this is a CONTROL statement because Leonard tries to explain to his peers that something is missing.
9. RENEILWE: they are gonna give it to us. Rene responds to Leonard that they were going to be given [Rene is aware of what Leonard is talking about and validates]. Agree

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Appendices 4.1 Examples of interrater coding comments

10. AMOS: relax guys, relax! *Ha ise le fetse le go ira dimechanism mara la* (You haven't even finished your mechanisms but you…) Amos encourages team members to relax and pointed out that they have not finished the mechanisms [Amos' comment implies that the team members were diverting attention to something else when they had not yet finished what they were currently working on. It's as if the team members were jumping to the next task before completing the task at hand so I see this as control of other in connection with the task-CTRL-OR-T]. I agree and will change accordingly
11. KAGISO: Are we not supposed to get a questionnaire? [*enquiring from the lecturer*] Kagiso makes inquiries from the lecturer about a questionnaire [Which I presume is the 'specialist group thing' Leonard was referring to in 8 above-Kagiso seeks clarification-CTRL] I agree I will therefore change it to CTRL_SR_T
12. LECTURER: a questionnaire? You are? Dirk have you still got them? Lecturer confirms that they need one.
13. LEONARD: *O ha ise le fetse go etsa mechanism* (this one hasn't even finished his mechanism) [*referring to team member*] Leonard comments that one team member hasn't finished his mechanism-evaluation-JUDG-OR-T We agree on this one
14. AMOS: *maar la phapha!* (but you guys are naughty!) [*referring to team members*] Amos comments that the team members are naughty [not clear whether the naughtiness was in connection with the task at hand but it is JUDG-OR] Amos is commenting on his team members' behavior thus I have coded this statement as JUDG_OR_BEHAV
15. LEONARD: *nna a ka fetsa go ira route C joe, wena o editse e otlhe?* (I have not finished doing route C man, have you done it all?) Leonard confirms that he has not finished doing route C[evaluation-JUDG-SR-T] and inquired if others have done everything [checking peers execution of task-MON-OR-T]. We agree on this one
16. AMOS: *ke editse route A le B* (I have done routes A and B) Amos confirms that he has done and finished routes A and B[??] I categorised such statements as substantive statements. These were not necessarily expressed with intentions to regulate cognition, task performance or behavior. **I see**

Appendices 4.1 Examples of interrater coding comments

17. LEONARD: *Eish!*(Oh no!) Leonard's response 'Eish' indicates a problem [Not clear what was problematic but it is evaluation-JUDG-SR-T?] I agree it indicates a problem but I interpreted this statement as not having enough information making it difficult to infer regulation of cognition from it. ok
18. KAGISO: the suggested route *ke* (is) this one right? Kagiso seeks confirmation of the correct route [can be considered checking understanding or seeking clarification-MON or CTRL-SR-T]. For this statement or rather question '18. KAGISO: the suggested route *ke* (is) this one right?' – when a statement ended with the word 'right' I interpreted it as a means for seeking validation for own thoughts about the task, i.e. Kagiso suspected that what was given was the suggested route but needed to confirm with his peers whether what he was thinking was correct. Hence, the statement was coded as MON_SR_COGN(T). I would have considered it a Control statement if it was phrased as 'is this the suggested route?'. See comment below, if I move 'seeking validation' into the CONTROL category then this statement will then be coded as a CONTROL statement. I will wait to hear your thinking about this. Your explanation makes sense. So I agree
19. RENEILWE: mmm [*agrees*] Rene confirms.
20. LEONARD: *ene C ke na le yona ne kere ke a copa daai boy* (and I do have route C I wanted to copy it from that boy) [I am not sure if the translation here is correct because if Leonard has route C already, why would he want to copy it from the other boy]. You are right, the correct translation should be '20.LEONARD: *ene C ke na le yona ne kere ke a copa daai boy* (and I do have route C **I wanted to copy, that boy**)' what had happened here is that their pre-lab assignments with their answers had been taken in by the student assistant, so I think he was saying that he had route C in his prelab assignment and the assistant took the assignment paper as he was trying to copy it.OK
21. KAGISO: and this is our starting material? [*asks team member*] Kagiso seeks confirmation regarding the starting material from team members [just as with 18 above, this can be checking understanding of seeking clarification about resource-MON or CTRL-SR-T] I

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agree that this sounds more like clarification seeking not validation seeking. I think it should be coded CTRL_SR_COGN(T)Agree

Appendices 4.1 Examples of interrater coding comments

22. RENEILWE: mm [*agrees*] Team member Rene confirms.
23. KAGISO: and we have to… thank you Kagiso's response has gaps but ends with a thank you
24. LEONARD: Who is writing? Leonard inquires from team members who will be recording (writing)[PLAN – I agree it should be PLAN_OR_TASK Ok
25. RENEILWE: *Chomie* (Friend) you have a better hand writing than I have. Rene affectionately suggests that a team member has better handwriting than her with implications that he should do the writing[JUDG-CTRL-OR-T] – I agree that it is both a judgements and a control statement but I think it is better placed as a planning statement on the basis that it falls under negotiation of roles and responsibilities so I can code it as PLAN_OR_TASK. What do you think? ok
26. LEONARD: I can't even read my own hand writing, let's do this quick. Leonard comments that he cannot read his own handwriting[leonard evaluates own handwriting] and then urges the team that they should quickly do what they have to do [JUDG-SR-CTRL-OR-T] – The first part I agree is an evaluative statement thus JUDG_SR_T, and the second part I had initially interpreted as regulation of behavior but I see your point here that it is a regulation of task performance hence, CTRL_OR_T Agree

Note: I struggled with seeking clarification from peers which is CONTROL and expressions in the form of questions with intentions to check understanding which falls under monitoring

I get your point with regard to the difficulty of distinguishing clarification and monitoring statements. I have categorized 'seeking validation or confirmation' as a monitoring statement and interpreted it as students bouncing off what their thinking on their peers and expecting them to confirm or disconfirm. But I struggle with my interpretation as well, I will categorise such statements as attempts of CONTROL i.e. as statements (questions) that students make to ensure that they are thinking along right lines by seeking validation and/or clarification from their peers or lecturer – what do you think?

Your explanation in 18 above clarified your decision for that particular instance. So maybe what is important is consistence and maybe rewording of the descriptions of CONTROL so that it is clearly different to MONITORING. Sorry, I could not do more as typing down my thinking and basis for

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my coding was rather time consuming. If you still need more validation, we can discus one or two more pages at the next PhD weekend.

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Appendices 4.2
Calculations of interrater reliability

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Appendices 4.2 Calculations of interrater reliability

Main Study <u>Initial</u> Interrater coding

Turn	Researcher	Independent coder
1	Non-MR	
2	Non-MR	
3	Non-MR	
4	Non-MR	
5	Non-MR	
6	Non-MR	
7	MON	CTRL
8	CTRL	CTRL
9	Non-MR	
10	EVAL	CTRL
11	MON	CTRL
12	Non-MR	
13	EVAL	EVAL
14	EVAL	EVAL
15	EVAL/MON	EVAL/MON
16	Non-MR	
17	Non-MR	
18	MON	MON/CTRL
19	Non-MR	
20	Non-MR	
21	MON	MON/CTRL
22	Non-MR	
23	Non-MR	
24	MON	PLAN
25	EVAL	EVAL
26	CTRL_BEHAV	CTRL_TASK

	PLAN	**MON**	**CTRL**	**EVAL**	**TOTAL**
PLAN	0	0	0	0	**0**
MON	1	1	4	0	**6**
CTRL	0	0	2	0	**2**
EVAL	0	0	1	3	**4**
TOTAL	**1**	**1**	**7**	**3**	**12**

$\sum_{\text{agreements}} = 0 + 1 + 2 + 3 = 6$

$$Expected\ frequency = \frac{row\ total\ \times column\ total}{overall\ total}$$

Expected frequency (PLAN) = (0 x 1)/12 = 0

Appendices 4.2 Calculations of interrater reliability

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Appendices 4.2 Calculations of interrater reliability

Expected frequency (MON) = (6 x 1)/12 = 0.5

Expected frequency (CTRL) = (2 x 7)/12 = 1.2

Expected frequency (EVAL) = (4 x 3)/12 = 1

	PLAN	**MON**	**CTRL**	**EVAL**
PLAN	0 (0)	0	0	0
MON	1	1 (0.5)	4	0
CTRL	0	0	2 (1.2)	0
EVAL	0	0	1	3 (1.0)

$\sum_{\text{expected frequencies}} = 0 + 0.5 + 1.2 + 1.0 = 2.7$

$$Kappa = \frac{\sum_{agreements} - \sum_{expected\ frequencies}}{N - \sum_{expected\ frequencies}}$$

$$Kappa = \frac{6 - 2.7}{12 - 2.7} = 0.35$$

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Appendices 4.2 Calculations of interrater reliability

Main Study <u>Revised</u> Interrater coding

Turn	Researcher	Independent coder
1	Non-MR	
2	Non-MR	
3	Non-MR	
4	Non-MR	
5	Non-MR	
6	Non-MR	
7	~~MON~~ CTRL	CTRL
8	CTRL	CTRL
9	Non-MR	
10	~~EVAL~~ CTRL	CTRL
11	~~MON~~ CTRL	CTRL
12	Non-MR	
13	EVAL	EVAL
14	EVAL	EVAL
15	~~EVAL/~~MON	~~EVAL/~~MON
16	Non-MR	
17	Non-MR	
18	MON	MON/CTRL
19	Non-MR	
20	Non-MR	
21	MON	MON/CTRL
22	Non-MR	
23	Non-MR	
24	~~MON~~ PLAN	PLAN
25	EVAL	EVAL
26	~~CTRL_BEHAV~~ CTRL_TASK	CTRL_TASK

	PLAN	**MON**	**CTRL**	**EVAL**	**TOTAL**
PLAN	1	0	0	0	**1**
MON	0	1	0	0	**1**
CTRL	0	2	5	0	**7**
EVAL	0	0	0	3	**3**
TOTAL	**1**	**3**	**5**	**3**	**12**

$\sum_{\text{agreements}} = 1 + 1 + 5 + 3 = 10$

$$Expected\ frequency = \frac{row\ total\ \times column\ total}{overall\ total}$$

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Appendices 4.2 Calculations of interrater reliability

Expected frequency (PLAN) = (1 x 1)/12 = 0.08

Expected frequency (MON) = (1 x 3)/12 = 0.25

Expected frequency (CTRL) = (7 x 5)/12 = 2.92

Expected frequency (EVAL) = (3 x 3)/12 = 0.75

	PLAN	**MON**	**CTRL**	**EVAL**
PLAN	0 (0.08)	0	0	0
MON	1	1 (0.25)	4	0
CTRL	0	0	2 (2.92)	0
EVAL	0	0	1	3 (0.75)

$\sum_{\text{expected frequencies}} = 0.08 + 0.25 + 2.92 + 0.75 = 4$

$$Kappa = \frac{\sum_{agreements} - \sum_{expected\ frequencies}}{N - \sum_{expected\ frequencies}}$$

$$Kappa = \frac{10 - 4}{12 - 4} = 0.75$$

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Appendices 4.3 – 4.9

Profile maps of patterns of metacognitive regulation for each student in *Team Kagiso* and *Team Bettie*

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Appendix 4.3 Manifestations of Self- and Other-regulation by Kagiso (*Team Kagiso*)

Planning (12)		Monitoring (82)	
SR (0)	**OR (12)**	**SR (43)**	**OR (39)**
COGN(C) [PLAN_SR_COGN(C)]	**COGN(C) [PLAN_OR_COGN(C)]**	**COGN(C) [MON_SR_COGN(C)] (28)** seeks validation of thought about the chemistry (28)	**COGN(C) [MON_OR_COGN(C)] (4)** checks peer's understanding about the chemistry (4)
COGN(T) [PLAN_SR_COGN(T)]	**COGN(T) [PLAN_OR_COGN(T)]**	**COGN(T) [MON_SR_COGN(T)] (11)** checks own understanding about the task with peer (3), checks task requirements with peers (1), checks with peers how best to approach task (1), seeks validation of thought about task (6)	**COGN(T) [MON_OR_COGN(T)] (4)** checks peer's reasoning about the task (1),checks if peer understands what he is saying (1), checks peer's understanding of task instructions (2)
BEHAV [PLAN_SR_BEHAV]	**BEHAV [PLAN_OR_BEHAV]**	**BEHAV [MON_SR_BEHAV]**	**BEHAV [MON_OR_BEHAV]**
TASK [PLAN_SR_TASK]	**TASK [PLAN_OR_TASK] (12)** negotiates roles and responsibilities (3), negotiates time required in lab (1), proposes strategy for sharing info with peers (1), proposes strategy to optimise task performance (7),	**TASK [MON_SR_TASK] (4)** checks group's progress on task with peer (1), checks own progress on task (1), checks own task performance (1), checks with peers how task should be performed (1)	**TASK [MON_OR_TASK] (31)** checks peer's performance of task (14), checks peer's progress on task (11), checks peers' progress on task (3), checks progress on task of group (2), checks with lecturer about groups' performance of task (1)

Control (302)		Evaluation (20)	
SR (90)	**OR (212)**	**SR (15)**	**OR (5)**
COGN(C) [CTRL_SR_COGN(C)] (66) activates own memory about the chemistry (2), corrects own thinking about the chemistry (6), seeks clarification from lab assistant about the chemistry (5), seeks clarification from lecturer about the chemistry (15), seeks clarification from peer about the chemistry (38)	**COGN(C) [CTRL_OR_COGN(C)] (149)** activates peer's prior experience (1), activates peer's prior knowledge (1), affirms peer's thinking about the chemistry (12), clarifies peer's thinking about the chemistry (82), corrects peer's thinking about the chemistry (19), critiques peer's thinking about the chemistry (5), draws peer's attention to information given (1), explains the chemistry to peer (13), justifies own thinking about the chemistry (7), questions peer's thinking about the chemistry (7), asks peer to elaborate (1)	**COGN(C) [JUDG_SR_COGN(C)] (12)** makes judgement about own knowledge (8), makes judgement about own memory (2), makes judgement about own understanding of the chemistry concepts(2)	**COGN(C) [JUDG_OR_COGN(C)]**
COGN(T) [CTRL_SR_COGN(T)] (13) seeks clarification from lecturer about the task (6), seeks clarification from peer about the task (7)	**COGN(T) [CTRL_OR_COGN(T)] (33)** affirms peer's thinking about the task (2), clarifies own thinking about task to peers (1), clarifies peer's thinking about the task (12), clarifies task to peers (1), corrects peer's thinking about his thinking about the task (2), corrects peer's thinking about task (3), critiques peer's thinking about task performance (3), critiques peer's thinking about task (3), explains task instructions to peer (3), justifies own task performance to peer (1), urges peer to carefully think about task (1), urges peers to consider other factors before making decisions (1)	**COGN(T) [JUDG_SR_COGN(T)**	**COGN(T) [JUDG_OR_COGN(T)]**
BEHAV [CTRL_SR_BEHAV]	**BEHAV [CTRL_OR_BEHAV] (3)** corrects peer's pronunciation (1), instructs peer to keep quiet (1), urges peer to wait (1),	**BEHAV [JUDG_SR_BEHAV]**	**BEHAV [JUDG_OR_BEHAV]**
TASK [CTRL_SR_TASK] (11) seeks clarification from lecturer about task performance(6), seeks clarification from peer about task performance (5)	**TASK [CTRL_OR_TASK] (27)** affirms peer's task performance (2), corrects peer's calculations (1), critiques peer's task performance (2), draws peer's attention to given information (2), draws peers' attention to task requirements (2), draws peers' attention to task (4), instructs peer how to perform task (5), point out information as important to peer (1), volunteers approach for task performance (4), urges peer to proceed with task (3), urges peer to allow him time to work on task (1)	**TASK [JUDG_SR_TASK] (3)** makes judgement about correctness of own calculations (1), makes judgement about own completion of task (2)	**TASK [JUDG_OR_TASK] (5)** makes judgement about group's task completion (3), makes judgement about peer's task performance (2)

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Appendix 4.4 Manifestations of Self- and Other-regulation by Amos (*Team Kagiso*)

Planning (7)		**Monitoring (73)**	
SR (0)	**OR (7)**	**SR (57)**	**OR (16)**
COGN(C) [PLAN_SR_COGN(C)]	**COGN(C) [PLAN_OR_COGN(C)]**	**COGN(C) [MON_SR_COGN(C)] (49)** seeks validation of thought about the chemistry (49)	**COGN(C) [MON_OR_COGN(C)] (3)** checks peer's knowledge (1), checks peer's understanding about the chemistry (1), checks with peer if he/she can remember experiment technique (1)
COGN(T) [PLAN_SR_COGN(T)]	**COGN(T) [PLAN_OR_COGN(T)]**	**COGN(T) [MON_SR_COGN(T)] (4)** seeks validation of thought about the task (4)	**COGN(T) [MON_OR_COGN(T)] (2)** checks peer's understanding about the task (2)
BEHAV [PLAN_SR_BEHAV]	**BEHAV [PLAN_OR_BEHAV]**	**BEHAV [MON_SR_BEHAV]**	**BEHAV [MON_OR_BEHAV]**
TASK [PLAN_SR_TASK]	**TASK [PLAN_OR_TASK] (7)** enquires about roles and responsibilities (1), instructs peer to take a picture of MSDS file (1), negotiates roles and responsibilities (1), puts forth plan to optimise task performance (4)	**TASK [MON_SR_TASK] (4)** checks own progress on task (1), checks progress on task with peer (3)	**TASK [MON_OR_TASK] (11)** checks group's performance on task (2), checks peer's performance of task (4), checks peer's progress on task (5)
Control (176)		**Evaluation (11)**	
SR (86)	**OR (90)**	**SR (4)**	**OR (7)**
COGN(C) [CTRL_SR_COGN(C)] (79) seeks clarification from lab assistant about the chemistry(1), seeks clarification from peer about the chemistry (78)	**COGN(C) [CTRL_OR_COGN(C)] (42)** activates peer's prior knowledge (1), clarifies peers thinking about the chemistry (21), critiques peer's thinking about the chemistry (6), justifies own thinking to peer (4), questions peer's thinking about the chemistry (10)	**COGN(C) [JUDG_SR_COGN(C)] (2)** judgement about own knowledge (1), judgement about own understanding (1)	**COGN(C) [JUDG_OR_COGN(C)]**
COGN(T) [CTRL_SR_COGN(T)] (6) seeks clarification from peer about the task(6)	**COGN(T) [CTRL_OR_COGN(T)] (9)** clarifies peer's thinking about task (3), corrects peer's thinking about the task (3), questions peer's thinking about task performance (1), questions peer's thinking about the task (2)	**COGN(T) [JUDG_SR_COGN(T)**	**COGN(T) [JUDG_OR_COGN(T)]**
BEHAV [CTRL_SR_BEHAV]	**BEHAV [CTRL_OR_BEHAV] (7)** calls peer(s) to order (2), urges peer to relax (4), urges peer to look at own work (1)	**BEHAV [JUDG_SR_BEHAV]**	**BEHAV [JUDG_OR_BEHAV] (2)** judgement about peers' behavior (2)
TASK [CTRL_SR_TASK] (1) seeks information from peers about task performance (1)	**TASK [CTRL_OR_TASK] (32)** critiques peer's task performance (3), draws peer's attention to experimental procedure requirements (1), justifies task performance (1), points out missing information (1), points out overlooked information (1), reminds peer about task instructions (1), suggests time to budget for (1), urges peer to finish task (2), urges peer to get on with task (12), urges peer to give answer (3), urges peer to start working on task (2), volunteers approach for task performance (4)	**TASK [JUDG_SR_TASK] (2)** makes judgement about own completion of task (2)	**TASK [JUDG_OR_TASK] (5)** judgement about task difficulty (1), makes judgement about group's task completion (1), makes judgement about peer's performance of task (3)

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Appendix 4.5 Manifestations of Self- and Other-regulation by Leonard (*Team Kagiso*)

Planning (14)		Monitoring (37)	
SR (0)	**OR (14)**	**SR (15)**	**OR (22)**
COGN(C) [PLAN_SR_COGN(C)]	**COGN(C) [PLAN_OR_COGN(C)]**	**COGN(C) [MON_SR_COGN(C)] (10)** checks own understanding about the chemistry with peer (1), seeks validation of thought about the chemistry (9)	**COGN(C) [MON_OR_COGN(C)] (4)** checks peer's memory (1), checks peer's understanding about the chemistry (2), checks peer's understanding (1)
COGN(T) [PLAN_SR_COGN(T)]	**COGN(T) [PLAN_OR_COGN(T)]**	**COGN(T) [MON_SR_COGN(T)] (2)** checks own understanding of task with peers (2)	**COGN(T) [MON_OR_COGN(T)] (2)** checks peer's understanding about task (2)
BEHAV [PLAN_SR_BEHAV]	**BEHAV [PLAN_OR_BEHAV]**	**BEHAV [MON_SR_BEHAV]**	**BEHAV [MON_OR_BEHAV] (1)** checks how peer feels about his behavior (1)
TASK [PLAN_SR_TASK]	**TASK [PLAN_OR_TASK] (14)** enquires about roles and responsibilities (2), negotiates roles and responsibilities (8), negotiates task execution approach (1), Puts forth plan to optimise task performance (3)	**TASK [MON_SR_TASK] (3)** checks with peer about task performance (2), seeks validation of task performance (1)	**TASK [MON_OR_TASK] (15)** checks peer's task performance (7), checks peers' progress on task (6), checks progress on task with peers (1), checks resource availability (1)

Control (175)		Evaluation (12)	
SR (49)	**OR (126)**	**SR (5)**	**OR (7)**
COGN(C) [CTRL_SR_COGN(C)] (24) corrects own thinking about the chemistry (2), searches info from the web (1), seeks clarification from lecturer (7), seeks clarification from peer (14)	**COGN(C) [CTRL_OR_COGN(C)] (74)** activates peer's prior knowledge (1), affirms peer's thinking about the chemistry (7), clarifies peer's thinking about the chemistry (47), corrects peer's thinking about the chemistry (8), explains chemistry to peer (1), critiques peer's thinking about the chemistry (1), explains chemistry to peer (1), justifies own thinking about the chemistry (6), points out information as important (1), questions peer's thinking about the chemistry (1)	**COGN(C) [JUDG_SR_COGN(C)] (2)** makes judgement about own knowledge (2)	**COGN(C) [JUDG_OR_COGN(C)] (1)** judgement about group knowledge (1)
COGN(T) [CTRL_SR_COGN(T)] (24) seeks clarification from lecturer (9), seeks clarification from peers (15)	**COGN(T) [CTRL_OR_COGN(T)] (12)** affirms peer's thinking about the task (2), clarifies peer's thinking about the task (4), corrects peer's thinking about task performance (2), questions peer's thinking about task (1), justifies own task performance to peer (3), questions peer's thinking about task	**COGN(T) [JUDG_SR_COGN(T) (1)** judgement about own understanding (1)	**COGN(T) [JUDG_OR_COGN(T)]**
BEHAV [CTRL_SR_BEHAV]	**BEHAV [CTRL_OR_BEHAV] (12)** calls peer to order (2), instructs peers to listen (2), urges peer not to worry (1), urges peer to relax (4), urges peer to wait (1), urges peers to keep it together (1), urges peers to relax (1)	**BEHAV [JUDG_SR_BEHAV]**	**BEHAV [JUDG_OR_BEHAV] (1)** makes judgement about peer's behavior (1)
TASK [CTRL_SR_TASK] (1) Seeks clarification from peers (10	**TASK [CTRL_OR_TASK] (28)** critiques peer's task performance (2), draws peer's attention to task (1), draws peers' attention to task requirements (1), explains approach for task performance (1), instructs peer how to perform task (8), points out missing information (1), urges increase in speed (2), urges peer to relax (1), urges peer to wait (6), urges peers to mind their own work (1), volunteers approach for task performance (4)	**TASK [JUDG_SR_TASK] (2)** judgement about own task performance (2)	**TASK [JUDG_OR_TASK] (5)** judgement about group's task completion (2), judgement about peer's task performance (3)

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Appendix 4.6 Manifestations of Self- and Other-regulation by Reneilwe (*Team Kagiso*)

Planning (18)		Monitoring (38)	
SR (3)	**OR (15)**	**SR (24)**	**OR (14)**
COGN(C) [PLAN_SR_COGN(C)]	**COGN(C) [PLAN_OR_COGN(C)]**	**COGN(C) [MON_SR_COGN(C)] (9)** seeks validation of thought about the chemistry (9)	**COGN(C) [MON_OR_COGN(C)] (1)** checks peer's knowledge (1)
COGN(T) [PLAN_SR_COGN(T)]	**COGN(T) [PLAN_OR_COGN(T)]**	**COGN(T) [MON_SR_COGN(T)] (10)** checks own understanding about task (4), checks task requirements with peer (4), seeks validation of thought about the task (2)	**COGN(T) [MON_OR_COGN(T)]**
BEHAV [PLAN_SR_BEHAV]	**BEHAV [PLAN_OR_BEHAV]**	**BEHAV [MON_SR_BEHAV]**	**BEHAV [MON_OR_BEHAV]**
TASK [PLAN_SR_TASK] (3) negotiates own roles and responsibilities (1), proposes strategy for own task performance (2)	**TASK [PLAN_OR_TASK] (15)** Negotiates peer(s)' roles and responsibilities (3), negotiates time required in lab (2), proposes strategy to optimise task performance (10)	**TASK [MON_SR_TASK] (5)** checks time left with peer (1), checks with peer about how best to perform task (4)	**TASK [MON_OR_TASK] (13)** checks peer's task performance (7), checks peers' task performance (4), checks task completion with peer (2**)**

Control (151)		Evaluation (4)	
SR (48)	**OR (103)**	**SR (3)**	**OR (1)**
COGN(C) [CTRL_SR_COGN(C)] (26) clarifies own thinking about the chemistry (1), seeks clarification from peer(s) about the chemistry (25)	**COGN(C) [CTRL_OR_COGN(C)] (42)** activates peers memory (6), corrects peer's thinking about the chemistry (2), validates peer's thinking about the chemistry (1), clarifies peer's thinking about the chemistry (31), affirms peer's thinking about chemistry (2)	**COGN(C) [JUDG_SR_COGN(C)] (1)** makes judgement about own understanding of the chemistry (1)	**COGN(C) [JUDG_OR_COGN(C)]**
COGN(T) [CTRL_SR_COGN(T)] (16) corrects own thinking about the task (1), seeks clarification from peer about the task(15)	**COGN(T) [CTRL_OR_COGN(T)] (25)** affirms peer's thinking about the task (2), clarifies peer's thinking about the task (10), corrects peer's thinking about task (7), critiques peer's thinking about task (1), regulates peers' thinking about the task (1), urges peers to wait and rethink (1) urges peer to continue with task (3)	**COGN(T) [JUDG_SR_COGN(T)**	**COGN(T) [JUDG_OR_COGN(T)]**
BEHAV [CTRL_SR_BEHAV]	**BEHAV [CTRL_OR_BEHAV] (14)** calls peer(s) to order (11), instructs peer to keep quiet (1), urges decrease of speed (1) urges peer not to worry (1)	**BEHAV [JUDG_SR_BEHAV]**	**BEHAV [JUDG_OR_BEHAV]**
TASK [CTRL_SR_TASK] (6) seeks clarification from peer about task performance(6)	**TASK [CTRL_OR_TASK] (22)** clarifies task performance expectations to peer (1), draws peer's attention to given information (2), draws peer's attention to task performance requirements (5), draws peers' attention to amount of work to be completed (2), draws peers' attention to task performance(9), instructs peer how to perform task (1), reminds peer of task performance strategy (1), urges peer to check resources given (1)	**TASK [JUDG_SR_TASK] (2)** makes judgement about own completion of task (2)	**TASK [JUDG_OR_TASK] (1)** makes judgement about group's task completion (1)

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Appendix 4.7 Manifestations of Self- and Other-regulation by Bettie (*Team Bettie*)

Planning (11)		Monitoring (34)	
SR (1)	**OR (10)**	**SR (19)**	**OR (15)**
COGN(C) [PLAN_SR_COGN(C)]	**COGN(C) [PLAN_OR_COGN(C)]**	**COGN(C) [MON_SR_COGN(C)] (18)** checks if she understands peer's question about the chemistry (1), checks own understanding about the chemistry (1), seeks validation of thought about the chemistry (16)	**COGN(C) [MON_OR_COGN(C)] (7)** checks if peer understands what she is saying (2), checks peer's thinking about the chemistry (2), checks peer's understanding about the chemistry (3)
COGN(T) [PLAN_SR_COGN(T)]	**COGN(T) [PLAN_OR_COGN(T)]**	**COGN(T) [MON_SR_COGN(T)]**	**COGN(T) [MON_OR_COGN(T)]**
BEHAV [PLAN_SR_BEHAV]	**BEHAV [PLAN_OR_BEHAV]**	**BEHAV [MON_SR_BEHAV]**	**BEHAV [MON_OR_BEHAV]**
TASK [PLAN_SR_TASK] (1) proposes how to spend waiting time (1)	**TASK [PLAN_OR_TASK] (10)** proposes strategy to optimise task performance (10)	**TASK [MON_SR_TASK] (1)** seeks validation for task performance proposal (1)	**TASK [MON_OR_TASK] (8)** checks if peer is alright (1), checks peer's task performance (2), checks peer's views about team's task performance (1), checks team's progress on task (1), checks team's task performance (2), checks with peers what task to perform next (1)

Control (333)		Evaluation (21)	
SR (99)	**OR (234)**	**SR (15)**	**OR (6)**
COGN(C) [CTRL_SR_COGN(C)] (84) clarifies own thinking about the chemistry (21), corrects own thinking about the chemistry (6), seeks clarification from lab assistant about the chemistry (12), seeks clarification from lecturer about the chemistry (4), seeks clarification from peer about the chemistry (41)	**COGN(C) [CTRL_OR_COGN(C)] (181)** affirms peer's thinking about the chemistry (41), clarifies peer's thinking about the chemistry (70), corrects peer's thinking about the chemistry (24), critiques peers' thinking about the chemistry (4), draws peer's attention to given information (1), explains the chemistry to peers (8), justifies own thinking about the chemistry to peers (16), objects to peer's thinking about the chemistry (2), points out important aspect of task for team to consider (3), points out important information to peer (1), questions peer's thinking about the chemistry (9), reminds peer of important aspect of task (2)	**COGN(C) [JUDG_SR_COGN(C)] (13)** makes judgement about own knowledge of the chemistry (4), makes judgement about own understanding of the chemistry (9)	**COGN(C) [JUDG_OR_COGN(C)]**
COGN(T) [CTRL_SR_COGN(T)] (6) clarifies own thinking about the task (2), seeks clarification from lab assistant about the task (1), seeks clarification from peer about the task (3)	**COGN(T) [CTRL_OR_COGN(T)] (5)** clarifies peers' thinking about the task (4), justifies own thinking about task to peers (1)	**COGN(T) [JUDG_SR_COGN(T)] (1)** makes judgement about own understanding of the task instructions (1)	**COGN(T) [JUDG_OR_COGN(T)]**
BEHAV [CTRL_SR_BEHAV]	**BEHAV [CTRL_OR_BEHAV] (7)** urges peer to repeat what they just said (1), urges peer to wait (6)	**BEHAV [JUDG_SR_BEHAV]**	**BEHAV [JUDG_OR_BEHAV]**
TASK [CTRL_SR_TASK] (9) justifies own task performance (1), plans own task performance (4), seeks clarification from peer about task performance (4)	**TASK [CTRL_OR_TASK] (41)** affirms peer's proposal for task performance (2), affirms peer's task performance (1), asks peer to explain task performance (1), cautions peers about task performance (1), clarifies peers' thinking about task performance (1), corrects peer's thinking about task performance (1), draws peer's attention to important aspect of task (1), draws peers' attention back to task (2), draws peers' attention to the amount of work (1), draws peers' attention to time left (1), explains own task performance to peers (3), instructs peer how to perform task (3), justifies own task performance to peers (6), proposes how team should perform task (1), seeks clarification from peers about task performance (2), updates peer on own task performance (4), updates peer on team's task performance (1), urges peer to check given information (1), urges peers to consult (1), urges peers to write down their work (1), urges team members to take a break (1), urges team to proceed with the task (4), urges team to seek clarity from lecturer (1)	**TASK [JUDG_SR_TASK] (1)** makes judgement about own task performance (1)	**TASK [JUDG_OR_TASK] (6)** makes judgement about group's task performance (3), makes judgement about team's progress on task (2), makes judgement about team's task completion (1)

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Appendix 4.8 Manifestations of Self- and Other-regulation by Ansie (*Team Bettie*)

Planning (6)		Monitoring (29)	
SR (0)	**OR (6)**	**SR (9)**	**OR (20)**
COGN(C) [PLAN_SR_COGN(C)]	**COGN(C) [PLAN_OR_COGN(C)]**	**COGN(C) [MON_SR_COGN(C)] (9)** seeks validation of thought about the chemistry (9)	**COGN(C) [MON_OR_COGN(C)] (7)** checks peer's thinking about the chemistry (6), checks what peers find confusing (1)
COGN(T) [PLAN_SR_COGN(T)]	**COGN(T) [PLAN_OR_COGN(T)]**	**COGN(T) [MON_SR_COGN(T)]**	**COGN(T) [MON_OR_COGN(T)]**
BEHAV [PLAN_SR_BEHAV]	**BEHAV [PLAN_OR_BEHAV]**	**BEHAV [MON_SR_BEHAV]**	**BEHAV [MON_OR_BEHAV]**
TASK [PLAN_SR_TASK]	**TASK [PLAN_OR_TASK] (6)** points out important aspect for future consideration of team (1), points out important future aspect for consideration (2), (proposes strategy to optimise task performance (3)	**TASK [MON_SR_TASK]**	**TASK [MON_OR_TASK] (13)** checks peer's progress on task (1), checks peer's task performance (9), checks team's task performance (1), checks teams progress on task (1), checks with peer how task should be completed (1)

Control (184)		Evaluation (7)	
SR (64)	**OR (120)**	**SR (4)**	**OR (3)**
COGN(C) [CTRL_SR_COGN(C)] (55) clarifies own thinking about the chemistry (5), corrects own thinking about the chemistry (1), seeks clarification from lab assistant about the chemistry (1), seeks clarification from peer about the chemistry (48)	**COGN(C) [CTRL_OR_COGN(C)] (96)** affirms peer's thinking about the chemistry (19), clarifies peer's thinking about the chemistry (42), corrects peer's thinking about the chemistry (10), draws peers' attention to important information (5), justifies own thinking about the chemistry (1), points out important aspect to consult about (1), questions peer's thinking about the chemistry (14), reminds peer of important aspect of chemistry (1), reminds the team of what the lab assistant said (2), urges peer to consult with lab assistant (1)	**COGN(C) [JUDG_SR_COGN(C)] (3)** make judgement about own thinking about the chemistry (1), makes judgement about own understanding of the chemistry (2)	**COGN(C) [JUDG_OR_COGN(C)] (1)** makes judgement about team's understanding of the chemistry (1)
COGN(T) [CTRL_SR_COGN(T)] (9) seeks clarification from lab assistant about the task (1), seeks clarification from peer about the task (8)	**COGN(T) [CTRL_OR_COGN(T)] (10)** affirms peer's suggestion for task performance (1), clarifies peer's thinking about the task (3), clarifies peers' thinking about task performance (1), clarifies peers' thinking about the task (3), justifies own thinking about the task to peers (1), Makes team aware of length of task (1)	**COGN(T) [JUDG_SR_COGN(T)] (1)** makes judgement about own understanding of task (1)	**COGN(T) [JUDG_OR_COGN(T)]**
BEHAV [CTRL_SR_BEHAV]	**BEHAV [CTRL_OR_BEHAV] (1)** urges peers to remain focused (1)	**BEHAV [JUDG_SR_BEHAV]**	**BEHAV [JUDG_OR_BEHAV]**
TASK [CTRL_SR_TASK]	**TASK [CTRL_OR_TASK] (13)** affirms peer's proposal for task performance (1), affirms peer's task performance (1), clarifies peer's task performance (1), clarifies peer about task performance (1), critiques peer's task performance (1), explains own task performance to peers (1), instructs peer how to perform task (2), justifies own task performance to peers (2), points out overlooked task (1), updates peer on team's task performance (1), urges peers to consult (1)	**TASK [JUDG_SR_TASK]**	**TASK [JUDG_OR_TASK] (2)** makes judgement about team's task completion (1), makes judgement about team's task performance (1)

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Appendix 4.9 Manifestations of Self- and Other-regulation by Lynette (*Team Bettie*)

Planning (8)		Monitoring (67)	
SR (2)	**OR (6)**	**SR (47)**	**OR (20)**
COGN(C) [PLAN_SR_COGN(C)]	**COGN(C) [PLAN_OR_COGN(C)]**	**COGN(C) [MON_SR_COGN(C)] (42)** checks own understanding of chemistry with peer (2), seeks validation of thought about the chemistry (40)	**COGN(C) [MON_OR_COGN(C)] (5)** checks peer's thinking about the chemistry (2), checks peer's understanding about the chemistry (3)
COGN(T) [PLAN_SR_COGN(T)]	**COGN(T) [PLAN_OR_COGN(T)]**	**COGN(T) [MON_SR_COGN(T)] (2)** seeks validation of thought about the task (2)	**COGN(T) [MON_OR_COGN(T)] (2)** checks peer's understanding about the task (1), checks if peer understands what she is saying (1)
BEHAV [PLAN_SR_BEHAV]	**BEHAV [PLAN_OR_BEHAV]**	**BEHAV [MON_SR_BEHAV]**	**BEHAV [MON_OR_BEHAV]**
TASK [PLAN_SR_TASK] (2) proposes strategy to optimise own task performance (2)	**TASK [PLAN_OR_TASK] (6)** proposes strategy to optimise task performance (6)	**TASK [MON_SR_TASK] (3)** checks own task performance against peers' (1), checks own task performance (2)	**TASK [MON_OR_TASK] (13)** checks peer's task performance (5), checks peers' task performance (1), checks team's task performance (2), checks team progress on task (2), checks with peer how they prefer to proceed with task (2), checks with peers whether to reconsider task execution strategy (1)
Control (166)		**Evaluation (14)**	
SR (80)	**OR (86)**	**SR (9)**	**OR (5)**
COGN(C) [CTRL_SR_COGN(C)] (73) clarifies own thinking about the chemistry (4), seeks clarification from lab assistant about the chemistry (11), seeks clarification from peers about the chemistry (58)	**COGN(C) [CTRL_OR_COGN(C)] (59)** affirms peer's thinking about the chemistry (4), clarifies peer's thinking about the chemistry (17), corrects lab assistant's thinking about the chemistry (2), corrects peer's thinking about the chemistry (9), critiques peer's thinking about the chemistry (5), explains the chemistry to peers (2), justifies own thinking to peer (5), points out important information to peer (2), reminds peer of important aspect to consider (4), reminds peers of important information (2), reminds peers what lab assistant said (2), Urges peer to clarify her thinking (2), Urges peer to wait and clarify the chemistry (3)	**COGN(C) [JUDG_SR_COGN(C)] (6)** makes judgement about own memory (2), makes judgement about own understanding of the chemistry (4)	**COGN(C) [JUDG_OR_COGN(C)] (1)** makes judgement about team's understanding of the chemistry (1)
COGN(T) [CTRL_SR_COGN(T)] (3) seeks clarification from peer about the task instructions (1), seeks clarification from peer about the task (2)	**COGN(T) [CTRL_OR_COGN(T)] (8)** affirms peer's thinking about the task (2), clarifies peer's thinking about the task (6)	**COGN(T) [JUDG_SR_COGN(T)] (1)** makes judgement about own understanding of task (1)	**COGN(T) [JUDG_OR_COGN(T)]**
BEHAV [CTRL_SR_BEHAV]	**BEHAV [CTRL_OR_BEHAV] (5)** urges peers to wait (5)	**BEHAV [JUDG_SR_BEHAV]**	**BEHAV [JUDG_OR_BEHAV]**
TASK [CTRL_SR_TASK] (4) clarifies own task performance (1), seeks clarification from lab assistant about task performance (2), seeks clarification from peer about task performance (1)	**TASK [CTRL_OR_TASK] (14)** clarifies peer about task performance (2), critiques peer's task performance (1), instructs peer how to perform task (1), points out error in teams calculations (2), proposes way forward (1), shows peer resource to use to optimise task performance (1), urges peers to correct calculations (1), urges peers to review task performance (1), urges peers to take a break (1), urges peers to visualize (1), urges peers to wait and explain (2)	**TASK [JUDG_SR_TASK] (2)** makes judgement about own task performance (2)	**TASK [JUDG_OR_TASK] (4)** makes judgement about group's task performance (2), makes judgement about team's task completion (2)

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