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Improving Classroom Discourse in Inquiry-Based Primary Science Education

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IMPROVING CLASSROOM DISCOURSE IN INQUIRY-BASED PRIMARY SCIENCE EDUCATION

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ABSTRACT

Teachers' capacity to use classroom discourse to deepen student learning through sustained conversation is considered crucial to increasing students' intellectual development. Learners actively construct knowledge and develop understandings from their shared experiences and via interaction with others (Driver, Asoko, Leach, Mortimer & Scott, 1994). However, talk that fosters students' capacity to reason is lacking in many classrooms (Alexander, 2006) and, what is more, teachers tend to control the discourse by asking a predominance of closed questions and using a question-answer recitation script which limits the exploration of students' ideas (Nystrand, Gamoran, Kachy, & Prendergast, 1997).

The purpose of this study was to investigate how teachers' beliefs and knowledge about managing classroom discourse and their teaching practice was influenced by their participation in an action-research based professional learning intervention. The guiding framework for the teachers' professional learning drew on Mortimer and Scott's communicative approaches, which were matched to the phases of scientific inquiry.

This study was a part of a larger research project entitled: *Enhancing Classroom Discourse in Primary Science Education* which utilised mixed methods and interpretive approaches, combining pre- and post-intervention observations and data collections involving a cohort of 12 teachers as well as a set of embedded case studies involving more extensive collection of data with five of the participants. These case studies provided the focus for this study.

Analysis of classroom video as well as teacher questionnaire and interview data gathered before, during and after the professional learning intervention provided insights into the impact of the intervention on teachers' understandings about: quality talk; the classroom culture needed to support whole-class talk; and, the skills of using puppets to engage students in discourse. A more detailed analysis and coding of the transcripts of whole-class discussions revealed changes to the way the teachers used questioning, discourse moves and communicative approaches to orchestrate sustained

conversations and the resultant impact this had on level of students' engagement and the quality of their talk.

Following the professional learning intervention, the case study teachers gained a deeper understanding of substantive talk and of the complex role of the teacher in managing classroom discourse to sustain a culture for talk. They made significant gains in confidence and self-efficacy for managing classroom discourse and developed a greater understanding of the conventions that are supportive of substantive talk. The case study teachers increased their capacity to conduct more purposeful discussions and they developed sophisticated understandings about how to use teacher questioning and discourse moves to elicit, explore and probe their students' ideas and to develop cumulative talk. Ultimately, the teachers developed a repertoire of discourse moves to support their questioning and differentiate their management of class discussions in order to match their communicative approach to the instructional focus of the lesson and phase of inquiry. Consequently, their students participated more readily in discussion and they gave increasingly elaborated responses. Furthermore, they were able to generate cumulative talk and to give progressively more complex descriptions, explanations and reasons. Some teachers also used puppets effectively to establish a supportive culture for talk, set up convincing investigations, and elicit elaborated responses and explanations from their students.

The findings of this research may be transferable to teachers who work in settings similar to those of the case study teachers. The set of codes that were developed to describe the teacher-student interactions will be useful for future researchers wishing to investigate classroom discourse. These codes along with the video footage and professional learning resources developed for this study will be used as the basis for future research and teacher professional learning.

Further studies might investigate how changes to the teachers' discourse practice were sustained over time and what impact this had on students' learning outcomes. It would also be useful to understand how the improvements seen in whole-class discourse translate to the student-to-student interactions in both whole-class and small group discussions and whether students are able to manage the talk so that they use 'talking for thinking'.

This study developed new approaches to and resources for teacher professional learning as well as new insights into teachers' discourse practices, which have informed an elaborated theoretical model that shows the variables impacting on quality classroom discourse.

DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

i)   incorporate without acknowledgement any material previously submitted for a degree or a diploma in any institution of higher education;

ii)   contain any material previously published or written by another person except where reference is made in the text of this thesis; or

iii)   contain any defamatory material.

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Contents

List of Figures

List of Tables

CHAPTER 1: INTRODUCTION

Background

Knowledge is seen to be central to the success of the Australian economy and to the continued quality of the nation's social and cultural life. Australia's capacity to develop a culture of innovation, to invest in scientific discovery and to develop technologies for commercial markets will determine its future success in the global economy (Dow, 2003; Department of Education, Science & Training [DEST], 2006; Goodrum, Hackling, & Rennie, 2001; Goodrum & Rennie, 2007). To be productive in such an environment, Australian citizens need to be well informed and capable of applying knowledge and skills in their personal lives as well as in their work environments. In the Western Australian context, the economy is dependent on the wealth generated by the oil, gas and mining activities of its resources sector. In the last few years, expansions of established industries and the development of new industries utilising advanced technology have intensified the demand for high level skills in engineering and other science-related occupations (Department of Education & Training [DET], 2004; DEST, 2006; Minerals Institute of WA, 2005).

While science education is acknowledged to have a fundamental role to play in building a culture of continuous innovation and in developing scientifically literate citizens, the numbers of students participating in science at the senior secondary level or in science-specific courses at the tertiary level has been static or in decline in Australia for some time (Ainley, Kos & Nicholas, 2008; DEST, 2006; Dow, 2003; Goodrum, et al., 2001; Goodrum & Rennie, 2007; Office of the Chief Scientist, 2012). Given the current shortage of workers with science, engineering or technology skills, such a trend is concerning not only for the status of scientific research in Australia but also for the future of industry. Clearly, the improvement of teaching and learning in science education in Australian schools is essential to the economic, environmental and social future of this country.

As a consequence, science education and the development of students' scientific literacy has become a key focus in the current educational context. In a recent report

about participation in science, maths and technology education in Australia, Ainsley, et al. (2008) concluded that "Generating higher levels of participation in science-related studies at university appears to be partly dependent on strengthening science education in schools" (p. 82). This opinion was echoed in the rationale for the *Primary Connections* Stage 3 project which states:

> High quality teaching of both science and literacy in Australian primary schools is a national priority in order to develop citizens who are scientifically literate and who can contribute to the social and economic well-being of Australia as well as achieve their own potential. A community with an understanding of the nature of science and scientific inquiry will be better equipped to participate in an increasingly scientific and technological world (Peers, 2006, p. 1).

Several national and international measures of student achievement reveal that the Australian standards of primary science education are of concern. The Trends in International Mathematics & Science Study (TIMSS) for 2007 and 2011 showed that Australia is falling behind its trading competitors, countries which previously performed at a comparable level to Australia (Thomson, Hillman, Wernert, Schmid, Buckley, & Munene, 2012; Thomson, Wernert, Underwood, & Nicholas, 2008). In fact, the data from TIMMS 2011 shows that, while there has been some improvement in Year 4 achievement in mathematics, the performance of Australian students in mathematics and science has remained at a standstill over the past 16 years. At the same time, countries such as Singapore, Hong Kong and Chinese Taipei demonstrated significantly improved performances and Korea and the United Stated maintained a steady improvement.

The national assessment of Year 6 students in science in 2003 showed that less than 60% of students reached benchmark standards (Ministerial Council on Education, Training and Youth Affairs [MCEETYA], 2005). Subsequently, the National Assessment Program - Science Literacy (NAP SL) Year 6 Report released in 2008 (MCEETYA, 2008) revealed that Western Australian students have fallen even further behind students in almost all of the other Australian states in science and literacy achievement. However, the NAP SL Year 6 Report for 2009 indicates that while there has been some improvement in the mean score for students from Western Australia, this is not a statistically significant improvement (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2010).

In addition, when reporting on the national review of science teaching in Australian schools, Goodrum, et al. (2001) identified a gap between the ideal or intended curriculum and the actual curriculum implemented in primary science classrooms. They found that the quality and quantity of science taught in primary schools was quite patchy with some primary schools not teaching science at all. While other research indicates that less than three per cent of curriculum time is allocated to science in Australian primary schools (Angus, Olney, & Ainley, 2007). The uncertainty among primary school teachers about how best to teach science as well as their relatively low levels of interest and academic attainment in science has also been documented for some time (Dow, 2003; Goodrum, et al., 2001). Concerns about primary teachers' lack of confidence and self-efficacy for teaching science, and their avoidance of science teaching have since been addressed by the professional development and teaching resources offered by the *Primary Connections* program (Hackling, Peers, & Prain, 2007).

The problem

To be effective, teachers need to develop three bodies of knowledge, including knowledge of content area, pedagogical knowledge and pedagogical content knowledge. Shulman describes pedagogical content knowledge as representing "…the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to diverse interests and abilities of learners, and presented for instruction" (1987, p. 8). While primary teachers can develop excellent pedagogical knowledge, their knowledge of science content is often limited, and consequently their pedagogical content knowledge for science teaching is not well developed (Goodrum & Rennie, 2007).

In science education, it is important for students to be able to examine evidence and to argue the merits of knowledge claims. In studies of British and American primary school classrooms, Alexander (2006) found talk that fosters students' capacity to reason is often lacking in many classrooms. Given the cultural similarity to Britain and America, it is quite probable that such issues would also be encountered in primary classrooms in Western Australia. Recent Australian research has also demonstrated

how classroom pedagogy impacts on the development of students' problem solving capacity and understandings, and how teachers need to expand their pedagogic repertoires to facilitate students' development of deeper levels of knowledge and intellectual engagement (Education Queensland, 2001). Teachers' capacity to use classroom discourse to scaffold the metalanguage of content area discourses and to deepen student learning through sustained conversation are considered crucial to increasing students' intellectual development (Freebody & Luke, 2003). Sustaining classroom conversation of high intellectual quality has been identified as an essential pedagogy by most Australian and international quality teaching frameworks (see Queensland's *Productive Pedagogies*, the New South Wales *Model of Pedagogy* and the Victorian *Principles of Learning and Teaching*). Additionally, it is woven into the personal and social capabilities as well as the critical thinking requirements for science articulated by the Australian National Curriculum (Science: General capabilities, ACARA, 2012).

To facilitate understanding in science by means of classroom discourse, first teachers need to believe that learning is constructed via talk, and then they need to know how to use different forms of discourse to orchestrate students' learning. This study reveals how primary school teachers' beliefs about teaching science and their pedagogical content knowledge for managing classroom discourse influenced their teaching practice as they implemented the *Primary Connections* program (Australian Academy of Science [AAS], 2005; Hackling et al., 2007) in the context of an action-research professional learning program. In addition, the study highlights some of the advantages and limitations of using puppets to facilitate student engagement and the development of a supportive culture for talk.

Rationale

Research has shown that the professional learning and curriculum resources offered by the *Primary Connections* program has positively impacted on teachers' confidence and self-efficacy beliefs for teaching science, improved their teaching practice, and increased the quality of science teaching and opportunities for learning in many primary classrooms (Hackling & Prain, 2005; Hackling, et al., 2007; Hackling & Prain, 2008). While these outcomes show that a program focused on a process of inquiry and supported by rich curriculum resources can be successful in many different learning

environments, significantly higher levels of student achievement and better standards of teaching practice will not be achieved without also addressing the issue of improved classroom talk (Alexander, 2006; Education Queensland, 2001; Freebody & Luke, 2003). In order to achieve sustainable improvements in students' learning in science there is a need to improve primary teachers' knowledge and, more specifically, their pedagogical content knowledge for managing classroom discourse. Given that sustaining classroom conversation of high intellectual quality has been recognised as an essential pedagogy, it was important to investigate how teachers could be supported to manage classroom discourse more effectively.

Significance

This research has contributed to the body of knowledge regarding classroom discourse and inquiry-oriented science teaching. By investigating how teachers construct and manage classroom discourse in primary science, the study has developed important new knowledge about teachers' practice. In the process, sociocultural and constructivist theory has been extended in relation to discourse practices and scientific inquiry. Consequently, the outcomes of this study are of great interest to the research community and will inform the future professional learning of science teachers.

Purpose

The purpose of this study was to document how primary teachers participated in an action-research professional learning process and to investigate the impact of that learning process on their science teaching beliefs, knowledge and practice.

Research questions

Several questions provided a focus for the research and the primary question asked:

How does participation in an action-research professional learning process impact on teachers' beliefs, knowledge and practice of utilising communicative approaches in primary science teaching?

Secondary research questions investigated teachers' beliefs, knowledge and practice to do with teaching science, developing a supportive classroom culture for discourse, as well as using classroom discourse and puppets in science teaching. The secondary research questions included:

Research Question 1: What impact does the professional learning program have on teachers' beliefs about students' learning of science?

Research Question 2: What impact does the professional learning program have on teachers' beliefs, knowledge and practice to do with developing a classroom culture that is supportive of discourse?

Research Question 3: What impact does the professional learning program have on teachers' beliefs, knowledge and practice to do with using classroom discourse?

Research Question 4: What impact does the professional learning program have on teachers' knowledge and practice to do with using puppets in science?

CHAPTER 2: LITERATURE REVIEW

Introduction

This study centres on the development of primary teachers' beliefs and knowledge for managing discourse and the teaching practices associated with sustaining classroom conversations of high intellectual quality in the context of inquiry-based science education. This chapter presents a review of the literature pertaining to discourse in primary science classrooms. In particular, the review shows how sociocultural approaches to discourse can be used to support teachers' effective management of classroom interactions as they orchestrate the process of inquiry. The impact of teachers' beliefs and knowledge on classroom practice are also examined and a review of the literature pertaining to effective teacher professional learning is given. A summary of the key ideas from the literature, which informed the professional learning component of this research project, is presented as an elaborated teaching and learning model. In addition, a conceptual framework for this study is developed from a synthesis of the literature.

Scientific literacy as the main purpose of science teaching in primary school education

Scientific literacy is considered to be the goal and purpose of contemporary science education (Roberts, 2007). It is seen as an essential tool for people living in a rapidly changing and increasingly scientific and technologically focused world. Understandings of science and scientific literacy enable people to achieve their personal goals and to contribute to the social and economic affairs of their local, national and global communities.

While no real consensus exists about the definition of scientific literacy (Roberts, 2007), the importance of scientific literacy as an essential outcome of schooling is recognised internationally. The Organisation for Economic Cooperation and Development (OECD) includes a measure of students' scientific literacy in the Program for International Student Assessment (PISA), which defines scientific literacy as "the capacity to use

scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (OECD, 1999, p. 60). This definition was constructed by the OECD as a basis for the PISA assessment program.

In Australia, the *Statements of Learning for Science* (MCEETYA, 2006) articulate the purpose for science education in primary schools is to develop students who are scientifically literate by providing opportunities for them to understand science as a body of knowledge, as a way to know, and as a human endeavour. The definition of scientific literacy given in this document is drawn from the national review of science teaching and learning (Goodrum, Hackling, & Rennie, 2001), which states that students who are scientifically literate:

> …have the capacity to be interested in and understand the world around them, can engage in the discourses of and about science, be sceptical and questioning of claims made by others about scientific matters, be able to identify questions and draw evidence-based conclusions and make informed decisions about the environment and their own health and wellbeing. (Goodrum, et al., 2001, p. 7)

This definition of scientific literacy gives emphasis to the importance of engaging students' interest in science and developing the language and literacies needed to participate in scientific processes and to carry out scientific investigations.

This focus on the language and literacies of science aligns with a sociocultural perspective, which maintains that science has its own culture and language (Bybee, 2001; Mortimer & Scott, 2003) and that science education can be regarded as a way of enculturing students into the language, behaviours and views of the scientific community. Consequently, learning science involves students understanding something of the discourse, culture and practises of science (Gee, 2004) and learning to talk science (Lemke, 1990). Students need to be explicitly scaffolded in how to use and to think about scientific language, their interpretations and arguments about science phenomena (Gee, 2004). Scientific literacy from this viewpoint entails learning how to construct and interpret scientific texts that are generated from verbal, mathematical, visual-graphic, or actional-operational languages (Lemke, 1998) and to understand the concepts and ideas represented by those texts (Norris & Phillips, 2002).

Norris and Phillips (2002) differentiate between a fundamental and derived sense of scientific literacy. The fundamental sense of scientific literacy refers to the basic literacy skills needed to read and write science texts, while the derived sense refers to the knowledge acquired by an individual about science. Norris and Phillips (2002) maintain that acquiring a deep level of scientific knowledge is not possible without fundamental literacy skills. Additionally, Unsworth (2001) argues that each subject area has its subject-specific literacies.

Ryder (2001) identifies functional scientific literacy as "science knowledge needed by individuals to enable them to function effectively in specific settings" (p. 3). Ryder argues that school science should develop students' basic understandings of the key concepts of science and of the ways in which knowledge claims in science are developed and justified. He states that the principle role of school science is to instil in students a positive attitude towards engaging with science, and to develop a perception of science that fosters life-long learning.

Roberts' (2007) broad review of the literature highlights the multi-dimensional nature of scientific literacy. He found that traditional approaches to science, which emphasise the processes and products of science, require knowledge of science-specific literacy practices used by the scientific community. While approaches to learning science that centre on the application of science for specific social purposes in real-life contexts foster broader understandings of literacy about science-related situations. Bybee (1997) also describes multiple dimensions of scientific literacy. He articulates a continuum of scientific literacy that encompasses four levels of development (nominal, functional, conceptual and procedural, and multidimensional). Bybee's continuum frames understandings to do with functional literacy, as well as conceptual and procedural knowledge of science, and their application to scientific and to real world contexts.

These aspects of scientific literacy are summarised by Hackling and Prain (2008) in their discussion of the approach to scientific literacy taken by the *Primary Connections* program. They refer to scientific literacy as "a multidimensional construct (Bybee, 1997; OECD PISA, 2006; Roberts, 2007) that requires citizens to be interested and engaged

with scientific matters and have the knowledge and skills that can be applied in real-world contexts to investigate, represent and communicate findings and solve everyday problems" (Hackling & Prain, 2008, p. 6).

Hackling and Prain (2008) argue that scientific literacy requires an understanding of scientific concepts and competence with the processes of scientific inquiry and literacies of science, as well as a positive attitude to science that fosters individuals' engagement with scientific matters in real world contexts. Figure 2.1 provides a diagrammatic sense of how these aspects inter-relate in the context of scientific inquiry.

Conceptual understandings

Science processes   SL   Literacies of science

Contexts

Attitudes
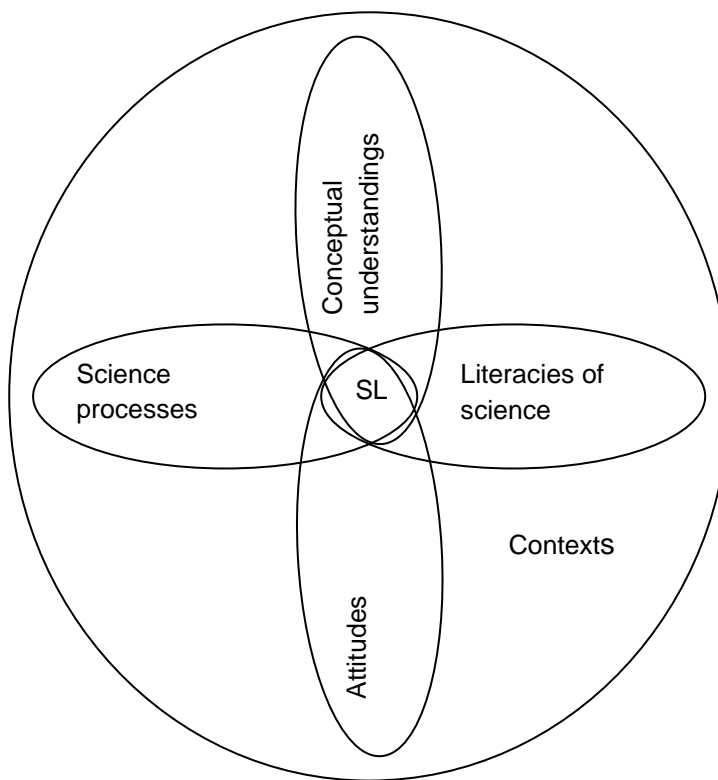
Figure 2.1: Scientific literacy (Hackling & Prain, 2008).

The *Primary Connections* program

The program, *Primary Connections: Linking science with literacy*, was developed in response to the recommendations made by the national review of science education (Goodrum, et al., 2001) to improve the teaching and learning of science in Australian

primary schools. Instigated by the Australian Academy of Science in 2003 and subsequently funded by DEST and DEEWR, *Primary Connections* comprises a comprehensive professional learning program supported with curriculum resources. The program seeks to develop teachers' confidence and competence to teach science using inquiry-oriented curriculum resources and to improve students' scientific literacy.

The *Primary Connections* professional learning program is designed to increase the quality and quantity of science teaching by improving teachers' capacity and confidence to teach, and by supporting the development of their pedagogical content knowledge (Peers, 2006). Primary science pedagogical content knowledge includes:

- Knowledge of curriculum, outcomes and standards

- Knowledge of science concepts, processes and the nature of science

- Knowledge of science teaching and assessment pedagogies

- Knowledge of literacy practices and forms of representations relating to science

- Knowledge of students and their learning

Primary Connections utilises student-centred inquiry and linking science with literacy as the foundations of its teaching program. An inquiry approach to learning engages students in active and meaningful experiences (Driver, Asoko, Leach, Mortimer, & Scott, 1994) and is seen to be most effective in developing scientific literacy. The *Primary Connections* teaching and learning approach draws on Bybee's (1997) 5Es model, which incorporates five phases of inquiry (Engage, Explore, Explain, Elaborate and Evaluate). The five phases are designed to facilitate conceptual change, with each phase having a specific function in guiding students' active construction of scientific understandings and developing science processes and attitudes.

The teaching and learning model employed in the *Primary Connections* program extends Bybee's 5Es model by integrating literacy with science, employing diagnostic, formative and summative assessment practices, and focusing on student-planned investigations. Teachers provide hands-on experiences and support students to construct questions, to plan investigations and to develop explanations of scientific phenomena.

Student inquiry is carried out through small group cooperative learning (AAS, 2005). Each group is encouraged to work as a team and to share their experiences with each other, to discuss their observations and ideas, and to grow their scientific explanations. Working in this way provides motivation for students to learn the social skills necessary for effective collaboration and communication.

Through explicit instruction, monitoring and feedback, teachers assist students to acquire the language of science and to use the conventions of scientific texts so that they can produce multimodal representations (AAS, 2005) of their understandings of scientific phenomena. The elements of the *Primary Connections* inquiry approach to teaching and learning are illustrated in Figure 2.2.
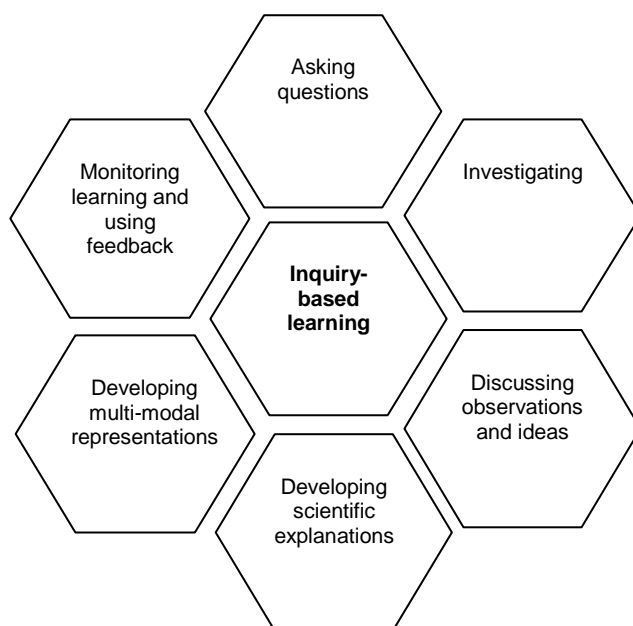
Figure 2.2: Elements of the Primary Connections *inquiry approach (AAS, 2005).*

The *Primary Connections* program integrates the learning of science with literacy. This approach is based on the assumption that students need to use their everyday literacy practices to understand science concepts and processes, as well as the scientific literacy practices used to represent them (Gee, 2004; Lemke, 1998; Norris & Phillips, 2003). As scientific literacy practices are made explicit, students develop their

understandings of the language and social practices of science (Gee, 2004) and are more able to represent their understandings and to use scientific reasoning in conventional ways. By also making a range of science-specific genres explicit (Lemke, 1998), students come to understand how the conventions of oral, written and visual texts are used to represent information and to communicate ideas about science.

Additionally, the *Primary Connections* program utilises a range of literacy practices and forms of representation to help students to link their understandings of science to their everyday world, and to demonstrate learning outcomes in both science and literacy (Peers, 2006). Some of the text types that are used include: student journals, storyboards, labelled diagrams, cross-sections, tables, timelines, graphs, models, role-plays, procedural texts, biographies, and the use of ICTs such as digital cameras and PowerPoint presentations (Hackling, 2006; Peers, 2006).

Furthermore, *Primary Connections* integrates diagnostic, formative and summative assessment into appropriate phases of the teaching and learning process. In the Engage phase, diagnostic assessments ensure that the teaching process is informed by and builds on students' prior knowledge. While in the Explain phase, formative assessments ensure that appropriate feedback is given to students as the learning progresses. Summative assessments are used in the Elaborate phase to evaluate students' capacity to use investigative skills, and in the Evaluate phase to assess students' conceptual understandings. A summary of the *Primary Connections* teaching and learning model is provided in Table 2.1.

Table 2.1: The Primary Connections *teaching and learning model (AAS, 2008).*

Phase	Focus
Engage	Engage students and elicit prior knowledge. *Diagnostic assessment.*
Explore	Provide hands-on experience of the phenomenon. *Formative assessment.*
Explain	Develop science explanations for experiences and representations of developing understandings. *Formative assessment.*
Elaborate	Extend understandings to a new context or make connections to additional concepts through student-planned investigations. *Summative assessment of the investigating outcome.*
Evaluate	Re-represent understandings, reflect on the learning journey and collect evidence about achievement of conceptual outcomes. *Summative assessment of the conceptual outcomes.*

The approach to teaching and learning taken by the *Primary Connections* program sets up a context for learning that is conducive to fostering students' productive disciplinary engagement (Engle & Conant, 2002). Engle and Conant explain that students' disciplinary engagement is productive "to the extent that they make intellectual progress" and they consider it is evident when students' arguments become more sophisticated, or they raise new questions, recognise confusions, make connections among ideas, or design something to achieve a goal" (2002, p. 403). Further, Engle and Conant (2002) state that students' greater engagement is evident when more students make substantive contributions to the topic under discussion; their contributions are often made in coordination with each other; they pay attention to each other and fewer students are off-task; and they are often passionately involved in discussions and remain engaged in the topic over time.

> Focusing on productive disciplinary engagement allows one to trace the moment-by-moment development of new ideas and disciplinary understandings as they unfold in real-life settings. It provides a complementary perspective to views of learning that rely on static comparisons of student understanding with pre- and post measures. By incorporating content and interaction, this perspective also highlights the ways in which learning is a simultaneously cognitive and social process. (Engle & Conant, 2002, p. 403)

Engle and Conant (2002) have put forward four guiding principles for fostering productive disciplinary engagement, including: problematising content; giving students authority; holding students accountable to others and to disciplinary norms; and providing relevant resources. Problematising content has to do with teachers or students presenting or identifying problems that need to be solved and then teachers encouraging students' questions, proposals, and challenges rather than expecting them to simply assimilate facts, procedures, and 'the answer'. Giving students authority involves teachers encouraging students to take an active role the learning process, "to be authors and producers of knowledge, with ownership over it, rather than mere consumers of it" (Engle & Conant, 2002, p. 404). Holding students accountable to others and to disciplinary norms means that, as they develop their understandings in a domain, teachers encourage students to consult others in order to consider and respond to alternative points of view. Providing relevant resources refers to the provision of the necessary physical resources to complete a particular investigation (e.g. books, equipment, internet access, etc), as well as sufficient time to work it through. Engle and Conant (2002) consider it is also important to give students the chance to use 'home-based modes of discussion' to talk about a problem as well as the models and norms of discourse developed in the classroom.

A social constructivist view of learning

Several key features of the *Primary Connections* teaching and learning model indicate that it is also consistent with social constructivist learning theory. For example, the model emphasises:

- An inquiry approach, where students actively work together to construct questions, plan investigations and develop explanations of scientific phenomena.

- The importance of accessing students' prior knowledge, which is the explicit purpose of the Engage phase as well as of the diagnostic assessment.

- The acquisition of the language of science and the use of science-specific texts.

- The use of formative assessment to mediate student's alternative conceptions towards more scientifically valid views.

- The use of talk and social interaction to develop science understandings and extend ideas.

Social constructivist learning theory holds that learners actively construct knowledge and make personal meaning from their shared experiences by drawing on their prior knowledge, and by interacting with their teachers, peers and environment (Bybee, 1997; Driver et al., 1994). The objective of constructivist learning is to help learners reconstruct their everyday understandings of science concepts by participating in activities that challenge their understandings while working within their zone of proximal development (Driver et al., 1994; Traianou, 2007). Meaning is seen to be developed through conversation and learners come to understand scientific concepts and ideas as they are constructed in conversation (Driver et al., 1994; Mercer, 1995; Mercer, Dawes, Wegerif, & Sams, 2004; Mercer, Wegerif, & Dawes, 1999). Given time to reflect on and interact with their teacher and peers about their experiences, individual students are supported to redefine, reorganise, elaborate, and build on their initial concepts to develop scientific ways of thinking about objects and phenomena (Bybee, 1997; Driver et al., 1994).

Setting up a coherent series of learning opportunities so that the learning is 'stretched-out-in-time' (Scott, Ametller, Dawes, Kleine, & Mercer, 2007) gives teachers the chance to explore their students' everyday views and to provide experiences that subsequently allow the students to investigate new concepts and to talk through their developing ideas as the investigation proceeds. In this way, students come to understand how the scientific view contrasts with their view and how it is used to explain scientific phenomenon (Bybee, 1997; Driver et al., 1994; Traianou, 2007). In addition, as they participate in science activities in the context of their classrooms, students are seen to be encultured into the discourses and practices of the scientific community (Driver et al., 1994; Edwards & Mercer, 1987; Lemke, 1990).

The social constructivists' emphasis on the active construction of knowledge within the learner's zone of proximal development and through interaction with more knowledgeable others is characteristic of Vygotskian perspectives. Vygotsky's theory centres on the social development of mind (Vygotsky, 1978) and is concerned with the development of an individual's higher mental functions through social interaction. Development and learning evolve from social contexts to individual understanding, and higher mental functions are seen to be embedded in or mediated by language. New ideas are rehearsed between people via talk, gesture, writing, visual stimulus or action. Vygotsky viewed these interactions as existing on the social plane and individuals

internalise new ideas by translating them from the social plane onto the individual plane. Following this process of appropriation, individuals make sense of new ideas, which then become tools for thinking.

Sociocultural approaches to teaching and learning

Sociocultural learning theory also draws on the work of Vygotsky and builds on social constructivist approaches to teaching and learning. While incorporating constructivist principles, sociocultural theory shifts its focus to the ways in which meanings are developed through language in the context of science classrooms. From this perspective, the context in which learning takes place is representative of a community and a culture that has its own way of viewing the world and of acting in it. Cultures are comprised of communities that use language as a social practice to generate sets of shared social meanings whilst also engaging in authentic activities (Traianou, 2007). Consequently, language is seen to derive meaning from the contexts in which it is used. Cultures are also shaped by the socially significant activities or functions of their communities (Traianou, 2007). Thus, by participating in the activities of a community, an individual develops understandings of shared social meanings as well as of the tools and processes needed to function successfully within that community. In this way, cultural knowledge is acquired as individual knowledge.

The transformation of cultural to individual knowledge occurs in what Vygotsky called the zone of proximal development. He defines this as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). For sociocultural theorists, the development of knowledge is a dynamic process where the social experience of language use (intermental activity) promotes individual understanding (intramental activity) (Mercer et al., 2004). When working at the zone of proximal development, individuals interact with more capable others and use language to construct understandings of the activities and contexts of their particular communities. Thus, meanings are negotiated and socially constructed in the context of activity and community, and the learner's actions and mental representations are integral to this context (Traianou, 2007).

The sociocultural approach views science as practice and scientists as belonging to particular communities of practice. Learners are seen to be enculturated into the practices of a scientific community and learn through cognitive apprenticeship (Traianou, 2007). In the classroom context, this involves exposing students to the scientific view, and developing their understandings of scientific concepts and procedures to use as tools for problem-solving. As students participate in authentic activities with their teachers, they learn about: the tools of science; how to identify a problem; how to progress towards a solution by trying out different concepts and raising questions; how to test their ideas; how to negotiate and discuss proposed solutions with other members of the community; and how to make claims from a scientific point of view. By acting in this way, students and teachers work together to co-construct knowledge (Traianou, 2007).

As discussed previously, Lemke (1998) asserts that being able to talk science requires that students understand not only the thematic patterns or ideas of science but also the structural patterns or genres for organising how to describe, argue or write about science (Lemke, 1990; 1998). Further, it must be acknowledged that language is but one mode of several used to make meaning in science (Kress, Jewitt, Ogborn, & Tsatarelis, 2001; Lemke, 1990; 1998) and that teachers 'orchestrate' different modes of meaning to develop students' understandings in science classrooms (Kress et al., 2001).

> Reasoning as a total activity is, of course, more than just a way of using language. It is usually part of some problem-solving activity, or some problem-posing activity. We use thematic patterns, which are built from the semantic relationships that language enables us to construct, but we also use visual images, diagrams and formulas, body movements and postures, writing and manual skills. In the laboratory, we work with apparatus in complex ways at the same time we talk ourselves through the steps of what we are doing, to make sense of them, their relations and results. Language is only one resource of our community for making meaning. We also have the resources of depiction, movement and actions. Whether we picture "to ourselves" or on paper, we construct relationships of meaning between images and their parts that may or may not have equivalents in the semantics of language. (Lemke, 1990, p. 123)

Communicative approaches linked to sociocultural theory

Learning how to talk science is frequently complicated by the fact that everyday language is often inconsistent with scientific discourse and Lemke (1990; 1998) asserts that if teachers are to make science make sense to students they must make connections between the themes of science topics and the ways students already talk about a topic. Since talk is seen to be central to the meaning making process and to learning, it is important for students to be able to articulate their 'everyday' conceptions as they work through science activities within their communities of practice. In the classroom context, teachers need to scaffold students learning by mediating their everyday language and interpretation of concepts and events towards scientific views. Mortimer and Scott (2003) put it this way:

> It is through talk that the scientific view is introduced to the classroom. Talk enables the teacher to support students in making sense of that view. Talk enables the students to engage consciously in the dialogic process of meaning making, providing the tools for them to think through the scientific view for themselves. (p. 3)

How, and if, students acquire the social language of school science is totally dependent on the skill and understanding of their classroom teacher. The teacher's role as an interpreter or mediator of the language of school science is central to this process and, following Vygotsky's theory of learning and development, Mortimer and Scott (2003, p. 17) argue that all science teaching must follow three fundamental phases where: first of all teachers need to make the scientific ideas available on the social plane of the classroom; then they need to assist students to make sense of and internalise those ideas; and ultimately, they need to support students to apply the scientific ideas and to take responsibility for their use.

Mortimer and Scott (2003) view the implementation of these three phases as a type of 'public performance' delivered on the social plane in the classroom and orchestrated by the teacher over a series of lessons. They envisage the roles of the teacher and students as changing. At times the students listen to what the teacher has to say, and at other times they participate in the 'performance' by asking questions and contributing to discussion. At other times, the students are involved in small group activities and the teacher supports them to take control of particular tasks. Thus, via the process of

appropriation, students come to understand science ideas as well as the discourses or speech genres of science (Bakhtin, 1953, in Mortimer & Scott, 2003) and how to use them.

In order to find out more about the speech genre of school science and the ways in which teachers use language to support students' development of school science social language, Mortimer and Scott (2003) developed an analytical framework to use as a tool for thinking about science teaching. A key aspect of the framework focuses on the communicative approach used by the teacher to attend to different ideas as they emerge in a lesson. Mortimer and Scott identified four different classes of communicative approach by categorising teacher-student interaction along two dimensions, which are dialogic-authoritative; and, interactive-non-interactive, see Figure 2.3. Classroom talk can be categorised as dialogic when more than one point of view is represented, and ideas are explored and developed; and authoritative when attention is focused on just one point of view, and there is no exploration of different ideas. Similarly, talk is categorised as interactive when it allows for the participation of students and the teacher; and non-interactive when one voice is seen to exclude the participation of others. When juxtaposed, the two dimensions create four classes of communicative approach: interactive/dialogic; non-interactive/dialogic; interactive/authoritative; and, non-interactive/authoritative. Mortimer and Scott summarise the four classes of communicative approach as follows:

- Interactive/dialogic: the teacher and students explore ideas, generating new meanings, posing genuine questions and offering, listening to and working on different points of view;

- Non-interactive/dialogic: the teacher considers various points of view, setting out, exploring and working on different perspectives;

- Interactive/authoritative: the teacher leads students through a sequence of questions and answers with the aim of reaching a specific point of view;

- Non-interactive/authoritative: the teacher presents one specific point of view.

	INTERACTIVE	NON-INTERACTIVE
DIALOGIC	**A** Interactive/dialogic	**B** Non-interactive/dialogic
AUTHORITATIVE	**C** Interactive/authoritative	**D** Non-interactive/authoritative

Figure 2.3: Four classes of communicative approach (Mortimer & Scott, 2003, p. 35).

Four classes of communicative approach matched to the 5Es phases of inquiry

In the course of orchestrating a sequence of science lessons, the instructional purposes change not only for each lesson but also for each phase of a lesson. Consequently, teachers need to understand how to utilise different communicative approaches to achieve their instructional purposes and Scott, Ametller, Dawes, Kleine, and Mercer (2007) describe how teachers need to move between dialogic and authoritative modes of talk to achieve this.

> In general terms, if students are invited to engage in dialogic exploration of ideas about some phenomenon, then there must be subsequent authoritative interventions where the scientific point of view is clarified or introduced. This follows from the fact that science itself is an authoritative body of knowledge which involves accepted ways of thinking and talking about phenomena. Conversely, if scientific views are presented in an authoritative way, then time needs to be allowed for dialogic exploration of those ideas by students. … In such a way, authoritative talk acts as a seed for dialogic exchanges and conversely dialogic talk prompts the need for authoritative intervention. (Scott, et al., 2007).

For the purposes of this study, the communicative approaches outlined by Mortimer and Scott (2003) have been linked to the instructional purposes of the 5Es phases of inquiry used by the *Primary Connections* program in Table 2.2.

Table 2.2: Classes of communicative approach matched to the Primary Connections *5Es phases of inquiry (Hackling, Smith, & Murcia, 2010).*

5Es phases of inquiry Bybee (1997)	Instructional purpose	Communicative approach Mortimer & Scott (2003)
Engage	Engaging students, eliciting prior knowledge and opening-up the scientific problem.	Interactive-Dialogic
Explore	Exploring the scientific phenomenon and exploring and working on students' views.	
Explain	Introducing and developing the scientific story.	Interactive-Dialogic ↕ ↓ Interactive-Authoritative ↕ Non-interactive-Authoritative
Elaborate	Guiding students to work with scientific views and handing over responsibility to students to apply and use them in a student planned investigation.	Interactive-Dialogic ↕
Evaluate	Maintaining the development of the scientific story, reflecting on learning and evaluating learning outcomes.	Interactive-Authoritative

In the Engage and Explore phases of inquiry, the instructional purposes focus on eliciting and exploring students' existing conceptions. These aims would be best achieved through an Interactive-Dialogic communicative approach, where the teacher orchestrates classroom discourse in order to maximise students' participation by using open-ended questions, inviting multiple responses, and delaying the evaluation of responses.

At the Explain phase, the instructional purpose is to draw on students' experiences of the science phenomenon gained in earlier lessons, recollect the range of ideas and explanations proposed by students and then, building on this background of experiences and ideas, introduce and develop the scientific explanation of the phenomenon. The instructional purpose initially requires an Interactive-Dialogic form of discourse to recollect the range of student experiences and ideas related to the phenomenon. Then, the discourse must shift to a more Interactive-Authoritative approach as the teacher uses questioning to develop the scientific view, and it may end

with a Non-interactive-Authoritative approach as the teacher outlines the scientifically valid explanation of the phenomenon.

At the Elaborate and Evaluate phases of inquiry, the instructional purposes are related to handing over ideas developed on the social plane for students to internalise and apply through student planned investigations (Elaborate); and, to develop the science story further through the completion of rich evaluation tasks (Evaluate). An Interactive-Dialogic form of communication will be required as the teacher rehearses ideas to be applied in the student planned investigation or used in the evaluation tasks. However, an Interactive-Authoritative approach may be required as the teacher scaffolds the students' reasoning with and interpretation of data arising from their investigations by using a sequence of closed questions to develop a valid scientific explanation.

Scott, Mortimer and Aguiar (2006) argue that when the understanding of science conceptual knowledge is the learning goal, the interaction necessarily shifts between authoritative and dialogic approaches over the course of a lesson or a series of lessons as teachers provide opportunities for students to explore and work on their everyday science ideas as well as to hear and assimilate the scientific view. They describe this tension between the authoritative and dialogic communicative approaches as characteristic of meaning making in science classrooms and consider that "…it is not sufficient for teachers to simply engage students in dialogue about their everyday views of scientific phenomena; there is the additional and central responsibility of introducing the scientific perspective" (Scott, et al., 2006, p. 622). Additionally, they consider teachers are highly skilled when they are able to respond to students in the midst of discussion in such a way as to move their thinking along a continuum from the everyday to the scientific view (Scott, et al., 2006).

This more authoritative, explicit way of working the discourse during discussions in science could prove challenging for teachers who favour a play-based or student-led teaching style, which is one of a repertoire of approaches used in early years classrooms. The Early Years Learning Framework (DEEWR, 2009) identifies play-based learning as well as intentional teaching and the teaching of early literacy and numeracy as essential aspects of the preschool curriculum. The focus on early literacy and numeracy means that teachers who favour a predominantly play-based approach

may need to find a balance between providing student-led and adult-led learning opportunities. Epstein (2007, p. vii) describes this balance between the extremes of play-based or "child-guided" and more explicit, "adult-guided" learning experiences as intentional teaching. She considers optimal learning opportunities for young children combine both "child-guided" and "adult-guided" experiences, where adults play intentional roles in student-led experiences and students have significant roles in teacher-led experiences (Epstein, 2007; Hackling & Barratt-Pugh, 2012). Thus, the focus for learning interaction may be triggered by the students' interests and questions, and the interaction between the teacher and students may initially follow the students' ideas but ultimately be guided by the teachers' goals for learning (Epstein, 2007; Hackling & Barratt-Pugh, 2012).

Discourse, dialogue and classroom talk

Clearly, understanding how to examine the coherence of evidence and to argue over the merits of knowledge claims is particularly important in science education. However, Alexander (2006) finds talk that fosters students' capacity to reason is often lacking in many classrooms. He argues that talk is the foundation of all learning and that the quality of student learning is closely linked to the quality of classroom talk. Alexander (2006) states that both student engagement and teacher intervention is required to support the development of an individual's capacity to think and to acquire knowledge, and that the "principal means by which students actively engage and teachers constructively intervene is through talk" (p. 12). Furthermore, Alexander (2006) maintains that educators should examine the interactions and exchanges of classroom discourse in order to understand more about the relationship between talking, thinking and learning. I draw on Alexander's discussion of British, American and European studies of primary classrooms to highlight what I shall call more productive and less productive aspects of classroom talk in order to discuss how they impact on the development of thinking and reasoning.

Less productive aspects of classroom talk
Less productive, but very common, aspects of classroom talk revealed by studies of British classrooms and reported by Alexander (2006) included a scarcity of interaction that challenged students to think for themselves. Teachers' questioning seemed to

present low levels of cognitive challenge, and closed questions were prevalent. Teachers also seemed to give 'bland', all-purpose praise rather than targeted feedback that diagnosed or informed students. In addition, some features of classroom organisation and climate were not supportive of productive interactions, including the ineffective use of group work; a lack of student-led discussion and problem-solving; and a tendency for classrooms to be places of "risk and ambiguity rather than security and clarity…where students manage to cope rather than engage" (Alexander, 2006, p. 14). Similar research into American classrooms (Nystrand, Gamoran, Kachy, & Prendergast, 1997) found a prevailing use of the question-answer 'recitation script' that resulted in monologic classroom discourse. It was also observed that teachers generated all the questions, few of which were authentic, and they rarely followed-up students' responses.

Linguistic research into classroom discourse confirms these findings and highlights similar kinds of interactive patterns, some of which are ingrained in teachers' practice. The question-answer 'recitation script' that Nystrand et al. (1997) found so prevalent in American classrooms is associated with teachers controlling the discourse with a minimum of interaction with the students. In this scenario, teachers follow a tightly scripted lesson to ensure topics are 'covered' and they use questioning to check on students' knowledge. This form of interaction follows an I-R-E pattern (Mehan, 1979) where the teacher asks questions (Initiation), listens to students' answers (Response), and assesses the correctness of these responses (Evaluation). This three-turn structure, also referred to as I-R-F (Initiation-Response-Feedback) (Sinclair & Coulthard, 1975 in Alexander, 2006) or triadic dialogue (Lemke, 1990), is used in all classrooms (Mortimer & Scott, 2003). Lemke (1990) also maintains that utilising the triadic pattern ensures teachers control the topic of discussion as well as which students will answer their questions, and which answers are deemed correct. When the I-R-E (I-R-F) pattern of interaction dominates classroom discourse, the possibility of sustained conversation is shut down, the opportunity for students to talk through their ideas is lost, and teachers are unable to gauge students' understandings or misunderstandings because they cannot hear how students talk about a topic (Lemke, 1990).

The primary purpose of questioning in teaching is to promote students' learning. Traditionally, teachers have used questions to determine levels of student

performance, to evaluate what has been learned; to maintain class control, and to increase student motivation and participation (Koufetta-Menicou & Scaife, 2000). When the instructional objectives are focused on knowledge reproduction, as is evident in the scenario above, teachers tend to focus on transmitting knowledge by using closed-ended questions. This ensures that only pre-specified responses will be received (Koufetta-Menicou & Scaife, 2000) and that students 'get the content' (Erodgan & Campbell, 2008). Questioning should be used as a tool for teachers to facilitate students' engagement and challenge them to think and reason for themselves. Morgan and Saxton explain that "Questioning generates the kind of talk and communication which can lead to learning… and questioning (by both teacher and students) establishes the cultural nature of the discourse which dictates the quality of the learning" (1991, p. 75).

More productive aspects of classroom talk

Alexander (2006) also reviewed studies of European classrooms that revealed a different picture of interaction and uses of talk. Some of the features of the more productive interaction included a cognitive purpose to talk that focused on building students' capacity to think and reason, and sustained interactions between teachers and students over a sequence of several question-answer exchanges. Teachers asked questions that promoted reasoning as opposed to right answers and they used wait time (Rowe, 1972; Tobin, 1987) to encourage students to think things out and to think aloud. Students' 'wrong' answers were treated of as a way into understanding, and teachers provided honest feedback and diagnosis on which students could build. One of the consequences of the extended talk sequences seen in these classrooms was that teachers paid attention to cognitive pace. Attention was also given to the differentiation and development of the speech genres required for different subjects and social situations. Classrooms that generated productive interactions also seemed to foster a public and confident culture around classroom talk. Students listened and expected to be listened to; and making mistakes was regarded as essential to learning rather than a matter of shame or embarrassment. In addition, aspects of classroom management – such as the layout, student organisation, the structure and sequencing of lessons, the handling of time and pace, and the routines and rules, were supportive of positive classroom interaction and maintained students' attention and time on task.

When the instructional emphasis is on knowledge construction, as is evident in the scenario above, teachers facilitate students' active inquiry by asking a significantly greater number of open-ended questions (Koufetta-Menicou & Scaife, 2000) that stimulate productive activity in the inquiry process (Elstgeest, 1985). In this context, teachers use guided discussion to develop students' conceptual understandings by building on their previous experiences, diagnosing and refining their ideas (Erodgan & Campbell, 2008). A range of students' ideas are received, and teachers use questioning to prompt and challenge thinking and reasoning (Erodgan & Campbell, 2008; Koufetta-Menicou & Scaife, 2000). Teachers also scaffold students' interactions by asking them for clarification or elaboration, and by using wait time (Rowe, 1972; Tobin, 1987) or 'practicing quietness' to give them the chance to make sense of their own ideas (van Zee, Iwasyk, Kurose, Simpson & Wild, 2001). Epstein (2007) also describes a positive class culture for talk as one where students are supported to use conversational strategies and teachers ask open-ended questions and give students time to formulate their ideas and express their thoughts.

Research has shown that there is a strong correlation between teachers' use of open-ended and higher-order questions and students' metacognitive awareness (Koufetta-Menicou & Scaife, 2000). Koufetta-Menicou and Scaife (2000) classify questions according to the mental functions required to answer them. They consider lower-order questions, such as those that require the answerer to recall information, to describe elements, or to identify simple relationships between variables, make very little contribution to the quality of teaching. They argue that teachers cannot assume that teaching has been effective in developing higher-level thinking unless they ask higher-order questions that call for students to make and justify judgements, arguments or explanations, to develop hypotheses, or to make predictions and draw conclusions (Koufetta-Menicou & Scaife, 2000).

In their study of teachers' questioning and interaction in classrooms utilising high and low levels of constructivist teaching practices, Erdogan and Campbell (2008) classify questions according to the impact they have on classroom interactions. They consider closed-ended questions focus classroom interaction on subject-matter and lead students to give pre-specified responses or 'right answers'. Whereas they consider open-ended questions open up the interaction by eliciting students' thinking and encouraging them to explore various lines of reasoning. While task oriented questions

are used to manage the learning process. Erdogan and Campbell (2008) found that teachers who utilised high levels of constructivist teaching practices (HLCTP) asked a significantly greater number of questions than teachers who utilised low levels of constructivist teaching practices (LLCTP). Additionally, teachers utilising HLCTP asked more open-ended questions than any other type, and they balanced open-endedness by using closed questions to focus students thinking as they carried out their investigations (Erodgan & Campbell, 2008).

The effect of wait time on the quality of classroom discourse was highlighted by Mary Budd Rowe in the 1970s. Rowe (1972) referred to the silent pauses between speakers as wait time, and she identified two types of wait time. Wait Time 1 (WT1) is defined as the duration of the pause after a teacher utterance, such as the pause following a teacher question. While Wait Time 2 (WT2) is defined as the duration of the pause after a student utterance, such as the pause that follows a student's response to a question. Rowe (1972) found that primary science teachers allowed an average of one second for a response to a question, and followed a student response by a comment within an average of nine-tenths of a second. When the WT1 and WT2 were extended to 3-5 seconds, Rowe noticed that teacher-student classroom interactions changed.

Rowe reported changes to the students' level of their involvement, and to the ways in which they interacted. Their responses increased in length and the number of their unsolicited but appropriate responses also increased. The level of student-to-student interaction also increased, while the numbers of students failing to respond to teachers' interactions decreased. In addition, there were increased contributions from students whom teachers considered 'slow'. Rowe (1972) also found evidence that the quality of the students' responses improved. The level of students' speculative responses increased, as did the number of inferences that were supported by evidence.

With the use of an extended wait time, Rowe (1972) found that teachers demonstrated greater flexibility in the way they responded to students, and while their number of questions was reduced, a greater variety of questions and more probing questions were asked. Additionally, teachers developed higher expectations of students they had previously rated as slow learners as these students performed better with extended wait times.

An extended wait time can facilitate substantial changes in classroom discourse. Tobin (1987) suggests that the increased silence allows teachers time to think and to formulate higher quality questions, while allowing students the space they need to construct more complex responses at a higher cognitive level. However, he cautions that students' increased capacity to think and reason is dependent on more than just the introduction of an extended wait time. Tobin (1987) states that improved classroom discourse and a curriculum that provides students with opportunities to develop higher cognitive level outcomes are also essential. He suggests that teachers should be supported to extend their use of wait time as this is initially quite difficult to sustain in practice.

Opening up classroom interaction to dialogue – what this means for teachers

Teachers traditionally tend to use a basic repertoire of classroom talk (rote, recitation and instruction/exposition) (Alexander, 2006) and avoid using higher-order categories of questions for several reasons. Using a limited repertoire of classroom talk affords teachers some security and ensures they remain in control of classroom events and the content of the lesson (Alexander, 2006; Koufetta-Menicou & Scaife, 2000; Rop, 2002). In addition, higher-order questions inevitably draw on students' divergent views and, consequently, topics can be introduced into the discussion about which teachers know little or nothing and which interrupt the focus of the lesson (Alexander, 2006; Koufetta-Menicou & Scaife, 2000). Unfortunately, teaching that is limited to low level talk is unlikely to offer the kinds of cognitive challenge needed to develop students' capacity to reason. In comparison, more dialogic discourse practices facilitate learning as they promote dialogue and have the greatest potential to challenge student understanding and thinking.

To develop dialogue in classroom interactions, teachers need to consider how to structure questions that provoke thinking and how to make the most of students' responses. Alexander (2006) considers authentic questions, where the teacher has not pre-specified or implied a particular answer, are dialogic because they indicate the teacher's intention to engage with what students think and know. While it is important to consider carefully the kinds of questions asked of students, there is also a need for teachers to pay attention to students' answers and to what they do with those answers.

Nystrand (1997) found that questions and discussion alone do not facilitate learning if children are not given the wait time (Rowe, 1972; Tobin, 1987) to think about their answer. He also refers to Collins (1982, in Nystrand, 1997) process of 'uptake', where teachers follow up on students' ideas by incorporating their responses into subsequent questions.

In addition, individual interactions can be chained into coherent lines of enquiry so that I-R-E patterns of discourse can be transformed into productive dialogue by supporting students to extend their contributions. Rather than evaluating students' responses to questions, teachers can build on I-R-E structures to develop chains of interactions, such as an I-R-F-R-F (Initiation-Response-Feedback-Response-Feedback) pattern of interaction (Mortimer & Scott, 2003) or as in a 'reflective toss' (van Zee et al. 2001) where the teacher's questions 'catch the meaning' of the students' dialogue and throw the responsibility for thinking back to the students. In both of these instances, the teacher's response encourages students to expand on and clarify their answers and to articulate their point of view. In this way, I-R-E patterns of discourse can be extended to support dialogic interaction.

Similarly, in her "questioning-based discourse" analytical framework Chin (2007) describes several teacher-questioning approaches that can be used to develop the discourse and support productive interaction. These include: Socratic questioning, where the teacher utilises a series of questions to guide student thinking; verbal jigsaw, where the teacher guides students to develop scientific terminology; semantic tapestry, where the teacher supports the students to draw together their ideas into a conceptual framework; and framing, where the teacher uses questioning to introduce a problem and shape the subsequent discussion.

Recently, the research of Simon, Naylor, Keogh, Maloney, and Downing (2008) demonstrated that teachers could facilitate a dialogic approach that promotes reasoning by providing students with opportunities to articulate their ideas. They found that teachers could use puppets as a pedagogical tool to enhance students talk. By presenting the puppets as 'experts' who posed problems and challenged students thinking they were able to scaffold students' to develop scientific arguments based on evidence, introduce alternative explanations, challenge conceptions and create

cognitive conflict. Alternatively, by presenting the puppets as someone in need of advice, the teachers could provide opportunities for the students to be the 'experts' and to articulate their thinking and reasoning. Simon et al. (2008) found that when lessons were focused on solving problems, the classroom discourse incorporated open-ended questions, argumentation and justification of ideas. More particularly, Simon et al. noted that using puppets during science teaching facilitated changes to teachers' discourse practice in a short period of time.

Alexander (2006) argues that dialogue is an essential tool for learning and should be more than just a feature of classroom interaction. He states that teachers need to be able to draw on a repertoire of classroom talk (rote, recitation and instruction/exposition, discussion and dialogue) to achieve a broad range of learning outcomes. Alexander (2006; 2008) also argues that dialogic teaching is a pedagogic approach that supports children to think and learn effectively, and he describes the essential features of a dialogic classroom in five principles:

- *Collective*: Teachers and students address learning tasks together, whether as a group or a class, rather than in isolation.

- *Reciprocal*: Teachers and students listen to each other, share ideas and consider alternative viewpoints.

- *Supportive*: Students articulate their ideas freely, without fear of embarrassment over 'wrong' answers; and they help each other to reach common understandings.

- *Cumulative*: Teachers and students build on their own and each other's ideas and chain them into coherent lines of thinking and enquiry.

- *Purposeful*: Teachers plan and facilitate dialogic teaching with particular educational goals in view.

Talk that is reciprocal, supportive, cumulative and purposeful, where teachers support students to build on one another's ideas and shape the talk to achieve planned educational outcomes, provides increased opportunities for sustained shared thinking (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2004) and the achievement of enhanced learning outcomes. Clearly, the quality of classroom talk depends on teachers orchestrating many factors including the length and patterns of interaction, the

use of questioning and feedback, cognitive challenge, as well as the culture and organisation of the classroom. Alexander (2006) acknowledges the challenge that this places on teachers' pedagogical content knowledge. He states: "…dialogic teaching challenges not only children's understanding but also our own. It demands that we have a secure conceptual map of a lesson's subject-matter, and that we give children greater freedom to explore the territory which that map covers" (Alexander, 2006, p. 31).

When reporting the interim findings from two schools involved in dialogic teaching development projects in the United Kingdom, Alexander (2008) found evidence of change to a range of aspects associated with talk, including: the classroom culture for talk; teacher questioning and responding; and student engagement and participation. He found that: both the teachers and students were more focused on talk and they devised ground rules for the management of discussion; students listened more carefully and respectfully to each other, and they talked collectively to reach a common goal; the changing dynamics of the classroom facilitated the participation of reluctant and less able students; and the students thought aloud and helped each other rather than competed to give a 'right' answer. Alexander (2008) noted that: teachers asked more open-ended questions that probed students' thinking and sought explanation and reasoning; their questions took into account the individual capacity of the students; they built on students' answers, developing longer teacher-student exchanges; and they gave students more time to think. In addition, he noted that: the students gave longer responses; they answered loudly, clearly and confidently; their responses became more diverse, including those that were expository, explanatory, justificatory, and speculative rather than just factual recall; and they built on one another's ideas.

Alexander (2008) also found that, in general, teachers could make considerable adjustments to their classroom culture for talk by specifying guidelines for 'speaking and listening' that their students could understand and use. He noted that this quickly impacted the dynamics and ethos of talk and helped the teachers to cultivate the collective, reciprocal and supportive aspects of a dialogic classroom (Alexander, 2008). However, he also reported that the cumulative and purposeful aspects of a dialogic classroom were more difficult for teachers to achieve (Alexander, 2008). More particularly, the cumulative aspect, which requires teachers to use discourse in a responsive way so that they scaffold their students thinking and progress their

understandings, was harder to achieve because it is dependent on the teacher's subject knowledge and their knowledge of each of their students' current understandings and learning needs (Alexander, 2008). Ultimately, Alexander (2008) concluded that in order to help teachers achieve a dialogic classroom, it would be expedient to initially establish the collective, reciprocal and supportive aspects, i.e. the ethos, dynamics and affective climate, before focusing on developing the more complex cumulative and purposeful aspects.

> Here, we can identify the purposes of the talk and use cumulation to steer it towards those purposes. We can work on listening to and building on answers and getting children to do the same. We can reflect on the feedback we provide. We can reassess the balance of drawing out (questioning) and putting in (exposition). We can consider how ideas are not merely *exchanged* in an encouraging and supportive climate but also *built upon*. (Alexander, 2008, p. 112)

Since this research focuses on the impact of a professional learning program on teachers' beliefs, knowledge and practice it is important to also review the literature relating to teacher beliefs and knowledge as well as that of teacher professional learning.

Teachers' knowledge and beliefs

While teacher beliefs have been described as a valuable concept to teacher education, they are also complex and difficult to define (Mansour, 2009; Pajares, 1992) and are linked to teachers' experiences and the way that they think about their work (Calderhead, 1996, in Mansour, 2009). Teachers hold beliefs about the educational process that focus on teachers and teaching, students and the learning process, the nature of knowledge, the role of schools in society, the curriculum, as well as beliefs about their work, the subject matter they teach and their roles and responsibilities (Levitt, 2001). Peterson, Fennema, Carpenter, and Loef (1993, in Levitt, 2001) talk about these beliefs as pedagogical content beliefs and they maintain that together with pedagogical content knowledge, these beliefs have a strong connection to classroom action.

Teachers' decisions about educational practices are contingent on their beliefs and knowledge (Brickhouse, 1990; Pomeroy, 1993). Research indicates that teachers' beliefs may be a stronger predictor of teachers' behaviour than teacher knowledge (Pajares, 1992), and that teachers' beliefs are seen to be enacted in their classroom practice (Pajares, 1992; Peterman, 1993; Tobin, 1993). Mansour (2009) cites Clarke and Peterson's (1986) description of teachers' beliefs as "the rich store of knowledge that teachers have that affects their planning and their interactive thoughts and decisions" and goes on to infer that teacher beliefs influence their behaviour and what they attend to in their environment. Furthermore, Levitt (2001) states that teachers' beliefs about teaching and learning affect their likeliness to enhance student learning and interest in all subject areas.

Teachers' beliefs are context-bound, tend to be experience-based rather than theory-based and are made visible through their classroom practice (Mansour, 2009). The manner in which teachers implement learning depends largely on their beliefs about teaching and learning (Levitt, 2001) and sometimes there is a mismatch between their beliefs and their practice (Mansour, 2009; Phillip, 2007; Thompson, 1992). For example, while teachers might understand how dialogic interaction and inquiry-based learning support students to construct knowledge, if they do not value shared interactions as a tool for learning, they might manage classroom talk in a way that inhibits student interaction and impedes the inquiry process. However, there can be many reasons for the mismatch between teacher belief and practice, including external factors such as learner behaviours, time, resources, and course content as well as constraints that relate to the school and broader educational contexts in which teachers work (Ajzen, 2002; Borg, Riding & Flazon, 1991).

The relationship between teachers' beliefs and behaviour is highly complex (Brickhouse, 1990; Clark & Peterson, 1986) and teachers' behaviour and actions influence the continual development of their beliefs and personal theories. Beliefs are reinforced or adapted according to the evidence gained from classroom practice and it is the events that teachers experience within classrooms and school settings that constrain or enhance the development of their beliefs and knowledge (Clark & Peterson, 1986). The research also shows that, when given the opportunity to reflect on their practice, teachers can change their beliefs (Luft, 1999; Tobin & LaMaster, 1995).

As stated previously, Alexander (2006) maintains that dialogic teaching places demands on teachers' pedagogical content knowledge and in order to be effective teachers need to also have "a secure conceptual map" of the content that they wish to teach (p. 31). Pedagogical content knowledge has been identified by teacher educators and researchers as a critical component of the knowledge needed to teach (Shulman, 1986, 1987). In 1986, Shulman initially proposed a model of teaching that comprised three domains of teacher knowledge, including: subject matter knowledge, curricular knowledge and pedagogical content knowledge. As his understandings of the domains of teacher knowledge evolved, Shulman listed pedagogical content knowledge as one of the seven knowledge bases for teaching along with: content knowledge, general pedagogical knowledge, curricular knowledge, knowledge of learners, knowledge of educational contexts, and knowledge of philosophical and historical aims of education. He defined pedagogical content knowledge as:

> That special amalgam of content and pedagogy that is uniquely the providence of teachers, their own special form of professional understanding… Pedagogical content knowledge… identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to diverse interests and abilities of learners and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue. (Shulman, 1987, p. 8)

Later work by Grossman (1990) delineated four areas of teachers' knowledge that she described as the cornerstones of the professional knowledge for teaching, including: general pedagogical knowledge, subject-matter knowledge, pedagogical content knowledge, and knowledge of context. Of these, pedagogical content knowledge was expected to have the greatest impact on teachers' classroom actions.

Morine-Dershimer and Kent (2002) suggest that, in the course of teaching, teachers' personal beliefs and perceptions gained from their practical experiences (personal pedagogical knowledge) are broadened and made objective, while their theoretical understandings of pedagogy (general pedagogical knowledge) are exemplified and contextualised. In the process, context-specific pedagogical knowledge is developed and the subtleties of applying general pedagogical knowledge to classrooms situations are learned. However, Magnusson, Krajcik and Borko (1999) also maintain that

teachers' knowledge and beliefs act as filters through which they come to understand the components of pedagogical content knowledge and, ultimately, these beliefs and knowledge either facilitate or impede change. They suggest that teachers' professional learning ultimately needs to focus at the level of their beliefs and knowledge in order to extend their pedagogical content knowledge.

Appleton (2006) describes science pedagogical content knowledge as the knowledge used by a teacher to construct science learning experiences which "…is a dynamic form of knowing that is constantly expanding and being transformed from other forms of teacher knowledge, and through experiences of planning, implementing, and evaluating science teaching and learning" (p. 35). Appleton states that science pedagogical content knowledge incorporates teachers' knowledge of how to shape science content so that the learning is appropriate for their students. This involves teachers not only selecting the appropriate kinds of learning experiences but also taking into account the students' particular learning needs and preconceptions about the topic. Such a process is influenced by teachers' views of teaching and learning and Appleton (2006) regards the "…outcome of science PCK [pedagogical content knowledge] being used is the enacted science curriculum" (p. 35). Appleton also considers that the level of teachers' science pedagogical content knowledge affects their capacity to make 'on-the-spot' decisions about how to respond to students' comments during the course of a lesson. Developing teachers' capacity to respond to students so that they enable their participation in substantive conversations that facilitate their deeper thinking is what lies at the heart of this research.

Teachers' professional learning

Educational reforms typically call for increased outcomes for students learning and, more often than not, improving teacher practice is seen as a way to reach such objectives. Darling-Hammond (1998) concurs, but she also believes that students attain high levels of understanding as a result of immensely skilful teaching and, in order for that to occur, schools need to be organised in such a way as to support teachers' continuous learning. High-quality teacher professional learning is frequently considered a key component of proposals for improving education and Guskey (2002) maintains that professional development programs usually seek to bring about change

in three key areas: the classroom practices of teachers; their attitudes and beliefs; and in the learning outcomes of students.

Early conceptions of teacher professional development centred on the notion that effective professional development would improve teacher instructional practices, which in turn would improve outcomes for student learning and, consequently, a substantial amount of the research focuses on identifying those processes and elements of effective professional development that achieve this (Opfer & Pedder, 2011). For example, the research relating to professional learning shows that teachers' knowledge and skill is likely to be enhanced when it is: focused on academic content as well as the way that students learn; engages teachers in meaningful discussions with their peers; and, hands on, providing opportunities for teachers to plan and implement new knowledge in their class contexts (Garet, Porter, Desimone, Birman, & Yoon, 2001). It also shows that changes to teachers' beliefs as well as practice are difficult for teachers to achieve and in order to facilitate such change teacher professional learning needs to be sustained over time (Appleton, 2006; Garet, et al., 2001; Guskey, 1986).

The research has also highlighted those pedagogical features that contribute to effective professional learning. It has shown that teachers learn most effectively when they are actively engaged with authentic teaching tasks and using the tools and resources relating to their everyday practice (Appleton, 2006; Darling-Hammond, 1998; Garet, et al., 2001; Hawley & Valli, 1999; Ingvarson, Meiers, & Beavis, 2005; Putnam & Borko, 2000). What is more, teachers learn more effectively when the learning is 'job-embedded' so that it is based in the meaningful contexts of teachers' schools and classrooms and integrated with their daily work (Adey, 2004; Appleton, 2006; Darling-Hammond, 1998; Garet, et al., 2001; Hackling, Goodrum, & Rennie, 1999; Hawley & Valli, 1999; Ingvarson, et al., 2005).

In addition, the research has found that the professional learning context needs to be supportive so that teachers are scaffolded as they take on the challenge of developing new practices (Appleton, 2006; Darling-Hammond, 1998; Ingvarson, et al., 2005). This means that teachers should receive ongoing support as well as opportunities for reflection and feedback as they attempt to integrate new instructional strategies into

their classroom practice (Adey, 2004; Appleton, 2006; Bray, 2002; Hackling, et al., 1999; Ingvarson, et al., 2005).

Putnam & Borko (2000) consider that teacher learning that is job-embedded also needs to be balanced with opportunities for learning in new and different contexts away from the school. They state that "The classroom is a powerful environment for shaping and constraining how practicing teachers think and act. Many of their patterns of thought and action become automatic – resistant to reflection or change" (p. 6). For this reason, Putnam and Borko (2000) recommend that teachers also engage in learning experiences that take them away from their school settings so that they can consider the focus of the professional learning in new ways.

The research also shows that teacher professional learning is more effective when teachers have the opportunity to interact and collaborate in strong professional communities of practice (Borko, 2004; Bray, 2002; Cochran-Smith & Lytle, 1999; Darling-Hammond, 1998; Garet, et al., 2001; Keady, 2007; Goldenberg & Gallimore, 1991; Putnam & Borko, 2000; Thomas, Wineburg, Grossman, Myhre, & Woolworth, 1998). Such communities of practice evolve when groups of teachers interact and collaborate to problem solve issues that relate to their teaching and devise strategies and solutions that improve their practice (Garet, et al., 2001; Keady, 2007; Thomas, et al, 1998).

Even as early conceptions of teacher professional development considered changes to teachers practice and student learning were driven by effective professional development, Guskey (1986; 2002) believed it was important to consider how change to teachers' classroom practices, their attitudes and beliefs, and students learning outcomes were achieved and sustained. While he acknowledges that the relationship between each of these outcomes is complex, he suggests that significant change is generally initiated by changes to teachers' practice. This is illustrated in his *Model of Teacher Change* (Figure 2.4), which Guskey (2002) maintains is based on the idea that "change is primarily an experientially based learning process for teachers" (p. 384).
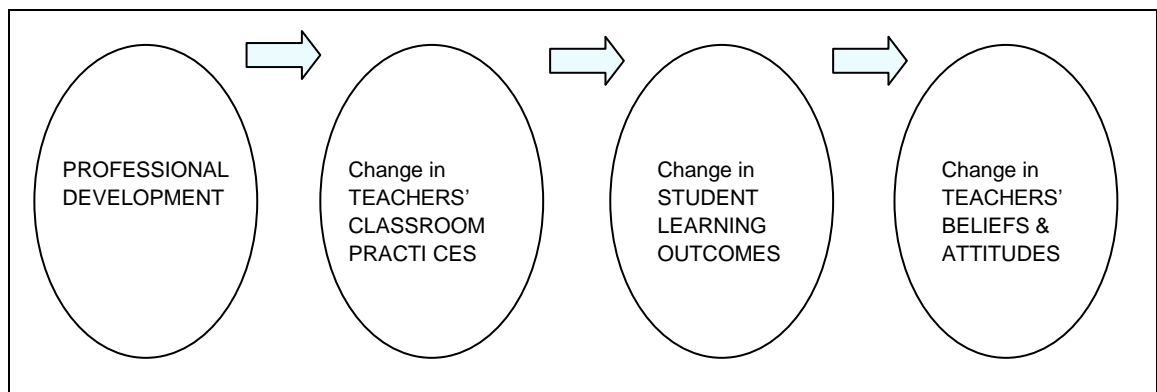
Figure 2.4: A Model of Teacher Change (Guskey, 2002, p. 383).

The model shows how significant change in teachers' attitudes and beliefs tends to occur after they have gained evidence of improvement in student learning and Guskey (1986; 2002) considers that it is not the professional development itself that significantly changes teachers' beliefs and attitudes but the evidence teachers gain from their practice and the resultant increase in students' learning outcomes. He also maintains that it is the evidence of clear and positive change to students' learning outcomes that ensures any change to teachers' practice is sustained (Guskey, 1986; 2002).

More recently, models of teacher professional learning such as Guskey's have been criticised for representing change as a linear process (Clarke & Peter, 1993) and teacher learning as a causal relationship (Opfer & Pedder, 2011). Such models have been criticised for being too simplistic and for disregarding the effect that teachers' professional lives and working contexts have on the effectiveness of teacher professional learning (Borko, 2004; Clarke & Hollingsworth, 2002; Timperley & Alton-Lee, 2008). A further significant limitation of Guskey's (2002) model is that it takes no account of teacher beliefs, knowledge and professional content knowledge, which are key factors determining the quality of practice and students learning outcomes.

The Interconnected Model of Teacher Professional Growth (Figure 2.5), initially developed by Clarke and Peter (1993, in Clarke & Hollingsworth, 2002) and later revised by the Teacher Professional Growth Consortium (1994, in Clarke & Hollingsworth, 2002), elaborated on Guskey's model in an attempt to map a much more dynamic and complex view of teacher learning. This model proposed that change

occurs via processes of reflection and enactment within four domains that encompass the teachers' world, including: the personal domain (teacher knowledge, beliefs, attitudes); the domain of practice (professional experimentation); the domain of consequence (salient outcomes); and the external domain (sources of information, stimulus or support) (Clarke & Hollingsworth, 2002). These four domains are considered to be comparable to the elements described in Guskey's *Model of Teacher Change* (1986; 2002) and, unlike Guskey's model, the significant influence of teachers' beliefs and knowledge (and so professional content knowledge) on their professional growth is recognised.
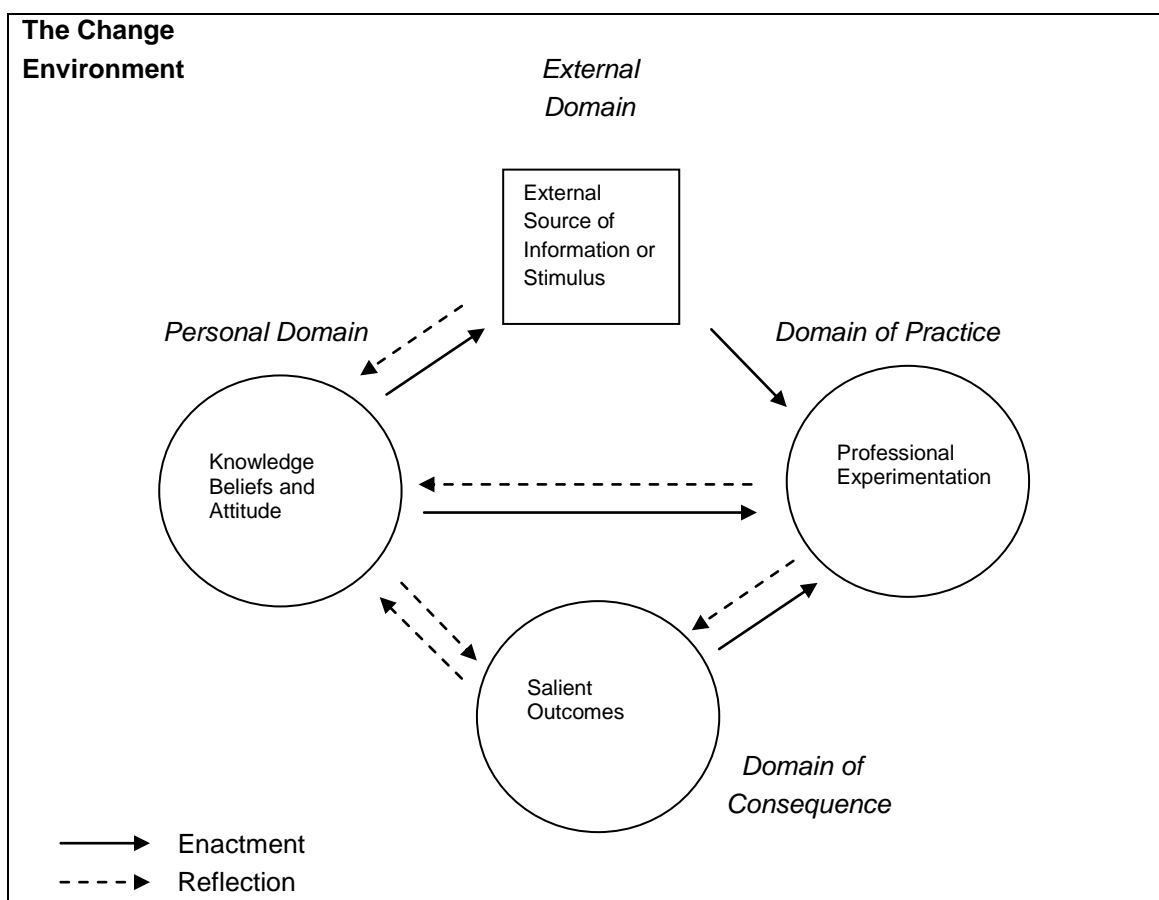
Figure 2.5: The Interconnected Model of Professional Growth *(Clarke & Hollingsworth, 2002, p. 951).*

The processes of reflection and enactment are represented in the *Interconnected Model* as arrows that connect the domains. The model shows teacher professional growth as complex and non-linear, and it identifies multiple pathways for growth between the domains while at the same time depicting professional growth as part of

an ongoing process of learning (Clarke & Hollingsworth, 2002). In this model, reflection and enactment are considered the mediating processes by which change occurs and change in one domain is seen to effect change in another (Clarke & Hollingsworth, 2002). The *Interconnected Model* also recognises that all teacher growth occurs in the context of social settings which incorporate constraints and affordances (Clarke & Hollingsworth, 2002) that ultimately impact on teachers' capacity to change.

The research shows that individual teacher's prior experiences, beliefs and knowledge exert a strong influence on the effectiveness of professional learning (Richardson, 1996). When considering teacher professional learning in science, Appleton (2006) believes that it is important for teacher educators to understand teachers' conceptions and alternative conceptions about the teaching of science. He suggests that teachers should be given the chance to examine, elaborate, and integrate new knowledge and beliefs about teaching and learning science into their existing systems of knowledge and beliefs by observing, analysing, and reflecting upon their own and other teachers' practice.

The research also suggests that teacher learning and change can be motivated by dissonance between teachers' personal expectations and sense of efficacy (Wheatley, 2002) and by creating cognitive conflict in order to challenge teachers' thinking (Cobb, Wood, Yackel, 1990). Wheatley (2002) found that teacher efficacy doubts can foster teachers learning by inducing disequilibrium and change, encouraging their reflection and motivation to learn, and promoting productive collaboration.

Schools also impact on the effectiveness of teacher professional learning and Ingvarson et al. (2005) point to the significant indirect impact that the existing school culture has on the outcomes of professional learning programs. Ingvarson et al. (2005) recommend that policy makers and school administrators pay attention to the development of a culture that is supportive of professional learning, which will "enable schools to provide fertile ground for professional learning on an ongoing basis and as a routine part of the job" (p.17).

Opfer and Pedder (2011) concur, stating that the current research on professional development and teacher learning tends to underplay the complexity of teacher learning, which leads to a focus on the micro context (individual teachers, activities or programs) with less consideration given to the influences from the meso (institutional) and macro (school system) contexts. In an attempt to develop an even more multifaceted conceptualisation of teacher professional learning, Opfer and Pedder (2011) employ complexity theory to identify systems within and across different bodies of research (teacher professional development, teaching and learning, organisational learning and teacher change). They maintain that when viewed as a complex system, teacher learning can be seen as "a nested system involving systems within systems" (such as teachers, grade level or subject groups, schools, education systems, and the broader political context), which are seen to be "interdependent and reciprocally influential" (Opfer & Pedder, 2011, p. 379). By re-viewing the research in this way, they hope to develop a new framework for conceptualising teacher learning and professional development and to shift the focus of the research from a cause-and-effect approach to causal explanation so as to understand more about why and how teachers learn (Opfer & Pedder, 2011).

Ultimately, the research shows that there is a great deal more to be learned about teacher professional learning but Darling-Hammond provides a good summary of a productive context for teacher learning:

> Good settings for teacher learning – in both colleges of education and schools – provide lots of opportunities for research and inquiry, for trying and testing, for talking about and evaluating the results of learning and teaching. The "rub between theory and practice" (Miller & Silvernail, 1994) occurs most productively when questions arise in the context of real students and work in progress, and where research and disciplined inquiry are also at hand. (Darling-Hammond, 1998, p. 8)

In this study, the teachers worked together in a professional learning context to better understand how to match the discourse practices they used in class discussions in primary science to the purpose of the lesson and phase of inquiry. In the process they came to understand how their beliefs and knowledge about teaching and classroom discourse impacted on their students' learning.

Summary: A teaching and learning model and a conceptual framework for this study

A summary of the key ideas from the literature, which informed the professional learning component of this study, is presented as an elaborated teaching and learning model in Table 2.3 which has been further developed from Hackling, Smith and Murcia (2010). The table shows how sociocultural ideas to do with the appropriation of knowledge and scientific discourses, and scaffolded instruction can be integrated. Essential concepts include:

- the three steps of science teaching (Scott & Mortimer, 2003), which represents sociocultural ideas to do with the appropriation of knowledge;

- the five phases of inquiry (Engage, Explore, Explain, Elaborate and Evaluate), which serve different instructional purposes (Hackling et al., 2007);

- the communicative approaches (Mortimer & Scott, 2003) framework of classroom discourse that describes and categorises discourse on two dimensions: interactive/non-interactive and dialogic/authoritative; and

- the questioning (Erdogan & Campbell, 2008), wait time (Rowe, 1972) and patterns of interaction (Mortimer & Scott, 2003) that are used to describe different types of discourse.

Table 2.3: An elaborated teaching and learning model.

Steps of Science teaching Scott & Mortimer (2003)		5E Phases of inquiry Phase	Instructional purpose	Communicative approach Mortimer & Scott (2003)	Questioning Erdogan & Campbell (2008)	Wait time Rowe (1972)	Patterns of interaction Mortimer & Scott (2003)
Step 1	Making ideas available on the social plane	Engage	Engaging students, eliciting prior knowledge and opening-up the scientific problem	Interactive-Dialogic	Open-ended	Increased WT1 & WT2 (3-5 secs)	IRF IRFRF
Steps 1 & 2	Making ideas available on the social plane ↓ Assisting students to make sense of & internalize ideas	Explore	Exploring the scientific phenomenon and exploring and working on students' views		Open-ended (Some task-oriented)	Increased WT1 & WT2 (3-5 secs)	IRF IRFRF
Step 2	Assisting students to make sense of & internalize ideas	Explain	Introducing and developing the scientific story	Interactive-Dialogic ↕ ↓ Interactive-Authoritative ↕ Non-interactive-Authoritative	Open-ended ↕ Close-ended	Increased WT1 & WT2 (3-5 secs) ↕ ↕ Shorter WT1 & WT2	IRF IRFRF ↕ ↕ IRFRF IRE
Steps 2 & 3	Assisting students to make sense of & internalize ideas ↓ Scaffolding students to independently apply & use ideas	Elaborate	Guiding students to work with scientific views and handing over responsibility to students to apply and use them in a student planned investigation	Interactive-Dialogic ↕	Open-ended ↕ Close-ended (Some task-oriented)	Increased WT1 & WT2 (3-5 secs) ↕ Shorter WT1 & WT2	IRF IRFRF
Step 3	Scaffolding students to independently apply & use ideas	Evaluate	Maintaining the development of the scientific story, reflecting on learning and evaluating learning outcomes	Interactive-Authoritative	Open-ended ↕ Close-ended	Increased WT1 & WT2 (3-5 secs) ↕ ↕ Shorter WT1 & WT2	IRF IRFRF ↕ IRE

When considered in relation to the phases of the 5Es inquiry model, it is evident that particular communicative approaches, styles of questioning and patterns of interaction are better suited to achieving the instructional purposes of the each phase. Mapping the communicative approaches and elements of discourse to each phase of inquiry also suggests how different types of discourse could be orchestrated over a series of lessons.

The manner in which teachers construct classroom discourse impacts on the development of students' thinking and reasoning. The patterns of teacher-student interaction, the teacher's use of questioning, wait time and feedback, and the level of cognitive challenge presented to students are all important aspects of classroom talk that influence the culture of the classroom and the kinds of discourse generated. A teacher's capacity to construct productive classroom discourse is dependent on their beliefs and knowledge about teaching and classroom discourse.

This study investigated how the professional learning program impacted on teachers' beliefs and knowledge about classroom discourse and the way students learn science, as well as their capacity to utilise communicative approaches to orchestrate sustained conversations in their science classrooms. The study developed new approaches to and resources for teacher professional learning, and new insights into teachers' discourse practices that could be used to develop theoretical models of the relationships between inquiry, instructional purposes and communicative approaches. Figure 2.6 provides a visual representation of the conceptual framework that was used to guide this study.

Classroom culture for talk
- Conventions and rules for talk
- Physical setting for whole-class discussions

Teacher's beliefs

Teacher's practice

Teacher's knowledge

Teacher's use of questioning and discourse moves

Teacher's communicative approach

Opportunities for students' sustained engagement with a discourse of inquiry

Development of the discourse required for effective science inquiry

Student reasoning and learning

Figure 2.6: A conceptual framework for this study.

CHAPTER 3: METHODOLOGY

Introduction

A mixed methods research design was used to investigate the impact of professional learning on teachers' beliefs, knowledge and practice of classroom discourse. This chapter explains the research approach of this study and details the research design, the selection of research participants, the data sources used, and how the data was analysed. Issues associated with validity, reliability and ethics are duly considered.

Research approach

This study was a part of a larger research project entitled: *Enhancing Classroom Discourse in Primary Science Education* (the *Discourse project*), which focused on developing teachers' beliefs, knowledge and practice to do with classroom discourse. The *Discourse Project* engaged teachers in a participatory action research process of designing, implementing and evaluating new ways of matching classroom discourse types to the phases of inquiry in science (Hackling, Smith & Murcia, 2011). The *Discourse Project* utilised mixed methods and interpretive approaches, combining pre- and post-intervention observations and data collections involving the whole cohort of participants, and a set of case studies involving a more extensive collection of data with five of the participants. These case studies became the focus of my research.

While the research combined mixed methods and interpretivist methodologies, it centred on an interpretivist approach set within a social constructivist worldview. The philosophical assumptions that underpin social constructivism hold that individuals seek understanding of the world in which they live and work, and that they develop subjective meanings of their experiences (Creswell, 2009). Meanings are seen to be constructed through interaction with others and through the historical and cultural conventions that operate in individuals' lives (Creswell, 2009). Consequently, in order to make sense of (or interpret) the settings of the participants, the research must focus on the process of interaction among individuals and on the specific contexts in which

they live and work (Creswell, 2009). Thus, with an interpretivist orientation to research, knowledge is seen to be gained from an inductive, theory-generating mode of inquiry (Merriam, 1998).

By taking a qualitative approach that utilises an interpretivist focus, this research served to understand the impact of the professional learning experience on teachers' beliefs and knowledge of communicative approaches, and how they utilised these approaches in their teaching practice. However, given the interpretivist aspect of the study, it was necessary for me as the Researcher to acknowledge that my reading of teachers' and students' interactions and the classroom contexts in which they work is filtered through my own beliefs and experiences of classroom teaching. As a trained primary school teacher, I have had extensive experience as a classroom practitioner, a specialist literacy intervention teacher, a school administrator, and a teacher educator. In addition, I have completed a research Master's thesis on teacher professional learning in literacy intervention, which utilised a discourse analysis. My personal perspective of teaching and learning aligns with Vygotskian theory and the social constructivist and sociocultural approaches. While the knowledge gained from these experiences and qualifications may influence the way in which I observe and read classroom activity, they also lend credibility to the interpretations I make.

Research design

The research design links the research questions to the strategy that was used to carry out the research (Punch, 1998). This study utilised case study and mixed methods strategies to answer the research questions outlined in the introduction chapter of this thesis. This section explains the research design, the conceptual framework, the subjects of the study, and the tools and procedures for collecting and analysing data.

The research design for the *Discourse Project* combined elements of participatory action research (Kemmis & McTaggart, 2000), design-based research collaboration (Schoenfeld, 2007) and Leach and Scott's (2002) approach to designing and evaluating science teaching sequences. Teachers and researchers collaborated in working from the teaching and learning framework to develop new pedagogical

strategies that can be used to scaffold classroom discourse. They designed ways of using these strategies to teach either *Primary Connections* or teacher-authored units in a manner that matches communicative approaches to instructional purposes and phases of inquiry. The teachers worked through two cycles of design, enactment, analysis and reflection, and redesign (Figure 3.1).

Principles derived from the conceptual framework → Develop pedagogies → Design approaches to teaching a *Primary Connections* unit ↓

Redesign approaches with a second *Primary Connections* unit ← → Enactment of design through teaching the unit ↓

Analysis and reflection — Analysis and reflection
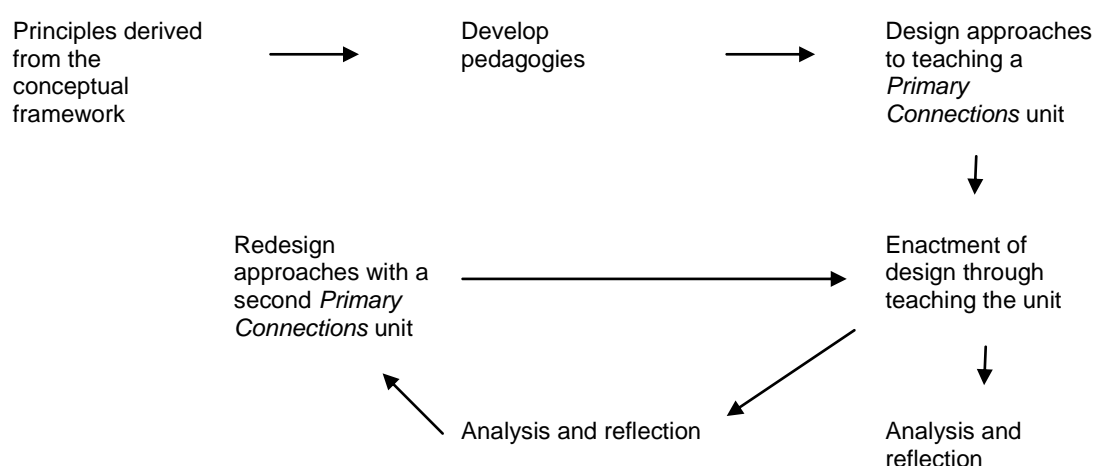
Figure 3.1: The design-based action research model.

Teachers were released from schools to participate in four days of collaborative research, development and professional learning that was led by Professor Mark Hackling from Edith Cowan University. As one of several researchers connected with the project, I supported the implementation of the professional learning but primarily took on a passive observer role. On the first professional learning day (PL Day 1), the teachers completed a pre-intervention questionnaire that documented: their beliefs about teaching science; their confidence with teaching science; their beliefs about being an effective manger of classroom talk; their knowledge about managing classroom discourse; and, their knowledge about using puppets. Subsequently, the teachers were introduced to the educational principles to do with inquiry, instructional purposes and communicative approaches as articulated in the conceptual framework for this study. Over the course of the day, they participated in three different sessions that focused on: using puppets to engage students in classroom discourse; managing classroom discourse in inquiry-based science; and, analysing questioning techniques. Each session provided the opportunity for the teachers to share their knowledge and

teaching practice as well as to engage with the literature that informed the professional learning intervention.

The next day, on PL Day 2, the teachers collaborated in small groups to plan the delivery of a *Primary Connections* unit of work of their choosing that incorporated the use of puppets and a plan for whole-class discussion which matched appropriate types of discourse to the purpose of the lesson and the phase of inquiry. Initially, the teachers focused on identifying the learning outcomes and the kinds of explanations that would indicate the learning had been achieved for a given topic. Then, they set about planning the discussion for the Engage phase when they would use the puppets to set the scene for the new unit of work, pose problems for the students to solve, and elicit their prior knowledge of the topic. Later in the day, the teachers also decided how they would use the puppets in the Explore and the Explain phases and they planned whole-class discussions to fit the different instructional purpose of those phases. Following PL Days 1 and 2, the teachers returned to their respective schools to enact their planned unit of work with their class.

When they attended PL Day 3, approximately eight weeks later, the teachers were able to reflect on the implementation of their planned unit of work and on their capacity to use an appropriate communicative approach to scaffold their students talk in whole-class discussions in order to meet the purpose of the Engage and Explain lessons. The teachers were encouraged to share what worked for them and what was problematic and permission was also sought from two of the teachers to share some of the video footage of their practice. Using the video footage proved to be a powerful and impactful way to share productive discourse practices as the teachers were able to see and hear what different discourse strategies looked and sounded like and to make connections to their own practice. Drawing on such a significant and relatable resource in this way also served to focus, contextualise and enrich the teachers' professional conversations. In the latter part of PL Day 3, the teachers collaborated once again to design the implementation of a new *Primary Connections* unit incorporating the use of puppets and planned whole-class discussions, which they once again enacted with their classes when they returned to their respective schools.

About eight weeks later, when the teachers attended PL Day 4, they were given the opportunity once again to participate in professional conversations about the implementation of their second *Primary Connections* unit and on their use of communicative approaches in whole-class discussions. Several more of the teachers were willing to share the video footage of their practice and this facilitated further rich discussion and reflection on the ways that their management of classroom discourse had changed over the course of the professional learning intervention. On PL Day 4, the teachers also collaborated to document the resources they had developed for implementing *Primary Connections* units using puppets and communicative approaches that matched the instructional purposes of phases of inquiry. These resources were subsequently shared with the partner organisations involved in the research project to support the professional learning of other teachers. Figure 3.2 shows how the four days correlated to the design-based action research process.

Day	Research and development and professional learning activities
Day 1 June 2, 2009	Introduce a set of educational principles about inquiry, instructional purposes and communicative approaches derived from the conceptual framework. Half-day workshop on pedagogies associated with using puppets in teaching primary science.
Day 2 June 3, 2009	Teams of three teachers work collaboratively to design approaches to teaching a *Primary Connections* unit incorporating use of puppets and scaffolding discourse types to suit the instructional purposes of the phases of inquiry.
June-August	Teachers enact the design through teaching the *Primary Connections* unit.
Day 3 August 31, 2009	Teachers analyse and reflect on their implementation of their design and on their scaffolding of communicative approaches. Teachers work in teams of three to redesign their approaches in the context of a second *Primary Connections* unit.
September-November	Teachers enact the design through teaching the *Primary Connections* unit.
Day 4 November 16, 2009	Teachers analyse and reflect on their implementation of their design and on their scaffolding of communicative approaches. Teachers document resources for implementing a *Primary Connections* unit using puppets and communicative approaches matched to instructional purposes of phases of inquiry.

Figure 3.2: Relationship between the four professional learning days and the design-based action research process.

Mixed methods as a research approach

Mixed methods research draws from both qualitative and quantitative approaches to data collection as a way to counter the limitations of any one method (Creswell, 2009). Mixed methods researchers assume that by collecting diverse types of data a better

understanding of the research problem is attained. By triangulating data sources, researchers can establish a consensus across qualitative and quantitative data methods, or integrate the data to reinforce findings. Creswell (2009) cites several procedures for mixed methods strategies of inquiry, including: sequential mixed methods, where one method expands on another; concurrent mixed methods, where data sources are merged; and transformative mixed methods, where a theoretical lens provides an overarching perspective that frames the study and utilises either sequential or concurrent procedures. Given the social constructivist framework that guides this research, transformative mixed methods were combined with concurrent procedures.

Case study as a strategy of inquiry

Case studies are utilised as a strategy of inquiry in qualitative research to explore in-depth the activities and processes of real world problems (O'Leary, 2005) in the context of their natural settings (Punch, 1998). Punch describes case studies as having a holistic focus that intends to preserve and understand the wholeness and unity of a case. To understand the experiences of an individual or community, researchers use a case study approach and draw on multiple sources of data (Punch, 1998) to delve into the detail (O'Leary, 2005) and to build rich, thick descriptions (Merriam, 1988) of the subjects they study.

Although case studies can be defined in terms of a research process, a unit of study or an end product, they are more generally defined in terms of a bounded system (Merriam, 1988). Case study research is bounded (or delimited) by the time and activity of the real-life contexts in which it is situated (Merriam, 1988; Stake, 1995) and researchers collect detailed information using a variety of data collection procedures over a sustained period of time (Stake, 1995). Miles and Huberman (1994) define a case as a phenomenon of some sort occurring in a bounded context, which has a focus (or heart) and an indeterminate boundary that defines the case and indicates what will not be studied.

Focusing the research in this way allows researchers develop holistic understandings as a result of their extended engagement and development of relationships and trust within specific contexts (O'Leary, 2005). While case studies may not always be

'representative' or 'generalisable' they can add a richness and depth of understanding that is not always possible in research of a larger scale (Merriam, 1988). For this reason case studies are particularly useful for investigating the processes, problems and innovations of educational contexts. Additionally, issues of generalisability can be mitigated by carrying out multiple case studies (Miles & Huberman, 1994) to develop conceptual understandings that can inform the further studies (Punch, 1998).

Consequently, a multiple case study approach was selected for this research as a way to explore in detail those aspects of context and process that facilitate teachers to sustain classroom conversations of high intellectual quality. The knowledge gained from a cross-case analysis of the case studies was triangulated with other data and used collectively to inform theory development. Ultimately, it will also be used to develop teachers' pedagogical content knowledge for classroom discourse and to facilitate teaching practice.

Selection of participants

The *Discourse Project* involved an advanced or 'second wave' of teacher professional learning and was therefore suited to confident teachers of primary science. Initially, twelve confident teachers of primary science were recruited from government and independent schools. From this cohort, five teachers were recruited to participate in case studies which involved more extensive data collections.

The selection of the final five to participate in case studies, in part, required the teachers to self-select. Teachers were briefed on the level of commitment required and the potential impact that this would have on their professional lives. More specifically, the case study teachers were made aware that the research would focus on the whole class discussions they conducted with their students in the context of primary science and that this would require them to open-up their classrooms for observation and video recording of lessons, in addition to reflecting on and discussing their teaching practice with me as the Researcher. As such, the cases were bounded by the teacher and class. Although involvement in the research process may seem both time consuming

and challenging for teachers, it also has the potential to provide a professional learning experience that is equally empowering for both teachers and researchers.

Appointments were made with the teachers who wished to be involved in the case studies to discuss in more detail what the case study entailed and to make arrangements to observe their classroom. An initial teacher interview was conducted at this time to develop an understanding of the teacher's beliefs and knowledge about classroom discourse and science teaching, their experiences with the *Primary Connections* program, and to begin to understand something of the context in which they worked. Figure 3.3 outlines the questions used in the initial interview of the case study teachers and this interview is also provided in Appendix 3.

Initial case study teacher interview
1. **Teachers' beliefs about classroom discourse and students' learning of science** How would you describe your approach to teaching primary science? What are your reasons for constructing the learning in this way? How do questioning and classroom discussion help students learn science concepts? 2. **Teachers' knowledge about: discourse moves, communicative approaches, questioning technique, and classroom culture; and how these aspects influence opportunities for students' learning science through inquiry** What do you think a teacher needs to know about discussion and questioning techniques that would enable them to facilitate students' learning in primary science lessons? What kinds of classroom environments foster students' interaction in primary science? 3. **a) Teachers' use of communicative approaches and questioning** What do you think are important characteristics of classroom discussions in your science lessons? **b) Teachers' capacity to match these aspects to the phases of inquiry** Do you think your classroom discussions and use of questioning are different at different stages of a science lesson or different phases of a science unit? 4. **Teacher's experience of the *Primary Connections* program** Do you use the *Primary Connections* resources? How long have you been using them? Which professional learning have you completed and when? Are you a facilitator for in-school professional learning for *Primary Connections* or any other programs? 5. **Current teaching context** Tell me something about that school you are currently working in. Where is it located? Which community does it serve? How many students attend the school?

What can you tell me about the cultural and social backgrounds of the students who attend the school? What can you tell me about the focus of the school?

Tell me about your class.
What year level/s are you teaching? How many students and how many boys/girls? What can you tell me about their cultural and social backgrounds and their educational needs?
What conventions have you developed for behaviour management in your class?
What conventions have you developed for managing talk?

Figure 3.3: Initial case study teacher interview questions.

Data sources

As discussed previously, this study utilised mixed methods and interpretive approaches and data were collected from several sources in order to build an account of teachers' beliefs and knowledge about classroom discourse and of their teaching practice. The research combined pre- and post-intervention observations and data were collected from the whole cohort of participants. Research methods included: pre- and post-intervention questionnaires gathered on PL Days 1 and 4; teacher reviews gathered on PL Day 3; pre- and post-intervention lesson observation and field notes, video recording of lessons, and follow-up interviews from Lessons 1 and 4.

In addition to this, more extensive data were collected from five of the 12 participants for the set of case studies which included: the initial case study teacher interview; the pre- and post-intervention questionnaires and teacher review mentioned above; as well as lesson observation and field notes, video recording of lessons, and follow-up interviews for all five lessons; and a final case study teacher interview.

The pre- and post-intervention questionnaires, the mid-intervention review were prepared by two experienced science education researchers and proof read by a research assistant and a PhD candidate. Any potential sources of ambiguity were removed to enhance reliability of the instruments. Similarly, the proformas for the lesson observation and field notes, and the follow-up post lesson interview were similarly developed and adjusted where necessary once the data collection

commenced. The initial and final case study teacher interviews were developed by me and reviewed and proof read by science education researchers.

The data collection procedures are summarised below in Figure 3.4. In addition, Appendix 1 provides an extensive overview of the research design used for this research project, showing how the data collection procedures link to the research questions; and a timeline for the research is also given in Appendix 2. Copies of the data collection tools, including the lesson observation record and field notes, the teacher interviews, questionnaires and review are also included in Appendices 3-9.

Data collections from the whole cohort of teachers (n=12)	Additional data collections from the case study teachers (n=5)
Pre-intervention: Initial teacher questionnaire	Pre-intervention: Initial case study teacher interview
Pre-intervention: Lesson observation and field notes, and video recording of an initial science lesson	Pre-intervention: Post Lesson 1 follow-up interview
	Early and mid-intervention: Lesson observation and field notes, and video recording of an additional three lessons with follow-up teacher interviews
Mid-intervention: PL Day 3 Review	
Late intervention: Final lesson observation and field notes and video recording of a science lesson during the teaching of the second *Primary Connections* unit	
Post-intervention: Final teacher questionnaire	Post-intervention: Final case study teacher interview

Figure 3.4: Data collection procedures.

Ultimately, once the data collection for the five case study teachers was complete it was decided that, given the richness of the data, it was only feasible to develop three case studies. The rationale for the selection of the three cases centred on the availability of a complete data set, as well as ensuring that the data represented a range of year levels (Kindergarten to Year 7) and school contexts; a balance of male and female teachers; and a range of teacher experience. Subsequently, the case studies were developed to show how the professional learning impacted on Penny, Ben and Holly.

The data for each case study were arranged in chronological order and this gave an organising structure to the case that reflected the unfolding of the professional learning intervention. The data from the pre-intervention phase comprised: the initial case study teacher interview; Lesson 1 observation and field notes, video recording, and follow-up interview; and the pre-intervention questionnaire from PL Days 1 and 2. The data from the early-middle part of the intervention comprised: Lessons 2 and 3 observation and field notes, video recordings, and follow-up interviews; PL Day 3 mid-intervention teacher review. The data from the final part of the intervention comprised: Lessons 4 and 5 observation and field notes, video recordings, and follow-up interviews; the PL Day 4 post-intervention questionnaire; and the final case study teacher interview. As the results of each data set were reported and the story of each teacher's professional learning journey unfolded, instances and examples of their progressive development were drawn from multiple sources and from the transcripts in particular.

Data analysis

A broadly interpretivist approach was taken to analyse and interpret the data with triangulation of data types and sources used to enhance the credibility and trustworthiness of research findings. As previously discussed, the three individual case studies were compiled from lesson observations and field notes, video recordings, interview data and questionnaire responses. A cross-case analysis was then used to identify the factors that influenced the effective implementation of communicative approaches.

Questionnaires

Pre- and post-intervention questionnaires included assessment scales that gauged teachers' confidence with science teaching and self-efficacy with managing classroom discussion. In addition, open-ended questions were asked to elicit teachers' beliefs and understandings about inquiry-based teaching and learning, classroom discussion and questioning techniques.

Responses on scale items were scored and descriptive statistics calculated. Responses to open-ended questions were read and re-read until categories of

responses could be identified and described. Then the responses were coded into categories with the frequencies of responses in each category calculated. Pre- and post-intervention scale mean scores and frequencies of responses in categories were compared using appropriate non-parametric statistics and changes to the type and frequency of responses before and after the intervention were documented.

Interviews

Interviews were digitally recorded using Olympus voice recorders. Digital audio recordings from interviews were imported into a PC, transcribed and analysed. The interviews were analysed using a form of constant comparative analysis to identify and document emergent codes and themes that could be used to analyse and track changes in teachers' responses over the period of the intervention.

Lesson observations and field notes

Field notes from lesson observations were used to write brief lesson outlines and to identify the phase of inquiry and intended instructional purpose of the lessons. These field notes facilitated the selection of excerpts of whole-class discussion for further analysis that were taken from the recordings of each lesson. The notes also facilitated the description of the case study teachers' classroom contexts as well as the preparation for and introduction of each lesson.

Video footage

Video recordings of science lessons were made using a single camera operated by the research assistant and by me, as the Researcher for case study teachers. Cameras were placed at the back of the classroom out of students' line of sight and were operated in classrooms for 90 minutes prior to recording lessons so that teachers and students became accustomed to the presence of the camera and operator. Video footage was recorded using Sony cameras on HD video tape. The teachers wore an FM lapel microphone. This and a second FM microphone placed in the middle of the classroom were linked to a receiver on the camera so that a clear recording of the discourse was made. Digital video recordings were downloaded through Final Cut

Studio onto a large external hard drive in SD format and imported into NVivo 8™ software for viewing, coding and analysis.

Segments of video recordings that showed parts of lessons involving whole-class discussion were viewed and transcribed verbatim. The transcripts were then analysed in NVivo 8™ to investigate how the teacher and the students participated in discussion and a set of codes was developed that described teacher questioning and discourse moves, the level of the teacher and student participation, and the quality of the students' contributions to discussion.

In the initial stages of this analysis, the data showed that the teachers' questions were of different types (e.g. open or closed) and asked for different purposes (e.g. questions to elicit descriptions, explanations or reasoning). In addition, they could be used as key questions that initiated interactions or as questions that maintained the momentum of the discussion (Hackling, Smith & Murcia, 2011). Subsequently, the analysis focused on the types and purposes of initiating questions that were asked by the teachers and several codes were used to categorise them. These categories included: *closed* questions, which elicit only a limited number of response options; *open-ideas* questions, which elicit a range of students' ideas; *open-description* questions, which elicit description of an observation or an event; *open-explanation~reason* questions, which elicit an explanation as to why something happened or a reason to justify a claim.

As well as examining how teachers used questioning in whole-class discussions, an important part of the analysis focused on identifying the kinds of discourse moves the teachers used to manage these discussions. While some categories of teacher discourse moves were imposed on the data (e.g. *wait time* and *extended thinking time*), several categories emerged from the data as the analysis progressed (e.g. *turn taking*, *prompt and scaffold*, *teacher restate*, etc.). Ultimately, it became evident that the teachers predominantly used discourse moves to initiate interaction, to open up and build the talk, and to close off an interaction or move the discussion on.

A character count of the teacher's and the students' contribution to discussion was used to ascertain the proportion of teacher/student talk. The character count was a simple quantitative measure that had no particular connection to the substantive meaning or content of an utterance. In this study, a character count was used in preference to a word count because words vary considerably in length and, by comparison, a character seemed a more consistent unit of measure. Additionally, the character count was used as a way to identify elaborated utterances. Elaborated utterances provided a measure of student participation in discussions and were defined as those student contributions comprising 100 or more characters in the transcript.

In order to analyse the quality of the students' contributions, their responses were coded according to their increasing complexity and abstraction. The codes used to categorise the students' responses were based on the Structure of the Observed Learning Outcome (SOLO) Taxonomy (Biggs, 2003; Biggs & Collis, 1982) and ranged from descriptions of concrete experiences to explanations of more abstract scientific concepts. More specifically, the students' responses were coded for: *Description*: When observable features or events are reported and either one aspect is reported (*unistructural*) or two or more aspects are reported (*multistructural*); *Explanation*: When an explanation is given of why something happened or how something will happen in the future; *Reasoning*: When an additional supporting reason or justification is given for an explanation, which usually has recourse to empirical evidence or a science idea.

The Coding Framework that was developed from this analysis is given below in Table 3.1 and it is also provided in Appendix 10.

Table 3.1: Codes developed to analyse classroom discourse.

Code	Definition of code
Teacher questions	
Closed	Elicits a limited number of response options.
Open - ideas	Elicits ideas. Includes 'What do you think?'
Open - description	Elicits a description. Includes 'What do you see?' 'What happened?'
Open-explanation/reason	Elicits an explanation (why something is so) or a reason to justify a claim (how do you know).
Teacher discourse moves	
Directed question	Teacher directs a question to a named student.

Turn taking (teacher nominated)	Teacher nominates one student after another to respond without calling for elaboration or explanation of their ideas.
Wait Time	Teacher pauses for greater than "one and two" (WAIT time) after asking a question (WT1) or after a student's response (WT2).
Extended Thinking Time	Teacher extends thinking time using strategies other than Wait Time, e.g. Think-Pair-Share, Thinking Time, writing a draft, other.
Recast the question	Teacher does not receive an answer or receives an unsuitable response and rephrases the question.
Teacher restates	Teacher repeats or restates what has been said.
Restate/clarify	Teacher asks a student to restate so audible to class or to clarify what was said.
Reframe	Teacher rephrases a student answer to improve expression.
Reframe scientifically	Teacher rephrases student answer to correct science.
Elaborate	Teacher asks for elaboration of a response (to say more about it).
Prompt and scaffold	Teacher provides cues before or after a question to prompt/scaffold student's responses.
Refocus	Teacher summarises to consolidate and refocus the discussion.
Teacher uptake	Teacher asks a follow-up question that includes (builds on) part of a previous answer.
Checks for consensus	Teacher asks the class to indicate who agrees with an idea.
Ignore	Teacher ignores a student response.
Acknowledge only	Teacher just acknowledges a student response with no further interaction.
Evaluate	Teacher indicates whether an answer is correct or incorrect.
Asks for other ideas	Teacher asks for other (different) ideas.
Moves on	Teacher asks a question which changes the focus of discussion.
Quality of student talk	
Description	Student provides descriptions of objects or events currently being observed or previously experienced. Coded as *unistructural* when one aspect is reported and *multistructural* when two or more aspects are reported.
Explanation	Student provides an explanation of how or why it is so and may include explanations of what is likely to happen next.
Reasoning	Student provides reasoning. Includes some scientific reason to justify an explanation.
Elaborated utterance	Student utterance is greater than 100 characters of transcript.

Cross-case analysis

As the development of each case progressed, key findings and assertions were raised regarding the teachers' beliefs, knowledge and practice as well as the students' participation and the quality of their talk. Generating key findings and assertions in this manner helped to reveal the way in which the teachers' and the students' participation in whole-class discussions developed over the course of the professional learning intervention. This also facilitated the cross-case analysis where the assertions from each case study were analysed collectively and a set of themes was developed that related to: teachers' beliefs about effective science teaching; teachers' beliefs, knowledge and classroom practice to do with developing a supportive classroom environment for talk; teachers' beliefs, knowledge and classroom practice to do with the use of questioning and teacher discourse moves, and adjusting their communicative approach; and, teachers' knowledge and practice of using puppets in their science lessons. These themes were interpreted by drawing on the literature to develop evidence-based general assertions, which informed the conclusions used to answer the research questions.

Issues of validity, reliability and ethics

Given the applied nature of educational inquiry, it is important for education and research communities to have confidence in the conduct of investigations and in the results that are obtained (Merriam, 1998). Research is central to our ability to learn and to develop new knowledge and at every step researchers need to handle the process responsibly and with integrity (O'Leary, 2009). Thus issues associated with the 'truth' (validity) of research findings, their generalisability (reliability), and the impact the research might have on the participants (ethical concerns) need to be carefully considered. This section discusses the validity, reliability and ethical issues that relate to this study.

Internal validity

 "One of the assumptions of qualitative research is that reality is holistic, multidimensional, and ever-changing…" (Merriam, 1998, p. 202), and consequently issues to do with internal validity centre on how well the research findings capture the

reality of the participants at the heart of the study. One of the most important aspects of internal validity has to do with the Researcher recognising how their world view and values can bias their interpretation of the research findings. In this instance, as the Researcher, I have acknowledged my own professional experiences and preconceptions of classrooms and interactions may influence the way in which I read classroom activity. However, they will also enable me to better understand the teachers I observe. Several other factors that will increase the internal validity of this study include: the use of a design-based action research model which involves teachers in all phases of the research; a long-term (six month) observation and data gathering phase; and, the triangulation of multiple methods of data collection and analysis as a way to confirm the findings (Merriam, 1998).

Reliability

In the context of qualitative research, issues of reliability refer to the dependability or consistency of the results with the data collected (Lincoln & Guba, 1985), meaning that the results make sense and that outsiders looking at the same sets of data would arrive at the same conclusions. In this study, reliability is increased by making explicit the theoretical underpinnings of the study, how the Researcher is positioned, who the participants are and how they are selected, the context in which the data were collected, and the triangulation of data (Merriam, 1998).

External validity

The external validity of the research is concerned with the generalisability of the findings from one context to another (Merriam, 1998). While notions of external validity in qualitative research are debated, it is possible to enhance the generalisability of a study. In this instance, generalisability is improved by utilising cross-case analyses of classroom discourse found in diverse contexts, in combination with predetermined questions and specific procedures for data coding and analysis (Merriam, 1998).

Ethics

"Qualitative researchers are guests in the private spaces of the world. Their manners should be good and their code of ethics strict" (Stake, 1994, p. 447). The conduct of

ethically informed research should be the goal for all researchers (Blaxter, Hughes & Tight, 2002), however, given the interest of the qualitative researcher in the personal views and circumstances of real people, there is a greater need for ethical considerations to be managed carefully. More specifically, researchers must address ethical concerns regarding privacy, informed consent, anonymity, and the truthfulness and desirability of the planned research (Blaxter et al., 2002). The ethical concerns that relate to this study centre on anonymity and confidentiality, informed consent withdrawal rights, appropriateness and future use of video footage.

Anonymity and confidentiality

Since video recording is the central observation tool used in this study it is not possible to maintain the anonymity of participants involved. However, principals, teachers, parents and students were informed of: the type of data to be collected; how it would be collected, analysed and reported on; as well as of the potential uses of the video footage captured.

As regards the use of the captured video footage, in addition to the video being analysed for this research study, the video tapes were edited to produce short highlights packages that illustrate effective teaching. With the participating teachers' consent, some highlights packages were used during the professional learning experience as a way to share the teachers' discourse practices. These packages will also be used to show other teachers as well as preservice teachers what effective science teaching looks like.

Confidentiality of all the research data has been maintained and transcripts, observational notes and electronic files have been stored securely and will be destroyed five years after completion of this study. No teacher, school or student will be identified in any research reports.

Informed consent

Participants can only give informed consent to be involved in a research study if they have a full understanding of their requested involvement (O'Leary, 2005). To this end,

separate information letters and consent forms were sent to the principals, teachers, parents and students for those schools participating in the study. These letters and consent forms outlined the time commitment, type of activity, focus of the study, and the management of potential risks. For example, any incidents that might have occurred during the video recorded lessons which might have caused embarrassment to the teacher, students or the school would have been erased from the video tapes.

Withdrawal rights

The teacher and students were free to choose not to participate in this study. It was made clear to participants that their voluntary involvement was sought and that they had the right to discontinue from the study at any time. Particular consideration was also given to parents who do not wish their child to participate in the study. When this occurred, rather than exclude students from the class, they were seated in an area of the classroom that the video cameras did not film. Arrangements were also put in place for the participating teachers who might have chosen to withdraw from the research to specify whether their withdrawal meant that any existing video footage or interview data could be used, or whether they would like to completely withdraw any data involving or depicting them from the study. Fortunately, none of the participating teachers chose to withdraw from this study.

Summary

This study was part of a larger research project, the *Discourse project*, which engaged teachers in a participatory action research process of designing, implementing and evaluating new ways of matching classroom discourse types to the phases of inquiry in science (Hackling, et al., 2011). Both mixed methods and interpretive approaches were used to gather data from the whole cohort of participants as well as a more extensive data collection with the case study teachers. A key feature of the data collection was the video footage that captured how the teachers and students participated in whole-class discussions over time.

The three cases studies that were developed from the data are presented in the next few chapters. Each case provides a description of the participating teacher's background, their school, and the teaching context in which they worked. The case

studies then document the teacher's initial beliefs, knowledge and practice to do with teaching science, managing classroom discourse and using puppets. Subsequently, the case studies describe how each teacher's beliefs, knowledge and practice changed as they worked with new pedagogical strategies to scaffold the whole-class discourse in their classrooms. As the story of each teacher's development unfolds, key findings and assertions are used to summarise and signpost salient changes. The assertions generated for each case facilitated the identification of themes which generated evidence-based general assertions. Ultimately, the general assertions were used to describe the overall impact of the professional learning intervention on the teachers' beliefs, knowledge and practice and to develop an elaborated theoretical model that identifies the variables impacting on quality classroom discourse. The teachers and the schools that are the focus of these case studies have been given pseudonyms in order to retain their anonymity. The next chapter presents Penny's case study.

CHAPTER 4: PENNY'S LEARNING JOURNEY

Introduction

This chapter explores Penny's (pseudonym) involvement in the professional learning program and the impact this has had on her teaching. The first section considers the contextual factors that have influenced Penny's development as a teacher and that currently impact on her teaching practice. The second section outlines her beliefs and understandings about the teaching of science and the management of classroom discourse. Finally, the third section examines how Penny managed whole-class discussions in science over the course of the year.

Introducing Penny

This section provides an overview of Penny's professional and educational background, her teaching role and the school environment in which she worked, and the class that she taught during the course of this study.

Professional and educational experiences

Penny teaches Year 6/7 at Eastbrook Primary School (EPS) (pseudonym) in the Perth metropolitan area of Western Australia. She has been a primary school teacher for seven years and most of her teaching experience has been in government schools in lower socio-economic areas such as the inner city schools of Inverness in Scotland and the outer metropolitan suburbs of Perth (Email, 6/7/2010). Penny has mostly taught Years 5 to 7 and, as well as being a general classroom practitioner, she has also worked as a Science Support teacher and as a mentor to other teachers (Email, 6/7/2010).

Penny grew up in Rhodesia (now Zimbabwe), completing both her primary and secondary schooling there (Email, 6/7/2010). In her primary years she remembers spending a lot of time outdoors learning about animal conservation and having many science experiences.

> In primary school I was lucky enough to have teachers that were probably ahead of their time, they cared about the environment and [we did] a lot of outdoor stuff. Because I grew up in Africa, it was basically an outdoor kind of country and we were in the bush and that was great. (Final teacher interview, 4/12/2009)

However, Penny also recalls having her enthusiasm for science shutdown when she began high school. She attributes this to the way her science teacher formalised the learning opportunities and also to the way that science was perceived at the time.

> High school for me took away my passion because it was - sit at a desk, boys can do the experiments and girls were pushed behind because it was a lab. My high school teacher… he sort of encouraged the boys a lot but not us girls. … If you were not really bright, if you were not in the A stream, well the teachers didn't see a future for you in science. So I always thought well "OK, science, obviously I'm not clever enough", without realising… because no-one pointed out that you don't have to be a rocket scientist, there's other science. (Final teacher interview, 4/12/2009)

Ultimately, Penny attained her General Science Certificate, a Year 12 qualification in Rhodesia, and she went on to gain an undergraduate degree in Library studies which had a science focus (Final teacher interview, 4/12/2009). Later on, when she came to live in Perth, she completed a Graduate Diploma in Education (Final teacher interview, 4/12/2009).

Penny has taught science using the *Primary Connections* (AAS, 2005) curriculum resources for the last two years and, consequently, she utilises the 5Es inquiry model and integrates science with other curriculum areas (Final teacher interview, 4/12/2009). She has also trained as a *Primary Connections* professional learning facilitator and has provided professional development for the teaching staff in her school and across the district (Final teacher interview, 4/12/2009). Currently, Penny manages the science cost centre for her school and she is responsible for organising and managing the upkeep of science resources.

Penny has also participated as a mentor teacher in the *Primary Science Project*, an initiative of the WA Department of Education. This project supported schools wishing to make science a priority by funding a mentor teacher to work alongside class teachers

who were keen to improve their practice. "So we'd go in and support them in their science lessons and do some planning, some modelling, and then work with them to build up their use of the [inquiry] processes" (Final teacher interview, 4/12/2009). In the last two years, Penny has worked with teachers from EPS as well as those in remote school contexts (Final teacher interview, 4/12/2009).

> So, it's a very successful way of doing it. You're not going in there and just taking over, you're working alongside and modelling … because I was exposed to so much great PD (professional development) that you could go in and share it. Instead of standing up the front of all the staff going "This is what I learnt and this is what we need to do", they're seeing it in practice. (Final teacher interview, 4/12/2009)

Key Finding 4.1

Penny attained an undergraduate degree in Library studies and subsequently she completed a Graduate Diploma in Education. She taught for a short time in Scotland and for 7 years in Perth metropolitan schools.

Penny manages the science cost centre at EPS and is responsible for organising and managing the upkeep of science resources.

She has trained as a *Primary Connections* professional learning facilitator and has experience in providing professional development for teachers. She has also participated in a WA Department of Education project as a science mentor teacher.

Eastbrook Primary School

EPS is a well-established metropolitan primary school that is situated near the eastern foothills in Perth, Western Australia. In 2009, there were 506 students enrolled at the school, 67 were pre-primary students and 439 were in Years 1-7. The Western Australian Socio-Economic Index (SEI) draws on a range of variables such as socio-economic status, geographical location, parents' occupations and the median pricing of residential properties to rank schools in the state from 1 to 10. A Decile ranking of 1 represents the most advantaged 10% of schools, whilst a Decile ranking of 10 represents the most disadvantaged 10% of schools. According to the SEI for 2006, EPS is currently ranked as a Decile 9 school (E-mail communication, 26/5/2010). A national indicator of disadvantage, the Index of Community Socio-Educational Advantage (ICSEA), takes account of the socio-economic characteristics of the areas where students live, whether a school is in a regional or remote area, and the fraction

of Indigenous students enrolled at the school (Australian Curriculum Assessment and Reporting Authority (ACARA), 2010). The average ICSEA value is 1000, with most schools having an ICSEA value between 900 and 1000 (ACARA, 2010). On this measure EPS has an ICSEA value of 863 and the data also shows that 20% of the student population at the school are Indigenous (ACARA, 2010). The Western Australian SEI ranking and the ICSEA value of EPS indicates that the school has lower than average socio-economic status.

EPS describes itself as an award-winning school and prides itself on the national recognition received for its school leadership and Literacy, Numeracy, and Information and Communications Technology (ICT) programs (EPS website, 24/8/2011). It has a pastoral care focus and the students and parents are supported by over 80 teaching and non-teaching staff (EPS Annual School Report, 24/8/2011). In addition, a school-based Community Liaison Officer and a chaplain are employed by the school and two Aboriginal and Islander Education Workers support the learning of Indigenous students (EPS Annual School Report, 24/8/2011). EPS is supported by a small group of parents who actively participate in school activities (EPS Annual School Report, 24/8/2011).

EPS upholds a set of core beliefs about how students learn, which emphasise the learner's capacity to: regulate themselves and their learning; act responsibly; make decisions and problem-solve challenges; self-evaluate; and accept reward in an intrinsic form (EPS Annual School Report, 24/8/2011). A similar set of beliefs about learning emphasise the need for learning to be: purposeful and culturally relevant; connected to real life contexts; integrated across the curriculum; and, provide opportunities for independent or collaborative learning (EPS Annual School Report, 24/8/2011). Organisational structures that support these core beliefs, include the use of multi-age grouping and 'looping', where students can remain with a teacher for a two to three year period (EPS Annual School Report, 24/8/2011).

In 2009, the school's priority areas included Reading and literacy acquisition in the early years; Mathematical computation; and Earth and Beyond and Working Scientifically in Science (EPS Annual School Report, 24/8/2011). The school offers a number of programs to support the learning of Indigenous students and a pastoral care

program to support the students and their families (EPS Annual School Report, 24/8/2011).

The school implements the Behaviour Management and Discipline Strategy (BMAD) established by the WA Department of Education to create positive learning environments for students and teachers and to ensure that all students, particularly those with challenging or disruptive behaviours, achieve significant learning and social outcomes (EPS Annual School Report, 24/8/2011). In 2009, the funding received by EPS to implement BMAD strategy was used to reduce class sizes, particularly in the Year 6/7 classes, and to support teachers to develop Individual Education Plans (IEPs) and Group Education Plans (GEPs) for students at educational risk (EPS Annual School Report, 24/8/2011).

The *National Assessment Program - Literacy and Numeracy* (NAPLAN) assesses all students in Australian schools in Years 3, 5, 7 and 9 in the domains of Reading, Writing, Language Conventions (Spelling, Grammar and Punctuation) and Numeracy. A 10 band national scale is used to report results for each year level (ACARA, 2010). In 2009, the NAPLAN scores for EPS students showed that students in Year 7 tend to be close to the average for schools serving students from statistically similar backgrounds for Reading, Writing, Grammar and Punctuation, and Numeracy and below the average for Spelling (ACARA, 2011). Additionally, these students were significantly below the national average for Reading, Writing, Spelling, Grammar and Punctuation, and Numeracy (ACARA, 2011).

Key Finding 4.2

EPS has a pastoral care focus and offers a broad range of programs to support the students and their families. The school is ranked below the average range of national (ICSEA) and state (SEI) socioeconomic indices.

In 2009, the NAPLAN scores showed that students in Year 7 tend to be close to the average for schools serving students from statistically similar backgrounds for Reading, Writing, Grammar and Punctuation, and Numeracy, and below the average for Spelling. These students were significantly below the national average for Reading, Writing, Spelling, Grammar and Punctuation, and Numeracy.

Penny's class

Penny had a Year 6/7 class in 2009, which included 23 students (12 females and 11 males), approximately 10% of whom were Indigenous. Eight of the students were on a GEP for Literacy and Numeracy, an autistic student was on an IEP and an individual behaviour plan, and another student who was very weak in Literacy and Numeracy was also on an IEP (Email, 6/7/2010). Of the 23 students in the class, 12 were participants in this research project. The remaining 11 students were either not given parental/carer permission participate in the project or they were not offered the opportunity for reasons relating to behaviour management.

Penny's classroom was one half of a double classroom structure that was divided down the middle by a concertina door. Both of these classrooms led onto an internal common area, which provided further work spaces and a wet area that was shared with another two classes. The classroom itself appeared to be a well-resourced learning environment with posters and the students' work displayed (Lesson 1 Observation Record, 18/05/2009). There were large desks that could accommodate groups of four students distributed across the back two-thirds of the classroom and the teacher's desk, whiteboards and mat area occupied the front third of the room (Lesson 1 Observation Record, 18/05/2009).

The mat area at the front of the classroom was used for whole-class discussions. Penny had created a space on the carpeted floor for the students to sit in front of the interactive white board (IWB) and she had placed a small whiteboard on an easel, a table and a chair to the left of the IWB. Generally, the students would sit cross legged on the mat during discussions whilst Penny sat on the chair in front of them (Lesson 1 Observation Record, 18/05/2009).

Penny felt that she had set up her class so that there could be a lot of discussion and she utilised strategies that provided opportunities for whole-class, small group and peer interactions (Email, 6/7/2010). Additionally, she encouraged the students to participate in discussions by raising their hands or calling out their responses where appropriate (Email, 6/7/2010).

Penny utilised a reward system that was linked to the schools behaviour management policy (Email, 6/7/2010). "I believe in intrinsic motivation with a small amount of extrinsic motivation and I always deal with the behaviour presented and not the person" (Email, 6/7/2010). In addition, she had created a charter with her class which outlined the accepted conventions to do with speaking and listening and the culture to do with classroom talk.

> In our classroom everyone's ideas are valid and everyone has got the right to talk. So that when someone's having their talk we all listen, people need to not butt in, no call outs. So if I have asked a question I say that people need to give each other time … the kids do respect each other... because that culture has been built up and they know that they will all have an opportunity to be listened to and that what they say is going to be heard and no-one is going to disregard them. (PL 2 interview, 27/8/2009)

During the course of the professional learning intervention (Terms 2-4) in 2009, Penny's class studied three science topics. Two were teacher-authored topics entitled Astronomy and Penny's Gardening Dilemma and one was a *Primary Connections* topic called Marvellous Micro-organisms.

Key Finding 4.3

Penny had a composite Year 6/7 class comprising 12 females and 11 males. During class discussions, the students generally sat in a group on the mat facing the teacher and either raised their hands to speak or called out when appropriate. During the professional learning intervention the *Primary Connections* topic Marvellous Micro-organisms was taught as well as two teacher-authored topic entitled Astronomy and Penny's Gardening Dilemma.

Pre-intervention: Penny's beliefs, knowledge and practice

Snapshots of Penny's beliefs and knowledge about teaching science were captured via interviews and questionnaires completed prior to the intervention and from data collected in the early, mid and later phases of the professional learning intervention. The data elicited related to: beliefs about teaching science; confidence with teaching science; knowledge about managing classroom discourse; knowledge about questioning; and capability with using puppets.

Beliefs about teaching science

The data collected from the initial teacher interview completed prior to the professional learning intervention and from the initial teacher questionnaire completed on the first professional learning day (PL Day 1) provided evidence of Penny's beliefs about the teaching of science. She identified developing students' conceptual understandings through the use of the 5Es inquiry learning model (Hackling et al., 2007) and developing, modelling and scaffolding skills for investigating as two of the most important characteristics of effective primary science teaching practice (Initial teacher questionnaire, 02/06/09). She felt that moving the students through each of the phases of the 5Es model and providing lots of hands on experiences allowed them to deepen their understandings of science concepts (Initial teacher interview, 29/5/2009).

Penny also believed that inquiry-based science teaching and learning should be integrated with literacy (Initial teacher questionnaire, 02/06/09). She believed that a student centred approach should be used and that this should be framed by a safe and supportive environment (Initial teacher questionnaire, 02/06/09) so that students felt confident to share their ideas (Initial teacher interview, 29/5/2009).

Key Finding 4.4

Penny believed that using a hands-on, inquiry approach to teaching science was an effective way to deepen students' conceptual understandings. She believed that it was important to develop the students' understandings by modelling and scaffolding the skills for investigation. She also believed that inquiry-based science teaching and learning should be integrated with literacy.

Penny believed that student centred approach should be used and a safe and supportive environment fostered so that students felt confident to share their ideas.

Confidence with teaching science

Prior to the professional learning intervention, Penny considered herself to be a confident teacher of primary science. When asked to indicate her confidence with nine aspects of science teaching (Initial teacher questionnaire, 02/06/09), Penny rated herself as 'Very confident' in: engaging students' interest in science; managing hands-on group activities; using computers and ICTs in science; and, in using a constructivist

model to plan science units of work (Initial teacher questionnaire, 02/06/09). She also considered herself as 'Confident' in managing discussions and interpretation of science observations (Initial teacher questionnaire, 02/06/09).

The initial mean scale score for confidence with teaching science strategies for all of the teachers involved in the professional learning intervention was 3.86/5, which is very close to the mean confidence scale score of 3.88 for a group of *Primary Connections* trial teachers who had participated in five days of professional learning and taught some *Primary Connections* units (Hackling et al., 2007). In comparison, Penny's initial mean scale score for confidence with teaching science strategies was 4.4/5, which was greater than the mean scale scores for either of these groups of teachers.

Key Finding 4.5

Penny considered herself very confident with four aspects of science teaching and confident with managing discussions and developing interpretations of observations. Her initial mean scale score for confidence with teaching science was 4.4/5.

Beliefs about being an effective manager of classroom talk

The data from initial teacher questionnaire showed that Penny believed herself to be an effective manager of classroom talk. When asked to indicate the degree to which she agreed or disagreed with 12 statements about the effective management of classroom talk, the data showed that Penny had a high level of self-efficacy (rated 5/5) for establishing an appropriate classroom climate; using wait time effectively; encouraging and supporting students to ask questions; engaging most students; and, using questioning to identify students' prior knowledge and initial science understandings (Initial teacher questionnaire, 02/06/09). She also indicated a high level of self-efficacy (rated 4/5) against seven other aspects of managing classroom discussions (Initial teacher questionnaire, 02/06/09).

The initial mean scale score for being an effective manager of classroom talk for all of the teachers involved in the professional learning intervention was 3.89/5. In comparison, Penny's initial mean scale score was 4.4/5, which is greater than the

mean scale score for the group of teachers involved in the professional learning intervention.

Key Finding 4.6

Penny believed that she was an effective manager of classroom talk, particularly for establishing an appropriate classroom climate, using wait time, encouraging and supporting students to ask questions, engaging most students, and using questioning to identify students' prior knowledge and initial science understandings. Her initial mean scale score for being an effective manager of classroom talk was 4.4/5.

Knowledge about managing classroom discourse

The initial teacher interview and the initial teacher questionnaire also provided evidence of Penny's understandings about how to manage classroom discourse. Penny thought that questioning and classroom discussion helped students to develop their understandings through interacting with others in a safe and supportive environment (Initial teacher questionnaire, 02/06/09). She thought that teachers needed to know how to ask a range of different questions in order to engage the students in discussion.

> They would have to know how to set … different questions because, you know, you've got closed questions but then you've got open ended questions and then questions that would engage children and encourage their discussion, I would say. So, we need to know a lot about that and just [how] to actually get them to discuss things. (Initial teacher interview, 29/5/2009)

Penny stated that in the beginning phases of inquiry she used classroom discussions and questioning to find out what her students knew about a topic and towards the end of the investigation she adjusted this by asking more in-depth questions so as to gauge what the students had learned about the topic (Initial teacher interview, 29/5/2009).

Penny felt a collaborative environment fostered student interaction in primary science, where the students felt safe to share their ideas without the fear of being told that they were wrong (Initial teacher interview, 29/5/2009).

> I like the *Primary Connections* [resources] starting with the Engage phase because the children are kind of giving you what they know without you saying its right or wrong. So you get an idea of… what misconceptions they might have and what their understanding is of the topic. And then you can kind of address that through your questioning and through the activities that you present to them. (Initial teacher interview, 29/5/2009)

Penny thought that good classroom discussion was evident when the discussion was "student directed", and when all the students were encouraged to share what they know with others and they were able to challenge the ideas that were put forward (Initial teacher questionnaire, 02/06/09). She suggested that the less confident students could be supported to share their ideas by participating in small group discussions, "So, that they are still sharing their ideas with their peers but maybe not kind of in front of the whole class, so [they know] their ideas are still important" (Initial teacher interview, 29/5/2009).

Key Finding 4.7

Penny thought that it was necessary to create a safe and supportive environment for classroom discussion so that the students felt comfortable to share their thinking and to challenge each other's ideas without the fear of being told they were wrong. She thought that it was important for all the students to know that their ideas were worthy and that less confident students could be supported to share their ideas by participating in small group discussions.

Penny also thought that teachers needed to know how to use questioning to engage students in discussion, to ascertain their initial understandings in the beginning phases of inquiry and to find out what students had learned in the later phases.

Knowledge about using puppets

Prior to the professional learning intervention, Penny's experience of using puppets in her teaching had been limited to using finger puppets during storytelling with junior primary students (Initial teacher questionnaire, 02/06/09).

Having considered some of the contextual factors, beliefs and understandings that may influence Penny's teaching, it is important to also examine how the professional learning intervention impacted on her practice and, more particularly, on the way that Penny managed whole-class discussions.

Over the course of the intervention data were gathered from science lessons prior to the professional learning intervention and from mid and later phases. The data were collected via video, classroom observation and post lesson follow up interviews. Specific observations included:

- Lesson 1: An Engage lesson in May, prior to the profession learning intervention. This lesson was drawn from a unit that Penny had developed to fit in with the International Year of Astronomy, which she simply called Astronomy.

- Lesson 2: An Engage lesson in July, following PL Days 1 and 2, from a new *Primary Connections* topic called Marvellous Micro-organisms (AAS, 2005).

- Lesson 3: An Explain lesson in October, a continuation of the Marvellous Micro-organisms topic commenced in Lesson 2.

- Lesson 4: An Engage lesson in October, following PL Day 3. This lesson marked the start of a new teacher-authored topic called Penny's Gardening Dilemma.

- Lesson 5: An Explain lesson in November, a continuation of the topic Penny's Gardening Dilemma that was commenced in Lesson 4.

In this chapter, the data are presented in the sequence that the professional learning intervention unfolded. Initially, Lessons 1, 2 and 3 are reported on here and the data from Lessons 4 and 5 are discussed later in the chapter. The following aspects of the data are discussed: the focus of the lesson and the classroom setting; the teacher's

use of questioning, discourse moves, and communicative approach; the proportions of teacher and student talk; and the students' elaborated utterances and the quality of their contributions to discussion.

Lesson 1, pre-intervention

The lesson

Lesson 1 was carried out prior to the commencement of the professional learning intervention and was an introductory lesson in the Engage phase of the topic Astronomy. This topic addressed science concepts relating to the Earth and Space strand of the science syllabus (MCEETYA, 2006) and focused on developing students' understandings about the Sun, the Earth and the Moon and on providing hands-on experiences and opportunities for the students to conduct investigations. Penny named this initial lesson Moon Magic and she used this as an opportunity to find out what the students knew about the Moon and to elicit their questions. The segments of the lesson included: all of the students brainstorming their ideas about the Moon; the teacher introducing a problem for the students to solve by reading the Concept Cartoon also called Moon Magic; and small groups researching and reporting back where the light of the Moon comes from. The data analysis in this lesson centred on the substantive discussion that was generated as the class completed the initial brainstorm activity.

The setting

Penny did not used puppets in this initial lesson. She commenced the discussion by brainstorming what the students knew about the Moon and inviting them to record their ideas on an image of the Moon on the IWB.

Penny and the students sat in the mat area at the front of the classroom, with Penny on a chair and the group 12 students on the floor facing her. When the students wished to share their ideas, they raised their hands and Penny nominated one of them to speak

(Video footage, 18/5/2009). Penny also nominated who should record their ideas on the IWB and when.

Key Finding 4.9

Penny did not use puppets in Lesson 1, an Engage lesson. The students sat in a group in front of her and raised their hands when they wished to speak. Penny managed the conversation by nominating speakers. She also managed the procedural aspects to do with the students recording their ideas on the IWB.

The teacher's role

In order to find out about the teacher's role in managing whole-class discussions and the forms of discourse this produced, it was necessary to analyse the transcripts of the excerpts of discussion that were taken from each lesson for the teacher's use of questioning and discourse moves as well as for the communicative approach taken. It is important to note that the data selected for analysis was taken from those episodes in the lesson that comprised whole-class substantive discussion and, consequently, the analysis of the discourse is only representative of those parts of the lesson.

Teacher questioning

In this segment of the lesson, Penny asked a total of six initiating questions to find out what the students knew about the Moon. The analysis showed that all six questions (100%) were classified as *open-ideas* questions.

Key Finding 4.10

In Lesson 1, Penny asked a total of six initiating questions in the opening phase of the lesson, all of which were *open-ideas* questions.

Teacher discourse moves

In Lesson 1, Penny wanted to engage all the students in the discussion as a way to find out what they knew about the Moon (PL 1 interview, 29/5/2009) and to get them to

record their ideas on the IWB. As a result, the interaction alternated between substantive talk about the Moon and procedural talk about who should write on the IWB (Video footage, 18/5/2009). Figure 4.1 below, provides examples of how the interaction alternated between substantive and procedural talk and how Penny responded to the students' ideas.

Turn	Utterances	Coding
1.	T: So thinking about what you know about the Moon, thinking about when you go outside at night and you look up at the Moon. Anything that you know about the Moon? Christine.	Initiating question, open–ideas question.
2.	**S:Chr: It's bright.**	
3.	T: Bright. OK, come and pop that up there. Jack?	Teacher restate. Procedural talk. Asks another student for his/her ideas.
4.	**S:Jac: It can change shape.**	
5.	T: Brilliant! We're going to do a little bit more about that today. I'm glad you said that because that's what we are going to be focusing on. I'll wait for Christine then we will get you to go up and write that down. Michael?	Evaluate. Procedural talk. Asks another student for his/her ideas.
6.	**S:Mic: The Moon moves.**	
7.	T: OK. Everything we know we are writing up there. So I'll wait for Jack to write his, then you go. Jacqui?	Acknowledge only. Procedural talk. Asks another student for his/her ideas.
8.	**S:Jac: Umm.. spacemen.**	
9.	T: So, spacemen. So what about spacemen and the Moon?	Teacher restate. Elaborate, open-ideas question.
10.	**S:Jac: Um … they travelled to the Moon.**	
11.	T: They travelled to the Moon. That's right. Sharon?	Teacher restate. Evaluate. Asks another student for his/her ideas.
12.	**S:Sha: Um, the… I got two.**	
13.	T: That's fine.	
14.	**S:Sha: Um..it's sort of shaped with a little man in the Moon.**	
15.	T: OK. So, you want to say something about the man in the Moon?	Clarify, closed question.

16.	**S:Sha: And it also it um.. the… it reflects from the Sun all the brightness.**	
17.	T: Good girl. Jacqui, you're the next person to go and write up... the Moon moves.	Evaluate. Procedural talk.
18.	**S:Jac: What do I write?**	
19.	T: Do you want to write up about the astronauts travelling to the Moon or people travelling to the Moon? [Long pause as students write in the IWB]	Clarify, closed question.

Figure 4.1: Lesson 1 - the teacher oscillated between substantive and procedural talk.

This excerpt (Figure 4.1) shows how Penny initially responded to Christine (S:Chr, turn 2) by restating what she had said (*teacher restate - teacher repeats or restate what has been said*, turn 3) and then asking her to write her response on the IWB (identified as Procedural talk, turn 3), before then asking another student for their ideas. Penny's subsequent interactions with the students tended to follow a similar pattern, oscillating between substantive talk as she elicited their ideas and procedural talk as she managed the way in which they wrote their ideas on the IWB. This pattern is evident in turns 3, 5, 7, and 17 above.

In addition, the coding for teacher discourse moves revealed that when a student had taken their turn, Penny was inclined to respond by restating what they had said (turns 3, 9, 11) and/or positively evaluating their response (*evaluate - teacher indicates whether an answer is correct or incorrect,* turns 5, 11, 17). When Penny responded to the students in this way, it resulted in short teacher-student exchanges (Teacher-Student-Teacher or T-S-T).

Less frequently, Penny would ask a student to elaborate on their ideas (*elaborate - teacher asks for elaboration of a response (to say more about it)*, turn 9) or she would seek clarification of the students' ideas (*clarify - teacher asks student to restate so audible to class or to clarify what was said*, turn 15). The code for this teacher discourse move, *restate/clarify*, is applied when a teacher asks a student to restate what they have said so it is audible to the class or to clarify what was said. In this instance, Penny sought clarification and, in the excerpts from the transcripts used in this study, the code *restate/clarify* has been shortened to *clarify*. When Penny called for

elaboration or sought clarification, a slightly longer teacher-student exchange was generated (T-S → T-S).

Key Finding 4.11

Penny's interactions with the students in Lesson 1 alternated between substantive talk as she elicited their ideas and procedural talk as they wrote their ideas on the IWB.

Penny tended to use *teacher restate* and/or *evaluate*, which resulted in short teacher-student exchanges. Less frequently, she used *elaborate* or *clarify*, which extended the interaction slightly.

By also asking different questions and rephrasing the students' ideas, Penny supported them to articulate their ideas clearly and at particular points in the discussion she would draw the students' ideas together in order to move the interaction on or draw it to a close. Figure 4.2 below, provides examples of how the Penny facilitated the interaction in this way.

Turn	Utterances	Coding
1.	**S:Bri: You can look.. you can look at the Moon in different ways.**	
2.	T: Oh, OK. So how can you look at it? Sharon and Brian?	Open-explanation~reason question.
3.	**S:Bri: You can look… you can sort of look at it at one thing and you can look at it the other thing, type of thing.**	Explanation.
4.	T: So you're looking at with your eyes?	Clarify, closed question.
5.	**S:Bri: Ah, well, you can sort of look at it one way and look at it another way. But you can see many things out of just that Moon place.**	Elaborated utterance. Explanation.
6.	T: Oh, OK. So when you're looking at the Moon, different people might see different things in the Moon. So, Sharon's put 'There's a shape of a man in Moon', that's right? That's what you wanted to write? And who wanted to… and you, Brian, you said that you can see a face there. And that's basically what Michael was saying. So when different people look at the Moon they see different things there. Because someone said they've see bunny ears.	Reframe. Refocus. Clarify, closed question

Figure 4.2: Lesson 1 - the teacher asked for explanation and then used reframe and refocus to clarify the talk.

This excerpt (Figure 4.2) shows how Brian made several attempts to express his idea that people to see different things when they look at the Moon, (S:Bri, turns 1, 3 and 5). Penny supported Brian by initially asking him to explain how people can look at the Moon (*open-explanation~reason* question, turn 2) and then by clarifying what he meant (*clarify*, turn 4). Ultimately, she rephrased his response (*reframe - teacher rephrases a student answer to improve expression*, turn 6) and drew the students' ideas together in order to move the interaction on (*refocus - teacher summarises to consolidate and refocus the discussion,* turn 6). Using the discourse moves *clarify*, *reframe*, and *refocus* in this way generated a slightly longer interaction consisting of six turns (T-S → T-S → T-S).

Key Finding 4.12

Sometimes in Lesson 1, Penny asked for an explanation and clarification (*clarify*) of a student's response, and she would *reframe* and *refocus* the students' ideas. This extended the teacher-student interaction slightly.

The analysis of the transcript also showed that there was no evidence in Lesson 1 of Penny's use of discourse moves that could be coded as *wait time* (*teacher pauses for greater than 'one and two' after asking a question*) or *extended thinking time* (*teacher extends thinking time using strategies other than wait time such as Think-Pair-Share or Thinking Time*).

Key Finding 4.13

Penny did not use teacher discourse moves that could be coded as *wait time* or *extended thinking time* in Lesson 1.

Communicative approach

The data shows that in Lesson 1, Penny asked *open-ideas* questions to find out what the students knew about the Moon. Utilising questioning in this way produced the type of interaction Mortimer and Scott (2003) describe as Interactive-Dialogic, where both the teacher and the students share many ideas. This form of interaction is considered

appropriate for an Engage lesson given the instructional purpose of this phase of inquiry is to elicit and clarify the meaning of students' existing ideas. In this lesson, Penny asked *open-ideas* questions and she predominantly used the *restate* and *evaluate* discourse moves to achieve this purpose. Occasionally she used *elaborate* and *clarify*, and at one point she also probed a student's ideas by asking an *open-explanation~reason* question and using *clarify*, *reframe*, and *refocus*.

Key Finding 4.14

In Lesson 1, an Engage lesson, Penny used an Interactive-Dialogic communicative approach to encourage the students to share their many ideas.

Proportions of teacher and student talk

The transcripts from each lesson were also analysed for the proportion of teacher and student talk in whole-class discussions of substantive lesson content. By calculating the total number of characters in the transcript, and those spoken by the teacher and the students, it was possible to compare the percentage of teacher talk with that of student talk. In this instance, the analysis showed that in Lesson 1 Penny utilised a large percentage of the talk time (73%) while the students used less talk time (27%) in whole-class substantive discussion.

Key Finding 4.15

In Lesson 1, Penny utilised about 73% of the talk time and the students utilised 27% in whole-class substantive discussion.

The students' role

It was also important to investigate how the students' contributed to whole-class discussions. In this study, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

Elaborated utterances were defined as those student contributions comprised of 100 or more characters in the transcript. In this instance, there were two *elaborated utterances* in Lesson 1. For example, in the previous excerpt from the transcript (Figure 4.2), Brian's contribution to the discussion (turn 5) has been coded as an *elaborated utterance*.

Quality of student talk

In Lesson 1, 68% of the students' responses were coded as *unistructural descriptions,* 16% as *multistructural descriptions,* and 16% as *explanations*.

Key Finding 4.16

The students often gave quite short responses in Lesson 1 but two were coded as *elaborated utterances*. Most responses were *unistructural description* (68%) and some were *multistructural description* (16%) or *explanation* (16%).

Lesson 1 summary

Lesson 1 was the first Engage lesson for the new Astronomy topic. In this lesson, Penny wanted to engage the students' interest in the topic as well as to ascertain their current ideas and prior knowledge of the Moon. To this end, she utilised an Interactive-Dialogic style of interaction where she asked several *open-ideas* questions to encourage the students to share their ideas.

The interaction alternated between substantive talk as Penny elicited the students' ideas and procedural talk as they wrote their ideas on the IWB. During the substantive parts of the discussion, Penny tended to use the *teacher restate* or *evaluate* discourse moves and the students responses were typically quite short, *unistructural descriptions*. This interaction was characterised by a prevalence of teacher talk and short teacher-student exchanges (T-S-T). Less frequently, Penny used the *elaborate* or *clarify* discourse moves, which extended the teacher-student interaction slightly (T-S → T-S).

She also used *reframe* and *refocus* to draw the students' ideas together. There was no evidence of the use of *wait time* or *extended thinking time* in this lesson.

Penny utilised a large proportion of the talk time in this lesson and the students gave only two elaborated responses. The great majority of their responses were *unistructural descriptions* and a few were *multistructural descriptions* or *explanations*.

Lesson 2, post Professional Learning Days 1 and 2

The first two Professional Learning (PL) days conducted in June 2009, introduced the teachers to principles regarding scientific inquiry and communicative approaches, as well as managing effective discourse, and using puppets to engage children in classroom discourse. The professional learning also provided an opportunity for the participating teachers to plan the implementation of a science topic using a *Primary Connections* unit of work. In the planning process, the teachers were required to identify learning outcomes and to describe the scientific explanations which would indicate the learning outcomes had been achieved for their chosen topic. For the Engage phase, the teachers had to plan how they would use puppets to set the scene for the investigation, to pose problems for the students to solve, and to elicit their prior knowledge. This also meant that the teachers had to consider: the communicative approach that they would need to use to elicit information from their students in the Engage phase; how they needed to adjust their communicative approach for the Explore and Explain phases of the inquiry; how to carefully plan their questions so that the introduction to the investigation really engaged the students; and, how to manage the class discussions to ensure that sustained conversations met the instructional purposes of each phase of inquiry. Ultimately, Penny used a larger girl puppet when Lesson 2 was carried out in August.

The lesson

Lesson 2 was an introductory lesson in the Engage phase of the topic Marvellous Micro-organisms. This topic addressed the science concepts related to the Living Things strand of the science syllabus (MCEETYA, 2006). It aimed to develop the students' conceptual understandings about yeast as a micro-organism and how it

functions in the production of bread; and to provide opportunities for the students to conduct investigations into the bread making process and to record and describe their observations. The initial Engage lesson was entitled The Y factor and was designed to find out what the students knew about bread-making and yeast; to provide opportunities for the students to make observations about bread; and to elicit their questions about the topic. The lesson was comprised of a whole-class discussion to set up a word wall about the topic and small group work when the students examined samples of bread (Video footage, 30/7/2009). The data analysis for Lesson 2 centred on the interaction that arose from the initial discussion.

The setting

During the discussion, Penny initially spent some time eliciting the students' ideas about the topic so that they could construct a word wall to support their later learning (Video footage, 30/7/2009) and then she introduced the puppet, Lucy, into the conversation and used her to find out the types of bread the students had eaten for breakfast (Video footage, 30/7/2009). Subsequently, in setting up for small group work, Penny showed the students some samples of different types of bread and led a discussion about the differences between them (Video footage, 30/7/2009).

Prior to Lesson 2, Penny had introduced the class to a pair of large puppets called Lucy and Charlie. Penny had represented the puppets as teenage twins, with Lucy being an obtuse and quarrelsome character and Charlie being more rational and curious. At that time, Penny had found managing both puppets was quite difficult and for that reason she had decided to only use Lucy in Lesson 2 (PL 2 interview, 27/8/2009).

In this lesson, the class were once again seated in the mat area at the front of the classroom, with Penny on a chair and a group of 10 students sitting on the floor facing her (Video footage, 18/5/2009). The students continued to raise their hands when they wished to speak (Video footage, 18/5/2009). In the initial part of the discussion, when they were setting up the word wall, Penny used a keyboard on her lap to record the students' ideas on the IWB (Video footage, 18/5/2009).

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In the first part of the discussion, Penny mostly asked *open-ideas* questions when she elicited the students' ideas to add to the word wall and she asked more *open-description* questions when she introduced Lucy into the conversation. Penny asked more *open-explanation~reason* questions in the last part of the discussion when the class discussed different samples of bread. Also, she often asked a *closed* question when she used the discourse moves *clarify, prompt and scaffold* or *teacher uptake*.

The analysis showed that Penny (and the puppet, Lucy) asked a total of 54 initiating questions during the discussion segments of this lesson. Of these questions, 22 were classified as *open-ideas* (41%) and a further 22 were classified as *closed* (41%) questions. In addition, five were classified *open-description* (9%) questions and a further five as *open-explanation~reason* (9%) questions.

The analysis revealed that in the first part of the discussion in Lesson 2, Penny used similar discourse moves to those she had used in Lesson 1 but it also showed that she frequently supported the students to make their ideas explicit. Figure 4.3 below, shows how Penny worked on the students' ideas in this segment of the discussion.

Turn	Utterances	Coding
1.	T: Sharon?	Asks another student for his/her ideas.
2.	**S:Sha: Um.. you know.. I like eating the French bread, is it?**	
3.	T: So the long skinny one. [Teacher scribes student's idea onto IWB]	Clarify.
4.	**S:Sha: Yeah, that's it.**	
5.	T: French, I think they call it a French stick.	Reframe.
6.	**S:Sha: With salad and stuff in it.**	
7.	T: Nice and crusty. Noelle?	Asks another student for his/her ideas.
8.	**S:Noe: Um.. cheese bread.**	
9.	T: Cheese bread. [Teacher scribes student's idea onto IWB] Lewis?	Teacher restate. Asks another student for his/her ideas.
10.	**S:Lew: There's bread at the canteen and it has those round fruit in them.**	
11.	T: OK, like raisins? Like a currant or a raisin, is that the one? [WT1] Do they toast it for your recess?	Clarify. Wait Time 1. Prompt and scaffold, closed question.
12.	**S:Lew: Yeah.**	
13.	T: OK, so can we kind of put that under fruit bread?	Clarify.
14.	**S:Lew: What about sultana bread?**	
15.	T: Sultana, so fruit bread, we can also say sultana bread. [Teacher scribes student's idea onto IWB]	Teacher restate.
16.	**S:1: I don't really know whether this is a bread but it's made from the same ingredients as some of those. Doughnuts?**	
17.	T: Doughnuts, shall we put that …	Teacher restate.
18.	**S:1: Put it with toast.**	
19.	T: So it's not something that you do with bread but we're saying.. oh, I'm trying to extend our page there. But you.. what about doughnuts? What made you think	Teacher uptake, open-

	about doughnuts?	ideas question.
	Because we're talking about bread, what was it about the doughnuts?	Prompt and scaffold, open-ideas question.
20.	**S:1: Because they're both made from dough and they're more or less the same… not materials, the same um.. ingredients.**	
21.	T: OK. So I'm going to write that there. I'm just going to make it just a bit separate. And I hope I've spelt that right. And I'm going to put there your explanation. What did you say? [Teacher scribes student's idea onto IWB]	Clarify.
22.	**S:1: Because they are made from more or less the same ingredients.**	
23.	T: So can I say 'similar'?	Reframe.
24.	**S:1: Made from similar ingredients.**	
25.	T: To what?	Clarify.
26.	**S:1: Ingredients to bread.**	
27.	T: So is that what made you think of them, is that why they popped into your head? I can see other hands going up so I think other some other people might have had a light bulb moment there. Jacqui?	Asks another student for his/her ideas.
28.	**S:Jac: Doughnuts are made from yeast and um.. so is bread.**	
29.	T: Brilliant, well done. I'm just going to put that there. And I'll put there… [Teacher scribes student's idea onto IWB] Have you made doughnuts before? They're pretty hard to make, I've tried before and mine weren't very good.	Evaluate.

Figure 4.3: Lesson 2 - the teacher supported the students to articulate their ideas clearly.

In this excerpt (Figure 4.3), Penny worked with the students to create a word wall for the new topic. By eliciting the students' ideas and then working on them to make them explicit, Penny was able to scaffold the students to express their ideas clearly and to use appropriate terminology. This tended to create a pattern of interaction where Penny would initially respond to a student's idea by restating it (turns 9, 15, 17) so that the students could hear it again and, if necessary, she would also seek further clarification (turns 3, 11, 13, 21 and 25*).* If she was happy with the way the student had expressed their idea, she often praised them (turns 14, 29) before she moved on to ask for other ideas. Penny would also work on a student's idea by asking further questions and using discourse moves such as *teacher uptake* (turn 19), *wait time* (turn 11), *prompt and scaffold* (turns 11, 19), and *reframe* (turns 6 and 23) to help them to articulate or develop their idea. In Lesson 2, there were four instances of discourse moves that were coded as *wait time* and one instance of *extended thinking time*.

Utilising the discourse moves in this way generated teacher-student interactions that ranged from the three-turn structures (T-S-T) seen in Lesson 1, to progressively longer exchanges such as the eight turns (T-S →T-S →T-S →T-S) seen above in the interaction with Lewis and the longer interaction comprising 12 turns (S-T → S-T → S-T → S-T → S-T → S-T) with Student 1 (Figure 4.3). Penny utilised these kinds of discourse moves repeatedly in Lesson 2.

Key Finding 4.19

In Lesson 2, Penny worked progressively through a range of discourse moves to support the students to express their ideas clearly and to use appropriate terminology. She often repeated and/or clarified a student's idea (*teacher restate, clarify*) so that the class could hear it again, and she often praised the idea (*evaluate*) before she moved on to ask for other ideas. Penny would also work on a student's idea by asking further questions and using discourse moves to help them to articulate or develop their idea (*teacher uptake*, *wait time, prompt and scaffold*, and *reframe*). Penny used both *wait time* and *extended thinking time* in Lesson 2.

Utilising discourse moves in this way generated teacher-student exchanges that ranged from three-turn structures to progressively longer interactions involving eight turns and one interaction of 12 turns.

Later on in the discussion, Penny briefly used the puppet Lucy (Puppet: Lucy or P:Lucy) to find out about the kinds of bread the students had eaten for breakfast. This gave Penny the chance to discover more about the students' prior knowledge of the topic whilst also developing her skills in using puppets. Figure 4.4 below, provides an example of the type of dialogue that arose in this part of the discussion.

Turn	Utterances	Coding
1.	[The teacher picks up the puppet from table next to her and sits it on her knee] T: OK. So I had a discussion this morning with Lucy about what I had for breakfast and Lucy said she would like to have a discussion with you guys about what you had for breakfast. So she's come to join us for our science today because Charlie's next door.	
2.	P:L: Morning, everyone. How are you?	
3.	**Ss: Good morning, Lucy.** [Peters out]	
4.	**S:Mic: Good morning, Lucy.**	
5.	P:L: Oh, thanks. Thanks, Michael.	

6.	T: Sharon, if you just come and join us on the mat please, that's alright we'll go back to the page just now.	
7.	P:L: Well, this morning for breakfast I sat down with my brother, Charlie, and I had two boiled eggs and a slice of wholegrain toast. What did you have for breakfast?	Initiating question, open-ideas question.
8.	**S:1: I had Nutrigrain.**	
9.	P:L: You had what?	Clarify.
10.	**S:1: Nutrigrain.**	
11.	P:L: Nutrigrain? So no bread?	Teacher (puppet) restate. Clarify.
12.	**S:1: No.**	
13.	P:L: No toast?	Clarify.
14.	**S:1: No.**	
15.	P:L: Oh boring. What did you have for breakfast?	Initiating question, open-ideas question.
16.	**S:2: Weetbix.**	
17.	P:L: Weetbix, no toast?	Teacher (puppet) restate. Clarify.
18.	**S:2: No toast.**	
19.	P:L: Oh, oh OK. Did anyone have bread for breakfast in here? [Several Ss put up their hands] Ahh, quiet young lady up the back, what did you have?	Acknowledge only. Recast the question. Initiating question, open-ideas question.
20.	**S:3: I had honey on toast.**	
21.	P:L: Honey, oh I love honey, mmm. Honey is my favourite. What toast did you have?	Teacher (puppet) restate. Clarify.
22.	**S:3: Um.. white bread.**	
23.	P:L: White bread. Oh.	Teacher (puppet) restate.
24.	T: Yep, it's written on our word wall, its covered already and I think we have a bit of white bread in here.	
25.	P:L: Who else had their hands up what they had for breakfast? OK, the quiet young gentleman in the back there, what did you have? I remember your name. It's Jason.	Directed question. Initiating question, open-ideas question.
26.	**S:Jas: I had white bread and Vegemite and cheese.**	
27.	P:L: White bread with Vegemite and cheese on your bread. Mmm. Did you have a sandwich or did you toast it?	Teacher (puppet) restate. Clarify.
28.	**S:Jas: Toast.**	

29.	T: Toasted it. Oh, like me. I had boiled eggs and toast. Brian, what did you have?	Teacher (puppet) restate. Directed question. Initiating question, open-ideas question.
30.	**S:Bri: I had jam.**	
31.	P:L: Just jam?	Clarify.
32.	**S:Bri: And toast.**	
33.	P:L: Oh OK. What toast? Like me wholegrain?	Clarify.
34.	**S:Bri: Rye.**	
35.	P:L: Do you remember what brand?	Initiating question, closed question.
36.	**S:Bri: No.**	
37.	P:L: No. OK, you're like me, you don't look. Mum just makes it and I just eat it. Michael?	Teacher (puppet) restate. Asks another student for his/her ideas.
38.	**S:Mic: Now, I did not have toast for breakfast I had Coco Pops, but for lunch I am having** [Interrupted]	
39.	P:L: Oh, you're lucky! My mum doesn't let me eat Coco Pops. She says there is too much sugar and I won't be able to concentrate when I come to school. How do you get away with that?	
40.	**S:Mic: My mum's nice.**	
41.	P:L: Oh yeah.	
42.	**S:Mic: Well for** [Interrupted]	
43.	P:L: I'll have to go home and talk to my mum. I have to sneak Coco Pops in the morning if I want them. My mum doesn't buy them though.	
44.	**S:Mic: For lunch, I have white bread which hasn't been toasted though.**	
45.	P:L: OK, so you don't bring toast for lunch?	Clarify.
46.	**S:Mic: No, no.**	
47.	P:L: OK. Sharon?	Acknowledge only. Asks another student for his/her ideas.
48.	**S:Sha: I had dark bread toast with um.. that jam.. no with the marmalade with um.. marmalade and we had a glass of milk. That's what it was.**	
49.	P:L: OK, so dark bread. Was it dark bread like that one? [S:Sha shakes her head] Was it dark bread because you burnt it in the toaster?	Teacher (puppet) restate. Clarify.
50.	**S:Sha: No. It was dark crusted bread.**	
51.	P:L: Dark crusted bread. Was it like any of these breads	Teacher (puppet)

	here?	restate. Clarify.
52.	**S:Sha: No.**	
53.	P:L: Mmm.	Acknowledge only.
54.	T: Well, I'm just going to turn back to our first page, if I can move this. OK. I'm just going to put Lucy to sit and listen to us for a little bit. Alright, Lucy, you need to listen and learn young lady. OK. Thank you.	

Figure 4.4: Lesson 2 - the teacher introduced a puppet into the discussion.

In this excerpt (Figure 4.4), Penny introduced the puppet into the discussion (turn 1) and then took on the role of Lucy, greeting the students (turn 2) and presenting a brief scenario about what she and Charlie had eaten for breakfast (turn 7). When Lucy then asked the students what they had for breakfast (turn 7), they began to talk about cereals rather than about bread (Student 1, turn 8; Student 2, turn 16) and she ended up having to ask a more focused question (*recast the question- no answer or suitable response, so teacher rephrases the question,* turn 19). The students then discussed the type of bread they had eaten and the toppings they had on them.

When using the puppet in this part of the discussion, Penny essentially reverted to asking *open-ideas* questions and using the *teacher restate* and *clarify* discourse moves to simply elicit a range of the students' ideas. While this generally produced teacher/puppet-student exchanges of several turns (T-S →T-S or longer), Penny did not use any other discourse moves to explore the students' ideas as she had done in the earlier part of the lesson (refer to Key Finding 4.19).

During the Post Lesson 2 interview (27/8/2009), after Penny had the chance to reflect on the lesson, she said that she felt the interaction with Lucy was "a bit stilted" and that she might have managed it better (PL 2 interview, 27/8/2009). When she had previously used the two puppets together she said she had found it easier to generate the interaction between them and then to draw the students into the discussion. In this lesson, when she had only used Lucy, she felt that she had to join in the discussion (as the teacher) to keep the interaction moving along (PL 2 interview, 27/8/2009). Penny also thought that the students did not respond as well to Lucy as they would have to the male character, Charlie (PL 2 interview, 27/8/2009). Additionally, she was unsure

that the students had been won over by the puppets and she felt that this may have affected the way that they participated in this segment of the lesson.

> I feel that because I have been doing science with most of these kids since they were in Year 5 and 6 [Penny's students were now Year 6 and 7] and I have been doing science [discussions without puppets] for a couple of years, they have become used to it and I have never used a puppet. So I feel that that's added a different factor to it and the kids can't quite work out why the puppets are there. I have fairly good discussions anyway because… I mean they were on the mat for a long time and they are generally quite happy to discuss stuff I find. So I find that the puppets didn't take away from the discussion, but I don't know if they added anything to it. Just a bit of an unknown factor where they think I've gone a little bit nuts. … They've got used to just me and now the puppets have come. (PL 2 interview, 27/8/2009)

Penny also felt that having a camera in the room had made her self-conscious when she used the puppet and she felt sure that this had impacted the students' interactions with the puppet as well. "Yeah, because they are older kids, you know, they won't relax as much as little kids do, they don't forget that there's a camera there" (PL 2 interview, 27/8/2009).

Key Finding 4.20

Penny used one puppet in Lesson 2 as she had previously found it difficult to manage two puppets. When she introduced the puppet into the discussion, she reverted to using only the *teacher restate* and *clarify* teacher discourse moves to simply elicit the students' ideas without exploring them further.

When reviewing the lesson, Penny felt the interaction was stilted and that the students did not respond very well to the puppet because they were older and less likely to be won over. Penny also felt self-conscious using the puppet whilst being videoed and she suggested that this could have affected how the students participated also.

Communicative approach

In Lesson 2, when Penny and her students were constructing the word wall and interacting with the puppet, the discussion was mostly driven by *open-ideas* questions with many suggestions and ideas being shared. Later in the discussion, when they began to look at different samples of bread the discussion was also driven by some *open-description* and *open-explanation~reasoning* questions. The communicative

approach in this lesson would be classified Interactive-Dialogic (Mortimer & Scott, 2003), which is an appropriate form of interaction for an Engage lesson when a teacher seeks to elicit the students' existing ideas. In this instance, the teacher also used a range of discourse moves to achieve this purpose, including *teacher restate*, *clarify*, *evaluate*, *teacher uptake*, *wait time*, *prompt and scaffold*, and *reframe*.

Key Finding 4.21

In Lesson 2, an Engage lesson, Penny used an Interactive-Dialogic communicative approach to support the students to share their ideas.

Proportions of teacher and student talk

The analysis showed that Penny utilised a large percentage of the talk time (73%), whether speaking as the teacher or as the puppet, and the students made fewer contributions (27%) in whole-class substantive discussion.

Key Finding 4.22

In Lesson 2, Penny utilised about 73% of the talk time and the students utilised 27% in whole-class substantive discussion.

The students' role

In Lesson 2, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

There were eight *elaborated utterances* (100 or more characters in the transcript) in Lesson 2, which is a significant increase compared to Lesson 1 when only two *elaborated utterances* were apparent.

In addition, there was some evidence in this lesson of the students' capacity to generate cumulative talk (Alexander, 2006) by building on each other's ideas. For example, an excerpt from the first part of the discussion (Figure 4.3), Student 1 had raised the idea that a doughnut has similar ingredients to bread (S:1, turns 16, 20, 22, 24, 26) and Jacqui added to this by stating that both doughnuts and bread are made from yeast (S:Jac, turn 28) (Video footage, 27/7/2009).

Key Finding 4.23

There were eight *elaborated utterances* in Lesson 2 and there was some evidence of the students' capacity to generate cumulative talk by building on one another's ideas.

Lesson 2 summary

Lesson 2 was the first Engage lesson for the new topic, Marvellous Micro-organisms. Penny utilised an Interactive-Dialogic style of interaction to engage the students in discussion and to elicit their ideas. Initially, she mostly asked *open-ideas* questions and later in the discussion she asked some *open-description* and *open-explanation~reasoning* questions. Penny worked progressively through a range of discourse moves (*teacher restate*, *clarify*, *evaluates*, *teacher uptake*, *wait time*, *prompt and scaffold*, and *reframe*) to support the students to express their ideas clearly and to use appropriate terminology. This tended to generate teacher-student exchanges that ranged from three-turn structures (T-S-T) to progressively longer interactions involving four-turns (T-S →T-S) and one interaction of 12 turns (S-T → S-T → S-T → S-T → S-T → S-T). In addition, Penny used both *wait time* and *extended thinking time* in this lesson.

When Penny used the puppet, she reverted to using the *teacher restate* and *clarify* discourse moves to simply elicit the students' ideas without exploring them any further. She thought the students did not respond very well to the puppet and she felt self-conscious using the puppet whilst being videoed.

Penny utilised a large percentage of the talk time, however, the students gave an increased number of eight *elaborated utterances* (eight) and there was some evidence of their capacity to generate cumulative talk (Alexander, 2006).

Lesson 3, post Professional Learning Days 1 and 2

The lesson

Lesson 3 was videoed in September, approximately eight weeks after Lesson 2, and was the first lesson in the Explain phase of the *Primary Connections* topic Marvellous Micro-organisms. The lesson was entitled Food observations and it aimed to support the students to summarise, represent and explain their observations about the yeast micro-organism. The lesson was comprised of: a whole-class discussion to review the students' investigations into the yeast micro-organism and the conditions that make it active; and the students writing and then sharing a summary of their findings. The data analysis for this lesson focused on the interaction that was generated by the whole-class discussion.

The setting

Penny did not use puppets in this lesson. She started the lesson by reading a series of questions from the IWB that would guide the discussion about the yeast experiments the students had conducted in the Explore phase of the investigation, and she discussed how the students would write a summary of their findings. Then Penny commenced the discussion, focusing on reviewing the students' investigations, their observations from the investigations, and what this told them about the yeast micro-organism.

Once again, Penny and the students were seated in the mat area at the front of the classroom, with Penny on a chair and the group of 13 students seated on the floor facing her (Video footage, 22/9/2009). The students continued to raise their hands when they wished to speak (Video footage, 22/9/2009). Penny had a keyboard on her

lap and from time to time she recorded students' ideas on the IWB as the discussion proceeded (Video footage, 22/9/2009).

Key Finding 4.24

Penny did not use puppets in Lesson 3. The discussion was driven by a series of questions which focused on the results of the students' experiments and what this had told them about the yeast micro organism. The students were seated in a group on the floor facing Penny and they raised their hands when they wished to speak. Penny continued to manage the discussion by nominating speakers and maintaining the speaking conventions.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In this lesson, the discussion was driven the initiating questions that Penny asked about the yeast micro-organism. These were mostly *open-description* questions which were followed up by an *open-explanation~reason* question, e.g. What have we been investigating about yeast? (*open-description*); What does it mean when we say yeast is a micro-organism? (*open-explanation~reason*); What conditions does yeast need to be active and create carbon dioxide gas? (*open-description*) How do you know? (*open-explanation~reason*). In addition, Penny often asked a *closed* question when she used the discourse moves *clarify*, *prompt and scaffold* or *teacher uptake*.

The analysis showed that Penny asked a total of 85 initiating questions in Lesson 3. Thirty-four (40%) of these questions were classified as *closed* questions; 24 (28%) were classified as *open-description*; 21 (25%) were classified as *open-explanation~reason*; and six (7%) were *open-ideas* questions.

Teacher discourse moves

In Lesson 3, Penny wanted to support the students to explain their understandings about the conditions needed for yeast to be active or inactive and the role of yeast in the bread-making process (Video footage, 22/9/2009). Two excerpts from the discussion in this lesson have been selected to show how Penny consistently scaffolded the students' explanations and use of scientific language, and how she led them to think through and explain their ideas.

Penny initiated the discussion in this lesson by reviewing what the students had been investigating about yeast and recalling some of the observations from their experiments (Video footage, 22/9/2009). Then she encouraged the students to think more deeply about their observations. The excerpt (Figure 4.5) picks up the interaction when Penny asked the students to describe the conditions that make yeast active.

Turn	Utterances	Coding
1.	T: OK. So has anybody got any ideas about that? How.. look at our questions here. What conditions does yeast need to be active and make carbon dioxide gas? So when we did that yeast investigation, we put yeast in the bottle, put warm water, cold water and hot water. And we put the balloon over the top, we put it in a warm spot. So... we've been investigating about yeast, how it works in the bread making process and someone said something about, that was Sharon, you said that yeast needed.. or yeast made the balloon rise.	Initiating question, open-description question. Refocus.
2.	**S:Sha: Yeah, needed the heat and the other stuff.**	
3.	T: OK. So what conditions, this question here, does yeast need to be active and make the carbon dioxide gas? Because we had someone, that was Brendon who was here the other day, said that it's carbon dioxide… dioxide gas that's formed. So what conditions does it need? Michelle, what conditions does yeast need to be active? [WT1] Active is when it's doing something.	Prompt and scaffold. Directed question. Wait time 1. Prompt and scaffold. Asks another student

	Someone help her out. Brian?	for his/her ideas.
4.	**S:Bri: Heat.**	
5.	T: It needs heat.	Teacher restate.
6.	**S:Bri: Or sunlight.**	
7.	T: What kind of heat? Does it need extremely hot heat? Christine?	Teacher uptake. Prompt and scaffold.
8.	**S:Chr: It needs warm.**	
9.	T: Warm. It needs warm. So it needs to be warm. What else does it need? What else did we put in that bottle to make the yeast active? Michelle?	Teacher restate. Prompt and scaffold.
10.	**S:Mich: Water.**	
11.	T: Water? What kind of water? [WT1] We did put three types, but which balloon went up first though?	Clarify. Wait time 1. Prompt and scaffold.
12.	**S: Hot water.**	
13.	**S:Mich: Warm water.**	
14.	T: Warm water, so we know we need warmth. Julie?	Teacher restate. Clarify. Asks another student for his/her ideas.
15.	**S:Jul: Um.. sugar for it to eat.**	
16.	T: Sugar for it to eat. Fantastic! It needed to have sugar for it to eat. OK.	Teacher restate. Evaluate. Teacher restate.

Figure 4.5: Lesson 3 - the teacher scaffolded the students' thinking.

In this excerpt (Figure 4.5), Penny helped the students to interpret her questions by summarising their observations (turn 1) and reminding them of relevant ideas that they had previously talked about (turn 3). She helped the students to articulate their ideas by giving them time to think (turns 3 and 11) and by asking questions that provided clues (turns 3 and 11). As the discussion progressed, Penny repeated key ideas to make them explicit (turns 5, 9, 14, and 16) and she asked questions that helped to link the students' ideas together (*teacher uptake*, turn 7; *prompt and scaffold*, turns 7 and 9). At the end of the excerpt, she confirmed a key idea by restating and praising it (turn 16) While the teacher-student interactions in this part of the discussion mostly comprised the three-turn structures (T-S-T), there were some that were slightly longer (T-S → T-S).

Key Finding 4.26

In Lesson 3, Penny supported the students to interpret her questions and by linking their responses together, she helped them to progress their thinking. She used: *refocus* and *prompt and scaffold* to help them interpret her questions; *clarify*, *prompt and scaffold*, *wait time* and *teacher uptake* to support them to articulate their ideas; and *teacher restate* and *evaluate* to make key ideas explicit. The teacher-student interactions tended to be quite short.

The next excerpt (Figure 4.6) shows how Penny helped the students to develop an explanation by asking *open-description* and *closed* questions and using discourse moves that kept their discussion focused. The discussion in Figure 4.6 below builds on from the previous excerpt (Figure 4.5).

Turn	Utterances	Coding
1.	How did you know that we needed sugar? Think about our bottle investigations. How did we know that it needed the sugar and the warm water? Hands down, guys. I'm going to ask a few people. So, thinking about that. So how did you know that.. how did you know or how could you see that it needed the warm water and it needed the sugar? [WT1] What showed you that that's what yeast needed? [WT1] When you were looking at that. Susannah? [WT1]	Initiating question, open-explanation~reason question. Prompt and scaffold. Extended thinking time. Prompt and scaffold, open-description question. Wait time 1. Prompt and scaffold. Wait time 1. Prompt and scaffold. Wait time 1.
2.	**S:Sus: Um..**	
3.	T: When we were observing. [WT1] What showed you that's what yeast needed? We've said warm water and sugar.	Prompt and scaffold. Wait time 1. Recast the question. Prompt and scaffold.
4.	**S:Sus: Well um.. if you put the yeast with the warm water and then you put salt with it, maybe it like.. the salt would rise the** [Interrupted]	
5.	T: No.	Evaluate.
6.	**S:Sus: yeast up.**	
7.	T: We didn't put salt in there.	
8.	**S:Sus: Sugar.**	
9.	T: It was just discussed. So sugar and warm water. What showed you that that was what the yeast needed?	Teacher restate. Recast the question.

	How did we know? Think back to our bottles and our bread making. OK, we made one lot of bread with yeast and one lot of bread without yeast. So what happened to that bread? Michelle?	Prompt and scaffold, open-description question. Asks another student for his/her ideas.
10.	**S:Mich: It rised and one didn't.**	
11.	T: It rose, yep, and one didn't. OK, the one that rose, what were we doing? We made it in a bread maker. What was.. what did the bread maker do to it?	Reframe. Evaluate. Teacher uptake, open-description question. Prompt and scaffold, open-description question.
12.	**S:1: Kneaded it.**	
13.	T: Kneaded it. And what else? [WT1] Was it cold in the bread maker, do you think? Christine?	Teacher restate. Elaborate. Wait time 1. Prompt and scaffold, closed question.
14.	**S:Chr: It needed the warmth from the sides of the bread maker.**	
15.	T: The warmth from the bread maker, because it warmed up, didn't it? We said you've got to be careful it's really hot in the bread maker. Sharon?	Teacher restate. Clarify. Asks another student for his/her ideas.
16.	**S:Sha: It alw.. it also moists it. Like moists it. Like sorta like..**	
17.	T: So we had liquid in there.	Reframe.
18.	**S:Sha: Um.. like, yeah, like um.. so when.. when they kneaded it, it turned into dough so it was moist dough, like it was like dough, like doughy.**	
19.	T: Yep, we made.. we made the dough but we're thinking about the yeast still within that. How did the yeast become active?	Recast the question, Initiating question, open-explanation~reason question.
20.	**S:Sha: We made..** [Interrupted]	
21.	T: What showed us that the yeast was active?	Recast the question, open-description question.
22.	**S:Sha: Because it made it um.. like, it made it rise.**	
23.	T: It made it rise. So the bread rose. And when we did the bottles, how did we know the yeast was active? Brian?	Teacher restate. Reframe. Initiating question, open-explanation~reason

		question.
24.	**S:Bri: 'Cos it blew up the balloon.**	
25.	T: We had the balloon rising. OK.	Reframe.

Figure 4.6: Lesson 3 - the teacher led the students to generate an explanation and she modelled correct use of language.

In this excerpt (Figure 4.6), Penny asked the students to explain how they knew the yeast needed sugar and warm water to make it active and she gave them some time to think about their response (turn 1; *extended thinking time - teacher extends thinking time using strategies other than wait time such as Think-Pair-Share or Thinking Time*). As the students were thinking, Penny continued to ask *open-description* questions, prompting them to think about the experiments and observations that they had made that showed them how yeast needed warm water and sugar (turn 1).

Ultimately, Penny helped the students to develop viable explanations by asking a series of *open-description* and *closed* questions (turns 9, 11, 13, 19, 21, 23) and using discourse moves that shaped the discussion by cutting off erroneous ideas and endorsing others (*evaluate*, turns 5 and 11; *teacher restate*, turns 9, 13, 15, and 23) and by keeping the students on track (*recast the question*, turns 9, 19 and 21; and *teacher uptake*, turn 11). Additionally, she continued to help the students to articulate their ideas clearly and to use scientific language appropriately (*reframe*, turns 11, 17, 23, and 25). In this lesson, there were 10 instances of discourse moves that were coded as *wait time* and five instances of *extended thinking time*.

Penny used similar kinds of questioning and discourse moves in the remainder of this lesson. This was inclined to generate teacher-student exchanges comprising three- (T-S-T) and four-turn structures, (T-S → T-S), and some that were slightly longer.

Key Finding 4.27

Penny led the students to ultimately answer an *open-explanation~reason* question in Lesson 3 by asking *open-description* and *closed* questions and using discourse moves to help them interpret the question (*prompt and scaffold, extended thinking time, wait time*). She also used discourse moves to shape the discussion by cutting off or endorsing ideas (*evaluate, teacher restate*), to maintain the focus (*recast the question, teacher uptake*), and to model correct expression (*reframe*). There were 10 instances of discourse moves that were coded as *wait time* and five instances of *extended thinking time*.

The teacher-student exchanges were predominantly comprised of three- and four-turn structures.

Communicative approach

In the early part of the discussion, Penny utilised an Interactive-Dialogic style when she asked the students to recall some of the observations from their experiments. However, this quickly became more Authoritative when she wanted the students to describe the conditions that made yeast active and when she led them to develop explanations about this. Such a shift in the style of interaction is consistent with the form of discourse required in the Explain phase where the instructional purpose is to introduce and develop the scientific explanation of the science phenomenon that is the focus of the investigation. This type of discussion requires the teacher to initially use an Interactive-Dialogic approach (Mortimer & Scott, 2003) to recall the students' experiences, ideas and explanations relating to the phenomenon; followed by a more Interactive-Authoritative approach (Mortimer & Scott, 2003) as the teacher uses questioning to develop the scientific view. In this lesson, Penny asked *open-description* and *open-explanation~reason* questions to initiate discussion and develop explanations. She also asked *closed* questions when she wanted to prompt the students' thinking and shape the discussion. She used discourse moves such as: *recast the question, prompt and scaffold, wait time* and *extended thinking time* when she wanted to support the students to interpret the focus questions; *evaluate* and *recast the question* when she wanted to shape the discussion; and *reframe* to support the students to articulate their ideas clearly.

Proportions of teacher and student talk

In Lesson 3, Penny continued to utilise a large percentage of the talk (73%) and the students made fewer contributions (27%) than the teacher.

The students' role

In Lesson 3, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances as well as the complexity of the students' responses.

Elaborated utterances

There were 16 *elaborated utterances* (100 or more characters in the transcript) in Lesson 3. This result represents a significant and continued increase in elaborated utterances over previous lessons.

Figure 4.7 provides an example of two of the student's contributions that have been coded as *elaborated utterances* (turns 6 and 10). This excerpt builds on from Figure 4.6 where Penny supported the students to explain the conditions that cause yeast to be active. In this segment, the discussion has moved on and Penny has asked the students what caused the yeast to be inactive. The excerpt begins at the point where

Penny has prompted the students to think about the differences between the bread they made with yeast and the bread they made without yeast.

Turn	Utterances	Coding
1.	T: So Thursday we had.. we made bread without yeast, Friday we made bread with yeast. So what was the difference?	
2.	**S:Tim: Um.. the one without the yeast, it was smaller and it turned all gooey in the middle.**	
3.	T: Gooey in the middle. Can you leave that please, Sharon. So what was different about it to the one on Friday?	
4.	**S:Tim: The one on Friday was bigger and it wasn't gooey in the middle.**	
5.	T: So it was bigger and it wasn't gooey in the middle. Why do you think.. so what we say.. what conditions cause yeast to be inactive? Walter has already said that cold water, no sugar.. so no food for it, and how do we know? So we know because the bread is…? Tim? [WT1] What happened to the bread? It was smaller, the one on Thursday. Christine?	
6.	**S:Chr: I think I know how the um.. without yeast it was all gooey inside, but with the like bread that we made with the yeast it wasn't all um.. gooey in the middle. I reckon it was because of the um.. carbon dioxide that the yeast makes dries it all out.**	Elaborated utterance. Explanation.
7.	T: So you think the carbon dioxide in the yeast has got something to do with drying out the bread in the middle. So not making it all gooey. That's a really big thing, Christine, well done. Can you hold that thought too, remember that. So the carbon dioxide is something really important in there. 'Cos we know that it makes carbon dioxide gas when it's active, don't we? So was there yeast in that bread on Thursday that was gooey?	
8.	**S: No.**	
9.	T: No, no carbon dioxide. So you think the carbon dioxide gas has got something to do with the gooeyness of the dough. Sharon?	
10.	**S:Sha: I have something to add to Christine's um.. thought. Um.. yeah, um.. with the kneading and the yeast, it's um.. the yeast wasn't in the one on Thursday, um.. it didn't knead the air out because there wasn't no yeast and there wasn't no sweetness to feed the yeast, but there wasn't no yeast to like make it rise or anything. That's why it was only a little bit rised but it was flat.**	Elaborated utterance. Explanation.
11.	T: OK. So you know that the conditions that cause the yeast to be inactive are no.. well we did have warmth on Thursday, didn't we? But we didn't have warmth with the bottles, but there was no yeast.	

Figure 4.7: Lesson 3 - the students provided elaborated utterances when they gave explanations and built on each other's ideas.

In this excerpt (Figure 4.7), Penny led the students to recall the differences between the breads with and without yeast (turns 1 and 3) and to consider what caused the yeast to be inactive (turn 5). Tim (S:Tim) described bread without yeast as smaller and "gooey in the middle" (turn 2) and the bread with yeast as bigger and not "gooey in the middle" (turn 4). Then, Christine (S:Chr) explained that the bread made with yeast was not gooey inside because the yeast produced carbon dioxide which dried the bread out (*elaborated utterance* and *explanation*, turn 6). Sharon (S:Sha) added to this idea, explaining that the bread without yeast was flat because it did not contain yeast or the sugar needed to feed the yeast (*elaborated utterance* and *explanation*, turn 8).

Quality of student talk

In Lesson 3, 46% of the students' responses were coded as *description*, 37% as *unistructural* and 9% as *multistructural*; 40% were coded as *explanation*; and a further 14% were coded as *reasoning*.

Key Finding 4.30

In Lesson 3, there were 16 *elaborated utterances*; 46% of the students' responses were coded as *description* (37% as *unistructural*; 9% as *multistructural*), 40% were coded as *explanation*, and a further 14% were coded for *reasoning*. The students gave explanations and built on each other's ideas.

Lesson 3 summary

Lesson 3 was the Explain lesson for the Marvellous Micro-organisms topic. Puppets were not used in this lesson. Penny and the students reviewed the investigations into yeast that were completed during the Explore phase and they developed explanations about what conditions made yeast active or inactive. Penny moved from an Interactive-Dialogic style of interaction, when she elicited the students' observations and descriptions, to a more Authoritative style when she wanted to develop explanations.

During the discussion, Penny asked mostly *open-description* and *open-explanation~reason* questions. She also asked *closed* questions when she wanted to prompt the students thinking and to shape the discussion. She also used a range of

teacher discourse moves to support the students to interpret her questions and articulate their ideas, and to make key ideas explicit (*teacher restate, clarify*, *prompt and scaffold*, *wait time* and *evaluate*). In addition, she led the students to develop explanations by asking *open-description* questions and using discourse moves to shape the discussion (*recast the question, prompt and scaffold, wait time,* and *evaluate*) and to model correct expression (*reframe*). Managing the discourse in this way produced teacher-student exchanges that were predominantly comprised of three- (T-S-T) and four-turn structures (T-S → T-S).

Even though Penny continued to utilise most of the talk time in Lesson 3, the number of elaborated students' responses increased again in this lesson. Additionally, the students built on each other's contributions and while quite a number of their responses were coded for *unistructural descriptions*, there was also an increased number coded for *explanation* and *reasoning*.

Mid-intervention: Penny's beliefs, knowledge and practice

On the third PL day (PL Day 3) in August 2009, the teachers participating in the professional learning intervention were asked to review their management of classroom discourse during the implementation of the initial science topic. For Penny, this related to the Marvellous Micro-organisms topic referred to in Lessons 2 and 3 of this case study.

Knowledge about managing classroom discourse

The data collected from the review showed that Penny had focused on developing the students' use of speaking and listening conventions. She had also attempted to ask a greater number of open-ended questions and to use *wait time* more frequently (PLD 3: Review, 24/08/09). Penny felt that she had been able to ask an increased number of open questions and that this had given the students the confidence to express their ideas whether they were right or not (PLD 3: Review, 24/08/09). In addition, she felt that she had used *wait time* and *extended thinking* time successfully and that this had

given the students the opportunity to listen to others' ideas whilst also taking some time to formulate their own responses (PLD 3: Review, 24/08/09).

Since Penny had received consent for only half of her class to be involved in this study, she had to organise for the students who were not involved to be removed from the room when the lessons were filmed. She felt that a more positive atmosphere was created for discussion when some of her more challenging students were not involved in the lessons (PLD 3: Review, 24/08/09). However, this also meant that she needed to repeat the lessons that were filmed to ensure all the students were familiar with the content covered and were given the same opportunity to develop their capacity to participate in discussions.

The review completed on PL Day 3 also asked that the teachers rate the extent to which they had been able to develop a classroom culture that was supportive of productive talk. The teachers had to rate (0-100%) the extent to which they had developed five characteristics of productive classroom talk (Alexander, 2006) and five ground rules for effective talk (Mercer, 2008). The characteristics of productive classroom talk articulated by Alexander (2006) describe talk that is: *Collective*, when teachers and children address learning tasks together; *reciprocal*, when teachers and children listen to each other and share ideas; *supportive*, when children articulate their ideas freely without fear of embarrassment; *cumulative*, when teachers and children build on each other's ideas and chain them into lines of thinking; *purposeful*, when teachers plan and steer classroom talk with a specific outcome in view. Penny indicated that she was most successful in creating a classroom culture to do with talk that was *collective* (90%) and *reciprocal* (80%). She also indicated that, thus far in the professional learning intervention, she had less success at developing classroom talk that was *cumulative* (70%), *purposeful* (70%) or *supportive* (60%).

The ground rules for effective talk, which are drawn from the *Thinking Together* project (Mercer, 2008), comprise five statements that support students to participate positively in discussion. These are: we share our ideas and listen to one another; we talk one at a time; we respect each others' opinions; we give reasons to explain our ideas; if we disagree we try to ask "why" (Mercer, 2008). Penny indicated that she was most

successful in creating a classroom culture in which students spoke one at a time (90%), respected each others' opinions (90%), and shared and listened to each others' ideas (80%) (PLD 3: Review, 24/08/09). She also indicated that she had been less successful at getting the students to give reasons to explain their ideas (60%) or to resolve their disagreements (50%) (PLD 3: Review, 24/08/09).

Penny felt that in her class the most improved characteristic of classroom talk was to do with sharing and listening to each others' ideas (PLD 3: Review, 24/08/09). She thought that this had come about because of the speaking and listening conventions she had set up in the room and also because she had used the puppets to engage reluctant speakers (PLD 3: Review, 24/08/09). Penny also identified giving reasons to explain ideas and asking "why?" when there was disagreement were two of the most difficult characteristics of classroom talk to establish. She thought that her students found this difficult because they lacked "verbal reasoning skills and language attainment" (PLD 3: Review, 24/08/09).

Key Finding 4.31

At mid-intervention review, Penny reported that she had focused on developing the students' use of speaking and listening conventions. She thought she had asked an increased number of open questions, which she considered had increased the students' confidence to express their developing ideas. She also felt that she had used *wait time* and *extended thinking time* successfully.

Penny indicated that she was most successful in creating a classroom culture to do with talk that was *collective* (90%) and *reciprocal* (80%), and that she had less success at developing classroom talk that was *cumulative* (70%), *purposeful* (70%) or *supportive* (60%).

She also indicated that she was most successful in creating a classroom culture in which students spoke one at a time (90%), respected each others' opinions (90%), and shared and listened to each others' ideas (80%). At this point in the professional learning intervention, she had been less successful at getting the students to give reasons to explain their ideas (60%) or to resolve their disagreements (50%).

Knowledge about using puppets

The review undertaken on the PL Day 3 also invited the teachers to reflect on their use of puppets during the implementation of the initial science topic. Penny had used a puppet in the Engage phase of the inquiry process to elicit the students' ideas (PLD 3:

Review, 24/08/09). She had found that the puppets had been useful in engaging most of the students in discussion and that the weaker students were keen to discuss their ideas with the puppets (PLD 3: Review, 24/08/09). She thought that the puppets had been fairly well received because they were something new and the students were curious about them (PLD 3: Review, 24/08/09).

Penny also reported that when she had introduced the puppets to the whole class, as opposed to the smaller group of students involved in this research project, it had been difficult to maintain a good level of student engagement, and that some of the students whom she perceived to be more challenging made fun of the puppets and began to "act up" (PLD 3: Review, 24/08/09). She thought that rather than introducing the puppets to the class mid-way through the year, if would be better to do this after the ground rules for talk had been established at the start of the year (PLD 3: Review, 24/08/09). Penny had also found it difficult to use two puppets at once because she found it hard to stay in character and to adjust her voice as she moved between the roles of the teacher and the puppets (PLD 3: Review, 24/08/09). Following the filming of Lesson 2, Penny did not use the puppets in any subsequent lessons associated with the professional learning intervention.

Key Finding 4.32

At the mid-point of the intervention, Penny reported that she had tried to use a puppet in the Engage phase to elicit the students' ideas. While she had found most of the students were engaged by the puppets and the weaker students were motivated to talk to them, some students were not won over by them and it was difficult to maintain a good level of engagement. She thought it would have been better to introduce the puppets to the class at the start of the year after the ground rules for talk had been established.

Penny found it difficult to use two puppets at once, to stay in character, and to adjust her voice as she moved between each role. Following the filming of Lesson 2, Penny did not use the puppets in any subsequent lessons.

On PL Day 3, the teachers were also given the opportunity to share and discuss some of the video footage of their teaching. This served to focus the teachers' on their own discourse practice and to provide them with ideas that they might try out in the second half of the intervention. Subsequently, the teachers planned the implementation of a

second science topic and, following the same planning process used in the first two professional learning days, they identified learning outcomes and described the scientific explanations that would indicate the learning outcomes had been achieved for the new topic. Once again, the teachers had to plan how they would use the puppets to set the scene for the investigation, to pose problems for the students to solve, and to elicit the students' prior knowledge. This also meant the teachers had to consider: the communicative approach needed to elicit information from the students in the Engage phase of the inquiry; how to adjust their communicative approach for the Explore and Explain phases; how to plan their questioning during the introduction so that the investigation engaged the students; and how to manage the class discussions to ensure that sustained conversations met the instructional purposes for each phase of inquiry.

Following PL Day 3, data was gathered from two more of Penny's science lessons via video, classroom observation and follow up interviews. Lesson 4 was filmed in October and was an Engage lesson that marked the start of a new teacher-authored topic called Studying Seeds. Lesson 5 was filmed in November and was an Explain lesson for the same topic. The data from these lessons is reported in the next part of this chapter.

Lesson 4, post Professional Learning Day 3

The lesson

This lesson was carried out soon after PL Day 3 and was the first lesson in the new topic, Studying Seeds. This topic addressed science concepts relating to the Life and Living strand of the science syllabus (MCEETYA, 2006). It aimed to develop the students' conceptual understandings about seeds and how they are adapted to suit a particular environment.

Lesson 4 was entitled Penny's Gardening Dilemma and was an introductory lesson in the Engage phase of the Studying Seeds topic. In this lesson, Penny wanted to engage the students' interest in seeds, to access their prior knowledge, and to find out what

questions they might have about seeds. The lesson involved: a whole-class discussion to introduce the topic and set the context for the investigation; group work to sort, identify and plant a range of different seeds; and the students recording their ideas and questions about seeds on See-Think-Wonder charts. The data analysis for this lesson centred on the initial whole-class discussion to introduce the topic and set the context for the investigation.

The setting

When she planned this lesson, Penny developed a scenario that would set the scene for the new topic about seeds and give her the opportunity to introduce a problem for the students to solve. The scenario was situated in Penny's garden, where she often fed seeds to the wild birds that came to visit.

> I set a scenario to do with feeding the wild birds on my decking and the seeds falling through and then different plants appearing and not knowing what seeds matched what plants basically. So there was a little bit of a story for it and then the lesson was for them to have a look at the seeds. And we discussed what a seed was just to get that prior knowledge, so they knew about seeds. And then getting them sorting seeds to plant in the different groups so that we could work out what sort of plant belonged to what seed. (PL 4 interview, 06/11/2009)

When the discussion commenced, Penny was seated on a chair in front of 15 students who were seated on the floor in the mat area of the classroom (Video footage, 28/10/2009). The students continued to raise their hands when they wished to speak (Video footage, 28/10/2009).

Key Finding 4.33

Penny developed a scenario for Lesson 4 that would set the scene for the new topic and to present a problem for the students to solve. She also wished to use the discussion to elicit the students' prior knowledge and initial understandings about seeds.

Penny and the students sat in the mat area of the classroom and the students raised their hands when they wished to speak.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In Lesson 4, the discussion was driven by *open-ideas* questions as Penny elicited the students' initial ideas about seeds and also by *open-description questions* as she explored their ideas further. *Closed* questions were often asked when the discourse moves *clarify*, *prompt and scaffold* or *teacher uptake* were used.

The analysis showed that Penny asked a total of 13 initiating questions in this discussion. Of these questions, five (38%) were classified as *open-ideas*; four (31%) were classified as *open-description*; and four (31%) were *closed* questions.

Key Finding 4.34

Penny asked a total of 13 initiating questions in Lesson 4, of these approximately 40% were *open-ideas* questions, 30% were *open-description* questions and a further 30% were *closed* questions.

Teacher discourse moves

Since Lesson 4 marked the start of a new topic, Penny wished to engage the students' interest in the topic by seeking their help to solve the problem she had with all the different plants that were growing underneath her decking. An excerpt of the discussion from this lesson shows how Penny elicited the students' ideas and engaged them in further interaction in order to explore their ideas in greater detail.

Once Penny had told the students about her dilemma she invited them to share what they knew about seeds. The excerpt below (Figure 4.8) picks up the discussion after several students had shared their ideas and Penny had nominated Sharon to speak.

Turn	Utterances	Coding
1.	**S:Sha: Um.. people can eat these**. [Refers to seeds in her hands] **They can be different shapes and sizes and colours.**	
2.	T: OK.	Acknowledge only.
3.	**S:Sha: And they can be sesame seeds, sunflower seeds, pomegranate seeds. No, yeah, yeah, yeah, and like seeds can be all fruit as well.**	
4.	T: So they come from fruit. So whereabouts in the fruit?	Reframe. Teacher uptake, open-ideas question.
5.	**S:Sha: Um.. in the middle of it.**	
6.	T: In the middle of the fruit and Christine said that sunflower seeds come from…? [T looks at Christine to answer] Sunflowers.	Teacher restate, closed question.
7.	**S:Chr: Sunflowers.**	
8.	T: So, we've got some seeds that come from fruit, some come from plants and then we know that some animals eat these seeds and we know that people eat seeds. So when you're eating an apple, you probably wouldn't eat.. well you could if you eat right through the core, you could eat the apple pips. Sorry, Brennan, I like the way that you put your hand up.	Refocus. Asks another student for his/her ideas.
9.	**S:Bre: So you could eat through like the core of the apple to get the seeds.**	
10.	T: To get seeds in the middle of the apple. Evan, I saw your hand go up there.	Reframe. Asks another student for his/her ideas.
11.	**S:Eva: My cousin eats like the whole apple, um.. if you give him an apple you won't get anything back.**	
12.	T: So he recycles the whole thing, that's really good. Michael?	Reframe. Asks another student for his/her ideas.
13.	**S:Mic: Um.. my sister, she ate an apple one day and cut it in half and got a seed and buried it and she thinks she is going to grow an apple tree.**	
14.	T: OK, has anything happened?	Teacher uptake, closed question.
15.	**S:Mic: Um.. it's sort of grown a bit, it's like all you can really see is leaves and a stalk.**	
16.	T: So leaves and a stalk. Oh, OK, that's interesting. So she thought she could grow an apple tree from the seed. Has anyone else done that in here? [Several students put up their hands] Brian?	Teacher restate. Reframe. Teacher uptake, closed question.

117

17.	**S:Bri: We have, we've got a nectarine tree.**	
18.	T: Oooh, lovely. So have you grown any nectarines from that? [Brian shakes his head] No. Did you plant your tree? [Brian shakes his head] Tim, I like the way your hand went up.	Teacher uptake, closed question. Clarify. Teacher uptake, closed question. Asks another student for his/her ideas.
19.	**S:Tim: I've got two things. I think it was the start of this year, my mum she was cutting potatoes and I asked if I could have a potato and I went outside and planted half the potato and it started to grow like little potatoes from that. And at the back of my house we've got oranges and mulberries and I cut an orange in half once and I took the seed out of it and planted um.. I planted the seed in the middle of the fruit garden thing and it's only just started to sprout.**	
20.	T: OK, so you planted an orange seed. What did you do to the seed when you planted it?	Teacher uptake, open-description question.
21.	**S:Tim: I actually.. I got.. because I've got a pool out the back of my house, I got the chlorine water, and yeah.**	
22.	T: So you put water on it. What else did you do? Where.. and when you planted it where did you put it to plant it?	Reframe. Teacher uptake, open-description question.
23.	**S:Tim: Near the orange tree, like under the ground.**	
24.	T: Near the orange tree, under the ground. So you had some soil, you had some water.	Teacher restate. Refocus.

Figure 4.8: Lesson 4 - the talk became more cumulative as the teacher elicited and explored the students' ideas

This excerpt (Figure 4.8) shows how Penny usually responded to the students ideas by restating or rephrasing what they had said and how she often probed their ideas by asking further questions which involved *teacher uptake*. In the transcript, this pattern of interaction is evident in the interactions with Sharon (turn 4), Michael (turns 14 and 16), Brian (turn 18) and Tim (turns 20, 22 and 24). Additionally, Penny supported the development of the discussion by periodically summarising and drawing the students' ideas together (*refocus*, turn 8). There were no instances of discourse moves that were coded as *wait time* or *extended thinking time* in this lesson.

By working the discussion in this way, Penny supported the students to make their ideas explicit and to say more. While there were a number of teacher-student exchanges comprising three-turn structures (T-S-T) in this lesson, the discussion

frequently resulted in interactions consisting of four turns (T-S →T-S) or six turns (T-S →T-S →T-S), and some that were even longer. In addition, as the discussion progressed, Penny was able to support the students to build on each others' ideas and to sustain longer chains of teacher-student interaction, thus developing more cumulative talk (Alexander, 2006).

Key Finding 4.35

As Penny elicited the students' ideas in Lesson 4, she often used *teacher restate* and *reframe* to repeat or rephrase them, and *teacher uptake* to explore their ideas. Periodically, she used *refocus* to summarise the students' ideas and this helped them to develop more cumulative talk. *Wait time* or *extended thinking time* were not used in this lesson.

Working the discourse in this way generated longer teacher-student interactions that consisted of four- or six-turn structures and there were some longer stretches of cumulative talk.

Communicative approach

The discussion in Lesson 4 was generated by a mixture of *open-ideas* questions and *open-description* questions, and also a number of *closed* questions. Even with such a range of questions, the communicative approach would be classified as Interactive-Dialogic (Mortimer & Scott, 2003) as Penny sought to find out the students' initial understandings and prior knowledge of seeds. This is an appropriate form of interaction for an Engage lesson when the teacher wishes to determine the students' existing ideas about a new topic. In this lesson, Penny asked *open-ideas* questions to elicit the students' ideas and she used the discourse moves *restate* and *reframe* to phrase them correctly and make them explicit. She also asked some *open-description* and *closed* questions and used the discourse move *teacher uptake* when she wanted to explore the students 'ideas.

Key Finding 4.36

In Lesson 4, an Engage lesson, Penny utilised an Interactive-Dialogic communicative approach as she supported the students to share their ideas.

Proportions of teacher and student talk

The proportions of teacher and student talk altered for the first time in Lesson 4. While Penny continued to manage the talk, the level of her contributions had slightly decreased (66%) and the level of student contributions had slightly increased to 34%.

Key Finding 4.37

In Lesson 4, the proportion of student talk increased slightly (34%) although Penny continued to utilise far more of the talk time (66%) in whole-class substantive discussion.

The students' role

In Lesson 4, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances as well as the complexity of their responses.

Elaborated utterances

In Lesson 4, there were four *elaborated utterances*. While this is a significant decrease compared to Lessons 2 and 3 the duration of the discussion should also be considered and, in Lesson 4, the discussion was shorter than in previous lessons. However, the students continued to generate cumulative talk (Alexander, 2006) by building on each other's ideas.

Quality of student talk

The students' responses in the discussion were predominantly coded for *description*. In total, 92% were coded as *description,* 52% as *unistructural* and 40% as multistructural; and the remaining 8% were coded as *explanation*.

> **Key Finding 4.38**
>
> There were four *elaborated utterances* in Lesson 4. 92% of the students' responses were coded as *description* (52% as *unistructural* and 40% as multistructural) and the remaining 8% were coded as *explanation*. The students continued to develop cumulative talk.

Lesson 4 summary

Lesson 4 was the first Engage lesson for the new topic, Studying Seeds, and Penny had developed a scenario to set the scene for the topic and to present a problem for the students to solve. The purpose of the discussion was to engage the students in the topic and to explore their prior knowledge. Consequently, Penny utilised an Interactive-Dialogic style of interaction, asking *open-ideas* questions and using discourse moves such as *teacher restate* and *reframe* to elicit the students' initial ideas. She also asked *open-description* and *closed* questions and used discourse moves such as *teacher uptake* to explore the students' ideas in more detail. This resulted in longer teacher-student interactions ranging from three- and four-turn structures to six-turn structures and longer. Penny would also use the discourse move *refocus* to draw the students' ideas together and to facilitate more cumulative talk (Alexander, 2006).

The amount of talk time the students used had slightly increased in this lesson and, while they gave fewer elaborated responses, they engaged in longer more cumulative interactions. The great majority of their responses were classified as descriptions.

Lesson 5, post Professional Learning Day 3

The lesson

Lesson 5 was videoed in November, two weeks after Lesson 4, and was the first lesson in the Explain phase of the investigation for the topic Studying Seeds. The aim of this lesson was to support the students to examine the findings from their experiments with seeds and for Penny to make sure that the scientific ideas and explanations were made explicit. The lesson comprised: a teacher-led review of the

students' experiments with seeds; small group discussions about the results of their experiments and the conditions that had affected the seeds growth; and a whole-class discussion where the groups shared their findings and the class developed some explanations for their results (Video footage, 12/11/2009).The data analysis for this lesson focused on the whole-class discussion following the small group work.

The setting

Penny began the lesson by reviewing the students' initial questions about seeds and what they had done in their groups to sort and sprout a variety of seeds. She led the students through a series of focus questions that were recorded on the IWB, which would guide the small group and whole-class discussions. Then, she asked the students to discuss their findings in their small groups and, subsequently, the whole class came together to share their results and develop explanations for their findings.

As in previous lessons, Penny and the students were seated at the front of the class adjacent to the IWB, with Penny seated on a chair and 15 students seated on the mat facing her (Video footage, 12/11/2009). Penny continued to nominate the speaker and the students raised their hands when they wished to speak (Video footage, 12/11/2009).

Key Finding 4.39

Penny used a series of focus questions in Lesson 5 to guide the discussion about how the students' seeds had sprouted and to help them develop explanations about their findings. The students sat on the floor facing Penny and they raised their hands when they wished to speak.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In this lesson, Penny asked *open-description* questions to find out how each group's seeds had sprouted, followed by *open-explanation~reason* questions to find out why. For example: Did all the different seeds sprout on the same day? (*open-description*); Why do you think this did (or didn't) happen? (*open-explanation~reason*); Which of your seeds sprouted first? (*open-description*) Why do you think they sprouted first? (*open-explanation~reason*). She also asked some *open-ideas* questions when she wanted to elicit the students' ideas about further investigations. Additionally, Penny often asked a *closed* question when she used the discourse moves *clarify*, *prompt and scaffold* or *teacher uptake*.

The analysis of this discussion showed that Penny asked a total of 48 initiating questions. Of these questions, 21 (44%) were classified as *closed*; 15 (31%) were classified as *open-explanation~reason*; nine (19%) were classified as *open-ideas* questions; and three (6%) were *open-description* questions.

Key Finding 4.40

Penny asked a total of 48 initiating questions in the whole-class discussion in Lesson 5, of these approximately 40% were *closed* questions and 30% were *open-explanation~reason* questions and a further 20% were *open-ideas* questions.

Teacher discourse moves

In Lesson 5, Penny wanted the students to describe how their seeds had sprouted and to develop scientific explanations about why some had sprouted and some had not (PL 5 interview, 4/12/2009). An excerpt of the discussion in this lesson (Figure 4.9) shows how she persistently adapted her questioning and use of discourse moves to guide the students to articulate explanations and scientific reasons for the ways in which their seeds sprouted.

Turn	Utterances	Coding
1.	T: OK, Michelle, your group. Did all your different groups of seed sprout on the same day?	Initiating question, closed question.
2.	**S:Mich: No, the wheat sprouted first and then the**	Multistructural

	others just sprouted all like together or something.	description.
3.	T: So about the same time? What day did the wheat sprout? [WT1] Where is it on your sheet? What day did your wheat sprout?	Clarify, closed question. Open-description question. Wait time 1.
4.	**S:Mich: I think it sprouted like yesterday and the others sprouted today.**	Multistructural description.
5.	T: OK, so your wheat really sprouted, you reckon, Day 6.	Reframes.
6.	**S:Mich: Yep.**	
7.	T: You had wheat sprouting first, what day did your wheat sprout?	Open-description question.
8.	**S: About Day 4.**	Unistructural description
9.	T: Day 4, a bit before. So why do you think your wheat took a little bit longer than this groups maybe?	Restate. Open-explanation~reason question.
10.	**S:Mich: Maybe we didn't water it enough or as much and it wasn't as close to the window.**	Explanation.
11.	T: OK. So why would it have to be closer to the window to make a difference?	Teacher uptake, open-explanation~reason question.
12.	**S:Mich: To get more sunlight.**	Reasoning.
13.	T: To get more sunlight. Anything else you want to share about why you think that might have happened and why the other seeds haven't sprouted or took so long to sprout? Jason?	Teacher restate. Elaborate. Open-explanation~reason question.
14.	**S:Jas: I think all the seeds sprouted at different times because of the heat.**	Reasoning.
15.	T: Because of the heat. The heat within the classroom? So why do you think the heat would have made a difference to the seeds?	Teacher restate. Clarify. Open-explanation~reason question.
16.	**S:Jas: Because you need heat for things to grow.**	Reasoning.
17.	T: You need heat for things to grow, well done. Walt?	Teacher restate. Evaluate. Asks another student for his/her ideas.
18.	**S:Wal: Well you… maybe its um.. temperature you know how it's cold and some seeds may need heat to grow.**	Reasoning.
19.	T: Definitely. So they need the heat and a certain temperature.	Evaluate. Reframes.

20.	**S:1: Others need hot and warm.**	Reasoning.
21	T: So different types of seeds need different conditions so different temperatures, some like a warm temperature, some would like it a little bit cooler. So I think we had a discussion, was it last time we discussed or when we talked about apples, when we talked about growing apples and we said they needed like a cooler temperature to grow those seeds, didn't they? So we'd see if we put an apple seed we'd have the same joy. So maybe our classroom has been quite warm, the conditions have been right do you think for these seeds? Christine?	Refocus. Prompt and scaffold. Asks another student for his/her ideas.
22.	**S:Chr: With the millet seed I reckon that they're kind of a cold kinda thing because they haven't grown that much.**	Reasoning.
23.	T: OK, so you think the millet has taken a time to sprout because it prefers the cold.	Reframe.

Figure 4.9: Lesson 5 - the teacher probed the students' ideas to elicit explanations and scientific reasons.

In this excerpt (Figure 4.9), Penny asked Michelle (S:Mich) about the seeds her group had planted (turn 1) and she established that their wheat seeds had sprouted first on Day 6 (*open-description question*, *wait time 1*, turn 3; *reframe*, turn 5). Penny compared these results with those of another group (turn 7) whose wheat seeds had sprouted on Day 4 and she asked Michelle why her group's wheat took longer to sprout (*open-explanation~reason question*, turn 9). Michelle thought that perhaps her group had not watered their wheat seeds enough and that they were not as close to the window. Penny picked up on her idea and asked why she thought putting the seeds closer to the window would make a difference (*teacher uptake, open-explanation~reason question*, turn 11). Michelle explained that it would give the seeds more sunlight (turn 12). Penny continued to ask further *open-explanation~reason* questions (*restate*, *elaborate*, *open-explanation~reason question*, turn 13; and *teacher restate*, *clarify*, *open-explanation~reason question*, turn 15) and she elicited additional explanations and reasons (Jason, S: Jos, turns 14 and 16) about the importance of heat in the germination process. Subsequently, Penny summarised the students' explanations (*refocus, prompt and scaffold*, turn 21) and the focus of the conversation turned to the conditions needed for the millet seeds to grow (Christine, S:Chr, turn 22).

In this lesson, Penny developed the interaction by asking *open-description* questions and then a succession of *open-explanation~reason* questions to elicit the students' explanations and reasons. Additionally, she used many of the teacher discourse moves

seen in previous lessons to support the students to articulate their ideas (*clarify, wait time, reframe, teacher restate, elaborate)* and to reinforce particular ideas *(teacher uptake, teacher restate, evaluate, refocus, prompt and scaffold, reframe*). In this lesson, Penny used *wait time* three times and she used *extended thinking time* twice. The teacher-student exchanges in this discussion were similar to previous lessons in that they comprised of a number of three-turn structures, but more four- and six-turn structures as well as some that were longer. In addition, the talk continued to be cumulative.

Key Finding 4.41

In Lesson 5, Penny asked *open-description* questions and then a succession of *open-explanation~reason* questions to elicit the students' explanations and reasons. She supported the students to articulate their ideas by using *clarify, wait time, reframe, teacher restate, elaborate* and she reinforced particular ideas by using *teacher uptake, teacher restate, evaluate, refocus, prompt and scaffold, reframe*. Penny used both *wait time* and *extended thinking time* in this lesson.

The teacher-student interactions comprised some three-turn structures, but more four- and six-turn structures and some that were longer. The talk continued to be cumulative.

Communicative approach

Penny utilised an Interactive-Dialogic style of interaction in those parts of the discussion where she wanted to elicit the students' observations about their seeds and to consider the focus of further investigations and how they might be carried out. To achieve this she asked a mixture of *open-ideas* and *open-description* and some *open-explanation~reason* questions and she used teacher discourse moves such as *clarify, wait time, reframe, teacher restate, elaborate*. Penny's approach became more Interactive-Authoritative when she wanted to reinforce particular ideas or to have the students explain why some of their seeds had sprouted,. When this occurred, she asked more *open-explanation~reason* questions and she used teacher discourse moves such as *teacher uptake, teacher restate, evaluate, refocus, prompt and scaffold, reframe*.

> **Key Finding 4.42**
>
> The communicative approach Penny used in Lesson 5 seemed to move from being Interactive-Dialogic, when she reviewed the students' observations or asked them to consider future investigations, to being more Interactive-Authoritative, when she led them to develop explanations and reasons.

Proportions of teacher and student talk

In Lesson 5, the proportions of teacher and student talk reverted to the ratios seen in earlier lessons where Penny utilised a large percentage of the talk time (74%) and the level of the student contributions was reduced (26%).

> **Key Finding 4.43**
>
> In Lesson 5, Penny utilised 74% of the talk time and the students utilised 26% in whole-class substantive discussion.

The students' role

In Lesson 5, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances as well as the complexity of their responses.

Elaborated utterances

In Lesson 5, there were 11 *elaborated utterances* and the students continued to generate cumulative talk (Alexander, 2006) by building on each others' ideas.

Quality of student talk

The students' responses to whole-class discussion were mostly coded for *explanation*. In total, 51% were coded as *explanation*; 33 % as *description* (21% as *multistructural* and 13% as *unistructural*); and 15% were coded as *reasoning*. Compared to the previous Explain lesson in Lesson 3, these results show a decrease in the percentage

of student responses that were coded as *unistructural descriptions* and an increase in the percentage of student responses coded as *multistructural descriptions* and *explanations.*

Key Finding 4.44

There were 11 *elaborated utterances* in Lesson 5. Fifty-one per cent of the students' responses were coded for *explanation,* 33 % as *description* (21% as *multistructural* and 13% as *unistructural*) and 15% *reasoning*. There has been an increase in the percentage of student responses coded as *multistructural descriptions* and *explanations* since the last Explain lesson (Lesson 3). In Lesson 5, the students continued to generate cumulative talk.

Lesson 5 summary

Lesson 5 was the first lesson in the Explain phase of the investigation for the topic Studying Seeds and Penny wanted to review the students' findings and to develop their explanations. In this lesson, it was necessary for Penny to adjust her communicative approach from being Interactive-Dialogic to being more Interactive-Authoritative in order to develop the scientific explanation. Consequently, when she wanted to elicit the students' observations and to consider further investigations, she utilised an Interactive-Dialogic style where she asked a mixture of *open-ideas* and *open-description* questions and used discourse moves such as *clarify, wait time, reframe, teacher restate,* and *elaborate*. When she wanted to reinforce particular ideas or to elicit the students' explanations and reasons, Penny's approach became more Interactive-Authoritative and she asked more *open-explanation~reason* questions and used discourse moves such as *teacher uptake, teacher restate, evaluate, refocus, prompt and scaffold,* and *reframe*. This tended to generate teacher-student exchanges comprising a number of three-turn structures, but more four- and six-turn structures and a few that were longer.

Although Penny continued to utilise most of the talk time in this lesson, the students still gave elaborated responses and were able to generate cumulative talk (Alexander, 2006). Their responses were predominantly comprised of explanations and descriptions, as well as some reasoning.

Post intervention: Penny's beliefs, knowledge and practice

On the final professional learning day in November 2009, the teachers participating in the professional learning intervention were asked to complete a questionnaire that captured data to do with: teacher beliefs about teaching science; teacher confidence with teaching science; teacher knowledge about managing classroom discourse; teacher knowledge about questioning; and teacher knowledge about using puppets.

Beliefs about teaching science

The data collected from the final teacher questionnaire and the final teacher interview provided evidence of Penny's beliefs about the teaching of science. She identified questioning skills and class discussions, and the development of a classroom culture that supports this as important characteristics of effective science teaching practice (Final teacher questionnaire, 16/11/09). She also considered planning lessons and units of work with purposeful outcomes to be an important characteristic of effective science teaching practice (Final teacher questionnaire, 16/11/09).

Penny believed that utilising a 5Es inquiry learning model (Hackling et al., 2007) and eliciting the students' prior knowledge in order to develop student centred investigations were two important characteristics of inquiry-based science teaching and learning (Final teacher questionnaire, 16/11/09). She also believed that giving the students hands-on experiences of phenomena was an equally important aspect of inquiry-based science teaching and learning (Final teacher questionnaire, 16/11/09).

Key Finding 4.45

Following the professional learning intervention, Penny believed questioning skills, class discussions, the development of a supportive classroom culture and planning lessons and units of work with purposeful outcomes were important characteristics of effective science teaching practice.

Penny believed that utilising a 5Es inquiry learning model, eliciting the students' prior knowledge in order to develop student centred investigations and giving the students hands-on experiences of phenomena were important characteristics of inquiry-based science teaching and learning.

Confidence with teaching science

The data collected from the final teacher questionnaire showed that Penny felt an increased confidence for 'Developing literacy skills needed for learning science' and for 'Assessing children's learning in science' (both initially rated as 'Confident' and subsequently as 'Very confident') (Final teacher questionnaire, 16/11/09). She continued to rate herself as 'Very Confident' for 'Engaging students' interest in science', and she remained 'Confident' with regard to 'Managing discussions and interpretation of science activities' and 'Explaining science concepts' (Final teacher questionnaire, 16/11/09).

The final mean scale score for confidence with science teaching strategies for all of the teachers involved in the professional learning intervention was 4.21/5, which is greater than the mean confidence scale score of 3.88 for a group of *Primary Connections* trial teachers who had participated in five days of professional learning and taught some *Primary Connections* units (Hackling & Prain, 2005). In comparison, Penny's final mean scale score for confidence with science teaching strategies was 4.6/5, which was greater than the mean scale scores for either of these groups of teachers.

Key Finding 4.46

At the end of the PL intervention, Penny remained a confident teacher of primary science, particularly for engaging students' interest and developing the literacy skills needed for learning science. She also felt confident in managing discussions and explaining science concepts. Her final mean scale score for confidence with teaching science was 4.6/5.

Beliefs about being an effective manager of classroom talk

The data from the final teacher questionnaire showed that Penny continued to believe she was an effective manager of classroom talk. She retained her level of self-efficacy for five aspects of managing classroom discussions, including: asking questions to suit the purpose of discussions; responding to students in ways that support the effective discussion of science ideas; having a rich knowledge of science which helps in responding to students; responding to students in ways that maintain and promote

discussion of science ideas; and being able to sustain discussions in order to thoroughly discuss science ideas (Final teacher questionnaire, 16/11/09).

However, Penny also reported a slightly lower level of self-efficacy for the remaining seven aspects of managing classroom discussions (Final teacher questionnaire, 16/11/09). This included: establishing an appropriate classroom climate (initially rated 5/5 and subsequently 4/5); drawing on knowledge of science to ask the right questions (initially rated 4/5 and subsequently 3/5); using wait time (initially rated 5/5 and subsequently 3/5); encouraging and supporting students to ask questions (initially rated 5/5 and subsequently 4/5); being effective in engaging most students in responding to questions (initially rated 5/5 and subsequently 4/5); and being effective in using questioning to identify students' prior knowledge and understandings (initially rated 5/5 and subsequently 4/5) (Final teacher questionnaire, 16/11/09).

The final mean scale score for being an effective manager of classroom talk for all of the teachers involved in the professional learning intervention was 4.09/5. In comparison, Penny's final mean scale score was 3.83/5, which is less than the mean scale scores for the group of teachers involved in the professional learning intervention.

Key Finding 4.47

Following the PL intervention, Penny continued to believe that she was an effective manager of classroom talk and she retained her level of self-efficacy for five aspects of managing classroom discussions. However, she indicated a slightly lower level of self-efficacy for the seven remaining aspects of managing classroom discussions. Her final mean scale score for being an effective manager of classroom talk was 3.83/5 which was lower than the mean scale scores for the group of teachers involved in the professional learning intervention.

Knowledge about managing classroom discourse

The data collected from the final teacher questionnaire also provided evidence of Penny's understandings about how to manage classroom discourse in order to facilitate students' learning in primary science lessons. She thought that students' learning was facilitated by questioning and classroom discussions as it was possible to

identify their level of understanding and, subsequently, to address their misconceptions (Final teacher questionnaire, 16/11/09).

Penny thought that good classroom discussion was the product of a supportive classroom environment where all ideas were accepted and the teacher facilitated the discussion and supported the students to build on each other's ideas (Final teacher questionnaire, 16/11/09).

Penny stated that at different phases of a topic she would vary her questioning and discussion style. During the Engage phase, she asked open questions and accepted all the students' ideas without evaluation, whilst in the Explain phase she asked more closed questions, clarified the students' ideas and summarised their understandings (Final teacher questionnaire, 16/11/09).

Key Finding 4.48

Following the PL intervention, Penny thought the level of students' understanding could be ascertained via discussion and their misconceptions subsequently addressed.

She thought that good classroom discussion was the product of a supportive classroom environment, where all ideas were accepted and the teacher facilitated the discussion and supported the students to build on each other's ideas.

Penny varied her questioning and discussion style by asking open questions and accepting all ideas without evaluation during the Engage phase and asking more closed questions, clarifying and summarising the students' understandings in the Explain phase.

Knowledge about using puppets

In the final teacher questionnaire, Penny stated that she had used the puppets in the Engage phase of inquiry to set the scene for a new topic, but that she did not use them in the Explain phase (Final teacher questionnaire, 16/11/09). Penny explained that she had stopped using the puppets as she felt that they did not add to the classroom discourse and she was worried that the personas she had created would reinforce gender stereotyping in her class (Final teacher questionnaire, 16/11/09).

Penny reported that she found it difficult to manipulate two puppets and manage three personalities (herself as the teacher as well as the two puppets) and she found it awkward to sustain classroom discussion when she used the puppets (Final teacher questionnaire, 16/11/09). Nevertheless, she indicated that her level of confidence for using puppets in her science teaching was okay (rated 3 on a scale of 5 indicators) (Final teacher questionnaire, 16/11/09).

When considering the impact the puppets had on student engagement and talk, Penny stated that "the students were engaged but not in the discussion, more in humouring me to support me" (Final teacher questionnaire, 16/11/09).

Key Finding 4.49

Penny had only used the puppets in the Engage phase of inquiry to set the scene for a new topic. She had stopped using the puppets as she felt that they did not add to the classroom discourse and she was worried that the personas she had created would reinforce gender stereotyping.

Penny found it difficult to manipulate two puppets and manage three personalities and she found it awkward to sustain classroom discussion. However, she indicated that her level of confidence for using puppets in her science teaching was okay.

When considering the impact the puppets had on student engagement and talk, Penny thought the students humoured her and were not really very engaged in the discussion.

Participation in the professional learning intervention

Penny had chosen to be involved in the professional learning intervention because *s*he saw it *as* an opportunity to strengthen her questioning skills and to develop a greater level of student involvement in class discussions (Initial teacher questionnaire, 02/06/09). She had previously attended a conference where she had seen puppets being used in science and she wanted to see how they would work in her classroom (PL 3 interview, 19/10/09).

> So there was sort of a bit of 'Oooh, would that work?' kind of situation. But then when I came along on the PD [professional learning intervention] I realized it wasn't just about the novelty of the puppets, but it's the whole thing, it's about the discourse and the questioning. So it's making me reflect on how important the questioning is in a lesson. It's the questions that we ask that give us the responses that

we require. … I think we just rush through things too quickly sometimes. But it just shows you, when you spend time on a concept to bring most of them [the students] along with you is really important. (PL 3 interview, 19/10/09)

Penny felt that her participation in the professional learning intervention had made her realise that it was important to consider the student outcomes she wished to achieve when pre-planning a discussion (Final teacher questionnaire, 16/11/09). She felt her involvement in the intervention had impacted on the quality of classroom talk because she had come to understand how discussion could be used as a tool to elicit the students' prior knowledge and to build their understandings and she thought more carefully about the types of questions she asked. In addition, she had come to realise how important it was to encourage the students to explain their thinking (Final teacher questionnaire, 16/11/09).

When considering what she might focus on next, Penny thought that she would like to develop the students' capacity to interact productively in small group contexts and she was very interested in using ICT to engage students in group discussions (Final teacher questionnaire, 16/11/09). She thought that she would be happy to experiment with establishing ground rules for talk and using puppets in science with her class in the new school year (PL 3 interview, questionnaire, 19/10/09).

> **Key Finding 4.50**
>
> Penny became involved in the professional learning intervention because she was intrigued by the use of puppets in science and she wished to develop her questioning skills and increase the level of student involvement in class discussions. When she attended the PL days she realised that using the puppets also required some understanding of how to use discourse and questioning in discussion.
>
> As a consequence of participating in the intervention, Penny felt she better understood the importance of pre-planning discussions. She thought the quality of her class discussions had increased because she understood how to elicit students' prior knowledge and develop their understandings, and she thought carefully about the types of questions she asked. She had also realised how important it was to encourage the students to explain their thinking.
>
> Penny was going to work on establishing ground rules for talk and using puppets in science in the new school year.

Summary

This chapter has explored Penny's involvement in the professional learning program and the impact this has had on the way that she used puppets and managed discussions in science. Key findings have highlighted the contextual factors, beliefs and understandings that may influence her teaching and also how she managed class discussions in practice.

Teacher beliefs and knowledge

Beliefs about teaching science

Over the course of the professional learning intervention, Penny maintained a number of her beliefs about effective science teaching. She believed that a hands-on, inquiry approach to teaching science was an effective way to increase students' conceptual understandings (KF 4.4; KF 4.45) and that eliciting the students' initial understandings was an important step in developing investigations that were student-centred (KF 4.4; KF 4.45). She also believed that a safe and supportive classroom environment encouraged students to share their ideas (KF 4.4; KF 4.45). Towards the end of the professional learning intervention, Penny also believed that the teacher's questioning skills and opportunities for class discussions were important characteristics of effective science teaching (KF 4.45).

Assertion 4.1

As Penny participated in the professional learning intervention, she strengthened her beliefs that a teacher's questioning skills and opportunities for class discussions were important aspects of effective science teaching.

Confidence to teach science

Penny initially rated herself as a confident teacher of primary science (KF 4.5) and her level of confidence increased at the end of the professional learning intervention, particularly for developing literacy skills needed for science and for assessing children's learning in science (KF 4.46). She also retained her level of confidence with managing discussions and explaining science concepts (KF 4.46).

Beliefs about being an effective manager of classroom talk

Penny initially believed that she was an effective manager of classroom talk (KF 4.6) and she retained her self-efficacy for five aspects of managing classroom discussions including: asking questions to suit the purpose of discussions; responding to students in ways that support the effective discussion of science ideas; having a rich knowledge of science helps in responding to students; responding to students in ways that maintain and promote discussion of science ideas; and being able to sustain discussions in order to thoroughly discuss science ideas (Final teacher questionnaire, 16/11/09) (KF 4.47). However, later in the intervention she reported a slightly lower level of self-efficacy for the remaining seven aspects of managing classroom discussions (KF 4.47), including: establishing an appropriate classroom climate; drawing on knowledge of science to ask the right questions; using wait time; encouraging and supporting students to ask questions; being effective in engaging most students in responding to questions; and being effective in using questioning to identify students' prior knowledge and understandings.

Assertion 4.3

While Penny retained her belief that she was an effective manager of many aspects of classroom talk, she adjusted her perceptions of her practice and her self-efficacy beliefs for teacher questioning and for some aspects of managing discourse declined as she came to appreciate the complexities of managing whole-class substantive discussions.

Knowledge about managing the classroom culture

At the start of the professional learning intervention, Penny thought that it was necessary to create a safe and supportive environment for classroom discussion so that the students felt comfortable to share their thinking and to challenge each other's ideas without the fear of being told they were wrong (KF 4.7). She thought that it was

important for all the students to know that their ideas were worthy and that less confident students could be supported to share their ideas by participating in small group discussions (KF 4.7). Mid-way through the intervention, Penny indicated that she was most successful in creating a classroom culture to do with talk that was *collective* (90%) and *reciprocal* (80%), but that she had been less successful at developing classroom talk that was *cumulative* (70%), *purposeful* (70%) or *supportive* (60%) (KF 4.31). While, Penny might have perceived that she had less success with developing the *cumulative, purposeful* and *supportive* aspects of her class discussions at that point in the intervention, the data shows that the students talk was *cumulative* (KF 4.23; KF 4.30; KF 4.38; KF 4.44) and that she consistently utilised an Interactive-Dialogic approach which enabled the students to share their ideas (KF 4.14; KF 4.21; KF 4.28; KF5.36; KF 4.42). In addition, the data shows that in the Explain lessons (Lessons 3 and 5) the discussions were *purposeful* as Penny utilised a set of planned focus questions to drive the discussion (KF 4.24; KF 4.39) and in the Engage lesson (Lesson 4) she had planned a scenario to set the scene for the new topic and to present a problem for the students to solve (KF 4.33).

Penny also reported that she had focused on developing the students' use of speaking and listening conventions (KF 4.31) and she thought she had been most successful in creating a classroom culture in which students spoke one at a time (90%), respected each others' opinions (90%), and shared and listened to each others' ideas (80%) (KF 4.31). However, at that point in the intervention, she had been less successful at getting the students to give reasons to explain their ideas (60%) or to resolve their disagreements (50%) (KF 4.31).

Assertion 4.4

Penny developed an increased understanding of the collective and reciprocal aspects of class discussions but at the mid-point of the intervention, she had yet to recognise the cumulative, purposeful and supportive aspects which were beginning to be evident in her practice. Her students had developed their use of speaking and listening conventions that supported productive discussions.

Knowledge about managing classroom discourse

At the start of the professional learning intervention, Penny thought that teachers needed to know how to use questioning to engage students in discussion, to ascertain their initial understandings in the beginning phases of inquiry and to find out what students had learned in the later phases (KF 4.7). Mid-way through the intervention, she noted that she had asked an increased number of open questions, which she thought had improved the students' confidence to express their developing ideas (KF 4.31) and she thought that she had used *wait time* and *extended thinking* time successfully (KF 4.31). Later in the intervention, Penny reiterated her perception that the level of students' understanding could be ascertained via discussion and their misconceptions subsequently addressed (KF 4.48). She also thought that she had varied her questioning and discussion style at different phases of the investigation by asking open questions and accepting all ideas without evaluation during the Engage phase and asking closed questions, clarifying and summarising the students' understandings in the Explain phase (KF 4.48).

Assertion 4.5

By differentiating the use of teacher questioning and discourse moves at different phases of inquiry, Penny demonstrated a clearer understanding of how to use discussion as a pedagogical tool.

Knowledge about using puppets

At the start of the professional learning intervention, Penny had limited experience of using puppets in her teaching (KF 4.8). The PL days offered via the intervention provided opportunities for the participating teachers to plan the implementation of science topics using puppets. Subsequently, Penny used a puppet in Lesson 2 in the Engage phase of the investigation to set the scene for a new topic and to elicit the students' ideas (KF 4.32; KF 4.49). However, she did not use the puppets in any lessons after that (KF 4.32).

While she had initially found most of the students were engaged by the puppets and the weaker students were motivated to talk to them, there were also some students

who were not won over by them (KF 4.32). Later in the intervention, when she had reflected on the impact the puppets had on student engagement and talk, Penny thought the students had humoured her and were not really very engaged in the discussion (KF 4.49). She also reported that she had stopped using the puppets as she felt that they did not add to the classroom discourse and she was worried that the personas she had created would reinforce gender stereotyping (KF 4.49).

Additionally, Penny had found it difficult to manipulate two puppets at once, to stay in character, and to adjust her voice as she took on each role (KF 4.32; KF 4.49). She also found it awkward to sustain classroom discussion when she used the puppet (KF 4.20; KF 4.49) and she felt self-conscious when she was being filmed (KF 4.20). In spite of this, Penny indicated that her level of confidence for using puppets in her science teaching was okay (KF 4.49).

Assertion 4.6

Penny's attempt to use a puppet in her science lessons was moderately successful and she developed an understanding about the importance of developing the puppet's persona. Ultimately, she stopped using the puppet because she found it difficult to convince all of her upper primary students to buy into the interaction. While Penny identified several challenges with using puppets and she did not develop her capacity to use puppets in this professional learning intervention, she remained confident with using puppets in her science teaching.

Teacher practice

Communicative approach, teacher questioning, and teacher discourse moves

Over the course of the PL intervention, Penny demonstrated an increased capacity to use teacher questioning and discourse moves to explore the students' ideas in Engage lessons. In the first Engage lesson at the start of the PL intervention, Penny's interaction with the students tended to alternate between substantive talk as she elicited their ideas and procedural talk as they wrote their ideas on the IWB (KF 4.11). Additionally, she mostly used a limited range of teacher discourse moves (*teacher restate* and/or *evaluate*), which resulted in short teacher-student exchanges (T-S-T) and sometimes she also used *elaborate* or *clarify*, which extended the teacher-student

interaction slightly (T-S → T-S) (KF 4.11). As the PL intervention progressed, Penny began to use a range of discourse moves to support the students to express their ideas clearly and to use appropriate terminology (KF 4.19). She often repeated and/or clarified a student's idea (*teacher restate, clarify*) so that the class could hear it again, and she often praised the idea (*evaluate*) before she moved on to ask for other ideas (KF 4.19). Penny would also work on or explore a student's idea by asking further questions and using discourse moves to help them to articulate or develop their idea (*teacher uptake*, *wait time, extended thinking time, prompt and scaffold*, and *reframe*) (KF 4.19; KF 4.35). Periodically, she used *refocus* to summarise the students' ideas and this helped them to develop more cumulative talk (Alexander, 2006) (KF 4.35). Utilising discourse moves in this way generated teacher-student interactions that ranged from three-turn structures (T-S-T) to progressively longer interactions involving eight (T-S →T-S →T-S →T-S) and 12 turns (T-S →T-S →T-S →T-S →T-S →T-S) (KF 4.19; KF 4.35).

As the PL intervention proceeded, Penny also demonstrated a deeper understanding of how to adjust her communicative approach during classroom discussions. She used an Interactive-Dialogic style in Explain lessons when she helped the students to review their observations and to articulate their ideas for future investigations. Then she shifted her approach to a more Interactive-Authoritative style as she led the students to develop explanations and reasons for their results (KF 4.28; KF 4.42). Penny became increasingly adept at using teacher questioning and discourse moves to help the students interpret her focus questions and develop explanations and reasoning. She would guide the students to answer an *open-explanation~reason* question by asking *open-description* and *closed* questions to help them interpret the question and using discourse moves (*prompt and scaffold, extended thinking time, wait time,* and *refocus*) to shape their response (KF 4.26; KF 4.27). Penny supported the students to articulate their ideas (*clarify*, *prompt and scaffold*, *wait time* and *teacher uptake*) (KF 4.26; KF 4.41) and she reinforced particular ideas and made key ideas explicit (*teacher uptake, teacher restate, evaluate, refocus, prompt and scaffold, reframe*) (KF 4.26; KF 4.41). Additionally, she frequently gave the students some time to think in Explain lessons (*wait time* and *extended thinking time*) (KF KF 4.27; KF 4.41). By consistently working the discourse in this way, the teacher-student interactions increased from three-turn structures (T-S-T) to more four- (T-S →T-S) and six-turn structures (T-S →T-S →T-S)

and some that were longer (KF 4.26; KF 4.27; KF 4.42). In addition, the talk became progressively cumulative (KF 4.23; KF 4.30; KF 4.38; KF 4.42; KF 4.48).

Students

At the beginning of the professional learning intervention, the students' responses were typically quite short (KF 4.16) but over time they progressively developed more elaborated responses and generated more cumulative talk (Alexander, 2006) (KF 4.23; KF 4.30; KF 4.38: KF 4.44). Additionally, the quality of their responses in Explain lessons increased over the course of the intervention as they provided more complex descriptions and explanations (KF 4.30; KF 4.44).

Assertion 4.7

Penny demonstrated an increased capacity to manage class discussions and to use talk for thinking more deeply about science. She aligned her communicative approach and use of teacher questioning and discourse moves not only with the purposes of the Engage and Explain lessons, but also with the specific learning needs of the students she taught. Ultimately, this change in her practiced supported the students to develop more cumulative talk.

Conclusion

As a consequence of participating in the professional learning intervention, Penny developed her beliefs, knowledge and practice for managing discussions and she increased the quantity and quality of her students' contributions to class discussions in science. This is a significant outcome given the sometimes challenging context in which she worked. Additionally, while Penny did not seem to make as much progress with using puppets with this particular class, she remains open to resuming this focus at another time. It should be acknowledged that contextual factors such as Penny's background in science, her confidence and experience as a primary science teacher and the school context in which she worked may well have contributed to these outcomes.

CHAPTER 5: BEN'S LEARNING JOURNEY

Introduction

This chapter explores Ben's involvement in the professional learning program and the impact this has had on his science teaching. The first section considers the contextual factors that have influenced Ben's development as a teacher and that currently impact on his teaching practice. The second section outlines his beliefs and understandings about the teaching of science and the management of classroom discourse. Finally, the third section examines how Ben managed whole-class discussions in science over the course of the year.

Introducing Ben

This section provides an overview of Ben's professional and educational background, his teaching role and the school environment in which he worked, and the class that he taught during the course of this study.

Professional and educational experiences

Ben teaches a Kindergarten/Pre-Primary class at Wildlake Community School (WCS) in the Perth metropolitan area of Western Australia. He undertook a three-year internship at WCS whilst completing his teaching degree and he took up his first substantive teaching role as the Kindergarten/Pre-Primary teacher at the school in 2009 (Final teacher interview, 3/2/2010). While most of his teaching experience has been at WCS, Ben also completed long term practicums in public and Catholic schools when he was at university. At WCS he has taught in Pre-Primary and Year 5/6, and he has taken on the Science Co-ordinator role (Email, 11/8/2010).

Ben completed his primary and secondary schooling in Perth (Final teacher interview, 3/2/2010). He loved science, particularly in primary school and he recalls his teacher used the *Primary Investigations* teaching resource in Year 5. "We did a fantastic series of lessons investigating our outdoor environment, looking at ecosystems, bugs and

things and I loved every minute of it. It was hands-on, real life, and even had me wanting to do homework" (Email, 11/8/2010). While he enjoyed the exploratory and investigative aspects that his primary experiences of science offered, Ben found that he became less interested when science became more formal in secondary school (Final teacher interview, 3/2/2010). "I guess when it started to become a bit more about formulas and things like that my brain kind of turned off" (Final teacher interview, 3/2/2010). Nevertheless, Ben studied Human Biology and Biology at secondary school and he attained Tertiary Entrance Exam (TEE, the Western Australian academic examination for secondary students) in Human Biology and went on to gain a Bachelor of Education (Primary) from Murdoch University, Western Australia (Final teacher interview, 3/2/2010).

Ben was familiar with the *Primary Connections* (AAS, 2005) curriculum resources but he had not used the 5Es model of inquiry and had only extracted elements of lessons and investigations from the program to incorporate into the student-directed projects he has completed with his class (Email, 11/8/2010). However, he has not implemented any topics in their entirety or attended *Primary Connections* teacher professional development (Email, 11/8/2010).

Key Finding 5.1

Ben attained a Bachelor of Education (Primary) and in 2009 he took up his first substantive teaching position. He had completed a three year internship at WCS prior to taking up this role. At WCS he has taught PP and Year 5/6. Ben is also the Science Co-ordinator for WCS.

Ben had limited experience using the *Primary Connections* resources and had not used the 5Es inquiry model. He had not attended any teacher professional development regarding the implementation of the program.

Wildlake Community School

WCS is a non-government school linked to the Association of Independent Schools WA (AISWA). The school is situated close to Wild Lake, an inner city lake just outside the Perth central business district. In 2009, the school catered for students from Kindergarten to Year 6, Year 9 and Year 10, and there were 140 students (52 females,

88 males) enrolled at the school. The data collected for the Index of Community Socio-Educational Advantage (ICSEA, a national indicator of disadvantage) shows that WCS has an ICSEA value of 1155 and the data also shows that none of the student population at the school is Indigenous (ACARA, 2010). Given that the average ICSEA value is 1000, with most schools having an ISCEA value between 900 and 1000 (ACARA, 2010), WCS has a higher than average socio-economic status.

WCS is an independent co-educational school and the school population is drawn mainly from nearby inner city suburbs (WCS website, 24/8/2011). The school is guided by a social constructivist view of learning and is inspired by the Reggio Emilia approach to teaching. It takes the view that children are contributors to their own learning and the curriculum can be constructed to suit the individual needs of a child as well as to meet governmental standards (WCS website, 24/8/2011).

> The philosophy of WCS holds at its core the right of the child to participate in a learning environment, which promotes mutual respect, shared learning, reflectivity, creativity, imagination and problem solving and participation in the life of the community. (WCS website, 24/8/2011).

At WCS each class is taught by a qualified teacher and a teaching intern. The school promotes a flexible approach to teaching so that the learning needs of individuals as well as groups of students are catered for (WCS website, 24/8/2011). Classes are constructed as multi-aged community classes and learning via collaboration and social interaction is fostered (WCS website, 24/8/2011). WCS promotes a broad curriculum, which integrates the eight mandated learning areas (the Arts, English, Health and Physical Education, Languages other than English, Mathematics, Science, Society and Environment, and Technology and Enterprise), and a developmental approach to learning (WCS website, 24/8/2011). Class teachers are given specialist teacher support in the areas of literacy, language, music, and by Bluearth accredited teachers who help to deliver the school's physical education program (WCS website, 24/8/2011). The school emphasises nature-based and place-based learning in the curriculum as well as in the natural environment, and has developed sites for learning, including: spaces for cubby building, kitchen gardens, a mud pit, a fire pit and water courses (WCS website, 24/8/2011).

The school takes a school community approach to behaviour management, providing clear protocols with regard to establishing a safe environment and maximising the learning opportunities for students. An emphasis is given to supporting students to develop appropriate behaviours and strategies for self-management and conflict resolution. The Mutual Respect Policy document and the Guidelines for Harassment and Bullying Behaviour outline expectations for acceptable behaviour, which apply to the whole school community (WCS website, 24/8/2011).

With its emphasis on collaboration rather than competition, WCS does not implement classroom testing for the purposes of ranking students, preferring to monitor student progress via teacher observation and by gathering evidence and artefacts that result from authentic tasks (WCS website, 24/8/2011). However, the school does participate in the compulsory National Assessment Program - Literacy and Numeracy (NAPLAN) for students in Years 3, 5, 7 and 9 and uses the EasyMark Diagnostic Tests for students in Years 4, 6 and 8 for diagnostic purposes (WCS website, 24/8/2011). The NAPLAN scores for 2009 showed that when compared to schools serving students from statistically similar backgrounds, WCS students in Year 3 were close to the average for Reading and for Grammar and Punctuation; below the average for Writing and for Numeracy; and substantially below the average for Spelling (ACARA, 2011). Similarly, when compared to the national average, WCS students in Year 3 were substantially above the average for Reading; above the average for Grammar and Punctuation and for Numeracy; close to the average for Writing; and below the average for Spelling (ACARA, 2011). It should be noted that at WCS less than 10 students per year group participate in the NAPLAN assessments, which may impact the statistical validity of the results.

Key Finding 5.2

WCS is a non-government, independent school that is situated near the central business district of Perth. The school is guided by a social constructivist view of learning and is inspired by the Reggio Emilia approach to teaching. The school is ranked above the average on the ICSEA index, a national indicator of educational disadvantage.

The results from NAPLAN testing shows that students at WCS in Year 3 tend to be substantially above the national average for Reading; above the national average for Grammar and Punctuation and Numeracy; close to the national average for Writing; and below the national average for Spelling.

Ben's class

In 2009, Ben's Kindergarten/Pre-Primary class included 23 students (8 females and 15 males) mostly from high socioeconomic backgrounds (Email, 11/8/2010). Four of the students were from German or Japanese backgrounds and spoke English as an additional language and one student had hearing difficulties and was on an individual education plan (IEP) (Email, 11/8/2010). Given the emphasis on learning in and from the natural environment, Ben had given his class the name 'Nature Runners' (Video footage, 22/5/2009).

WCS has recently relocated to its current site near Wild Lake and several of the classes are situated in demountable classrooms, Ben's being one of them. The class has a veranda that runs along the front of it where the students' bags are kept on hooks and a sliding door gives entry into the classroom (Lesson 1 Observation Record, 22/05/2009). On the opposite side of the classroom, there is a work room that also functions as a storage area and another sliding door that leads out onto the Kindergarten/Pre-Primary playground. The classroom is rectangular in shape and has been sectioned off by a room divider, an aquarium, and some large pot plants (Video footage, 22/5/2009). On one side of the divider, there are several low student-appropriate tables that seat groups of four to six students, and on the other side there is a circular rug on the floor, a couch and a mobile whiteboard (Video footage, 22/5/2009). Ben has created a sense of space in the class by organising the room in a way that is clutter-free (Video footage, 22/5/2009). There is also a quiet ambience to the room, which he has achieved using soft lighting from several lamps and by artistically displaying some of the students' art work (Video footage, 22/5/2009).

Ben drew on the school's Mutual Respect Policy to manage classroom behaviour (Email, 11/8/ 2010) and he utilised explicit speaking and listening conventions. With the school's emphasis on learning via social interaction and dialogue, the teachers actively modelled speaking and listening conventions.

> We do a lot in the first term each year with the different groups to model how to say things such as "I like that idea" and how to use that kind of language. And how do you show that you are listening, so what does listening look like… because it's about a conversation, it's not about a teacher then student response. It's that dialogue, it's that conversation. Or if they [the students] don't agree we say that's fine,

you don't have to agree with everything that's said, but you have to have a reason why you don't agree. And the flip side of that is that the person who says something that someone doesn't agree with needs to accept the other person might not agree. So that's a big point. (PL 3 interview, 29/9/2009)

Class meetings provide regular opportunities for discussion at WCS and are used from Kindergarten to Year 10. Whenever they were held in Ben's class, the students were expected to: sit in a circle on the mat so that they faced each other; observe conventions for sharing turns; listen to each other as they spoke; and use a 'Thinking Thumb' to indicate they wished to speak (Video footage, 22/5/2009).

During the course of the professional learning intervention (Terms 2-4, 2009), Ben's class studied three teacher-authored science topics entitled Nature, What Plants Need to Grow, and The Function and Form of Plants.

Key Finding 5.3

Ben had a composite Kindergarten/Pre-Primary class comprising 8 females and 15 males. During class discussions, the students generally sat in a circle on the mat facing each other, observed turn taking conventions, listened to each other as they spoke, and used a 'Thinking Thumb' to indicate they wished to speak. During the professional learning intervention, three teacher-authored science topics entitled Nature, What Plants Need to Grow, and The Function and Form of Plants were taught.

Pre-intervention: Ben's beliefs, knowledge and practice

Snapshots of Ben's beliefs and knowledge about teaching science were captured via interviews and questionnaires completed prior to the intervention and from data collected in the early, mid and later phases of the professional learning intervention. The data elicited related to: beliefs about teaching science; confidence with teaching science; knowledge about managing classroom discourse; knowledge about questioning; and, teacher knowledge about using puppets.

Beliefs about teaching science

The data collected from the initial teacher interview completed prior to the professional learning intervention and from the initial teacher questionnaire completed on the first Professional Learning (PL) day provided evidence of Ben's beliefs about the teaching of science. The three most important characteristics of effective primary science teaching that he identified included: following the students' interests to inform planning; allowing time and being flexible; and, connecting to a student's place-based experiences (Initial teacher questionnaire, 02/06/09).

Ben believed that discussion, which was facilitated by the teacher and allowed the students to develop their ideas, was one of the most important characteristics of inquiry-based science teaching and learning (Initial teacher questionnaire, 02/06/09). He believed that giving students the freedom to ask any questions and ensuring that investigations were engaging were also important to inquiry-based science teaching and learning (Initial teacher questionnaire, 02/06/09).

Ben believed discourse was an important tool in science teaching because he thought that students could access knowledge very well through discussion (Initial teacher interview, 02/06/2009). He also thought discussion was a valuable tool for examining students' ideas.

> So looking at an idea or a confusion that they may have or questions that they have and really talking about it. Because that way they are constructing knowledge with each other, they're talking about the ideas that they do have and so it is possible for the teacher to see where gaps or misunderstandings occur. And that is a great way to then provide the next step in an investigation or the next level of information to help fill those gaps. (Initial teacher interview, 02/06/2009)

Ben believed that it was important to use the students' questions as the basis for their investigations. "I feel that children have a real innate sense of what they need to know at a particular stage of their development and that pretty much relates to what the curriculum says anyway. So they ask questions that relate to their development" (Initial teacher interview, 02/06/2009).

Confidence with teaching science

Prior to the professional learning intervention, Ben considered himself to be a confident teacher of primary science. When asked to indicate his confidence with nine aspects of science teaching (Initial teacher questionnaire, 02/06/09), Ben rated himself as 'Very confident' in: engaging students' interest in science; and in using a constructivist model to plan science units of work (Initial teacher questionnaire, 02/06/09). He also considered himself as 'Confident' in managing hands-on group activities; managing discussions and interpretation of science observations; and teaching science processes (Initial teacher questionnaire, 02/06/09). Ben felt 'Less confident' in assessing children's learning in science (Initial teacher questionnaire, 02/06/09).

The initial mean scale score for confidence with teaching science strategies for all of the teachers involved in the professional learning intervention was 3.86/5, which is very close to the mean confidence scale score of 3.88 for a group of *Primary Connections* trial teachers who had participated in five days of professional learning and taught some *Primary Connections* units (Hackling & Prain, 2005). In comparison, Ben's initial mean scale score for confidence with teaching science strategies was 3.66/5, which was slightly lower than the mean scale scores for either of these groups of teachers.

Beliefs about being an effective manager of classroom talk

The data from initial teacher questionnaire showed that Ben believed himself to be an effective manager of classroom talk. When asked to indicate the degree to which he agreed or disagreed with 12 statements about the effective management of classroom talk, the data showed that Ben had a high level of self-efficacy (rated 5/5) for establishing an appropriate classroom climate; and sustaining discussions in order to thoroughly discuss science ideas (Initial teacher questionnaire, 02/06/09). He also indicated a high level of self-efficacy (rated 4/5) against eight other aspects of managing classroom discussions, including being effective in asking open and closed questions to suit the purpose of the discussion; responding to students in ways that develop the discussion; drawing on his rich knowledge of science to ask the right questions; and using questions to ascertain the students prior knowledge and initial understandings (Initial teacher questionnaire, 02/06/09). Ben also indicated that he was uncertain about how effective he was in varying his style of talk to match the instructional purpose or phases of inquiry; and how effectively he used *wait time* (Initial teacher questionnaire, 02/06/09).

The initial mean scale score for being an effective manager of classroom talk for all of the teachers involved in the professional learning intervention was 3.89/5. In comparison, Ben's initial mean scale score was 4.0/5, which is greater than the mean scale scores for the group of teachers involved in the professional learning intervention.

Knowledge about managing classroom discourse

The initial teacher interview and the initial teacher questionnaire also provided evidence of Ben's understandings about how to manage classroom discourse so as to facilitate students' learning in primary science lessons. Ben thought that questioning and classroom discussion allowed students to socially construct their understandings, and allowed for "clarification and open processing of thoughts" (Initial teacher questionnaire, 02/06/09).

He thought that good classroom discussion looked like a conversation, with open dialogue where the students can contribute openly and share their ideas (Initial teacher questionnaire, 02/06/09). He stated that he varied his questioning and discussion style by asking open-ended questions based around the inquiry at the start of the investigation (Initial teacher questionnaire, 02/06/09) and then by asking more focused questions to direct the learning as a series of lessons continued over time (Initial teacher interview, 02/06/2009).

He thought that teachers needed to know how to listen to students, to give them time to think, and also to reword a question in order to elicit more from them.

> I think a teacher needs the skills, first of all, to listen. I think that is a really important skill and one which is not something that comes straight away or naturally. That is something that we actually need to work on as teachers. And to provide the time for students' thinking… it's about that think time aspect, and having a question posed by the teacher and then having a chance for them to have a think about it…

whether that's time in the discussion or whether it's time to go away and think about it and then come back. In regards to asking questions within a conversation, I think it's about reflecting on what's been said, re-wording a question and then re-posing it to the students. So, to throw it back to them and each time you do that maybe add a little bit more information or change the complexity of the question to get them to think a bit deeper. (Initial teacher interview, 02/06/2009)

Ben thought a student-centred classroom fostered student interaction, where the student's ideas drive the direction that the learning takes and where the students are given the time to investigate.

Whether it's a whole morning or an afternoon that they have got to explore their ideas or… allowing things to go over a whole week or even a whole term, for an investigation to continue and for it to be more about getting deep into ideas rather than just surface level. (Initial teacher interview, 29/5/2009)

Key Finding 5.7

Ben thought that students socially construct their understandings via discussion and this allowed for "clarification and open processing of thoughts".

He considered that good classroom discussion looked like a conversation, with open dialogue and the students contributed openly and shared their ideas.

Ben thought he varied his style of interaction, asking open-ended questions at the start of the investigation and more focused questions to direct the learning as the lessons continued.

He thought teachers needed to know: how to listen to students; how to give them time to think; and how to reword a question in order to elicit more from them.

He also thought a student-centred classroom fostered student interaction, where student's ideas drive the learning and they are given the time to investigate and to deepen their understandings.

Knowledge about using puppets

Prior to the professional learning intervention, Ben worked as a puppeteer at Scitech while he completed his undergraduate degree and he had used puppets to discuss conflict resolution and how to deal with bullying (Initial teacher questionnaire, 02/06/09).

Having considered some of the contextual factors, beliefs and understandings that may influence Ben's teaching, it is important to also examine how the professional learning intervention impacted on his practice and, more particularly, on the way that Ben managed whole-class discussions.

Over the course of the intervention data were gathered from science lessons prior to the professional learning intervention and from mid and later phases. The data were collected via video, classroom observation and post lesson follow up interviews. Specific observations included:

- o Lesson 1: An Engage lesson in May, prior to the profession learning intervention. This lesson was drawn from a teacher-authored topic called Nature.

- o Lesson 2: An Engage lesson in August, following PL Days 1 and 2, which was from a new a teacher-authored topic called What Plants Need to Grow.

- o Lesson 3: An Explain lesson in September, which was a continuation of the topic What Plants Need to Grow commenced in Lesson 2.

- o Lesson 4: An Engage lesson in October, following PL Day 3. This lesson marked the start of a new teacher-authored topic called The Function and Form of Plants.

- o Lesson 5: An Explain lesson in December, which was a continuation of the topic The Function and Form of Plants commenced in Lesson 4.

In this chapter, the data are presented in the sequence that the professional learning intervention unfolded. Initially, Lessons 1, 2 and 3 are reported on here while the data from Lessons 4 and 5 are discussed in a later part of the chapter.

Lesson 1, pre-intervention

The lesson

Lesson 1 was carried out prior to the commencement of the professional learning intervention and was an introductory lesson in the Engage phase of the topic Nature. This topic addressed science concepts related to the Living Things strand of the science syllabus (MCEETYA, 2006) and was an open-ended investigation into how things grow. This initial lesson was called Seeds Brainstorm and Ben used this as an opportunity to find out the students' initial understandings about the seeds and to elicit their questions. The segments of the lesson included: a whole-class discussion where Ben used some branches with fruit and seeds attached and a range of other seeds as a stimulus for discussion; a whole-class brainstorm about seeds; and individual work where the students drew seeds and what they thought they might turn into. The data analysis in this lesson centred on the substantive talk that was generated by the whole-class discussion and the by initial brainstorm activity.

The setting

Ben did not use puppets in this lesson. He initiated the discussion by making links to the Nature topic the students had been studying and by focusing the students' attention on some eucalypt branches with fruits (honky nuts) attached that he had found in the school yard. When the discussion was underway, Ben showed the students a larger collection of seeds and invited them to brainstorm what they knew about them. He also asked the teaching intern to record the students' ideas on a whiteboard.

Ben, the teacher intern and 20 students were seated on the floor in the mat area of the classroom. The class sat in a circle so that they faced each other and the students used a 'Thinking Thumb' to indicate when they wished to speak. This meant that the students simply placed their hands in their lap, put up their thumb when they had something to say, and waited for the teacher to nominate them to speak. At the start of the discussion, Ben reminded the students about using their Thinking Thumbs and speaking with a loud voice so that everyone could hear (Video footage, 22/5/2009).

The teacher's role

It was possible to examine how the teacher managed whole-class discussions and how this influenced the discourse by analysing the transcripts from each lesson for the communicative approach, and the teacher's use of questioning and discourse moves.

Teacher questioning

In this segment of the lesson, Ben asked a total of 38 initiating questions to find out what the students knew about seeds. The analysis showed that 29 of these questions (76%) were classified as *open-ideas* questions; four (10%) were *open-explanation~reason*; 3 (8%) were *closed*; and another two (5%) were classified as *open-description* questions.

Teacher discourse moves

In Lesson 1, Ben used the branches, fruit and seeds as a stimulus for discussion so that he could elicit the students' ideas about what seeds are for (PL 1 interview, 2/7/2009). This helped him to gauge the students' level of knowledge, identify their misconceptions, and decide how the learning should proceed (PL 1 interview, 2/7/2009). The interaction captured in Figure 5.1 below, shows how Ben elicited the students' ideas and encouraged their interaction. The excerpt picks up the discussion after Ben has shown the students the eucalypt branches and they have begun to share their ideas.

Turn	Utterances	Coding
1.	T: Adrian just said something really interesting. I was wondering if, Adrian, you could say that again just so we could hear what you said.	Restate.
2.	**S:Adr: Um.. well, on that one there will turn into the big nut and the big nut will turn into the big leaves.** [Indicates branch with leaves]	
3.	T: Really? And you said something about so they can grow the same again.	Clarify.
4.	**S:Adr: Yep.**	
5.	T: What do you mean by that?	Clarify.
6.	**S:Adr: Um.. they should actually grow back to the normal size...**	
7.	T: Hmmm.	
8.	**S:Adr: …that they were.**	
9.	T: OK. … That's an interesting idea. We might look further into that. What do you notice about them Linda? [WT1]	Acknowledge. Asks another student for his/her ideas. Wait time 1.
10.	**S:Lin: That they're gumnut leaves and so they're gumnuts.**	
11.	T: How do you know that?	Open-explanation~reason question.
12.	**S:Lin: Because they smell like them.**	
13.	T: Oh, they smell like them. Oh, so you're using your sense of smell to tell you what you think they are. Fantastic. Heath, what do you think?	Teacher restate. Reframe scientifically. Asks another student for his/her ideas.
14.	**S:Hea: Um… well, I.. I haven't thought about them. When will we be hearing these?** [Indicating story books he has brought to the circle]	
15.	T: Uh, very soon, OK? Put them behind your back and I'll remember about them. Nina, what do you have to say?	Maintains conventions for discussion. Asks another student for his/her ideas.
16.	**S:Nin: Well, um.. the big nut will grow** [Students talk over Nina]	
17.	T: Louise, voice off please.	Maintains conventions for discussion.
18.	**S:Nin: …um, into big nuts and then they can fall on the ground and then they can start a new life again.**	
19.	T: Wow! Is that what happens?	Acknowledge.
20.	**S:Nin: Yeah. So they fall off the old tree and then they**	

	grow into new trees.	
21.	T: Well, it seems like you guys know a lot about these.	

Figure 5.1: Lesson 1 - the teacher highlighted an idea and elicited other ideas.

This excerpt (Figure 5.1) shows how Ben encouraged the students' participation in the discussion and explored their ideas. At the start of the excerpt (turns 1-9), he made room in the conversation for Adrian (S:Adr) to speak so that everyone could hear what he had to say (*restate*, turn 1). By clarifying what he meant, Ben supported Adrian to say more (coded as *clarify*, turns 2 and 3). When he chose not to pursue the interaction further, Ben acknowledged Adrian's idea and moved on to ask another student for their ideas (*acknowledge only*; *asks another student for his/her ideas*, turn 9).

The next segment of the transcript (turns 9-13) shows how Ben used a similar pattern of interaction to explore Linda's (S:Lin) ideas, asking her what she had noticed about the branches (turn 9), probing her idea by asking further questions (*open-explanation~reason question*, turn 11), and repeating and rephrasing her explanation (*teacher restate*; *reframe scientifically- teacher rephrases a student answer to correct science*, turn 13). At the start of this particular interaction, Ben paused after he had asked Linda what she had noticed, giving her some time to think about her response (*wait time 1*, turn 9). Ben used *wait time* in this way several more times in this discussion.

Exploring the students ideas using discourse moves such as those seen in the first two segments of this excerpt, frequently generated teacher-student exchanges comprising three- (T-S-T) and four-turn structures (T-S →T-S), some six- (T-S →T-S →T-S) and eight-turn structures (T-S →T-S →T-S→T-S), and some that were longer.

Throughout the discussion in Lesson 1, Ben consistently kept the students focused by managing their behaviour and maintaining the conventions for talk. This is evident in the above excerpt (Figure 5.1) when he dealt with Heath (turn 15), who wanted to read the story books he had brought to school, and then with Louise (turn 17), who spoke over Nina as she shared her ideas.

Key Finding 5.11

Ben encouraged the students' participation and explored their ideas in Lesson 1. He used *restate* to encourage students to repeat their ideas so that everyone could hear and he used *clarify* when he wanted them to state more clearly what they meant. Ben used *wait time* after asking a question to give a student time to think about a response. He also probed the students' ideas by asking further questions, and he used *teacher restate* and *reframe scientifically* to reiterate an idea or rephrase an explanation. When he chose not to pursue an interaction further, Ben acknowledged the student's idea and moved on.

Exploring the students' ideas using these kinds of discourse moves frequently generated teacher-student exchanges comprising three- and four-turn structures, some six- and eight-turn structures, and some that were longer.

Ben consistently kept the students focused throughout the discussion by managing their behaviour and maintaining the conventions for talk.

In the next excerpt, Ben linked several of the students' ideas and asked further questions to build a long chain of interaction. The interaction below (Figure 5.2) begins with Ben asking Nina (S:Nin:) what she knew about nuts and seeds.

Turn	Utterances	Coding
1.	T: Other things people know about nuts and seeds. Someone had their Thinking Thumb up. Ah, Nina, what do you know about nuts and seeds?	Initiating question, open-ideas question.
2.	**S:Nin: Well, my mummy told me that if seeds grow and… you know how you find out? By eating them.**	
3.	T: What, eating the seeds?	Clarify. Teacher uptake.
4.	**S:Nin: Yep.**	
5.	T: What do you mean? Tell me more about that.	Clarify. Elaborate.
6.	**S:Nin: So, you're eating the vegetables.**	
7.	T: So, what before they grow?	Clarify.
8.	**S:Nin: No, um.. when they've grown.**	
9.	T: Ah, so you plant them and then you wait till they grow?	Clarify. Teacher uptake.
10.	**S:Nin: Yes, and then you eat them just like that. And my daddy eats.. always eats chilli.**	
11.	T: Do you think chillies grow from a seed?	Teacher uptake.
12.	**S:1: Yes.**	
13.	**S:Lee: No.**	

14.	**Ss: Yes.**	
15.	T: Oh, you don't think so?	Clarify.
16.	**S:Lee: No they don't.** [Students talk over each other]	
17.	T: What do they come from then, Lee?	Recast the question.
18.	**S:Lee: They come from a animal.** [Students talk over each other]	
19.	**S:Noe: They come from a factory.**	
20.	T: Chillies come from an animal, Lee thinks. Interesting.	Teacher restate.
21.	**S:Noe: No, they come from a factory.**	
22.	T: From a factory, Noel? [Students talk over teacher]	Clarify.
23.	T: Macy, you tell us what you think. [Students talk over each other]	Directed question. Asks another student for his/her ideas.
24.	**S:Mac: I've got a chilli tree.**	
25.	T: Yeah.	Acknowledge.
26.	**S:Mac: That's.. that's made from a seed because it's in my garden.**	
27.	T: So you have chilli.. a chilli tree that you [Interrupted] [Andy waves his hand in T's face] Excuse me Andy. That's rude.	Teacher uptake. Maintains conventions for discussion.
28.	**S:Mac: I.. I've got a chilli plant.**	
29.	T: Yeah. And that's where you get your chillies from?	Clarify. Teacher uptake.
30.	**S:Mac: Yeah.**	
31.	T: And do you think it was grown from a seed?	Teacher uptake.
32.	**S:Mac: Um.. yeah, uh.. and.. it was a seed.**	
33.	T: Oh. Sally (T:S, teacher intern), do you want to write up there, sorry, that chillies come from a plant which come from a seed as well.	Teacher restate.
34.	T:S: Chillies come from a plant which come from a seed as well.	
35.	**S:Mac: I get chillies from a seed. And my mum's got some at home.**	
36.	T: Oh, fantastic.	Acknowledge.

Figure 5.2: Lesson 1 - the teacher used clarify *and* teacher uptake *to build a chain of interaction.*

In this excerpt (Figure 5.2), Ben developed the interaction with Nina (turns 1-10) by asking follow-up questions to help her to develop (*teacher uptake*, turns 3 and 9; *elaborate*, turn 5) and articulate her ideas more clearly (*clarify*, turns 3, 5, 7, 9). Then, using further *teacher uptake* (turn 11), Ben asked the rest of the group if they thought chillies grew from seeds and several students argued about this (turns 12-16) until Ben asked Lee (S:Lee) where chillies came from (*recast the question*, turn 17). Lee suggested they came from an animal (turn 18) and then Noel (S:Noe) suggested they come from a factory (turn 19). Ben simply reiterated these ideas (*teacher restate*, turn 20; clarify, turn 22) and went on to ask Macy (S:Mac) what she thought (*directed question, asks another student for his/her ideas*, turn 23). Ben once again developed the interaction with Macy (turns 23-36) by picking up on her idea and asking further questions (*teacher uptake*, turns 27, 29, and 31) and Macy was ultimately able to tell Ben that chillies grow from a seed (turns 32 and 35). By repeatedly using discourse moves such as *clarify* and *teacher uptake*, Ben was able to facilitate extended teacher-student interactions, some as long as 10 turns, which developed into a lengthy chain of interaction and generated some cumulative talk.

Key Finding 5.12

In Lesson 1, Ben developed the teacher-student interaction by asking follow-up questions and using *teacher uptake, elaborate* and *clarify* to help the students develop and articulate their ideas clearly. By repeatedly using discourse moves such as *clarify* and *teacher uptake*, Ben was able to facilitate extended teacher-student interactions which developed into a lengthy chain of interaction, thus generating a small amount of cumulative talk.

The analysis of the transcript also showed that Ben used *wait time* eight times in Lesson 1, but there was no evidence of discourse moves that could be coded as *extended thinking time*.

Key Finding 5.13

There were eight instances of *wait time* coded in Lesson 1 and no instances of *extended thinking time*.

Communicative approach

In Lesson 1, the discussion was mostly driven by *open-ideas* questions as Ben wanted the students to share their initial ideas and understandings about seeds (PL 1 interview, 2/7/2009). This produced an Interactive-Dialogic style of interaction (Mortimer & Scott, 2003) which is considered an appropriate form of interaction for an Engage lesson given the instructional purpose of this phase of inquiry is to elicit and clarify the meaning of students' existing ideas. In this lesson, Ben mostly asked *open-ideas* and some *open-explanation~reason* questions and he frequently used *teacher restate*, *clarify* and *teacher uptake* to achieve this purpose.

Key Finding 5.14

In Lesson1, an Engage lesson, Ben utilised an Interactive-Dialogic communicative approach to facilitate the students to share many ideas.

Proportions of teacher and student talk

The transcripts from each lesson were also analysed for the proportion of teacher and student talk in whole-class discussions of substantive lesson content. In Lesson 1, Ben utilised a slightly less of the talk time (46%) compared to the students (54%) in whole-class substantive discussion.

Key Finding 5.15

In Lesson 1, Ben utilised about 46% of the talk time and the students utilised 54% in whole-class substantive discussion.

The students' role

It was also important to investigate how the students contributed to whole-class discussions. In this study, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of their responses.

Elaborated utterances

There were 14 *elaborated utterances* coded in the transcript from Lesson 1.

Quality of student talk

In Lesson 1, 39% of the students' responses were coded as *unistructural descriptions,* 34% as *explanations*, and 27% as *multistructural descriptions.*

In this lesson, Ben wanted the students to listen to each other and to begin to build on each other's ideas and he was also conscious of making sure that all of the students were heard (PL 1 interview, 2/7/2009).

> The group does have what we refer to as 'loud talkers', so the ones who are really happy to contribute and have their voice and they know how to use it in a discussion. And we do have some of the more quiet talkers who we know have ideas but don't necessarily share them as easily as the others. So I guess my focus for some of the lesson was to really gauge the students to see if those more quiet talkers had something to say [and whether they] needed a little bit more help saying it. So helping them to have their voice and asking the others that have had a go to respect them and allow them to contribute as well. (PL 1 interview, 2/7/2009)

Key Finding 5.16

The students frequently gave extended responses in Lesson 1 and 14 of these were coded as *elaborated utterances*. Their responses were a combination of *unistructural description* (39%), *explanation* (34%), and *multistructural description* (27%).

Lesson 1 summary

Lesson 1 was the first Engage lesson for the new Nature topic and Ben wanted to engage the students' interest in the topic and to encourage them to share their initial understandings and ideas during the discussion. He achieved this by utilising an Interactive-Dialogic style of interaction where he mostly asked *open-ideas* questions. Ben enabled the students' participation in the discussion by managing the talk so that individual students could be heard and their ideas explored and woven into the flow of the conversation. To do this he used discourse moves such *wait time* to give the

students time to think and *restate* and *elaborate* to encourage them to repeat their ideas or to say more. Ben developed the interaction by asking follow-up questions and using *teacher uptake, elaborate* and *clarify* to help the students expand on and clearly articulate their ideas. He also used *teacher restate* and *reframe scientifically* to repeat or rephrase the students' explanations for everyone to hear. When he chose not to pursue an idea any further, Ben used *acknowledge only* to accept the student's idea and then he moved on. Using the discourse moves in this way resulted in the students utilising slightly more of the talk time and generated extended chains of teacher-student interaction, which were comprised of four- (T-S →T-S) and six-turn structures (T-S →T-S →T-S) and a small amount of cumulative talk was generated by a longer chain of interaction.

In Lesson 1, Ben utilised slightly less of the talk time than the students. There were 14 elaborated student responses in this lesson and most of the students' responses were coded for *description* and a good number were coded as *explanation*.

Lesson 2, post Professional Learning Days 1 and 2

Following the first two professional learning days in June 2009, Ben developed a new topic that he called What Plants Need to Grow.

The lesson

Lesson 2 was in the Engage phase of the topic, What Plants Need to Grow, which addressed the science concepts related to the Living Things strand of the science syllabus (MCEETYA, 2006). This topic built on the Nature topic Ben had implemented earlier in the year and aimed to extend the students' understandings about the conditions that facilitate plant growth. The idea for the topic arose from a problem that one of the students (Heath) had with planting mandarin seeds in the wild space, a section of the school that had been retained as natural bush (Video footage, 11/8/2009). Heath had wanted to grow some mandarin trees from seeds but he was concerned that they would not grow because there was only sand in the wild space and he did not think seeds could grow in sand (Video footage, 11/8/2009). This problem led

163

to the development of the new student-directed investigation and, prior to the lesson, the students had planted different sorts of seeds in different locations - some in the ground and some in pots, some in sand and some in soil. During the discussion in this lesson, Ben wanted to find out what the students thought their seeds would need to begin to grow. The data analysis in this lesson centred on the substantive talk that was generated by this whole-class discussion.

The setting

Ben did not use puppets in this lesson. Heath had planted some mandarin seeds in a pot of soil and Ben used this as a stimulus for discussion, placing it on the mat in the centre of the circle (Video footage, 11/8/2009). Ben initiated the discussion by asking Heath to talk about his idea to plant mandarin seeds. When Heath had shared his problem with the class, Ben invited them to think about the difference between soil and sand and to share their ideas (Video footage, 11/8/2009). As the discussion got underway, the teaching intern began to record the students' ideas on a clipboard (Video footage, 11/8/2009).

Ben, the teacher intern, and 20 students sat in a circle on the floor in the mat area of the classroom (Video footage, 11/8/2009). Before the discussion commenced, Ben spent some time reminding the students about the speaking and listening conventions they should use during class meetings. This included: sitting in a circle so that both speakers and listeners could see each other; sitting with crossed legs; using a Thinking Thumb to indicate they wished to speak; speaking to the whole group and to each other; and, looking at the speaker. In this particular lesson, Ben also asked the students to take responsibility for sharing speaking turns, staying on topic, and remembering how to ask questions (Video footage, 11/8/2009). When the discussion began, Ben nominated speakers and maintained these speaking conventions.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

Ben mostly asked *open-ideas* questions when he elicited the students' ideas about sand and soil, and he asked *open-explanation~reason* questions when he explored their ideas. Additionally, he often asked *closed* questions when he used the discourse moves *clarify* or *teacher uptake*.

The analysis showed that Ben asked a total of 45 initiating questions during the discussion in this lesson. Twenty-one of these questions were classified as *open-ideas* (49%); 13 were classified as *closed* (29%) questions; nine were classified *open-explanation~reason* (20%) questions; and a further two as *open- description* (4%) questions.

Teacher discourse moves

In Lesson 2, Ben wanted the students to talk through their ideas about soil and sand so that they could begin to consider what they should do next in the investigation to help Heath grow his seeds (PL 2 interview, 27/8/2009). The analysis of the discussion in Lesson 2 showed that once he had introduced the context for the new investigation, Ben tended to use similar discourse moves to initiate and sustain the discussion to those he had used in Lesson 1. Essentially, he would ask an initiating question to elicit the students' ideas and use discourse moves such as *teacher restate* and *clarify* to ensure he had understood their response, and *reframe* to rephrase their ideas. Ben generally asked further questions and used *teacher uptake* to explore the students' ideas, and sometimes he simply used *elaborate* to ask them to say more. He used *wait time 1 and 2,* and at one point in the discussion he also used *extended thinking time* to get all the students to stop talking and consider the range of ideas that had been shared. From time to time, Ben used *refocus* as a way to gather the groups' collective thoughts before moving the discussion forward and he used *refocus* again at the end of the discussion to summarise what had been said. Ben also managed the discussion by asking *directed questions* of specific students and he used *acknowledge only* to simply accept an idea without exploring it further.

Managing the discussion in this way generated many teacher-student interactions comprising three- (T-S-T) and four-turn structures (T-S →T-S), plus some longer eight- (T-S →T-S →T-S→T-S) and 12-turn structures (T-S →T-S →T-S→T-S→T-S→T-S) and several lengthy chains of interaction developed as the discussion unfolded.

Key Finding 5.19

In Lesson 2, Ben used similar discourse moves to those used in Lesson 1. He used *teacher restate* and *clarify* to ensure he had understood the students' responses, and *reframe* to rephrase their ideas. When he wanted to explore the students' ideas, he asked further questions and used *teacher uptake* and *elaborate*. Ben used *refocus* as a way to gather the groups' collective thoughts and to summarise the students' ideas at the end of the discussion. Ben managed the discussion by asking *directed questions* and *acknowledge only* to accept an idea without exploring it further. In Lesson 2, there was one instance of *wait time 1* and of *wait time 2*, and another one instance of *extended thinking time.*

Using these kinds of discourse moves generated many teacher-student interactions comprising three- and four-turn structures and some eight- and 12-turn structures, thus generating several lengthy chains of interaction and cumulative talk.

As in Lesson 1, Ben's focus alternated between developing substantive talk and maintaining and developing the students' use of the conventions for talk. At the start of this lesson he asked the students to take more responsibility for using the conventions for discussion and the excerpts below (Figure 5.3) show how they worked on staying on topic, sharing turns, and understanding how to ask questions. Figure 5.3 comprises excerpts from the initial, middle and later parts of the discussion in Lesson 2.

Turn	Utterances	Coding
	Early on in the discussion	
1.	T: And I was very curious about that because I didn't quite know what the difference between sand and dirt was. So, I was wondering if any one of the Nature Runners had an idea [Interrupted]	
2.	**S:1: Me!**	
3.	T: ..about what the difference is? Use our Thinking Thumbs guys. Adrian?	Maintains conventions for discussion.
4.	**S:Adr: Um.. actually, well you know what? Once like a plant gets bigger and the weeds get longer the pot needs to be bigger so they will want to get that big pot.**	
5.	T: Good question. Let's come back to that one in a moment.	Acknowledge only. Maintains conventions for discussion, staying on topic.
6.	**S:Ali: When…**	
7.	T: Hang on there, Alistair, one second. That's a great question. Hang on Alistair, that's a great question but let's have a think about what the question is right now. Lee, go and sit down please. OK. So my question was if anybody had an idea about what the difference between sand and soil was or sand and dirt. Um.. just put it in your pocket for now, Lee, because the bin is outside still. Rachel, what do you think?	Acknowledge only. Maintains conventions for discussion, staying on topic.
	Mid-way through the discussion	
8.	T: So when it gets to summer, Andy, and the rain stops and it gets a bit drier, what's going to happen with the seed?	
9.	**S:And: Um.. what's going to happen with the seed is I think it's going to.. you know some plants can stay green in summer. So the seed might die, the seed might stay green or.. and even, I've got another question to tell you. Um.. when plants are green they can still go down like that.**	
10.	T:I: Is that a question?	Maintains conventions for discussion,

		focusing on asking questions.
11.	**S:2: Yeah, because that means.. that means they're dying.**	
12.	**S:And: No.** [Students talk over one another]	
13.	T: Andy, you said you had a question. Was that a question or just a bit of information you wanted to share?	Maintains conventions for discussion, focusing on asking questions.
14.	**S:And: Just a bit of information and another thing um..** [Interrupted]	
15.	T: Hang on Andy, we might hold it there. You've had a big space to talk, let's allow some other people to talk, OK. Just before we move on, we've got Louise who has got something to say, and Elice and Nina have been waiting for a very long time.	Maintains conventions for discussion, focusing on sharing turns.
16.	**S:Adr: And me.**	
17.	T: Heath's got something else to add, I want you to look around Nature Runners, one second Adrian, I want you to look around and make sure that if you've had a chance to talk you allow some other people to have a talk too. Have a think about what we are talking about and the things that other people have said about what plants need to grow, the difference between sand and dirt and what might be in dirt. Have a think about those things.	Maintains conventions for discussion, focusing on sharing turns. Refocus. Extended thinking time.
18.	**S:Mar: Are we going to do all these people?**	
19.	T: So keep your Thinking Thumbs for the moment and just have a think about all of those things.	Refocus. Extended thinking time.
20.	**S:Mar: Are we going to do all these people?**	
21.	T: Maybe, Mara, we'll see how long the meeting goes. But I want you to just not talk for a minute and just think for a moment. Think about all those things we've just talked about and see if you've got an idea that comes to your mind about how seeds grow, what they need to grow, what sand and dirt is, and what's in sand and dirt. Have a think about those things.	Refocus. Extended Thinking Time.
22.	**S:3: What's the difference.**	
23.	T: And what the difference is. Elice, what do you have to say? [WT1]	Refocus.
24.	**S:Eli: Um.. um.. when, when it's summer you don't just leave it you water it, because there's not much rain.**	
25.	T: Oh, so in summer we need to water it, so you don't just leave it. OK, what do people think about that? Louise, do you agree with what Elice said?	
26.	**S:Lou: Um.. I agree with what Elice said because she**	

	said that if the summer comes [Interrupted]	
27.	T: Cayan, sitting on your bottom please.	Maintains conventions for discussion.
28.	**S:Lou: ..you can't leave it because when the summer comes it doesn't have any rain at all so you need to water it.**	
29.	**S:Cal: I don't think that. I don't agree actually.**	
30.	[Teacher talks over S:Cal] T: Sit up a little bit, sit forward um.. so you're not touching the construction. You don't agree, Caleb?	Maintains conventions for discussion.
31.	**S:Cal: No.**	
32.	T: Why not? What's your opinion?	
33.	**S:Cal: Well really um..** [Interrupted]	
34.	T: Felix and Adrian.	Maintains conventions for discussion.
35.	**S:Cal: Really um.. you don't really have to leave your plants alone. But you can't, but sometimes you do really have to get um.. the hose and really sprinkle lots of water on it, especially on a very, very, very hot day at summer.**	
36.	T: Rachel, can you sit on your bottom please and Zach take your shirt off your legs please. Cam, why do plants need water?	Maintains conventions for discussion.
37.	**S:Cam: To grow. To help all the um.. all the um.. just like.. just like us drinking. It.. it's how they get their water.**	
38.	T: It's just like us drinking it.	
39.	**S:Cam: And if they wouldn't do that, then they would just die.** [WT2]	
40.	T: They would just die?	
41.	**S:Cam: Yes, they don't have** [Interrupted]	
42.	**S:Lou: The plants are just like a human being.**	
43.	T: How do you mean, Louise?	
44.	**S:Lou: We drink water and they need water too, to keep them alive and water keeps us alive too.**	
45.	**S:Adr: Actually food does.**	
46.	[Teacher talks over S:Lar] T: So.. oh, food as well, Adrian, I was just thinking the same thing, because I was thinking that if Louise thinks [Interrupted]	
47.	[S:Kat talks over teacher] **S:Kat: Plant food is.. plant food is.. plants are also alive and also water helps your blood very much.**	

48.	[Students talk over one another]	
49.	[Teacher talks over students] T: Woah, there's some interesting ideas. Hold that thought for a second, Katy. Louise you just said [Interrupted]	Maintains conventions for discussion, staying on topic.
50.	[Students talk over one another and teacher and teacher intern take some time to settle the class down] T:I: I just think you guys are so great at listening don't spoil it and it's so good to hear. I'm normally down at Kindy but you guys are great at showing each other such respect. It's really good, I'm very impressed.	Maintains conventions for discussion, focusing on sharing turns.
51.	T: Louise, I wanted to go back to your point, you said plants are just like humans and they need water to drink. And then Adrian said that plants need food as well. Because I was thinking well we need food [Interrupted]	
52.	**S:4: No, we need food to eat and plants.**	
53.	T: And plants need food as well?	
	S:And: Plant food [Interrupted]	
54.	T: So if we need food [Interrupted]	
55.	[Student talks over teacher] **S:And: I don't know that plants have food because I just thought** [Interrupted]	
56.	[Students talk over one another] **S:4: Andy, Andy, what the plant's food is.. the plant's food is** [Interrupted]	
57.	[Students talk over one another and many have moved to look at the pot of soil in the middle of the circle] T: Oh, I think we've hit an interesting idea. Nature Runners, let's go back to the edge of the circle. [Students talk over one another and continue to argue about whether soil or water are plant food]	
	Later in the discussion	
58.	T: Hang on, Caleb, Linda's about to speak. [Teacher re-groups the students and asks them to be ready for Linda to speak]	Maintains conventions for discussion, focusing on sharing turns.
59.	**S:Lin: Well, if they stay in the sun for a really, really, really long time they will just die to be brown.**	
60	T: They will go brown. I wonder why that happens, Linda, do you have any ideas?	
61.	**S:Adr: Um, I've got a good question for Linda.**	
62.	T: Do you have a question for Linda? OK.	
63.	**S:Adr: Um, Linda, also I've got something to show as well.**	
64.	T: Is this the question, Adrian?	Maintains conventions

		for discussion, focusing on asking questions.
65.	**S:Adr: Yes.** [S:Adr gets up and shows one of the students something]	
66.	T: So what's your question Adrian? Adrian what's your question?	Maintains conventions for discussion, focusing on asking questions.
67.	**S:Adr: Tiny bits, tiny bits.** [S:Adr shows another student something then puts it back in the pot in the middle of the circle]	
68.	T: That's not quite a question. Remember a question starts with a 'who', a 'what', a 'where', a 'when', a 'why'. Do you think that might have been something you just wanted to share? Adrian, go back to your spot and we'll let Linda finish. Mara, did you have a question for Linda? What's your question?	Maintains conventions for discussion, focusing on asking questions.
69.	**S:Mar: Well, Linda, and also if you didn't put water in this and it's very hot outside then these will die and they will dry up since they don't have any more water.**	
70.	**S:6: Yeah, and its dead, it's dead.**	
71.	T: So what's your question for Linda, Mara?	Maintains conventions for discussion, focusing on asking questions.
72.	**S:Mar: And if they dry up they will just soak out of the bottom because they will be in the ground.**	

Figure 5.3: Lesson 2 - the teacher maintained the conventions for discussion and supported the students to take responsibility for staying on topic, sharing turns and asking questions.

Ben worked on the way that students participated in the discussion as the opportunities arose throughout the lesson. At the very outset, when he had asked the students the difference between sand and dirt (turns 1 and 3), Adrian's response drifted off topic (S:Adr, turn 4). Ben responded quickly by acknowledging Adrian's idea and setting it aside for later consideration, and then he steered the discussion back to the focus of his initiating question (turns 6 and 7). Ben responded in a similar way later on when the discussion erupted with the students giving many ideas at once and Katy was trying to make some links between the needs of plants and humans (turn 47). In this instance, Ben asked her to hold onto her thought while he finished his interaction with another student (turn 49).

Ben also maintained a focus on sharing turns and he asked the students to look for spaces in the conversation to talk. In Figure 5.3, this is particularly evident when he asked Andy (turn 15) and the rest of the group (turn 17) to give other people a chance to talk. This particular segment also shows how he used *refocus* and *extended thinking time* to remind the students of the focus of the discussion and to give them a moment to collect their thoughts (coded as *refocus* and *extended thinking time*, turns 17, 19, 21, 22). Later in the discussion, the teacher intern indirectly reinforced the conventions for sharing turns when she praised the students for showing respect when they listened to what others had to say (turn 50). More frequently though, Ben simply asked students to wait when it was somebody else's turn to speak as is evident later in the discussion when he spoke to Caleb (turn 58).

The subject of asking questions arose several times in Lesson 2 when some of the students showed they did not understand how to frame a question or they simply wanted more talking time. In Figure 5.3, after a long turn, Andy effectively bought more talking time when he stated that he had a question to ask (turn 9). When he failed to ask anything and simply continued his turn, Ben intervened (turn 13) and he reminded the group to share turns (turns 15, 17). Later in the discussion, when Adrian did something similar (turns 61, 63, 65) Ben prompted him to ask a question (turn 66) and then gave the group a clear explanation about how to ask questions (turn 68). Even so, immediately after this Mara indicated that she wanted to ask Linda a question but failed to do so (turn 69) and by also prompting her, Ben reinforced the focus on asking questions once again (turn 71).

Key Finding 5.20

While Ben did focus on developing substantive talk via class discussions in Lesson 2, he also worked on maintaining and developing the students' use of the conventions for talk (sitting in a circle, sitting cross-legged, using Thinking Thumbs, speaking to the whole group, staying on topic, sharing turns, and understanding how to ask questions). In addition, he explicitly focused on the students taking responsibility for staying on topic, sharing turns, and understanding how to ask questions.

Communicative approach

In this lesson, Ben mostly asked the students *open-ideas* questions to elicit their ideas and understandings about what helps seeds to grow. This created an Interactive-Dialogic style of interaction (Mortimer & Scott, 2003), which is an appropriate form of interaction for an Engage lesson. Ben achieved his purpose by asking *open-ideas* and *open-explanation~reason* questions and using a range of discourse moves, including *teacher restate*, *clarify*, *reframe*, *teacher uptake*, *elaborate*, *wait time, extended thinking time, directed question* and *acknowledge only*.

Key Finding 5.21

Lesson 2 was an Engage lesson and Ben utilised an Interactive-Dialogic communicative approach to support the students to share their many ideas.

Proportions of teacher and student talk

The analysis showed that Ben utilised a greater proportion of the talk time (61%) and the students used less (39%) in whole-class substantive discussion.

Key Finding 5.22

In Lesson 2, Ben utilised about 60% of the talk time and the students utilised about 40% in whole-class substantive discussion.

The students' role

In Lesson 2, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

There were 18 *elaborated utterances* in Lesson 2, which is a slightly more than in Lesson 1.

There was also evidence that the students were able to generate cumulative talk (Alexander, 2006). For example, in the previous excerpt (Figure 5.3), the interaction that developed between the students regarding the amount of water and food plants need (turns 24 – 47) showed how their ideas began to build one upon the other and that through their interaction the students were beginning to extend and clarify their ideas. In the Post Lesson 2 interview, Ben reinforced this idea when he shared his observations of the way the students talked (PL 2 interview, 21/8/2009).

> But [in this discussion] we were playing with ideas and grappling with new concepts and they used their dialogue, their discourse, to kind of work through those ideas. And you can see it with a few of the children, especially when they talk [and] they take a bigger chunk of time, as their thought process actually happens while they are speaking. Whereas with other children, you can obviously see that they've had a think about what they want to say and when they are ready to say it they have got the ideas kind of solidified in their head before they say it. So, it's interesting to find the children that have a difference in that.

Key Finding 5.23

There were 18 *elaborated utterances* in Lesson 2 and, through their interaction, the students were beginning to extend and clarify their ideas. There was some evidence of the students' capacity to generate cumulative talk by building one another's ideas.

Lesson 2 summary

Lesson 2 was an Engage lesson for the new topic, What Plants Need to Grow. Ben utilised an Interactive-Dialogic style of interaction, asking mostly *open-ideas* questions to elicit the students' ideas and some *open-explanation~reasoning* questions to explore them further. Ben orchestrated the discussion by using a range of teacher discourse moves and by managing the conventions for talk. More specifically, he used *wait time* and *extended thinking time* to give the students time to think, and when he wanted to make certain he had understood their responses he used *teacher restate* and *clarify*, and he used *reframe* to rephrase their ideas. Ben asked further questions and used *teacher uptake* and *elaborate* to explore the students' ideas, and he used *refocus* as a way to gather the groups' collective thoughts and to summarise their understandings. Ben also directed the talk by asking *directed questions* and using *acknowledge only* when he decided not to pursue an idea. Using these kinds of discourse moves

generated many teacher-student interactions comprising three- (T-S-T) and four-turn structures (T-S →T-S) and some eight- (T-S →T-S →T-S→T-S) and 12-turn structures (T-S →T-S →T-S→T-S→T-S→T-S), which developed into several lengthy chains of interaction, and thus cumulative talk.

Ben utilised an increased amount of talk time compared to Lesson 1, however, the number of elaborated students' responses also increased in this lesson. There was evidence that the students were beginning to extend and clarify their ideas through their interactions and that they were able to generate cumulative talk (Alexander, 2006) by building on one another's ideas.

While Ben focused on developing substantive talk in this discussion, he also worked on maintaining and developing the students' use of the conventions for talk (sitting in a circle, sitting cross-legged, using Thinking Thumbs, speaking to the whole group, staying on topic, sharing turns, and understanding how to ask questions). In this lesson he explicitly focused on the students taking responsibility for staying on topic, sharing turns, and understanding how to ask questions.

Lesson 3, post Professional Learning Days 1 and 2

The lesson

Lesson 3 was videoed in September, approximately six weeks after Lesson 2, and was an Explain lesson for the topic What Plants Need to Grow. During the discussion in the previous Engage lesson, Ben had noticed that the students were developing a range of their own theories about what was in soil (PL 3 interview, 29/9/2009). Consequently, during the Explore phase, he had encouraged them to collect different samples of soil and to look at them under a microscope. The students were also encouraged to put some samples in jars of water and to shake them up so that the components of the soil separated and the students could draw their observations (PL 3 interview, 29/9/2009). During the discussion in this lesson, Ben wanted to talk about the students' observations and to elicit some description of what they had seen when they looked at

their soil samples under a microscope. The data analysis for this lesson focused on the interaction that was generated by this whole-class discussion.

The setting

Ben did not use puppets in this lesson. He initiated the discussion by reminding the students about the activities they had completed during the Explore phase and inviting those students who had looked at the soil through the microscopes to share their observations (Video footage, 8/9/2009). As they began to talk about their experiences and observations, Ben recorded the students' ideas on a clipboard (Video footage, 11/8/2009).

Ben, the teacher intern, and 23 students sat in a circle on the floor in the mat area of the classroom (Video footage, 11/8/2009). Ben continued to manage the discussion by nominating speakers and prompting the students to: maintain their focus; remain seated; use their Thinking Thumbs; and, to respect each other by listening and sharing turns (Video footage, 11/8/2009).

Key Finding 5.24

Ben did not use puppets in Lesson 3. The discussion focused on the students' observations and descriptions of soil samples viewed under a microscope. The teacher, the teacher intern and the students sat in a circle on the mat. Ben continued to manage the discussion by nominating speakers and he prompted the students to: maintain their focus; remain seated; use their Thinking Thumbs; and, show respect by listening to each other and sharing turns.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

During the discussion in this lesson, Ben asked a few *open-description* questions to elicit the students' observations, but he mostly asked *open-ideas* questions to draw out their ideas and explanations of what they had seen. He also asked a number of *closed* questions when he used discourse moves such as *clarify* and *teacher uptake*.

The analysis showed that Ben asked a total of 47 initiating questions in Lesson 3. Twenty (43%) of these questions were classified as *closed* questions; 11 (23%) were classified as *open-explanation~reason*; 10 (21%) were classified as *open-ideas*; and six (13%) were *open-description* questions.

Key Finding 5.25

Ben asked a total of 47 initiating questions in the whole-class discussion in Lesson 3. Of these, approximately 40% were *closed*, a further 40% were either *open-explanation~reason* or *open-ideas* questions, and the remaining 10% were *open-description* questions.

Teacher discourse moves

Throughout the discussion In Lesson 3, Ben maintained the dual focus seen previously where he developed the dialogue with the students whilst also maintaining the conventions for talk. He used a similar range of teacher discourse moves to those he had used in previous lessons to elicit the students' observations and explanations. More specifically, Ben used *teacher restate* to reiterate the students' ideas, and *clarify* when he wanted them to state more clearly what they meant. He used *wait time 1* (6 instances) to give the students time to think after asking a question, and *wait time 2* (2 instances) after they had responded. Ben asked further questions and used *teacher uptake* to probe the students' ideas and to seek explanations, and periodically he used *reframe* to rephrase their responses. At certain points in the discussion, he used *refocus* to highlight particular ideas and to draw the students' ideas together. Ben also managed the talk by asking *directed questions* and using *ignore* (*ignore - teacher ignores a student response*) and *acknowledge only* to close off an interaction.

In this lesson, Ben also began to draw attention to certain ideas by endorsing those student responses that were "on the right track" (PL 3 interview, 29/9/2009) and the excerpt below (Figure 5.4) shows how he used the teacher discourse move *evaluate* to do this.

Turn	Utterances	Coding
1.	T: I wonder if we can go onto the other thing that you said, Louise. You said ah.. little white gems or little white stones?	
2.	**S:Lou: Little white pebbles.**	
3.	T: Little white pebbles. I wonder what people think they might be those little white pebbles in the soil.	Initiating question, open-explanation~reason question.
4.	**S:Cal: Can I say something? Lots of the bark is at the um.. is at the um.. is at the water course.** [Refers to the previous interaction about where the wood chips in some of the soil samples might have come from]	
5.	T: Lots of the bark?	Clarify.
6.	**S:1: Yeah.**	
7.	T: Maybe it blew over there, do you think? Mmm.	
8.	**S:Cal: That's because there are lots of trees near there.**	
9.	T: There are, Caleb. So going back to the little white pebbles, what do people think that might have been in the sand?	Recast the question.
10.	**S:And: Um..**	
11.	T: Andy, what do you think?	Directed question.
12.	**S:And: Um.. well I've got another thing that.. well** [Interrupted]	
13.	T: Is this to do with Louise's point about the little white pebbles? [WT1] Because we can come back to your idea.	Wait time 1.
14.	T:I: Elice had a good idea, I think. Looks like it.	
15.	T: What do you think, Elice?	Asks another student for his/her ideas.
16.	**S:Eli: Well, I think that the little white pebbles that Louise saw were actually when the bark flew over they were little bits of wood and when they fell into the sand pit then… then some whiteness covered over it… so white bits in the sand covered over it so it looks like a pebble.**	
17.	T: Ahh… so it covered over the wood? Mm... now, those white bits of sand, do you think they could have been from the sand pit as well? Is that where you think they came from?	Clarify. Teacher uptake.

	[S:Eli nods]	
	OK.	
18.	**S:Eli: Because there's loads of wood chips over near where the road is.**	
19.	**S: Loads and loads.**	
20.	T: Umm.. OK.	Acknowledge only.
21.	**S:Eli: Where they went.. where there could be high school.**	
22.	T: Yep. So there are lots of wood chips over there? OK.	Clarify.
23.	**S:Eli: And they could have blown there.**	
24.	T: OK. Alright.	Acknowledge only.
25.	**S:Lou: I think Elice's idea and Caleb's are right.**	
26.	T: You think they're right? Yeah, I think they are really good ideas too.	Evaluate.
27.	**S:2: Me too.**	
28.	T: Mara, what do you have to add to our conversation? [WT1] Did you have a look in the microscope, Mara? [WT1] [S:Mar nods] What do you want to tell us then? [WT1]	Directed question. Asks another student for his/her ideas. Wait time 1.
29.	**S:Mar: I think that dirt...** [long pause] **has sand in it because dirt has sand in.**	
30.	T: Ah, OK. That is a really good idea, Mara. So we'll just let everyone know in case you didn't hear. Cyra and Adrian, can you make sure you are focussing on the meeting please?	Evaluate.
31.	**S:3: I like that idea.**	
32.	T: Mara said that she thinks the dirt that we saw had sand in it because dirt has sand in it. Is that what you said? [S:Mar nods] Because dirt is made of sand? [S:Mar nods] Mmm. So, so far we've got that the dirt that we found had sand in it, had sand bits, had wood chips and bits of bark from the wood [Interrupted]	Teacher restate. Reframe. Clarify. Refocus.
33.	**S:Zac: And bits of things that look like ice.**	
34.	T: And bits of things that look like ice. That's interesting. I want to explore that one a bit more, Zach.	Teacher restate.
35.	[S:Lar talks over teacher] **S:Lou: And little white.. and little white.. and little white pebbles.**	
36.	T: And little white pebbles. So, wow! There are lots of things so far that we've seen in our wood. Andy, did you have something else that you saw?	Teacher restate. Directed question. Asks another student

			for his/her ideas.
37.	**S:Zac: No, you mean.. you mean in the soil.**		
38.	**S:And: Yeah.**		
39.	T: Yeah, in the soil. Thanks for reminding me, Zach.		
40.	**S:4: I like Mara's id..** [Interrupted]	Ignore.	
41.	T: Andy?		
42.	**S:And: Well, one thing um… one time ah… when I was looking around in the black soil… well, some people said um... its... well, actually the microscopes... so the microscopes that makes the stuff bigger. It's not that they're pebbles. If you look out the microscope they're sand. So, it's the microscope that makes it bigger. It's not... it's nothing making... holding them up, that's what Zach suggested.**		
43.	T: Mmm.		
44.	**S:And: Zach said something was holding them up but they're not. They're just the microscopes are making them bigger. And I've got another one. When I was looking in the um... like dirt...**		
45.	T: Mmm.		
46.	**S:And: ...one time it was like a cliff.. was half of like a cliff clutter... a cliff cutter was... was going down the cliff and cutting half of the cliff. That's what it looked like with this shape in it.** [S:Ang demonstrates a half moon shape with his hands]		
47.	T: Mmm, OK.		
48.	**S:And: And um... the other time it looked like a... it looked like a normal cliff and** [Interrupted]		
49.	T: Quick, Dana, go. [Aside to a student wanting to go to the toilet]		
50.	**S:And: ...usually the square was black and there was a circle in there and there was a picture of the dirt, right, and then** [Interrupted]		
51.	[Students talk over one another]		
52.	T: Can you come in front of Mara, Dana? Dana, in front of Mara.		
53.	[S:And talks over the teacher] **S:And: … and then um... I'd look in there and there was a proper cliff and there might be those tiny, tiny, tiny, little bugs were trying to climb that dirt cliff.**		
54.	T: Did you see bugs in the microscope [Interrupted]	Clarify.	
55.	**S:And: No, but…** [Interrupted]		
56.	[Teacher talks over S:And] T: But you think there might have been some there?	Clarify.	
57.	[S:And talks over the teacher]		

	S:And: there might have been bugs because there were tiny… Um... and what else did I... And when I looked in this tiny, white sand pebbles... you put some water in it, it was really… actually really cool.	
58.	T: When we put water in it?	Clarify.
59.	**S:And: Yeah, and um... when you looked at it, it was quite a bit like iceblocks were about to melt. But they didn't actually melt, it was um... sand and... yeah, but we didn't… Zach, you're interrupting. Um... and... there was also a bit of like little tiny bugs climbing that pebble... white pebble cliff.** [WT2]	Wait time 2.
60.	T: OK.	Acknowledge only.
61.	**S:And: And that's all.**	
62.	T: OK, thanks Andy. I think it was interesting, Andy, that you said that there weren't white pebbles in there, that it was just making the sand look bigger. I thought that was an interesting point. And that's true that our microscopes actually make the things that we are looking at bigger, so that we can see them a bit closer. So people that have said that they saw pebbles, maybe it was just the sand that they saw that looks like pebbles. Is that what you meant, Louise?	Evaluate. Clarify.
63.	**S:Lou: Yeah, but I thought it made something look different.**	
64.	T: So, Andy said it looked bigger and Louise you think it looked different. Yeah? Maybe we need to go back to that microscope and have a look once again and see if we can have another look at it.	Teacher restate. Clarify.

Figure 5.4: Lesson 3 - the teacher used evaluate *to endorse students' ideas that were "on the right track" in Lesson 3.*

In this excerpt (Figure 5.4), Ben initially used the *evaluate* teacher discourse move to confirm some of the students explanations of what they had seen when they looked at their soil samples under the microscope. Earlier on in the discussion, Louise (S:Lar) had said that she had seen "tons of little wood things" (Video footage, 8/9/2009) and Caleb had suggested that these could be wood chips that had come off the nearby trees. Louise (S:Lar) also said that she had seen "little white pebbles" in the soil (Video footage, 8/9/2009) and Elice suggested that pieces of bark and little bits of wood had blown over into the sand pit and were covered in white sand which looked like pebbles. (S:Eli, turn 16, 18, 21, 23). Louise said she thought Elice's and Caleb's ideas were right (turn 25) and Ben agreed with her (coded *evaluate*, turn 26).

Later on in the discussion, Andy said that the microscope made objects look bigger and he suggested that the pebbles Louise thought she had seen were really grains of sand that simply looked bigger under the microscope (turn 42). At the end of a rather lengthy turn, where Andy disagreed with an observation that Zach had made earlier (turns 42 and 44) and then made several observations of his own (turns 46, 48, 50, 53, 55, 57, 59), Ben used the *evaluate* teacher discourse move to confirm his explanation that microscopes make things look bigger (*evaluate*, turn 62). Then he verified this idea with Louise to see if she also thought the pebbles she had seen could have been a magnified image of some sand (*clarify*, turn 62). Ben used the *evaluate* discourse move several more times in this discussion.

The range of discourse moves that Ben used in this lesson generated teacher-student exchanges comprising three- (T-S-T) and four-turn structures (T-S →T-S), but when he interacted with particular students to elicit their observations and explanations the interactions were comprised of six- (T-S →T-S →T-S) and eight-turn structures (T-S →T-S →T-S→T-S) and longer. Consequently, several lengthy chains of interaction were developed in this lesson.

Key Finding 5.26

In Lesson 3, Ben maintained the dual focus seen previously where he developed the dialogue with the students whilst also maintaining the conventions for talk. He used a similar range of teacher discourse moves to those he had used in previous lessons to elicit the students' observations and explanations (*teacher restate*, *clarify*, *teacher uptake, reframe, refocus*, *directed questions*, *ignore*, *acknowledge only* and *evaluate*). There were 6 instances of *wait time 1* in this lesson and 2 instances of *wait time 2*.

Utilising this range of discourse moves generated teacher-student exchanges comprising three- and four-turn structures, and frequently six- and eight-turn structures and longer. Several lengthy chains of interaction or cumulative talk were developed in this lesson.

Communicative approach

Since this lesson was an initial Explain lesson and not all the students had looked at their soil samples under the microscope, Ben was hesitant to make the scientific explanation explicit before they had a chance to do so.

> So I started to put some of that language in [the discussion] and started to pull out the children who were on the right track with the actual content information that I was after and I started to focus on their comments. But I was still happy for it to be almost like an Engage lesson as well, to continue to bring out some of their theories still. But I tried to…I am not sure how successful I was, but I tried to point out the difference between their theories and the ones that have the right information, who were on the right track. (PL 3 interview, 29/9/2009).

Consequently, Ben began the discussion using an Interactive-Dialogic style of interaction (Mortimer & Scott, 2003) as he elicited the students' experiences and observations of soil. He continued to use this approach even as he asked more probing questions and helped the students to develop explanations for what they had seen. However, Ben's interactive style did become a little more Interactive-Authoritative (Mortimer & Scott, 2003) when he wanted to endorse or make explicit an idea that was "on the right track" (PL 3 interview, 29/9/2009). Even though this shift in interactive style was only slight, it is consistent with the form of discourse required in the Explain phase when the teacher wishes to develop the scientific explanation of the science phenomenon that is under investigation. In this instance, the scientific explanation would continue to be developed over the course of several Explain lessons as the students continued to look at their soil samples under the microscope.

In this lesson, Ben achieved his purpose by initially asking *open-description* questions to elicit the students' observations, then *open-ideas* and *open-explanation~reason* questions to elicit their ideas and to develop explanations, and he asked *closed* questions as he shaped the discussion. Ben also used discourse moves such as: *teacher restate*, *clarify*, and *wait time* to support the students to think about and articulate their ideas; *teacher uptake,* and *reframe* to develop their explanations; *refocus* and *evaluate* to endorse particular ideas and to summarise their thinking; and *directed questions*, *ignore* and *acknowledge only* to manage the interaction.

Key Finding 5.27

In Lesson 3, an Explain lesson, Ben used an Interactive-Dialogic communicative approach which helped the students to share their observations and develop explanations. Ben's communicative approach shifted to become slightly more Interactive-Authoritative when he endorsed some of the students' ideas.

Proportions of teacher and student talk

In Lesson 3, Ben continued to utilise slightly more of the talk (58%) and the students slightly less (42%) in the class discussion.

Key Finding 5.28

In the whole-class discussion in Lesson 3, Ben utilised approximately 60% of the talk while the students utilised approximately 40% in the class discussion.

The students' role

In Lesson 3 a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

There were 20 *elaborated utterances* in Lesson 3. This represented another increase in elaborated utterances compared to previous lessons.

Quality of student talk

In Lesson 3, 65% of the students' responses were coded for *description*, 44% as *multistructural* and 21% as *unistructural*; 35% were coded for *explanation*; and none were coded for *reasoning*. The students continued to generate cumulative talk (Alexander, 2006) by building on each other's ideas.

Ben was a quite pleased with the level of student participation in this discussion even though there were some students who had not yet engaged with the microscopes during the Explore phase. He thought their contributions to the discussion were very useful and, while some were a little tangential, he thought most the students' contributions were also very relevant (PL 3 interview, 29/9/2009). At this point in the intervention, he felt that the students were well able to sustain conversations, particularly when they had the chance to engage with a topic of interest to them which

connected to their own questions and the activities they were working on in the classroom. "I think they can sustain conversation for a very long time, and really quality conversation as well" (PL 3 interview, 29/9/2009).

Key Finding 5.29

There were 20 *elaborated utterances* in Lesson 3 and 65% of the students' responses were coded for *description* (44% as *multistructural* and 21% as *unistructural*), 35% were coded for *explanation* and none were coded for *reasoning*. The students gave explanations and continued to build on each other's ideas and generating cumulative talk.

Lesson 3 summary

Lesson 3 was an Explain lesson for the topic What Plants Need to Grow. Ben did not use puppets in this lesson. He supported the students to share their observations about soil and to develop explanations for what they saw. Ben predominantly utilised an Interactive-Dialogic approach as he elicited the students' observations and explanations, and a slightly more Interactive-Authoritative approach when he endorsed some of their ideas. He continued to focus on building the dialogue with the students as well as maintaining and developing their use of the conventions for talk.

During the discussion, Ben asked some *open-description* questions to elicit the students' observations, a combination of *open-ideas* and *open-explanation~reason* questions to work on their explanations, and *closed* questions to clarify the students' ideas and to shape the discussion. He used similar discourse moves to those used in previous lessons, specifically: *teacher restate*, *clarify*, and *wait time* to support the students to think about and articulate their ideas; *teacher uptake*, and *reframe* to develop their explanations; *refocus* to accumulate or summarise the students' ideas; *evaluate* to endorse particular ideas; and *directed questions*, *ignore* and *acknowledge only* to manage the interaction. Utilising the discourse moves in this way generated teacher-student exchanges comprising three- (T-S-T) and four-turn structures (T-S →T-S), and frequently six- (T-S →T-S →T-S) and eight-turn structures (T-S →T-S →T-S→T-S) and longer. Additionally, several lengthy chains of interaction developed, thus generating cumulative talk.

Even though Ben utilised a little more of the talk time than the students in Lesson 3, the number of elaborated students' responses increased again in this lesson. The students continued to build on each other's contributions and quite a number of their responses were coded for *multistructural descriptions* and *explanation*.

Mid-intervention: Ben's beliefs, knowledge and practice

On the third PL day in August 2009, the teachers participating in the professional learning intervention were asked to review their management of classroom discourse during the implementation of the initial science topic. For Ben, this related to the What Plants Need to Grow topic referred to in Lessons 2 and 3 of this case study.

Knowledge about managing classroom discourse
The data collected from the review showed that Ben thought he had been successful at keeping his class meetings focused and using *wait time* to give the students time to think and *elaborate* to get them to say more (PLD 3: Review, 24/08/09). He thought he had also been successful at using students' ideas, which initially seemed tangential to the discussion, as a springboard for talk in subsequent class meetings (PLD 3: Review, 24/08/09). He thought that the students use of conventions for talk, such as sitting in a circle and using Thinking Thumbs, helped to keep the discussion more focused and that class discussions worked well because time was dedicated to it (PLD 3: Review, 24/08/09).

Ben perceived that it was his job as facilitator of the class meeting to make a space in the discussion for students who were less verbal or confident to contribute, and to remind those students who were more verbal that they needed to share the time for talk (PLD 3: Review, 24/08/09). He said that he had found it tricky to ensure that less verbal or confident students actually joined in the discussion and he often had to follow them up after a meeting to talk with them one-on-one (PLD 3: Review, 24/08/09).

The review completed on PL Day 3 also asked that the teachers to rate the extent to which they had been able to develop a classroom culture that was supportive of productive talk. The teachers had to rate (0-100%) the extent to which they had developed five characteristics of productive classroom talk (Alexander, 2008) and five ground rules for effective talk (Mercer, 2008). With regard to the characteristics of productive classroom talk (Alexander, 2008), Ben indicated that he was most successful in creating a classroom culture to do with talk that was *collective* (100%), *reciprocal* (100%), *supportive* (100%), and *cumulative* (100%) (PLD 3: Review, 24/08/09). He also indicated that, thus far in the professional learning intervention, he was slightly less successful at developing classroom talk that was *purposeful* (70%) (PLD 3: Review, 24/08/09).

Regarding the ground rules for effective talk (Mercer, 2008), Ben indicated that he was most successful in creating a classroom culture in which the students shared and listened to each other's ideas (100%) and gave reasons to explain their ideas (100%) (PLD 3: Review, 24/08/09). He also indicated that he had been very successful at getting the students to respect each other's opinions (90%) and to ask "why" when they disagreed (90%), and only slightly less successful at getting them to talk one at a time (80%) (PLD 3: Review, 24/08/09).

Ben thought getting the students to speak one at a time had been the characteristic of classroom culture which had been the most difficult to establish because of the age of his students (PLD 3: Review, 24/08/09). He also felt that he had made the greatest improvement in getting the students to ask "why" when they disagreed because he had modelled this for them (PLD 3: Review, 24/08/09).

Key Finding 5.30

At the mid-intervention review, Ben thought he had been successful at keeping his class meeting focused and using *wait time* and *elaborate* during discussions. He thought sitting in a circle formation and using a Thinking Thumb had helped the students to stay focused during the discussion. He also thought that his class discussions had improved because he had devoted time to them.

Ben indicated that he was most successful in creating a classroom culture to do with talk that was *collective* (100%), *reciprocal* (100%), *supportive* (100%), and *cumulative* (100%) and slightly less successful at developing classroom talk that was *purposeful* (70%).

He also indicated that he was most successful in creating a classroom culture in which the students shared and listened to each other's ideas (100%), gave reasons to explain their ideas (100%), respected each other's opinions (90%), and asked "why" when they disagreed (90%). He indicated he was only slightly less successful at getting the students to talk one at a time (80%).

Knowledge about using puppets

The review undertaken on the PL Day 3 also invited the teachers to reflect on their use of puppets during the implementation of the initial science topic. Ben had introduced two small dog puppets to the students and used them in short individual or small group interactions as a way for the students to talk about what they had been doing during the Explore phase of an inquiry (PLD 3: Review, 24/08/09). At this stage of the intervention, he felt he needed to develop more confidence with using the puppets before he used them with the whole class and he was more comfortable in using just one puppet at a time (PLD 3: Review, 24/08/09). Ben had also found it difficult to find a reason to use the puppets in his class discussions because he thought his class used discourse well and there was little need for the puppets to assist in this process (PLD 3: Review, 24/08/09). Ultimately, Ben did not use the puppets in any lessons associated with the professional learning intervention.

Following PL Day 3, data was gathered from two more of Ben's science lessons. Lesson 4 was filmed in late October, eight weeks after PL Day 3, and was an Engage lesson for a new teacher-authored topic called The Function and Form of Plants. Subsequently, Lesson 5 was filmed in early December and was an Explain lesson for the same topic. The data from video, classroom observation and follow up interviews are presented in the next part of this chapter.

Lessons 4, post Professional Learning Day 3

The lesson

The new topic, The form and function of plants, addressed science concepts related to the Life and Living strand of the science syllabus (MCEETYA, 2006) and built on the previous two topics that Ben had implemented earlier in the year. This topic aimed to further develop the students' understandings about the various the parts of a plant and the functions they perform.

Lesson 4 was called Proscope and in this lesson Ben used a proscope (a hand-held high resolution digital microscope) to look at some seedlings the students had grown. Greatly magnified images of the seedlings were projected onto a screen and Ben used these as a stimulus for discussion. In this lesson, he wanted the students to describe each seedling, to share their ideas about the function of its various parts, and to articulate their questions so that he could plan the next steps of the investigation. The lesson involved the whole-class discussion and individual work where the students

189

drew their seedlings and labelled its parts. The data analysis for this lesson centred on the whole-class discussion that was generated via the proscope.

The setting

Ben did not use puppets in this lesson. He initiated the discussion by demonstrating the proscope, showing the students how it could be used to greatly magnify an image. When he began to focus on the students' seedlings, Ben invited the students to make some observations and to share their ideas about what they could see (Video footage, 28/10/2009). The teaching intern recorded the students' ideas on a clipboard as the discussion proceeded (Video footage, 28/10/2009).

Ben held this lesson in the school library. The teacher intern and 20 students sat in a semi-circle on a mat facing the projector screen and Ben sat to the right of the screen facing the students (Video footage, 28/10/2009). He held the proscope, which was attached to his laptop and connected to the projector screen. The students were very excited and curious about the proscope (Video footage, 28/10/2009). As well as maintaining the speaking conventions described in previous lessons, Ben encouraged the students to take responsibility for "finding a space to talk" during the discussion (Video footage, 28/10/2009).

Key Finding 5.32

Ben used a proscope to stimulate discussion about seedlings in Lesson 4. He wanted to elicit the students' descriptions, their ideas about the function of a seedling's various parts, and their questions for investigation. The class sat in a semi-circle on the mat area of the library. They used the speaking conventions seen in previous lessons and Ben encouraged the students to take responsibility for "finding a space to talk" during the discussion.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In Lesson 4, Ben asked a few *open-description questions* to elicit the students'
descriptions of their seedlings but more frequently he asked *open-ideas* questions to
find out what they thought the different parts of the seedlings were for. He also asked
some *open-explanation~reason questions* when he probed their ideas and *closed*
questions when he used discourse moves *clarify*, *prompt and scaffold* or *teacher
uptake*.

The analysis showed that Ben asked a total of 59 initiating questions in this discussion.
Of these questions, 38 (64%) were classified as *open-ideas*; ten (17%) were *closed*
questions; nine (15%) were *open-explanation~reason* questions; and two (3%) were
classified as *open-description* questions.

Key Finding 5.33

Ben asked a total of 59 initiating questions in the whole-class discussion in Lesson 4.
Of these, approximately 65% were *open-ideas* questions, 20% were *closed* questions
and a further 15% were *open-explanation~reason* questions.

Teacher discourse moves

The analysis of the discussion in Lesson 4 showed that once Ben began to elicit the
students' observations and ideas about the parts of the seedlings he tended to use
similar discourse moves to those he had used in previous lessons. More specifically,
after asking an initiating question he used: *teacher restate, clarify* and *wait time* (two
instances) to support the students to think about and articulate their ideas, and *reframe*
to improve their expression; *teacher uptake* and *elaborate* to explore the students'
ideas; and *refocus* to accumulate their ideas and summarise what they had said. Ben
continued to manage the interaction by asking *directed questions* and using *evaluate* to
endorse particular ideas, *as well as ignore* and *acknowledge only* to accept an idea
without examining it further.

In this lesson, the teacher-student interactions generated were mostly comprised of
three- (T-S-T) and four-turn structures (T-S →T-S). Compared to previous lessons,

there were fewer interactions that were comprised of six- (T-S →T-S →T-S) and eight-turn structures (T-S →T-S →T-S→T-S) and fewer chains of interaction were developed.

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Key Finding 5.34

In Lesson 4, Ben used similar discourse moves to those he had used in previous lessons (*restate, teacher restate*, *clarify*, *elaborate*, *teacher uptake, refocus*, *evaluate, prompt and scaffold, directed questions*, *ignore*, *acknowledge only, moves on)*. There were two instances of *wait time* in this lesson. The teacher-student interactions that were generated were mostly comprised of three- and four-turn structures and, compared to previous lessons, fewer chains of interaction were developed.

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Communicative approach

The discussion in Lesson 4 was mostly driven by *open-ideas* questions, as well as some *open-explanation~reason* questions and a few *open-description* questions. The communicative approach would be classified as Interactive-Dialogic (Mortimer and Scott, 2003) as Ben sought to elicit the students' descriptions of seedlings and understandings of the function of their various parts. As such, this is an appropriate form of interaction for an Engage lesson when the teacher wishes to determine the students' existing ideas and questions about a topic.

In this lesson, Ben achieved his purpose by initially asking a few *open-description* questions to elicit the students' observations, then *open-ideas* and *open-explanation~reason* questions to explore their ideas and develop explanations of their observations. Ben also asked *closed* questions as he shaped the discussion and he used the same kinds of discourse moves seen in previous lessons explore the students' ideas and manage the interaction.

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Key Finding 5.35

Lesson 5 was an Engage lesson and Ben utilised an Interactive-Dialogic communicative approach to support the students to share their ideas.

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Proportions of teacher and student talk

In Lesson 4, the proportions of teacher and student talk were approximately equivalent but compared to the last lesson, the level of student talk increased slightly (51% of the total characters of the discussion transcript) and the level of teacher talk decreased slightly (49% of the total characters of the discussion transcript).

Key Finding 5.36

In Lesson 4, the proportions of teacher (49%) and student talk (51%) were approximately the same.

The students' role

In Lesson 4, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

In Lesson 4, there were 17 *elaborated utterances* (100 or more characters in the transcript), which is slightly less than in Lesson 3. There was some evidence of cumulative talk (Alexander, 2006) in this lesson.

Quality of student talk

The students' responses in the discussion were predominantly coded for *description*. In total, 58% were coded as *description*, 47% as *unistructural* and 11% as *multistructural;* and the remaining 42% were coded as *explanation*.

Key Finding 5.37

There were 17 *elaborated utterances* in Lesson 4 and 58% of the students' responses were coded as *description* (47% as *unistructural* and 11% as multistructural) and the remaining 42% were coded as *explanation*. There was some evidence of cumulative talk in this lesson.

Lesson 4 summary

Lesson 4 was an Engage lesson for the new topic, The form and function of plants. Ben used a proscope to show the students enlarged images of their seedlings as a way to stimulate discussion. The purpose of the discussion was to elicit the students' descriptions and ideas about the function of the parts of the seedlings, and to find out their questions for further investigation.   Ben used an Interactive-Dialogic style of interaction; asking a few *open-description* questions to elicit the students' observations, and then *open-ideas* and *open-explanation~reason* questions to elicit their ideas and develop explanations of their observations. Ben also asked *closed* questions as he shaped the discussion and he used the same kinds of discourse moves seen in previous lessons to explore the students' ideas and manage the interaction.

Ben and the students shared approximately the same amount of talk time in this lesson, and, while this was a slight increase for the students, they gave fewer elaborated responses and engaged in less cumulative interactions compared to previous lessons. The great majority of their responses were classified as either *unistructural descriptions* or *explanation*.

Lesson 5, post Professional Learning Day 3

The lesson

Lesson 5 was videoed approximately five weeks after Lesson 4, and was a lesson in the Explain phase of the investigation for the topic The form and function of plants. In the Explore phase of the investigation, the students had placed some climbing bean seeds onto wet cotton wool inside Snaplock plastic bags, which had then been taped to one of the classroom's sliding doors (Lesson 5 Observation Record, 1/12/2009). Most of the seeds had sprouted and grown into seedlings but there were mixed results. Some of the seedlings were growing well, some needed a frame to support their further growth, and some had received too much exposure to the Sun and were beginning to die (Lesson 5 Observation Record, 1/12/2009). In this discussion, Ben wanted the students to explain their results and to consider what conditions the seedlings required

to grow well (Lesson 5 Observation Record, 1/12/2009). The data analysis for this lesson focused on this whole-class discussion.

The setting

Ben initiated the discussion by reviewing how well the students' seeds had grown and he invited them to share their observations and to develop some explanations for their results (Video footage, 1/12/2009). As the discussion progressed, The Teacher Intern recorded the students' ideas on a clipboard (Video footage, 1/12/2009).

As in previous lessons, Ben, the Teacher Intern and the 22 students sat in a circle on the floor in the mat area of the classroom (Video footage, 1/12/2009). At the start of the discussion, Ben informed the students that they did not need to use their Thinking Thumbs in this lesson and that, when they had an idea, they should look around to see who was speaking and find a space in the discussion to talk (Video footage, 1/12/2009) Ben still managed the discussion by nominating speakers and prompting the students to maintain their focus and to respect each other by listening and sharing turns (Video footage, 1/12/2009).

Key Finding 5.38

The discussion in Lesson 5 focused on the students' observations and explanations about the growth of their seedlings. The teacher, the Teacher Intern and the students sat in a circle on the mat. Ben asked the students to try to find a space in the discussion to talk rather than using their Thinking Thumbs when they had an idea to share. Ben still managed the discussion by nominating speakers and prompting the students to maintain their focus and to respect each other by listening and sharing turns.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In Lesson 5, Ben asked *open-description* questions to review what the students had done and to find out how their seeds had sprouted, and he asked *open-explanation~reason* questions to find out why. He also asked *open-ideas* questions to elicit the students' interpretations of their observations, their ideas about what to do next, and their predictions about their seedlings future growth. In this lesson, Ben asked *closed* questions when he wanted to narrow the focus of the discussion and when he used the discourse moves *clarify*, *prompt and scaffold* or *teacher uptake*.

The analysis of this discussion showed that Ben asked a total of 26 initiating questions. Of these, 11 (42%) were classified as *closed* questions; eight (31%) were classified as *open-ideas*; four (15%) were classified as *open-explanation~reason* questions; and three (12%) were *open-description* questions.

Key Finding 5.39

In the whole-class discussion in Lesson 5, Ben asked a total of 26 initiating questions of which approximately 40% were *closed* questions, 30% were *open-ideas* questions and a further 30% were either *open-explanation~reason* or *open-description* questions.

Teacher discourse moves

In Lesson 5, Ben wanted the students to describe how their seeds had sprouted and to develop scientific explanations about why some had sprouted and some had not (PL 5 interview, 4/12/2009). As in previous lessons, Ben maintained a dual focus by developing the dialogue with the students whilst also maintaining the conventions for talk. He also used many of the same teacher discourse moves seen in previous lessons to elicit the students' observations (*teacher restate, clarify, reframe*); to probe their ideas and seek explanations (*teacher uptake, prompt and scaffold*); and to shape and manage the discussion (*directed questions, refocus, ignore, acknowledge only*). Ben did not use *wait time* or *extended thinking time* in this lesson. On one occasion he used the teacher discourse move *evaluate* to reinforce a particular point, but more generally he drew attention to key ideas by speaking explicitly about them (using an Interactive-Authoritative approach).

The teacher-student interactions generated in this discussion were similar to the previous lesson in that they were mostly comprised of three- (T-S-T) and four-turn structures (T-S →T-S) and some six-turn structures (T-S →T-S →T-S). There were a few longer interactions with some students when Ben wanted to establish how they had planted their seeds.

Key Finding 5.40

In Lesson 5, Ben used many of the same teacher discourse moves seen in previous lessons to elicit the students' observations and explanations (*teacher restate*, *clarify*, *elaborate*, *teacher uptake, reframe, refocus*, *recast the question, prompt and scaffold, evaluate, directed questions*, *ignore*, and *acknowledge only, moves on*). Ben did not use *wait time* or *extended thinking time* in this lesson. He used *evaluate* once to reinforce a particular point, but more generally he drew attention to key ideas by speaking explicitly about them (using an Interactive-Authoritative approach).

The teacher-student interactions that were generated were mostly comprised of three- and four-turn structures and some six-turn structures.

Communicative approach

Ben was much more explicit in the way that he talked about the key ideas in this lesson. He began the discussion using an Interactive-Dialogic style of interaction (Mortimer & Scott, 2003) as he elicited the students' experiences and observations about their seedlings but, at certain points in the discussion, he began to use an Interactive-Authoritative approach (Mortimer & Scott, 2003) when he asked more probing questions and helped the students to develop explanations for what they had seen. His interactive style also became more Interactive-Authoritative (Mortimer & Scott, 2003) when he wanted to make an idea explicit. This shift in interactive style was much more evident than in the previous Explain lesson, Lesson 3, and is consistent with the form of discourse required in the Explain phase when the teacher wishes to develop a scientific explanation. In the Post Lesson 5 interview, Ben explained that it was important to utilise a more Authoritative communicative approach so that the students' ideas were synthesised concisely using the correct scientific language and that they heard a coherent scientific explanation at the end of the learning experience (PL 5 interview, 3/2/2010).

In this lesson, Ben achieved his purpose by initially asking some *open-description* questions to elicit the students' observations, and *open-ideas* and *open-explanation~reason* questions to elicit their ideas and to develop explanations. He also asked *closed* questions as he shaped the discussion. Ben used discourse moves such as: *teacher restate* and *clarify* to help the students articulate their ideas; *teacher uptake,* and *prompt and scaffold* to help them develop their explanations; *refocus* and *evaluate* to endorse particular ideas and to summarise their thinking; and *directed questions*, *ignore* and *acknowledge only* to manage the interaction.

Key Finding 5.41

The communicative approach in Lesson 5 was initially Interactive-Dialogic as Ben elicited the students' observations and ideas and it became more Interactive-Authoritative when Ben wanted to make key ideas explicit or he supported the students to develop explanations.

Ben thought it was important to use a more Authoritative communicative approach to synthesise the students' ideas and to use the correct scientific language to develop a coherent scientific explanation.

Proportions of teacher and student talk

In Lesson 5, the proportions of teacher and student talk reverted to the ratios seen earlier in Lesson 2, where Ben utilised a large percentage of the talk time (66% of the total characters of the discussion transcript) and the level of the student contributions was reduced (34% of the total characters of the discussion transcript).

Key Finding 5.42

In the whole-class discussion from Lesson 5, Ben utilised 66% of the talk time and the students utilised 34%.

The students' role

In Lesson 5, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

In Lesson 5, there were 9 *elaborated utterances* (100 or more characters in the transcript), which is a significant drop compared to previous lessons. There was evidence in this lesson that the students continued to generate cumulative talk (Alexander, 2006) by building on each others' ideas.

Quality of student talk

The students' responses to whole-class discussion were mostly coded for *description*. In total, 58% were coded as *description*, 49% were coded as *unistructural* and 9% as *multistructural;* 40% as *explanation*; and 2% as *reasoning*. These results are very similar to those from previous Explain lesson in Lesson 3 where most of the student responses were also coded as *unistructural descriptions* or *explanations*.

Key Finding 5.43

There were nine *elaborated utterances* in Lesson 5. In total, 58% were coded as *description*, 49% were coded as *unistructural* and 9% as *multistructural;* 40% as *explanation*; and 2% as *reasoning*. In Lesson 5, the students continued to generate cumulative talk.

Lesson 5 summary

Lesson 5 was an Explain lesson for the topic The form and function of plants and Ben wanted the students to explain the results of their experiments and to consider what conditions their seedlings needed to grow well. When Ben wanted to elicit the students' experiences and observations of their seedlings he utilised an Interactive-Dialogic style of interaction where he asked *open-description* and *open-ideas* questions and used discourse moves such as *teacher restate, clarify,* and *elaborate*. When he wanted to reinforce particular ideas or to elicit the students' explanations, Ben's approach became more Interactive-Authoritative and he asked more *open-explanation~reason* and *closed* questions, and used discourse moves such as *teacher uptake, prompt and scaffold, evaluate, reframe,* and *refocus*. In addition, Ben used *directed questions*, *ignore* and *acknowledge only* to manage the interaction.

In this lesson, Ben achieved his purpose by initially asking some *open-description* questions to elicit the students' observations, and *open-ideas* and *open-explanation~reason* questions to elicit their ideas and to develop explanations. He also asked *closed* questions as he shaped the discussion. Ben used discourse moves such as: *teacher restate* and *clarify* to help the students articulate their ideas; *teacher uptake,* and *prompt and scaffold* to help them develop their explanations; *refocus* and *evaluate* to endorse particular ideas and to summarise their thinking; and *directed questions*, *ignore* and *acknowledge only* to manage the interaction. This tended to generate teacher-student interactions that were mostly comprised of three- (T-S-T) and four-turn structures (T-S →T-S) and some six-turn structures (T-S →T-S →T-S).

Although Ben utilised most of the talk time in this lesson, the students still gave elaborated responses and were able to generate cumulative talk (Alexander, 2006). Their responses were predominantly comprised of *unistructural descriptions* and *explanations.*

Post intervention: Ben's beliefs, knowledge and practice

On the final professional learning day in November 2009, the teachers participating in the professional learning intervention were asked to complete a questionnaire that captured data to do with: teacher beliefs about teaching science; teacher confidence with teaching science; teacher knowledge about managing classroom discourse; teacher knowledge about questioning; and, teacher knowledge about using puppets.

Beliefs about teaching science
The data collected from the final teacher questionnaire and the final teacher interview provided evidence of Ben's beliefs about the teaching of science. He identified the three most important characteristics of effective science teaching practice were to do with: discourse, questioning, science talk and pure discussion; an emergent, contextual, student-centred environment; and, explorative, hands-on experiential learning (Final teacher questionnaire, 16/11/09).

Additionally, Ben believed that the three most important characteristics of inquiry-based science teaching and learning were the: identification of the phase of inquiry; whole-class discourse, including quality questioning; and real life, contextual learning experiences (Final teacher questionnaire, 16/11/09).

Key Finding 5.44

Following the professional learning intervention, Ben believed the three most important characteristics of effective science teaching practice were to do with discourse (questioning, science talk and pure discussion); an emergent, contextual, student-centred environment; and, explorative, hands-on experiential learning.

He also believed that the three most important characteristics of inquiry-based science teaching and learning related to the identification of the phase of inquiry; whole-class discourse, including quality questioning; and, real life, contextual learning experiences.

Confidence with teaching science

The data collected from the final teacher questionnaire showed that Ben felt an increased confidence for: 'Using computers and ICTs in science' (initially rated as 'OK' and subsequently as 'Very confident'); 'Teaching science processes' (initially rated as 'Confident' and subsequently as 'Very confident'); 'Explaining science concepts' and 'Developing literacy skills needed for science learning' (both initially rated as 'OK' and subsequently as 'Confident'); and 'Assessing children's learning in science' (initially rated as 'Limited confidence' and subsequently as 'OK') (Final teacher questionnaire, 16/11/09).

Ben continued to rate himself as: 'Very confident' for 'Using a constructivist model to plan science units of work' and 'Confident' for 'Managing hands-on group activities in science' and 'Managing discussions and interpretation of science observations' (Final teacher questionnaire, 16/11/09). However, he rated himself as less confident for 'Engaging students' interest in science' (initially rated as 'Very confident' and subsequently as 'Confident') (Final teacher questionnaire, 16/11/09).

The final mean scale score for confidence with teaching science strategies for all of the teachers involved in the professional learning intervention was 4.21/5, which is greater

than the mean confidence scale score of 3.88 for a group of *Primary Connections* trial teachers who had participated in five days of professional learning and taught some *Primary Connections* units (Hackling & Prain, 2005). In comparison, Ben's final mean scale score for confidence with teaching science strategies was 4.2/5, which was close to the mean scale score for teachers involved in the professional learning intervention and greater than the mean scale scores for teachers involved in the *Primary Connections* trial.

Key Finding 5.45

After the intervention, Ben felt an increased confidence for teaching science processes, explaining science concepts, developing the literacy skills needed for learning science, using computers and ICTs, and assessing children's learning. He remained very confident in using a constructivist model to plan science units, and he remained confident for managing hands-on group activities in science, and managing discussions and interpretation of science observations. However, he felt less confident with engaging students' interest in science. His final mean scale score for confidence with teaching science was 4.2/5.

Beliefs about being an effective manager of classroom talk

The data from final teacher questionnaire showed that Ben continued to believe he was an effective manager of classroom talk. He retained his level of self-efficacy for seven aspects of managing classroom discussions, including: establishing an appropriate classroom climate; responding to students in ways that support the effective discussion of science ideas; drawing on a rich knowledge of science to ask the right questions; responding to students in ways that maintain and promote discussion of science ideas; being effective in engaging most students in responding to questions; being able to sustain discussions in order to thoroughly discuss science ideas; and being effective in using questioning to identify students' prior knowledge and understandings (Final teacher questionnaire, 16/11/09).

Additionally, Ben reported an increased level of self-efficacy for the remaining five aspects of managing classroom discussions (Final teacher questionnaire, 16/11/09). This included: using wait time (initially rated 3/5 and subsequently 5/5); asking questions to suit the purpose of discussions (initially rated 4/5 and subsequently 5/5);

having a rich knowledge of science that helps in responding to students (initially rated 4/5 and subsequently 5/5); encouraging and supporting students to ask questions (initially rated 4/5 and subsequently 5/5); varying the type of talk to match the instructional purpose of the phases of inquiry (initially rated 3/5 and subsequently 4/5) (Final teacher questionnaire, 16/11/09).

The final mean scale score for being an effective manager of classroom talk for all of the teachers involved in the professional learning intervention was 4.09/5. In comparison, Ben's final mean scale score was 4.5/5, which is greater than the mean scale scores for the group of teachers involved in the professional learning intervention.

Key Finding 5.46

Ben continued to believe that he was an effective manager of classroom talk and he retained his level of self-efficacy for seven aspects of managing classroom discussions. Additionally, he indicated an increased level of self-efficacy for using *wait time*; asking questions to suit the purpose of discussions; having a rich knowledge of science that helps in responding to students; encouraging and supporting students to ask questions; and varying the type of talk to match the instructional purpose of the phases of inquiry. His final mean scale score for being an effective manager of classroom talk was 4.5/5 which was greater than the mean scale scores for the group of teachers involved in the professional learning intervention.

Knowledge about managing classroom discourse

The data collected from the final teacher questionnaire also provided evidence of Ben's understandings about how to manage classroom discourse in order to facilitate students' learning in primary science lessons. He thought that questioning and classroom discussions helped students' learning because they facilitated the social construction of knowledge and set up the students as co-constructors of their own learning (Final teacher questionnaire, 16/11/09).

Ben thought that good classroom discussion was the product of an open, safe and caring environment, where all members interacted and contributed ideas, and the teacher used "great and varied questioning" (Final teacher questionnaire, 16/11/09).

Ben stated that he varied his questioning and discussion style at different phases of a science lesson or topic. He thought he varied his questioning and discussion style by asking for more information from the students, and by exploring their ideas deeply and seeking explanations in the early phases of an investigation. He thought he was more directional and asked more guiding questions during the later phases. (Final teacher questionnaire, 16/11/09).

Key Finding 5.47

Ben thought questioning and classroom discussions helped students' learning because they facilitated the social construction of knowledge and set up the students as co-constructors of their own learning.

He thought that good classroom discussion was the product of an open, safe and caring environment, where all members interacted and contributed ideas, and the teacher used "great and varied questioning".

Ben thought he varied his questioning and discussion style by asking for more information from the students and by exploring their ideas deeply and seeking explanations in the early phases of an investigation. He thought he was more directional and asked more guiding questions during the later phases.

Knowledge about using puppets

In the final teacher questionnaire, Ben stated that he had not used the puppets very much at all during the professional learning intervention (Final teacher questionnaire, 16/11/09). He felt that when he had tried to use the puppets they detracted from the focus of the lesson and were more of a distraction during discussions (Final teacher questionnaire, 16/11/09). Ben thought that when he did use the puppets they replaced rather than complemented his role in the discussion (Final teacher questionnaire, 16/11/09).

Ben reported that he had difficulty establishing a connection between the students and the puppets and that he could not find a purpose for them in his whole-class discussions (Final teacher questionnaire, 16/11/09). He thought they had made very little impact on the level of student engagement or talk because he had hardly used them (Final teacher questionnaire, 16/11/09). However, Ben indicated that his level of

confidence for using puppets in his science teaching was okay (rated 3 on a scale of 5 indicators) (Final teacher questionnaire, 16/11/09).

Key Finding 5.48

Ben had hardly used the puppets at all during the professional learning intervention. He felt that they detratcted from the focus of the lesson and were distracting. He thought that the puppets replaced rather than complemented his role in the discussion.

Ben had difficulty establishing a connection between the students and the puppets or finding a purpose for them in his class discussions. He thought the puppets had made very little impact on the level of student engagement or talk in his class given the lack of use. However, he indicated that his level of confidence for using puppets in his science teaching was okay.

Participation in the professional learning intervention

At the start of the professional learning intervention, Ben stated that he wished to participate in the project because he wanted to learn how to develop and plan a science topic based on the students' initial understandings of concepts (Initial teacher questionnaire, 02/06/09). More specifically, he wanted to be able to focus his teaching so that he was able to develop clear learning outcomes for science (PL 3 interview, 29/9/2009). Additionally, Ben chose to participate in the professional learning intervention because he wanted to be involved in a project that he felt would help teachers to engage with science more in their classrooms (PL 3 interview, 29/9/2009).

Ben thought his participation in the professional learning intervention had helped him to engage more as a reflective teacher and that it had given him "research and didactic tools for practices he was already utilising" (Final teacher questionnaire, 16/11/09). He thought his participation in the intervention had impacted on the quality of talk in his classroom because it had helped him to understand the theory behind the way he managed the talk in his class and to identify the kinds of talk that his students engaged in (Final teacher questionnaire, 16/11/09).

While Ben used an inquiry model as the basis for most of his classroom teaching, he had indicated part way through the intervention that he wanted to develop his

understandings about how to use the 5Es inquiry learning model (Hackling et al., 2007) in his science lessons and, more particularly, how to match his style of interaction to the appropriate phase of inquiry (PL 3 interview, 29/9/2009).

> I think I need to continue to identify the phases in which the children are working and also the phases of inquiry that I'm asking them to be involved in and how they interact, because I guess I've been aware of the phases but seen them almost as isolated incidents. So seeing the 5Es not as the five [phases] that you need to do but that you can go back and forth between [them]. And linking them to the way I work as a teacher generally, and seeing the similarities. (PL 3 interview, 29/9/2009)

At the end of the professional learning intervention, Ben stated that he would like to continue to work on matching the appropriate communicative approach to the different phases of a science investigation (Final teacher questionnaire, 16/11/09).

Key Finding 5.49

Ben initially became involved in the professional learning intervention because he wanted learn how to plan a science topic based on the students' initial understandings of concepts and to develop specific learning outcomes for his students in science. He also wanted to be involved in a project that would help teachers to engage with science more in their classrooms.

Ben felt his participation in the project, had helped him to become a more reflective teacher, and given him the "research and didactic tools for practices he was already utilising". He also thought his involvement in the project had helped him to understand the theory underpinning the way he managed classroom talk, and to identify the kinds of talk that his students engaged in.

Ben indicated that he wanted to continue to develop his understandings about how to use the 5Es inquiry learning model in science and how to match his style interaction to the appropriate phase of inquiry.

Summary

This chapter has explored Ben's involvement in the professional learning opportunity and the impact this has had on the way that he managed discussions in science. Key findings have highlighted the contextual factors, beliefs and understandings that may influence his teaching and also how he managed class discussions in practice.

Teacher beliefs and knowledge

Beliefs about teaching science

Ben retained a number of his beliefs about effective science teaching that he had articulated at the start of the professional learning intervention. He believed that it was important for science teaching to be emergent, explorative and student-directed (KF 5.4; KF 5.44). Ben also believed that teachers should plan investigations that align with students' interests and questions, and that the learning should be contextualised, hands-on, and connected to the students' real life and place-based experiences (KF 5.4; KF 5.44).

Ben believed that discussion was an important characteristic of inquiry-based science teaching and learning, particularly when it was facilitated by the teacher, supported students' to develop their ideas, and incorporated quality questioning (KF 5.4; KF 5.44). Later in the intervention, Ben began to believe that identifying the phase of inquiry was also important to inquiry-based science teaching and learning (KF 5.44).

Assertion 5.1

As Ben participated in the professional learning intervention, he came to believe that it was important to identify the phase of inquiry in inquiry-based science teaching.

Confidence to teach science

At the start of the professional learning intervention, Ben considered himself a very confident teacher of primary science and for managing class discussions but his mean scale score for confidence with teaching science strategies was lower than that for all the teachers involved in the intervention (KF 5.5). By the end of the professional learning program, his level of confidence had increased considerably, particularly for teaching science processes, explaining science concepts, developing the literacy skills needed for learning science, using computers and ICTs, and assessing children's learning (KF 5.45).

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Assertion 5.2

Ben retained a high level of confidence for managing class discussions and his confidence as a teacher of primary science increased as a result of his participation in the professional learning intervention.

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Beliefs about being an effective manager of classroom talk

Although Ben believed he was an effective manager of classroom talk (KF 5.6) at the start of the professional learning intervention, he was also uncertain about how effective he was in using *wait time* or in varying his style of talk to match the instructional purpose of the phase of inquiry. At the end of the professional learning intervention, Ben retained his self-efficacy for seven aspects of managing classroom discussions, including: establishing an appropriate classroom climate; responding to students in ways that support the effective discussion of science ideas; drawing on a rich knowledge of science to ask the right questions; responding to students in ways that maintain and promote discussion of science ideas; being effective in engaging most students in responding to questions; being able to sustain discussions in order to thoroughly discuss science ideas; and being effective in using questioning to identify students' prior knowledge and understandings (KF 5.46). He also reported an increased level of self-efficacy for the remaining five aspects, including: using *wait time* and varying the type of talk to match the instructional purpose of the phases of inquiry (KF 5.46).

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Assertion 5.3

Through his participation in the professional learning process, Ben began to believe that it was important to differentiate the communicative approach used in discussion for different phases of inquiry.

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Knowledge about managing the classroom culture

Throughout the professional learning intervention, Ben maintained that students construct their understandings through social interaction and that discussion and questioning facilitate the social construction of knowledge (KF 5.7; KF 5.47). He

thought that good classroom discussion was the product of an open, safe and caring environment, (KF 5.47) and that it looked like a conversation, with open dialogue and all members of the class interacting and contributing ideas, and the teacher using a varied questioning technique (KF 5.7; KF 5.47). Ben also thought that a student-centred classroom fostered interaction, that the learning should be driven by the students' ideas, and the students should be given time to investigate and to deepen their understandings (KF 5.7). This student-directed focus to seemed to be an appropriate approach to teaching and learning given the age of the young children in Ben's class and it was also very much part of the Reggio Emilio inspired approach taken by WCS (KF 5.2).

When Ben managed his whole-class discussions, he worked with the students to develop substantive talk but he also focused explicitly on developing their understandings and use of the conventions for talk. This dual focus was clearly evident in each lesson as he supported the students to articulate their ideas in one turn and prompted them to take responsibility for using the conventions for talk in the next (KF 5.9; KF 5.17; KF 5.24; KF 5.32; KF 5.38). As the professional learning intervention progressed, Ben adjusted his expectations of the students and asked them to take more responsibility for using the different conventions for talk, e.g. sharing speaking turns, staying on topic, remembering how to ask questions (KF 5.17; KF 5.24; KF 5.32; KF 5.38) and finding a space in the discussion to talk (KF 5.32; KF 5.38).

At the midpoint of the intervention, Ben was very confident that he been most successful in creating a classroom culture in which the students shared and listened to each others' ideas (100%), gave reasons to explain their ideas (100%), respected each others' opinions (90%), asked "why" when they disagreed (90%), and spoke one at a time (80%) (KF 5.30). He was also confident that he had created a classroom culture to do with talk that was *collective* (100%), *reciprocal* (100%), *supportive* (100%), and *cumulative* (100%) (KF 5.30). However, he considered that he had been less successful at creating a classroom culture to do with talk that was *purposeful* (70%), i.e. when teachers plan and steer classroom talk with a specific outcome in view (KF 5.30). Given Ben's student-directed approach to teaching and learning and the age of his students, a lesser focus on *purposeful* talk is not unexpected.

Knowledge about managing classroom discourse

At the start of the professional learning intervention, Ben thought that teachers should know something about how to manage class discussions. He thought they needed to know how to listen to students and give them time to think, and how to reword a question in order to get them to say more (KF 5.7). At the midpoint of the intervention, he reported that he had focused on using *wait time* to give the students a chance to think, and on asking the students to elaborate on their ideas (KF 5.30). He also reported that he had been successful at keeping the students on topic during the discussion, and he thought that sitting in a circle formation and using a Thinking Thumb had helped them to stay focused (KF 5.30). Ben also thought that his class discussions had improved because he devoted time to them (KF 5.30).

Early on in the intervention, Ben thought that he varied his style of questioning and interaction at different phases of a science investigation by asking open-ended questions at the beginning of an investigation and more focused questions to direct the learning as the lessons continued (KF 5.7). Later in the intervention, he thought he varied his questioning and discussion style by asking for more information from the students, and by exploring their ideas deeply and seeking explanations in the early phases of an investigation (KF 5.47). He also thought he was more "directional" and asked more guiding questions during the later phases (KF 5.47).

Assertion 5.5

Ben had a developed understanding of how to manage many aspects of whole-class discussions. As he participated in the professional learning intervention, he demonstrated an increased understanding of how to differentiate the use of teacher questioning and discourse moves at different phases of inquiry.

Knowledge about using puppets

Ben had some experience of using puppets at the start of the professional learning intervention (KF 5.8). The professional learning days offered opportunities for the participating teachers to plan the implementation of science topics using puppets and, subsequently, Ben reported that he had briefly introduced two puppets to small groups of his students as they worked on activities in the Explore phase of an investigation (KF 5.31). At the midpoint of the intervention, he reported that he was more comfortable in using just one puppet at a time and that he wished to develop more confidence with using the puppets before he used them with the whole class (KF 5.31).

Ultimately, Ben did not use the puppets in any lessons associated with the professional learning intervention and he gave several reasons for this. He stated that he had found it difficult to find a reason to use the puppets in whole-class discussions (KF 5.31; KF 5.48) because he thought his class used discourse well and there was little need for the puppets to assist in this process (KF 5.31). He also felt that the puppets detracted from the focus of the lesson and were distracting (KF 5.48). Ben said that he had difficulty establishing a connection between the students and the puppets and he thought that the puppets replaced rather than complemented his role in the discussion (KF 5.48). Given the lack of use, he thought the puppets had made very little impact on the level of student engagement or talk in his class (KF 5.48). At the end of the intervention, Ben indicated that his level of confidence for using puppets in science teaching was okay (KF 5.48).

Teacher practice

Communicative approach, teacher questioning, and teacher discourse moves

From the early stages of the professional learning intervention, Ben demonstrated that he understood how to utilise an Interactive-Dialogic communicative approach during Engage lessons. He was adept at orchestrating teacher questioning and discourse moves to encourage the students' participation and to elicit their ideas and questions for the investigation. Ben asked *open-ideas* and some *open-explanation~reason* questions to elicit and explore the students' ideas (KF 5.10; KF 5.18; KF 5.33) and then he worked on their responses using a range of discourse moves. He often used *teacher restate* and *clarify* to ensure he understood what the students had to say (KF 5.11; KF 5.19; KF 5.34), and he asked further questions and used *teacher uptake*, *clarify,* and *elaborate* when he wanted to explore their ideas (KF 5.11; KF 5.19; KF 5.34). Ben also used *wait time* after he had asked a question to give a student time to think (KF 5.11; KF 5.19; KF 5.34). He used *reframe* to rephrase the student's ideas (KF 5.11; KF 5.19; KF 5.34) and *reframe scientifically* to model appropriate scientific language (KF 5.11; KF 5.34). He also used *refocus* as a way to gather the groups' collective thoughts and to summarise the students' ideas at the end of the discussion (KF 5.19; KF 5.34). Ben managed the flow of the discussion by asking *directed questions* and using *acknowledge only* to accept an idea without exploring it or *moves on* to initiate a new phase of discussion (KF 5.11; KF 5.19; KF 5.34). Working the discourse in this way, generated many teacher-student interactions comprising three- (T-S-T) and four-turn structures (T-S $\rightarrow$T-S), as well as some six- (T-S $\rightarrow$T-S $\rightarrow$T-S) and eight-turn structures (T-S $\rightarrow$T-S $\rightarrow$T-S$\rightarrow$T-S) (KF 5.11; KF 5.19; KF 5.34). When When Ben asked probing questions so as to explore a student's idea, even longer teacher-student interactions were generated (KF 5.11; KF 5.19).

Over the course of the professional learning intervention, Ben began to adjust his communicative approach in Explain lessons as he became more explicit in the way that he talked about the scientific ideas (KF 5.27; KF 5.41). In the initial Explain lesson (Lesson 3), he predominantly utilised an Interactive-Dialogic approach when he helped the students to share their observations and develop explanations (KF 5.27). His approach became only slightly more Interactive-Authoritative when he endorsed some of the students' ideas (KF 5.27). In the later Explain lesson (Lesson 5), Ben started off using an Interactive-Dialogic style but there was a noticeable shift to a more Interactive-Authoritative approach when he wanted to make key ideas explicit or to support the students to develop explanations (KF 5.40).

Students

From early on in the professional learning intervention, the students consistently participated in quite lengthy interactions, often giving elaborated responses (KF 5.16; KF 5.23; KF 5.29: KF 5.37; KF 5.43) and generating cumulative talk (Alexander, 2006) by building on each other's ideas (KF 5.23; KF 5.29: KF 5.37; KF 5.43). The quality of the students' responses remained consistently high as they gave simple and complex descriptions and explanations in the Engage and the Explain lessons (KF 5.16; KF 5.29: KF 5.37; KF 5.43).

Assertion 5.7

Ben was accustomed to using an Interactive-Dialogic approach in discussion, which aligned well with the purposes of the lessons in the Engage phase. He demonstrated an increased understanding of how to adjust his communicative approach so that the scientific ideas were made explicit in Explain lessons.

Conclusion

As Ben participated in the professional learning intervention, he came to believe that inquiry-based science teaching and learning was well supported by the different phases of inquiry and that it was important to differentiate the communicative approach used in discussion for the different phases. Ben also developed his confidence as a teacher of primary science and increased his beliefs, knowledge and

practice of managing discussions, particularly for adjusting his communicative approach to match the purpose of the lesson in the Explain phase. Several contextual factors may well have contributed to these outcomes including the school's social constructivist approach to teaching and learning, Ben's own confidence and experience in using discourse as a tool for inquiry, and his understandings of science.

CHAPTER 6: HOLLY'S LEARNING JOURNEY

Introduction

This chapter explores Holly's involvement in the professional learning program and the impact this has had on the way that she taught science. The first section considers the contextual factors that have influenced Holly's development as a teacher and that currently impact on her teaching practice. The second section outlines her beliefs and understandings about the teaching of science and the management of classroom discourse. Finally, the third section examines how Holly managed class discussions in science lessons over the course of the year.

Introducing Holly

This section provides an overview of Holly's professional and educational background, her teaching role and the school environment in which she worked, and the class that she taught during the course of this study.

Professional and educational experiences

Holly is a Year 2/3 teacher at Southport Primary School (SPS), which is in the Perth metropolitan area of Western Australia. She has taught for six years at SPS and has been a primary school teacher for 10 years. Holly has held substantive positions at several primary schools in the southern metropolitan district and she has also taught as a relief teacher in many schools. In her substantive roles, Holly has predominantly taught Pre-Primary to Year 4 students (Email, 25/5/ 2010). In addition, she has worked as the support teacher for Students at Educational Risk (SAER). At SPS, Holly has taken on the Science Coordinator role in addition to her full-time teaching role (Email, 25/5/ 2010).

While she really enjoys being a classroom teacher, Holly has a passion for science and her positive attitude toward the subject was something that was engendered at an early age by her mother who was also a primary school teacher.

Holly went to a Catholic primary school and then a Catholic college in her secondary years. She was inspired by her Biology teacher in Year 11 and 12 to go on to do Zoology and Botany at university (Final teacher interview, 27/11/09). "[She] was so hands on, so innovative, creative. The stories that she could tell! She'd lived in Africa and other places and she was just a natural teacher and biologist" (Final teacher interview, 27/11/09). Subsequently, Holly went to the University of Western Australia (UWA) and gained a Bachelor of Science with First Class Honours. She worked at UWA as research officer in Botany from 1983 until 2000. While at UWA, Holly was offered a scholarship to commence her PhD but ultimately she decided to become a teacher and she completed a Diploma in Education.

> I had spent 12 years working as a volunteer parent in my kids' school and going in the classrooms all the time. ... I really liked that. … When I was working at uni a lot of my job was [sic] tutoring and doing excursions with the first and second year students and marking their assignments. I always had a teaching role in the lab, so I quite liked that. So, I thought why don't I become a teacher. I'm enjoying teaching. (Final teacher interview, 27/11/09)

All of the teachers at SPS teach Science using *Primary Connections* (AAS, 2005) curriculum resources. This is the fifth year that Holly has been using *Primary Connections* in her classroom and she is very familiar with the inquiry approach to teaching science (Final teacher interview, 27/11/09). Three years ago, she trained as a *Primary Connections* professional learning facilitator and since then she has provided professional learning for all of the staff in her school as well as for teachers in other schools. Currently, Holly trains new staff in the use of the *Primary Connections* resource and ensures existing staff remain up to date with the program (Final teacher interview, 27/11/09).

As the Science Co-ordinator for SPS, Holly is responsible for promoting science in the school. She does this not only by providing professional learning for the staff but also

by supporting the teachers to successfully implement the *Primary Connections* program in their classes (Final teacher interview, 27/11/09). For instance, Holly has developed a scope and sequence plan for the school's science program for the next three years and she frequently supports teachers by modelling how to teach science in their classes. Amongst other things, she has also developed investigation planners, an electronic content management system for science documents, and a range of science kits containing the resources needed to teach *Primary Connections* topics.

It is also Holly's desire to create a whole school focus for science and to better utilise the natural environment that surrounds the school.

> We've got this school… [and] it's in a fantastic location. We've got the Southport Wetlands surrounding us, we've got bushland at the school that's surrounding us … 10 minutes down the road you've got the Southport Beach area, which is coastal wet. … So we've got wetlands, bushland, coastal. We've got such [sic] really great environment around here. We could start our own garden … do one of the garden schools and grow vegetables and all those sorts of things. We've got the opportunity to do so much at this school. And that's where I'd like to take it further. … So next year I'd like to maybe do a whole wetlands thing throughout the whole school, everybody. And we'd do a big display for parents to see and involve the community, more community awareness as well. (Final teacher interview, 27/11/09)

Key Finding 6.1

Prior to becoming a primary school teacher, Holly had gained a Bachelor of Science with First Class Honours and worked as research officer in a university Botany department for 17 years. She completed a Graduate Diploma in Education and has subsequently gained 10 years of teaching experience in Perth metropolitan primary schools. Holly had trained as a *Primary Connections* professional learning facilitator and she has provided professional development for teachers. As the Science Co-ordinator for SPS, Holly was responsible for promoting science in the school.

Southport Primary School

SPS is a WA DoE school that is located in a southern corridor of the Perth metropolitan area in Western Australia (SPS website, 27/5/2010). In 2009, the school had a cohort 391 students. Of these, 46 were pre-primary students and 345 were students in Years 1-7. The data collected for the Western Australian Socio-Economic Index (SEI) for

2006, shows that SPS is currently ranked as a Decile 5 school (E-mail communication, 26/5/2010). Additionally, the data collected for the Index of Community Socio-Educational Advantage (ICSEA, a national indicator of disadvantage) shows that SPS has an ICSEA value of 955 and the data also shows that eight per cent of the student population at the school are Indigenous (ACARA, 2010). The Western Australian SEI ranking and the ICSEA value of SPS indicates that the school has an average socio-economic status.

SPS was opened in1999 to serve the suburb of Southport, one of a string of new suburbs in a rapidly expanding area (SPS website, 27/5/2010). The residents of Southport come from a diverse range of cultural and social backgrounds and are employed in a wide range of occupations (SPS Annual School Report, 27/5/2010). With the continued release of new land, it is expected that Southport will maintain a steady rate of growth as the area undergoes further development (SPS Annual School Report, 27/5/2010). The school has developed important partnerships with local community groups, council, business and industry to build a strong sense of community and to promote Southport as a desirable suburb in which to live (SPS Annual School Report, 27/5/2010). With further expansion and development in the area, the enrolments at SPS are expected to increase significantly (SPS website, 27/5/2010).

SPS is committed to developing a school community that respects cultural diversity and to establishing a culture that is supportive of students learning and academic achievement. The ethos and purpose of the school is focused on the development of students' knowledge, skills and confidence to achieve their individual potential and to establish the foundations of lifelong learning (SPS Annual School Report, 27/5/2010). The school motto, Stand Tall, symbolises a whole school philosophy that embraces positive behaviours and protocols. Stand Tall also refers to the school's pastoral care program, which is a whole-school approach to behaviour management. The Pastoral Care and Behaviour Management program focuses on rewarding positive behaviours, developing more effective social conventions and pastoral care processes, and working with the wider community (SPS Annual School Report, 27/5/2010).

For the last several years, the school's priority areas have included Literacy, Numeracy and Science (SPS website, 27/5/2010). For Literacy and Numeracy, this involves the analysis of data and the development of whole-school plans that provide cohesion and continuity in teaching strategies across the School. The implementation of the *Primary Connections* program is focused on improving student competency in working scientifically across the school (SPS Annual School Report, 27/5/2010). In 2009, the NAPLAN scores for SPS students showed that students in Years 3 tend to be close to the national average for Numeracy, Reading, Writing, Spelling, Punctuation and Grammar (ACARA, 2010).

Key Finding 6.2

SPS provides schooling for students from pre-primary to Year 7 and is located in a southern corridor of the Perth metropolitan area. SPS is committed to developing a school community that respects cultural diversity and establishing a culture that is supportive of students learning and academic achievement. The school is ranked close to the mid-range of national (ICSEA) and state (SEI) socioeconomic indices.

SPS students in Years 3 who participated in NAPLAN testing tend to be close to the national average in each of the literacy and numeracy domains.

Holly's class

In 2009, Holly's Year 2/3 class was comprised of 22 students (12 females and 10 males), two of whom were Indigenous and six were on Individual Education Plans (Email, 25/5/ 2010). The students in Holly's class mostly came from working class families and only one student came from a very low income, single parent family. Over the course of the year, family splits occurred for four of the students in the class (Email, 25/5/ 2010).

As SPS was a relatively new primary school, Holly's classroom was modern and provided a comfortable learning environment. The classroom appeared light and airy and the students' work was displayed around the room adding colourful points of focus (Lesson 1 Observation Record, 13/05/2009). The teaching space was well organised with desks for each of the students grouped towards the centre of the classroom in front of a large whiteboard (Lesson 1 Observation Record, 13/05/2009).

On the left side of the classroom a mat area provided a place for the whole class to gather. This was a space defined by a large rectangular carpet on which the class sat during whole-class discussions. Holly had positioned a couch on the rear edge of the carpet and she had placed a mobile whiteboard and a chair at the front. Typically, four students would sit on the couch and the remaining students would sit cross legged on the mat whilst Holly sat on the chair (Lesson 1 Observation Record, 13/05/2009).

The class followed the school's Stand Tall behaviour management policy and in particular the school's golden rule of "Treat others how you would like to be treated" (Email, 25/5/ 2010). In class, Holly reinforced and modelled active listening protocols which meant that the students were expected to demonstrate their attention to a speaker by sitting still, looking at them, and listening to what they had to say (Email, 25/5/ 2010).

Holly's class studied four science topics in 2009. In Terms 1-3, they completed one teacher-authored topic called Magnetism and two *Primary Connections* topics including, Sounds Sensational, and Schoolyard Safari. In Term 4, Holly wrote another science topic entitled Lifecycles. During the course of the professional learning intervention (Terms 2-4), the topics Sounds Sensational, Schoolyard Safari, and Lifecycles were covered.

Key Finding 6.3

Holly had a composite Year 2/3 class comprising 12 females and 10 males. During class discussions, the students generally sat in a group on the mat facing the teacher and active listening protocols were reinforced. During the professional learning intervention, the *Primary Connections* topics Sounds Sensational and Schoolyard Safari were taught as well as a teacher-authored topic entitled Lifecycles.

Pre-intervention: Holly's beliefs, knowledge and practice

Snapshots of Holly's beliefs and knowledge about teaching science were captured via interviews and questionnaires completed prior to the intervention and from data

collected in the early, mid and later phases of the professional learning intervention. The data that was elicited related to: beliefs about teaching science; confidence with teaching science; knowledge about managing classroom discourse; knowledge about questioning; and, teacher knowledge about using puppets.

Beliefs about teaching science

The data collected from the initial teacher interview completed prior to the professional learning intervention and from the initial teacher questionnaire completed on the first Professional Learning day (PL Day 1), provided evidence of Holly's beliefs regarding the teaching of science. Holly followed an inquiry approach to teaching science and she used the *Primary Connections* curriculum documents (AAS, 2005) and the 5Es inquiry learning model (Hackling et al., 2007) to create learning opportunities for the students in her class. Holly listed developing students' use of processes and strategies of investigation as one of the three most important characteristics of primary science teaching practice (Initial teacher questionnaire, 02/6/09). She believed that the students should know how to research, conduct, plan, process and evaluate investigations and that they need to be able to interpret data and make judgements about science learning (Initial teacher questionnaire, 02/6/09).

Holly believed it was important for the students to see how science is relevant to their lives and the world that they live in (Initial teacher questionnaire, 02/6/09). She emphasised the need for science investigations to be meaningful and tailored to the students' interests as well as to their developmental level and their learning needs (Initial teacher questionnaire, 02/6/09). Holly was also keen to make science engaging for the students by providing exploratory sessions where the students could pursue their curiosity (Initial teacher questionnaire, 02/6/09).

Holly also believed that science ought to be integrated into a range of curriculum areas, including Literacy, Numeracy, Society and Environment and Technology (Initial teacher questionnaire, 02/6/09). She stated that she often draws on science topics to provide a theme for a unit of work and that she collaborates with other teachers to integrate particular curriculum areas.

> This time we're doing Sounds Sensational, so I'm linking that with health and we're learning about ears and hearing as well as the science aspect of it. In music, they're actually doing sound at the moment as well, so they're doing some of the things from Sounds Sensational. The music teacher is linking those together. (Initial teacher interview, 25/5/09)

Given the integrated nature of her science program, Holly also believed that it was necessary to devote extended periods of class time to science.

> My science is never an hour. I've either had science days where I do science and technology activities all day or at the moment it's over a couple of hours. So a science lesson is never just a solitary single lesson, it's always longer and I include a lot more literacy, especially writing activities. I'm keen on them doing reflective science journals. (Initial teacher interview, 25/5/09)

Holly believed that teacher questioning and class discussion supports students to share their thinking and to develop a common set of ideas. "Often they learn from their peers more than they sometimes learn from what a teacher might say. So they get ideas" (Initial teacher interview, 25/5/09). She utilised discussions at the beginning of her science lessons to help students brainstorm and get their "ideas flowing" so that they could "share their prior knowledge, interests and things they would like to learn about" (Initial teacher questionnaire, 02/6/09). Holly also used class discussions to conclude her science lessons because the students get to share the results of their observations (Initial teacher interview, 25/5/09). She described the discussion in Explain lessons as an opportunity for students to share and consolidate what they have learned, while discussion in Evaluate lessons provided opportunities for students to explore "what if" and to think about how they could change or improve their investigations (Initial teacher questionnaire, 02/6/09).

Holly also believed that class discussion supports those students who are reticent to share their ideas. "If they actually hear some other people's ideas first then it clicks for them and they can then relate, too, and then they feel a bit more confident in sharing"

(Initial teacher interview, 25/5/09). She used a range of whole-class, small group or one-on-one strategies to increase students' confidence to participate in classroom talk.

> Sometimes it might be *Think Pair Share*, they might go with a partner for a minute [to] give them the opportunity to have a little discussion and then participate. Or play some activities … where they can rotate [and] share ideas and then they come up with a common set of ideas or brainstorm ideas that the group has thought of. So they feel they are participating as well. (Initial teacher interview, 25/5/09)

Key Finding 6.4

Holly followed an inquiry approach to teaching science and she believed that it was important to develop the students' capacity to use the processes and strategies of investigation and to interpret data and make judgements about science.

She believed it was important for the students to understand how science is relevant to their lives. She felt science investigations should engage the students' curiosity and cater to their interests, developmental levels and learning needs.

Holly believed that science should be integrated into a range of curriculum areas, particularly literacy, and that it was necessary to devote extended periods of class time to science.

She believed that teacher questioning and class discussion supports students to share their thinking and to develop a common set of ideas. She also believed that class discussion supports reluctant students to share their ideas.

Confidence with teaching science

Prior to the professional learning intervention, Holly considered herself to be a confident teacher of primary science. When asked to indicate her confidence with nine aspects of science teaching (Initial teacher questionnaire, 02/6/09), Holly rated herself as 'Very confident' in developing [students'] literacy skills needed for learning science, and using a constructivist model to plan science units of work. She also considered herself as 'Confident' in managing discussions and interpretation of science observations (Initial teacher questionnaire, 02/6/09).

The initial mean scale score for confidence with teaching science strategies for all of the teachers involved in the professional learning intervention was 3.86/5, which is very close to the mean confidence scale score of 3.88 for a group of *Primary Connections* trial teachers who had participated in five days of professional learning and taught

some *Primary Connections* units (Hackling & Prain, 2005). In comparison, Holly's initial mean scale score for confidence with teaching science strategies was 4.2/5, which was greater than the mean scale scores for either of these groups of teachers.

Key Finding 6.5

Holly considered herself confident with managing discussions and developing interpretations of observations. Her initial mean scale score for confidence with teaching science was 4.2/5.

Beliefs about being an effective manager of classroom talk

The data from the initial teacher questionnaire showed that Holly believed herself to be an effective manager of classroom talk. When asked to indicate the degree to which she agreed or disagreed with 12 statements about the effective management of classroom talk, the data showed that Holly had a high level of self-efficacy (rated 5/5) for establishing an appropriate classroom climate (Initial teacher questionnaire, 02/6/09). She also indicated a high level of self-efficacy (rated 4/5) against 10 other aspects of managing classroom discussions (Initial teacher questionnaire, 02/6/09). Additionally, the data showed that Holly had a lower level of self-efficacy for responding to students' answers in ways that maintain and promote further discussion of the science ideas (Initial teacher questionnaire, 02/6/09).

The initial mean scale score for being an effective manager of classroom talk for all of the teachers involved in the professional learning intervention was 3.89/5. In comparison, Holly's initial mean scale score was 4.0/5, which is greater than the mean scale scores for the group of teachers involved in the professional learning intervention.

Key Finding 6.6

Holly believed that she was an effective manager of classroom talk, particularly for establishing an appropriate classroom climate. However, she felt less confident that she could respond to students' answers in ways that maintain and promote further discussion of the science ideas. Her initial mean scale score for being an effective manager of classroom talk was 4.0/5.

Knowledge about managing classroom discourse

The initial teacher interview, the initial teacher questionnaire and the Post Lesson 1 interview (PL 1 interview) provided evidence of Holly's understandings about how to manage classroom discourse so as to facilitate students' learning in primary science lessons. Holly considered it was important that teachers create a classroom environment that is supportive of students' participation in discussion. She thought that such an environment should be comfortable and non-threatening (Initial teacher interview, 25/5/09) and one where the teacher is "non-judgemental" and the students feel free to share their ideas and understandings (Initial teacher questionnaire, 02/6/09). In the Post Lesson 1 interview, Holly elaborated on this idea, stating that she thought that it was essential for the students to feel that everybody was entitled to answer questions, not just the students who could give a right answer (PL 1 interview, 25/5/09).

Holly thought a supportive classroom culture was one where there is a high level of student participation that is guided by conventions for listening and sharing turns (Initial teacher questionnaire, 02/6/09). She thought it was necessary to manage student behaviour so that everyone had a turn to speak (PL 1 interview, 25/5/09) and she considered students' positive participation in discussions was demonstrated when their behaviour was under control, they used their listening skills, gave sensible responses to questions, and asked relevant questions (Initial teacher interview, 25/5/09).

Holly also thought that by following the 5Es inquiry model (Hackling et al., 2007) the students became familiar with the phases of inquiry and came to know what was expected of them. She found that the structured science lesson format, characterised by familiar routines for discussion and group work, contributed to a supportive learning environment. Holly thought that teachers should schedule discussion times into science lessons, part of which should be given over to eliciting students' questions in order to allow the "free flow of thinking" (Initial teacher interview, 25/5/09).

Holly thought that teachers should be encouraging and accepting of students' responses to their questions. She believed that a non-evaluative teacher response

fostered an inclusive classroom culture. She suggested that students' incorrect responses should, in fact, be used as opportunities for them to set up their own investigations. "So you never put the students down, you always try and turn it around so that they then find out for themselves that they were wrong rather than you telling them that they're wrong" (Initial teacher interview, 25/5/09).

Holly thought teachers needed to construct questioning that took into account the students' age as well as their current understandings (Initial teacher interview, 25/5/09). She maintained that by monitoring the way in which students respond to their questions, teachers can determine the level of student engagement in discussion. She thought that using discourse strategies such as *wait time* encouraged students' participation as it gave them time to respond to questions without feeling pressured (Initial teacher interview, 25/5/09).

Holly described questioning in science as necessarily different for each phase of inquiry. She explained that she used "non-threatening types of questions" in the Engage stage to elicit students' prior knowledge, to stimulate their interest in a new topic of study and to motivate them to become engaged (Initial teacher interview, 25/5/09).

> In the Engage stage, you want to make sure that your questions … get information from them about what they know but you don't want to be telling them answers about things that they're going to learn. … And you've got to be careful not to let on. … Or they might say something that you know is not correct but instead of putting them down and saying 'No, that's not correct', you say ... 'Well maybe we can explore that as a possibility' and 'Let's have a look and we might be able to then talk about that again at the end'. (Initial teacher interview, 25/5/09)

Holly also used questioning in the Engage lesson to discover what the students were really interested in so that she could incorporate what they wanted to learn from a topic or integrated unit of study (Initial teacher interview, 25/5/09).

Holly explained that once a new topic is underway, the Explore phase gave the students time to participate in activities that allowed them to discover for themselves

the scientific phenomenon under investigation and to work out if their initial understandings were accurate (Initial teacher interview, 25/5/09). In the Explain phase she used teacher questioning to find out what the students had found out from their initial activities and to monitor their developing conceptual understandings (Initial teacher interview, 25/5/09). Subsequently, in the Elaborate phase Holly used questioning during discussion to make conceptual understandings explicit. "That's when you'll be telling them… the answers if they haven't still got the concept" (Initial teacher interview, 25/5/09). And finally, in the Evaluate phase the questioning centred on finding out what the students had learned (Initial teacher interview, 25/5/09).

Holly also understood that teacher questioning is explicitly linked to the assessment points associated with each phase of inquiry. She used questioning in the Engage phase to gain diagnostic information about the students; in the Explain and Elaborate phases to gain formative information about their progress; and in the Evaluate phase to gain summative information about what they had learned (Initial teacher interview, 25/5/09).

Key Finding 6.7

Holly considered it was important to create a comfortable and non-threatening classroom environment that is supportive of students' participation in discussion. She also thought that it was important to follow the inquiry process and to provide a structured science lesson format so that the students become familiar with the phases of inquiry as well as the routines for discussion and group work.

Holly thought that it was essential for the students to feel that everybody was entitled to answer questions and that it was necessary to manage student behaviour so that everyone had a turn to speak. She thought that teachers should be encouraging and accepting of students' responses to questions and that a teacher's questioning should take into account the students' age as well as their current understandings. She also thought that *wait time* encouraged student participation by giving them time to think.

Holly thought that teacher questioning should be differentiated to correspond with each phase of the inquiry process and she used teacher questioning for diagnostic, formative and summative purposes.

Knowledge about using puppets

Holly began the professional learning intervention with no previous experience of using puppets in her teaching (Initial teacher questionnaire, 02/6/09).

Key Finding 6.8

Holly had no experience of using puppets in her teaching at the start of the professional learning intervention.

Having considered some of the contextual factors, beliefs and understandings that may influence Holly's teaching, it is important to also examine how the professional learning intervention impacted on her practice and, more particularly, on the way that Holly managed whole-class discussions. Over the course of the intervention data were gathered from science lessons prior to the professional learning intervention and from mid and later phases. The data were collected via video, classroom observation and post lesson follow up interviews. Specific observations included:

- o Lesson 1: An Engage lesson in May, prior to the profession learning intervention. This lesson was drawn from the *Primary Connections* topic, Sounds Sensational (AAS, 2008).

- o Lesson 2: An Engage lesson in July, following PL Days 1 and 2. This lesson was drawn from a new *Primary Connections* topic, Schoolyard Safari (AAS, 2005).

- o Lesson 3: An Explain lesson in August, a continuation of the Schoolyard Safari topic commenced in Lesson 2.

- o Lesson 4: An Engage lesson in October, following PL Day 3. This lesson marked the start of a new topic called Lifecycles which was developed by Holly.

- o Lesson 5: An Explain lesson in November, a continuation of the Lifecycles topic commenced in Lesson 4.

The data are presented in the sequence that the professional learning intervention unfolded. Consequently, the data from Lessons 1, 2 and 3 are initially reported on here while those from Lessons 4 and 5 are discussed in a later part of the chapter.

Lesson 1, pre-intervention

The lesson

Lesson 1 was carried out prior to the commencement of the professional learning intervention and was an introductory lesson in the Engage phase of the topic Sounds Sensational. This topic addressed science concepts related to the Energy and Force strand of the science syllabus (MCEETYA, 2006). As its name suggests, the unit focused on developing students' conceptual understandings about the characteristics of sound and how it is produced, and on providing opportunities for them to conduct simple investigations. This initial lesson was entitled Sound Ideas and it aimed to engage the students in the topic, to find out what they thought they knew about sound and to elicit their questions. The lesson included listening to and discussing sounds; documenting the students' observations in a class journal; introducing a problem for the students to solve; and recording the students' individual understandings about sound. In this instance, the data analysis centred on the whole-class substantive discussion that was generated by the initial listening activity.

The setting

Prior to the professional learning intervention, Holly had not used puppets as a pedagogical tool and, consequently, they were not used in this initial lesson. Holly commenced the discussion by introducing the new topic Sounds Sensational and then she engaged the students in the listening activity. The students were required to close their eyes and listen to a sound that Holly made with a hidden object. Then the students shared what they had heard by naming and describing the sound, and guessing what had produced it. Subsequently, Holly repeated this process for a series of different sounds.

Holly and the students were in the mat area with four students seated on the couch and the remaining 18 students sitting cross legged in a pod shape on the mat. All of the students faced Holly, who was seated in front of them on the chair. When Holly asked the students to share their ideas she invited them to raise their hands before she nominated someone to speak. She reinforced this convention by praising the students and, when necessary, she would remind them to not call out and to raise their hands if

they wished to speak (Video footage, 13/5/2009). Holly would also ignore or 'shh' those students who persisted in speaking out of turn (Video footage, 13/5/2009).

Key Finding 6.9

Holly did not use puppets in Lesson 1. The students sat in a group in front of Holly and were expected to raise their hands when they wished to speak. Holly managed the conversation by nominating speakers and maintaining speaking conventions.

The teacher's role

In order to find out about the teacher's role in managing whole-class discussions and the forms of discourse this produced, it was necessary to analyse the transcripts of each lesson for the teacher's use of questioning and discourse moves as well as for the communicative approach taken.

Teacher questioning

In Lesson 1, the discussion was driven by the initiating questions Holly asked about the sounds she had made. This included open-ended questions that elicited some description of the sound and the students' ideas about what produced the sound, for example: What sounds did you hear? (*open-description*); What was the sound like? (loud or soft, high or low) (*open-description*); What do you think produced that sound? (*open-ideas*).

The analysis showed that Holly asked a total of 53 initiating questions in this segment of the lesson. Of these questions, 36 (68%) were classified as *open-ideas*; 15 (28%) *open-description*;   one (2%) was *open-explanation~reason*; and another one (2%) was classified as *closed*.

Key Finding 6.10

In the whole-class discussion in Lesson 1, Holly asked a total of 53 initiating questions of which approximately 70% were *open-ideas* questions and 30% *open-description* questions.

Teacher discourse moves

The transcript from Lesson 1 showed that Holly tried to maximise student involvement in the discussion by nominating several students in succession to respond to each of her questions (Video footage, 13/5/2009). Consequently, a teacher-nominated *turn taking* pattern of interaction evolved as the discussion proceeded. Figure 6.1 below, provides an example of this *turn taking*.

Turn	Utterances	Coding
1.	T: What was the sound like? Can you describe what the sound was like? Who'd like to do that? Tara?	Initiating question, open–description question.
2.	**S:Tar: Um.. like a rustle, rustle sound.**	
3.	T: Rustle, rustle. Alison?	Teacher restate. Asks another student for his/her ideas.
4.	**S:Ali: Like a.. kind of like a rubbing something hard sound.**	
5.	T: Rubbing sound. Lucy?	Teacher restate. Asks another student for his/her ideas.
6.	**S:Luc: Um.. kind of like a scratching sound.**	
7.	T: A scratching sound. John?	Teacher restate. Asks another student for his/her ideas.
8.	**S:Jos: Shaking sound.**	
9.	T: Shaking sound. [Points to another child]	Teacher restate. Asks another student for his/her ideas.
10.	**S: A rattle sound.**	
11.	T: A rattle sound. OK.	Teacher restate.

Figure 6.1: Lesson 1 - an example of teacher nominated turns, coded as turn taking.

The excerpt (Figure 6.1) began with an initiating question where Holly attempted to elicit the students' descriptions about the sound they had heard and she nominated Taylor to answer (turn 1). Tara described a rustling sound (S:Tar, turn 2) and Holly restated what she had said and then nominated another student to give their ideas (*teacher restate*, turn 3). The coding of this discussion revealed that Holly frequently nominated a student to answer her question, restated what they had said and, without

further interaction, moved on to nominate another student for their ideas (turns 3, 5, 7, 9 and 11). In this study, when a teacher repeatedly responded in this way the interaction was coded as (teacher nominated) *turn taking*.

The *turn taking* pattern of interaction resulted in short teacher-student exchanges (Teacher-Student-Teacher or T-S-T) such as the three-turn structures described by earlier research. For example, the I-R-E (Initiation-Response-Evaluate) pattern described by Mehan (1979) and the I-R-F (Initiation-Response-Feedback) described by Sinclair and Coulthard (1975, in Alexander, 2006). In this instance, the interaction also included: Initiation-Response-Restate or I-R-R.

Key Finding 6.11

Turn taking was the predominant pattern of interaction in Lesson 1. This consisted of short teacher-student exchanges where the teacher asked a question then nominated a student to respond, restated what the student had said and, without further interaction, moved on to nominate other students for their responses. This is considered a three-turn structure comprising Initiation-Response-Restate or I-R-R.

In conjunction with the *turn taking* style of interaction, Holly often attempted to clarify the students' contributions to the discussion. An example of clarification is given in Figure 6.2 below and this segment of the discussion follows on from the excerpt in Figure 6.1.

Turn	Utterances	Coding
1.	T: And what do you think actually made that sound? Some people have already said some kind of suggestions. What do you think actually it was? Hayes?	Initiating question, open–ideas question.
2.	**S:Hay: A plastic bag.**	
3.	T: You think a plastic bag? [Waits for S:Hay to nod then points to another child] Kane.	Clarify. Asks another student for his/her ideas.
4.	**S:Kan: Umm.. paper wrap.**	
5.	T: Paper wrap. [Points to another child]	Teacher restate. Asks another student for his/her ideas.
6.	**S: A box.**	

7.	T: A box. [Points to another child]	Teacher restate. Asks another student for his/her ideas.
8.	**S: Paper.**	
9.	T: Paper, just paper itself? [Waits for student to nod then points to another child] Jack?	Clarify. Asks another student for his/her ideas.
10.	**S:Jac: Paper.. a paper bag.**	
11.	T: A paper bag. [Points to another child] Alison?	Teacher restate. Asks another student for his/her ideas.
12.	**S:Al: Um.. like um.. cardboard and a paper bag.**	
13.	T: Ah! Two things together, cardboard and a paper bag. [Waits for S:Al to nod then points to another child] Luke?	Clarify. Asks another student for his/her ideas.
14.	**S:Luk: Um.. bubble wrap.**	
15.	T: Bubble wrap again. [Points to another child] Lyle?	Teacher restate. Asks another student for his/her ideas.
16.	**S:Lyl: Cardboard.**	
17.	T: That's right, you and Remi said cardboard. [Points to another child] John?	Teacher restate. Asks another student for his/her ideas.
18.	**S:Jos: A plastic bag.**	
19.	T: A plastic bag. [Points to another child]	Teacher restate. Asks another student for his/her ideas.
20.	**S: Cellophane and a box.**	
21.	T: OK. And what about you, Mischa?	Acknowledge only. Asks another student for his/her ideas.
22.	**S:Mis: Cellophane as well.**	
23.	T: OK. Well, I'll show you what it was. Here it is. [Moves over to the box and pulls plastic shopping bag from the box]	
24.	**Ss: <overtalking>**	
25.	T: It was a plastic bag! OK.	

Figure 6.2: Lesson 1 - the teacher sought clarification.

In this excerpt (Figure 6.2), Holly sought to elicit the students' ideas about what could have been used to make the sound (*open–ideas* question in turn 1). The coding for

teacher discourse moves shows that Holly briefly followed up the student response with a further question in order to clarify what was said (*clarify*, turn 3). Once the student had nodded (giving a non-verbal response) to indicate that Holly had understood him correctly, Holly went on to ask another student for their ideas and to resume to the *turn taking* pattern of interaction (turn 3). Holly repeated this pattern of interaction with other students in turns 9 and 13. Using the discourse move *clarify* in this way generated slightly longer teacher-student interactions (T-S → T-S).

Key Finding 6.12

In Lesson 1, Holly would sometimes ask a follow up question to seek clarification of a student's response, which extended the teacher-student interaction slightly.

At certain points, Holly would refocus the discussion by repeating and drawing together the students' ideas. In the following excerpt (Figure 6.3), Holly had already elicited quite a number of the students' ideas about what had made a particular sound by the time she nominated Alison and Joss to speak (turns 1 and 3). Subsequently, she concluded the discussion by summarising all of the students' ideas (*refocus,* turn 7) and moved the discussion on by revealing the article used to make the sound (*moves on*, turn 7).

Turn	Utterances	Coding
1.	T: Alison?	
2.	**S:Ali: Um a fork and a knife.**	
3.	T: Uh-huh. Joss?	
4.	**S:Jos: Triangle.**	
5.	T: Triangle. Well seems like the consensus is.. hands down now..	
6.	**Ss: <overtalking>**	
7.	T: Seems like some people think it's like utensils, spoons knives and forks, one of those, and the other half of the class seem to think it's more like maybe a triangle. So I'll show you it.	Refocus. Moves on.

Figure 6.3: Lesson 1 - the teacher refocused the discussion and moved on.

The analysis of the transcript also showed that there was no evidence in Lesson 1 of Holly's use of discourse moves that could be coded as *wait time* or *extended thinking time*.

Communicative approach

In this lesson, Holly asked predominantly *open-ideas* and some *open-description* questions in order to ascertain the students' prior knowledge and understandings about sound. Utilising questioning in this way produced the type of interaction Mortimer and Scott (2003) describe as Interactive-Dialogic, where both the teacher and the students share many ideas. This form of interaction is considered appropriate for an Engage lesson given the instructional purpose of this phase of inquiry is to elicit and clarify the meaning of students' existing ideas. In this instance, the teacher utilised many *open-ideas* and some *open-description* questions and *restate* and *clarify* discourse moves to achieve this purpose.

Proportions of teacher and student talk

The transcripts from each lesson were also analysed for the proportion of teacher and student talk in whole-class discussions of substantive lesson content. The analysis showed that in Lesson 1 Holly utilised a large percentage of the talk time (70%) while the students used less talk time (30%) in whole-class substantive discussion.

Key Finding 6.16

In Lesson 1, Holly utilised about 70% of the talk time and the students utilised 30% in whole-class substantive discussion.

The students' role

In this study, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

No *elaborated utterances* were coded in the transcript of the whole-class discussion from Lesson 1.

Quality of student talk

Ninety-six per cent of the students' responses were coded as *unistructural descriptions* in Lesson 1 and 4% were coded as *multistructural descriptions*.

Key Finding 6.17

The students' responses were quite short in Lesson 1 and none were coded as *elaborated utterances*. Most responses were *unistructural description* (96%), a few were *multistructural description* (4%), and none were coded as *explanation* or *reasoning*.

Lesson 1 summary

Since Lesson 1 was the first Engage lesson for a new unit of study, Holly wished to engage the students' interest in the topic and to elicit their ideas and prior knowledge. To do this she utilised an Interactive-Dialogic style of interaction where she asked many *open-ideas* and *open-description* questions to encourage the students to share their ideas. Holly also wished to maximise the number of students involved in the discussion and so she would nominate several students in succession to respond to her questions. She mostly used the *teacher restate* and *clarify* discourse moves to achieve this and, while many students did contribute to the discussion, their responses were typically very short, lower order descriptions. Consequently, this resulted in a (teacher nominated) *turn taking* pattern of interaction, which was characterised by the predominance of teacher talk and the development of short teacher-student exchanges (T-S-T or T-S→T-S). There was no evidence of the use of *wait time* or *extended thinking time* in this lesson.

In Lesson 1, Holly dominated the talk and since the students' responses were quite short, none were coded as *elaborated utterances*. Almost all of their responses were coded as *unistructural description* and a small number were coded as *multistructural description*.

Lesson 2, post Professional Learning Days 1 and 2

The first two professional learning days conducted in June 2009, provided an opportunity for the participating teachers to plan the implementation of a science topic using a *Primary Connections* unit of work. During the planning process, the teachers were required to identify learning outcomes and to describe the scientific explanations which would indicate the learning outcomes had been achieved for their chosen topic. For the Engage phase, the teachers had to plan how they would use puppets to set the scene for the investigation, to pose problems for the students to solve, and to elicit their prior knowledge. This also meant that the teachers had to consider: the communicative approach that they would need to use to elicit information from their students in the Engage phase; how they needed to adjust their communicative approach for the Explore and Explain phases of the inquiry; how to carefully plan their questions so that

the introduction to the investigation really engaged the students; and, how to manage the class discussions to ensure that sustained conversations met the instructional purposes of each phase of inquiry. Subsequently, in Lesson 2 Holly began to use two small dog puppets when she implemented the topic Schoolyard Safari with her class in July.

The lesson

Lesson 2 was carried out following PL Days 1 and 2. This was an introductory lesson in the Engage phase of the topic, Schoolyard Safari. This topic addressed the science concepts related to the Living Things strand of the science syllabus (MCEETYA, 2006). It aimed to develop the students' conceptual understandings about small animals, their features, habitats and behaviours; to provide opportunities for the students to conduct simple investigations about small animals; and to record and describe their observations. This initial Engage lesson, entitled In the yard, was designed to capture the students' interest in the topic, to find out what they knew about the small animals in their schoolyard environment, and to elicit their questions. The lesson comprised several components that included: a discussion that explored the meaning of 'schoolyard' and 'safari' and elicited the students' predictions about what they might find in their schoolyard; documenting the students' predictions in a class journal; and the students role-playing some of the animals that they had predicted they would find.

Instead of working her way through each component of the lesson as they are listed above, Holly began the lesson by using two puppets to play out the scenario that she had planned during PL Days 1 and 2 (PL 2 interview, 18/8/2009). The data analysis for Lesson 2 centred on the interaction that arose from this initial whole-class discussion.

The setting

When preparing to use the puppets to introduce a new topic of inquiry it was important for the teachers to develop a scenario whereby the puppets elicited the help of the class to solve a problem. This facilitated the students' engagement in the topic and provided a meaningful context for their subsequent investigation. Furthermore, the teachers needed to develop each puppet's voice and personality as well as the skills to

physically manipulate them. As a result, Holly had acquired two small dog puppets to use specifically during her science lessons and she had created quite different personalities for them. The first puppet was a small dog with a long, fluffy white coat that was named Tilly. Tilly was depicted as a young, scatterbrained little dog that was always getting into trouble. The second puppet was a larger dog with a short brown and white coat that was named Detective Doug. Detective Doug was portrayed as a very sensible, dependable dog that loved to investigate problems.

In setting the scene for the new Schoolyard Safari topic, Holly had created a scenario where Tilly sought help from Detective Doug.

> The little puppet, the little girl dog that tends to get into trouble, had a situation where she went outside and she was playing around and got stung by insects and she was too scared and upset to go back outside anymore. And so Doug, the bigger dog, wanted the children's help to work out what might be the problem and how we could help her. (PL 2 interview, 18/8/2009)

During PL Days 1 and 2, Ben (the teacher who is the subject of the previous case study) shared the video footage taken prior to the professional learning intervention of his Kindergarten/Pre-primary class participating in substantive discussion. The video showed how the students and teachers sat on the floor in a circle to talk to each other and that the students used a Thinking Thumb when they wished to speak.

In this second lesson, it was evident that Holly had adopted some of the ideas Ben had shared during PL Days 1 and 2 as she had made several changes to the ground rules for discussion. The most obvious was that the class no longer sat in a pod shape facing the teacher but rather in a circle so that the students and the teacher could face each other (Video footage, 27/7/2009). In this instance, Holly sat on a chair at the top end of the circle and four students were seated on the couch directly opposite her while the remaining 19 students were seated cross legged on the mat around the sides of the circle (Video footage, 27/7/2009). In addition, while Holly or the puppets continued to nominate who should speak, the students had begun to use a Thinking Thumb to indicate that they wished to share their ideas (Video footage, 27/7/2009). Holly thought that the students' use of a Thinking Thumb to indicate they wished to speak seemed less intrusive on the discussion than when they raised their hands. She felt that this

change, in conjunction with the altered seating arrangements, seemed to facilitate the students' active listening (PL 2 interview, 18/8/2009).

During the discussion, Holly initially used the puppets to set up the problem and then to elicit the students' prior understandings about the small animals they might find in their school yard. Once Tilly had explained that she had been stung by an unidentified creature and that she was now too frightened to play in her back yard, Detective Doug invited the students to share their ideas about how they might help her understand what had bitten her and why (Video footage, 27/7/2009).

Key Finding 6.18

In Lesson 2, Holly used two small dog puppets, Detective Doug and Tilly, to set the scene for the new topic and to present a problem for the students to investigate. Holly had to plan the scenario, develop each puppet's voice and personality as well as the skills to physically manipulate them.

The conventions for discussion had changed. Holly and the students now sat in a circle facing each other and the students used a Thinking Thumb to indicate they had something to say.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

Once the puppets had set up the problem to be investigated and invited the students to share their ideas, the discussion in Lesson 2 was mostly driven by the *open-ideas* questions they asked. There were a small number of *open-explanation~reason* and *closed* questions asked when Holly picked up on one child's suggestion to use a magnifying glass to look at the small creatures they might find in the schoolyard.

The analysis showed that Holly and the puppets asked a total of eight initiating questions in this segment of the lesson. Five of these questions were classified as

open-ideas (62%); two were classified as *open-explanation~reason* (25%); one was a *closed* question (12%); and there were no (0%) *open-description* questions asked.

Key Finding 6.19

In the whole-class discussion in Lesson 2, Holly asked a total of eight initiating questions of which 62% were *open-ideas* questions and 25% were *open-explanation~reason* questions.

Teacher discourse moves

The analysis of the discussion in Lesson 2 revealed similar patterns of teacher-student (or teacher/puppet-student) interaction to those Holly used in Lesson 1. The data showed that when Holly used the puppets to elicit the students' ideas she was inclined to use *teacher restate* where she repeated what they had said and then moved on to ask another student for their ideas. At times, she would also *clarify* a student response. These teacher discourse moves developed into the (teacher nominated) *turn taking* pattern of interaction seen in Lesson 1 (refer to Key Finding 6.11), where Holly tended to simply restate what each students had said before moving on to seek new ideas. While the students took longer turns than in Lesson 1, the teacher/puppet-student exchanges were just as short. The teacher discourse moves that comprise these interactions included *teacher restate* and *clarify*.

Key Finding 6.20

Holly used the *turn taking* pattern of interaction and she regularly sought clarification of a student's idea in Lesson 2. *Turn taking* consisted of short teacher-student-teacher exchanges where the teacher nominated a student to respond, restated what they had said and, without further interaction, moved on to ask other students for their ideas. When clarification was sought, the teacher/puppet-student interaction was slightly longer.

Further on in the discussion, Holly switched roles between Tilly and the teacher in order to explore Mary's suggestion about using a magnifying glass to study the small animals or insects they might find, see Figure 6.4 below.

Turn	Utterances	Coding
1.	T: Mary, what have you got to say?	Directed question, open–Ideas question.
2.	**S:Mar: We can use a magnifying glass so Tilly can look at them closely.**	
3.	T: Oh, we could use a magnifying glass so Tilly can look at them closely and that's a good idea too. I like that, a magnifying glass. What is a magnifying glass? Because I don't know if Tilly knows. I know what a magnifying glass is, but maybe you could explain what a magnifying glass is for Tilly.	Teacher restate. Teacher uptake, open-explanation~reason question.
4.	**S:Mar: It's like glass but it has a frame, yeah, it's like a frame and you can look closer.**	
5.	T: You can look closer. And what does it do to the things that you look at?	Teacher restate. Teacher uptake, open-explanation~reason question.
6.	**S:Mar: It turns bigger.**	
7.	T: Ahh! It makes them bigger, good. Do you understand that, Tilly?	Reframe. Evaluate.
8.	P:Tilly: Yeah, I think so. That sounds interesting, something that makes something bigger. Ooh, I'd like to see that.	Teacher restate.

Figure 6.4: Lesson 2 - the teacher used a probing strategy to seek more information using directed question, teacher restate, teacher uptake, reframe *and* evaluate*.

Prior to the start of this excerpt (Figure 6.4), the students had suggested that they could search for some of the small animals or insects that may have bitten Tilly and bring them back to the classroom to study. When asked what she thought (*directed question*, turn 1), Mary suggested they should use a magnifying glass to show Tilly what the small animals or insects looked like (turn 6). Holly picked up on her idea and asked her to explain to Tilly what a magnifying glass was (*teacher restate* and *teacher uptake*, turn 7). Mary gave an initial explanation (turn 8) and then Holly asked her to also explain what effect a magnifying glass has on the object that is viewed through it (*teacher restate* and *teacher uptake*, turn 9). Mary responded that "It turns bigger" (turn 10) and Holly rephrased and praised her answer (*reframe*, turn 11). Finally, Holly used Tilly to reiterate Mary's explanation (*teacher restate*, turn 12).

This segment was quite different to the earlier parts of the discussion in that it showed how Holly picked up on one student's response and probed for more information by

asking questions that required further explanation. This resulted in a longer teacher/puppet-student exchange consisting of an 11-turn structure (P-S→ P-T-S→ T-S→ T-S→ T-P) using the *directed question*, *teacher restate teacher uptake*, *reframe*, *evaluation*, *teacher restate* discourse moves.

The analysis of the discussion in Lesson 2 shows that there is no evidence of Holly's use of discourse moves that could be coded as *wait time* or *extended thinking time*.

Key Finding 6.21

At one point in the discussion in Lesson 2, Holly used a range of teacher discourse moves to probe a student's ideas, including *directed question*, *teacher restate*, *teacher uptake*, *reframe*, and *evaluate*. This resulted in a much longer teacher/puppet-student exchange of 11 turns. Holly did not use *wait time* or *extended thinking time* in this lesson.

Communicative approach

In Lesson 2, the discussion between the teacher, the puppets and the students was mostly prompted by *open-ideas* questions with many suggestions and ideas being shared (PL 2 interview, 18/8/2009). In this instance the communicative approach would be classified Interactive-Dialogic (Mortimer & Scott, 2003) which is an appropriate form of interaction for an Engage lesson when a teacher seeks to elicit the students' existing ideas. In conjunction with *open-ideas* questions, Holly mostly used *restate* and *clarify* discourse moves to achieve this purpose and at one point she also probed a student's ideas using a *directed question*, *teacher restate*, *teacher uptake*, *reframing*, and *evaluation*.

Key Finding 6.22

In Lesson 2, an Engage lesson, Holly utilised an Interactive-Dialogic communicative approach to facilitate the students to share their ideas.

Proportions of teacher and student talk

In Lesson 2, the analysis showed that when speaking as the teacher or as the puppets, Holly utilised a large percentage of the talk time (76%). In addition, the students made fewer contributions (24%) than in Lesson 1 when the puppets were not used.

Key Finding 6.23

In Lesson 2, Holly utilised about 76% of the talk time and the students utilised 24% in whole-class substantive discussion.

The students' role

In Lesson 2, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

In Lesson 2, there were nine *elaborated utterances*. Given there were no *elaborated utterances* in Lesson 1, this is a significant increase and suggests a positive change to the way that the students participated in the discussion. The example given in Figure 6.5 below shows two of the student's contributions (turns 3 and 12) that have been coded as *elaborate utterances*.

Turn	Utterances	Coding
1.	**S:Luk: You did say that you jumped on the creatures.**	
2.	P:Tilly: I might have jumped on them.	
3.	**S:Luk: Maybe that's why they killed you because they might be… I think that's why they bit you because you might be jumping on them and then those creatures might have bitten on you because you done that to them.**	Elaborated Utterance.
4.	P:Tilly: Oh Luke, so you think maybe I wasn't being very nice to them and I didn't realize I was doing that.	
5.	**S:Luk: I think you might have to watch out.**	
6.	P:Tilly: Oh Miss Holly, maybe I need to learn a lesson here too, ooh, about what I have to do when I am outside in the environment. Ooh, I didn't think about that one either.	

7.	T: Yes, Remi.	
8.	**S:Rem: I think they bit you because they probably was scared like you.**	
9.	P:Tilly: You think they were scared of me? But I'm so nice and sweet who would be scared of me?	
10.	**S:Rem: Because you were jumping on them.**	
11.	P:Tilly: Oh, because I was jumping on them? Yes, Anna.	
12.	**S:Ann: Just like Remi said and you were like bigger so they think you are a big giant thing so that's why they bit you because they were trying to protect their home or themselves.**	Elaborated Utterance.
13.	P:Tilly: Oh, so to them maybe I'm really big and I'm a giant and I look scary.	
14.	**S:Ann: Because they are so tiny and they can look up and you will be like really big.**	
15.	P:Tilly: Oh, I didn't think of all these things maybe they were scared like me too. Oh Doug, I think it's really important if we find out about… because maybe I need to learn not just about them because they bit me but maybe I need to learn about what I need to do when I go outside and play so that this doesn't happen again.	

Figure 6.5: Lesson 2 - the students gave elaborated utterances.

Holly had also noticed that, aside from the students taking more turns to speak during class discussions, they actually made eye contact with each other and listened more to what each other had to say rather than simply waiting for their turn to speak (PL 2 interview, 18/8/2009). The data also shows that the students began to build on each other's contributions and to generate cumulative talk (Alexander, 2006). For example, in turns 1, 3 and 5 in Figure 6.5 above, Luke (S:Luk) suggested that Tilly may have provoked the creatures that bit her because she had jumped on them and that she should watch what she was doing. Then Remi (S:Rem) explained that the creatures might have bitten Tilly because they were as scared as she was when she jumped on them (turns 8 and 10). Anna (S:Ann) agreed and explained that Tilly must have appeared enormous to the little creatures that had bitten her and that they were trying to protect themselves (turns 12 and 14) (Video footage, 27/7/2009).

Key Finding 6.24

In Lesson 2, there were nine *elaborated utterances* and the students took longer turns, made eye contact, and listened to each other. They began to build on each other's ideas and to generate cumulative talk.

Lesson 2 summary

Lesson 2 was the first Engage lesson for a new unit of study and Holly used the puppets to engage the students in the topic and to elicit their ideas and prior knowledge. She utilised an Interactive-Dialogic style of interaction where she asked several *open-ideas* questions and she began to engage the students in longer interactions by asking follow up questions that required them to say more.

When using the puppets Holly typically utilised a (teacher-nominated) *turn taking* pattern of interaction and she regularly followed up with questions that *clarified* what the students had to say. While these discourse moves continued to result in short exchanges (T-S-T or T-S →T-S) and a predominance of teacher talk, the increased number of the students' elaborated utterances indicates that they had begun to take significantly longer turns and their talk also became more cumulative. On one occasion, Holly used a range of discourse moves (*directed question*, *teacher restate*, *teacher uptake*, *reframing*, and *evaluation)* to probe a student's idea and explore it in more detail, which resulted in a much longer teacher/puppet-student exchange (P-S→ P-T-S→ T-S→ T-S→ T-P). Holly did not use *wait time* or *extended thinking time* in this lesson.

Lesson 3, post Professional Learning Days 1 and 2

The lesson

Lesson 3 was videoed in August, approximately four weeks after Lesson 2, and was the first lesson in the Explain phase of the *Primary Connections* topic, Schoolyard Safari. The lesson, entitled Same and Different, provided opportunities for the students to represent and explain their understanding about the similarities and differences between small animals and for the teacher to introduce the scientific view about the features, habitats and behaviour of small animals. The lesson was comprised of: a whole-class discussion to review what the students knew about earthworms, snails and ants; group work, with individual students researching and recording a description of a small animal, then sharing their description with their group so as to find the similarities and differences between two animals; and, the groups sharing their conclusions with

the class. The data analysis for this lesson centred on the interaction that arose during the initial whole-class discussion.

The setting

In this lesson, Holly began the discussion by briefly reviewing what the students had been learning about during the Engage and Explore phases of the Schoolyard Safari topic. She then used the puppets, Tilly and Detective Doug, to revisit the problem Tilly had with playing in the natural environment and she asked the students to explain what they had learned from the Engage and Explore lessons. This gave the students the chance to report their findings and to offer some solutions to Tilly's dilemma. Finally, taking advantage of his detective persona, Holly used Detective Doug to initiate a discussion that explored in more depth what the students had learned about the features of small animals.

As in Lesson 2, Holly and the students were seated in a circle facing each other in the mat area of the classroom, with Holly on a chair at the top end of the circle and four students seated on the couch directly opposite her (Video footage, 26/8/2009). The remaining 18 students sat cross legged on the mat around the sides of the circle (Video footage, 26/8/2009). Holly and the students had come to call this arrangement the "Sharing Circle" (PL 3 interview, 1/10/2009). Either Holly or the puppets nominated the speaker and the students used a Thinking Thumb to indicate that they wished to have a speaking turn (Video footage, 26/8/2009).

Key Finding 6.25

Initially, Holly used the puppets in Lesson 3 to review the problem and to elicit the students' ideas and solutions to the problem. Then she used them to find out more about what the students had learned regarding the features of small animals.

Holly and the students sat in their Sharing Circle and the students used a Thinking Thumb to indicate they had something to say.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In Lesson 3, when the students were invited to share with Tilly and Detective Doug what they had discovered during the Explore phase, the discussion was driven by *open-ideas* questions. When the discussion moved on to more explicit talk about the features of different small animals, there were more *open-description* questions and some *open-explanation~reason* questions asked. In addition, a feature of the puppets' interactive style was that they tended to use *closed* questions when they asked the students to clarify their ideas, consequently, this increased the total number of *closed* questions asked in this lesson.

The analysis of the discussion showed that Holly and the puppets asked a total of 39 initiating questions in Lesson 3. Nineteen (49%) of these questions were classified as *closed* questions; nine (23%) were classified as *open-ideas*; eight (20%) were classified as *open-description*; and three (8%) were *open-explanation~reason* questions.

Key Finding 6.26

In the whole-class discussion in Lesson 3, Holly asked a total of 39 initiating questions of which approximately 50% were *closed* questions and 40% were either *open-ideas* questions or *open-description* questions and a few were *open-explanation~reason* questions.

Teacher discourse moves

Since Lesson 3 was an Explain lesson, Holly wanted to ensure that the key ideas and concepts to do with the investigation were made explicit (PL 3 interview. 1/10/2009). Several excerpts have been selected from the discussion in this lesson to show how Holly used the puppets to elicit the students' ideas and to probe their explanations in

order to resolve the problem under investigation and to reinforce the scientific point of view. The excerpts also capture how Holly used Thinking Time and how the group supported each other to articulate their ideas (Video footage, 26/8/2009).

As previously stated, Holly initiated the discussion by reviewing which small creatures the students had been studying. Then she invited them to tell Detective Doug and Tilly what they had learned and to see if they could help solve Tilly's problem. The interaction captured below (Figure 6.6) shows how Holly used the puppets to elicit the students' ideas and to help them to relate their thinking to the problem. Holly also used the Thinking Time strategy to give a student more time to think (Video footage, 26/8/2009). The excerpt commences with Brigid (S:Bri) sharing her ideas.

Turn	Utterances	Coding
1.	**S:Bri: Well, outside there's some bugs that are not as dangerous and some of them don't hurt you as much as other ones. And normally they are helpful to people sometimes, like bees they make honey for you.**	
2.	P:Tilly: Oh, OK. So, I think I'm getting a bit of an idea that not all bugs will hurt me?	Clarify.
3.	[S: Bri shakes her head]	
4.	P:Tilly: Aahhh! And some little mini beast creatures can actually be useful to us.	Teacher restate.
5.	**S:Bri: Yep, and some um.. some can be an animal like a spider it has eight legs, it's not an insect, so that will hurt too.**	
6.	P:Tilly: Ahhh. That might help me be able to work out what bit me because I remember it had six legs. So would that have been a spider then, Brigid?	Teacher uptake, Closed question.
7.	**S:Bri: No.**	
8.	P:Tilly: No. Mmm. Yes, Tara?	Teacher restate. Asks another student for his/her ideas.
9.	**S:Tar: You don't have to be afraid of all bugs but some…** [long pause]**… I forgot.**	
10.	P:Tilly: You forgot, that's OK. Now Miss Holly she forgot, what could she maybe do about that?	
11.	T: Well, that's OK, Tara, because we could give you a little bit more thinking time and we can always come back to you like we said we could maybe come back to you later on. So you can have a little bit more time to think.	Extended thinking time.

Figure 6.6: Lesson 3 - the teacher provided extended thinking time*.*

249

In the above excerpt (Figure 6.6), Holly used a range of discourse moves to maximise her interaction with individual students and to progress the discussion towards a solution to Tilly's problem. At the start, Brigid stated that not all small creatures were dangerous and that some could be helpful (turn 1). Tilly responded by clarifying (turn 2) and then restating what Brigid had said (turn 4). Then Brigid differentiated between spiders and insects by saying "… a spider it has eight legs, it's not an insect" (turn 5). Picking up on Brigid's idea, Tilly asked whether it could have been a spider that had bitten her (*teacher uptake*, turn 6). Brigid clearly stated "No" (turn 7) and Tilly moved on to ask Tara for her ideas (turn 8).

In the next part of the interaction (turns 8-11), Holly used Tilly to highlight the Thinking Time strategy that the students could use during discussions (Video footage, 26/8/2009). In turn 8, Tilly nominated Tara to share her ideas and part way through her turn Tara lost her train of thought, stating "I forgot" (turn 9). Tilly responded by asking Holly what the students could do when they forgot what they wanted to say (turn 10). Holly explained that they could take some time to think and then join the discussion at a later point (*extended thinking time*, turn 11).

Key Finding 6.27

Holly used a range of teacher discourse moves in Lesson 3 to maximise her interaction with individual students and to help them to link their ideas to the problem. This included *teacher restate*, *clarify*, and *teacher uptake*. She also used *extended thinking time* to give individual students time to think.

In the next excerpt (Figure 6.7), Holly used the puppets to shape the discussion so as to highlight some important ideas from the Schoolyard Safari topic about how to behave responsibly in the natural environment.

Turn	Utterances	Coding
1.	T: Luke, would you like to share something with Tilly and Doug?	Directed question, open-ideas question.
2.	**S:Luk: We've just been outside and it was... so there are some creatures out there but we're not scared of them because they are little to us because we are bigger than them. We enjoy going outside and stuff like**	

	that. **There is insects but just don't be afraid cause we're.. you're bigger than an insect.**	
3.	P:Tilly: Ahh…so I am bigger, but they still scared me.	Teacher restate.
4.	**S:Luk: But.. yeah, because you.. I think you was actually doing the wrong thing because you was jumping on their home, wasn't you?**	
5.	P:Tilly: Oh, so you're saying that maybe because I was jumping on their homes that maybe I was doing the wrong thing? Oh, oh, I wouldn't like to think I was doing the wrong thing. So what could I do about that, Luke? What could I do?	Clarify. Open-ideas question.
6.	**S:Luk: Stop doing that so that they won't bite you.**	
7.	P:Tilly: Oh, stop jumping around everywhere or just maybe stop jumping [interrupted]	Clarify.
8.	**S:Luk: Stop jumping on the homes. You can still jump around.**	
9.	P:Tilly: Oh but not.. oh but watch where I'm jumping maybe?	Clarify.
10.	**S:Luk: Yup.**	
11.	**S: Yeah.**	
12.	P:Tilly: Oh fantastic. That's an excellent idea, Miss Holly, maybe I need to make sure that when I'm jumping around that I look at what I'm jumping on. That sounds a great suggestion, Luke.	Evaluate. Teacher restate.

Figure 6.7: Lesson 3 - the teacher used the puppets to highlight important ideas.

In this excerpt (Figure 6.7), Holly asked Luke (S:Luk) to share his ideas with the puppets (turn 1) and he encouraged Tilly not to be afraid of the creatures in the garden that were smaller than her (turn 2). Tilly reiterated his idea but remained adamant that the small creatures still scared her (*teacher restate*, turn 5) and so Luke explained that by jumping on the creatures' homes it was she who had done the wrong thing (turn 6). Realising that she might have been stung because of her own actions, Tilly clarified what Luke had said (*clarify*, turn 7) and then asked him what she should do (*open-ideas* question, turn 7). This initiated further interaction (turns 8-13) about how Tilly should take care not to jump on the homes of small creatures and by seeking further clarification Tilly highlighted Luke's ideas twice more (*clarify*, turns 9 and 10). Finally, Tilly wrapped up the interaction by praising and reiterating Luke's suggestions (*evaluate* and *teacher restate*, turn 14).

By asking an open question and then restating and clarifying what the Luke had said, Holly used simple discourse moves to support him to articulate some key ideas. Holly utilised these teacher discourse moves twice in this particular segment and she reinforced the messages at the end of the interaction by praising (*evaluate*) and reiterating them (*teacher restate*). By highlighting particular ideas in this way, Holly was effectively using the puppets to make the scientific ideas explicit. The teacher discourse moves used in this particular chain of interaction generated a conversation thread of 12 turns (T-S→ P-S→ P-S→ P-S→ P-S→ P). Holly went on to use these same teacher discourse moves several more times during the discussion in Lesson 3.

Key Finding 6.28

Holly used the puppets to make science ideas explicit in Lesson 3. She used simple teacher discourse moves (*teacher restate* and *clarify*) to highlight important ideas in the discussion. This resulted in a longer teacher/puppet-student chain of interaction comprising 12 turns.

The next excerpt (Figure 6.8) shows how the students were able to make significant contributions to the discussion when given some time to think. Earlier in the discussion, (Figure 6.10), Holly had given Tara some Thinking Time when she forgot what she wanted to say (Video footage, 26/8/2009). A little later she was able to share her ideas with the class and when she had some difficulty trying to pronounce the word 'colony' Holly and the students were able to support her.

Turn	Utterances	Coding
1.	P:Tilly: Tara, did you think about what you thought before?	Directed question, open-ideas question.
2.	**S:Tar: Yep, um.. you don't have to be afraid because they just.. they just bit you on the nose where ever animal because they were protecting um.. their um.. their c-o-l..**	
3.	**S:1: Conoly?**	
4.	**S:Tar: um.. conoly.. um..**	
5.	**S:2: Colony.**	
6.	T: Colony?	Prompt and scaffold.
7.	**S:Tar: colony…**	
8.	P:Tilly: Oh.	

9.	**S:Tar: colony from harm.**	
10.	T: So, Tara, you think that.. that.. that like a colony.. like an ants col.. like the colony they live in? So that was their home?	Clarify.
	So, Tilley do you understand that? A colony is where ants live and that's like their home to them. And maybe you were jumping on their home and that's what Tara is saying that they were defending themselves and protecting themselves and that's the reason why they bit you.	Reframe. *(Change from Interactive-Dialogic to Interactive-Authoritative)*
11.	P:Tilly: Oh, I think I'm beginning to understand. Can you understand that too, Doug?	
12.	P:Doug: Yes, it all sounds very sensible to me. I think that Tilley needs to make sure that she is careful when she goes outside. So, like Luke said, maybe she needs to watch where she is jumping. And like Brigid said that she needs to be um.. she can go near them 'cause they all don't bite, they're not all so harmful. And like Tara was saying, that maybe they were just protecting themselves and that they weren't trying to be mean to you, Tilley. They actually were just as scared of you, just like you've been scared of them now.	Refocus. *(Interactive-Authoritative)*

Figure 6.8: Lesson 3 - the teacher and students supported each other to articulate their ideas.

In the above excerpt (Figure 6.8), Holly asked Tara (S:Tar) if she recalled what she had previously wanted to say (turn 1). Tara had remembered and she explained to Tilly that the creatures had bitten her because they were trying to protect their colony (turn 2). When Tara had difficulty articulating the word 'colony', two students attempted to help her (S:1 in turn 3 and S:2 in turn 5). Then Holly prompted her (*prompt and scaffold*, turn 6) and Tara picked up the correct pronunciation (turn 7) and finished what she had to say (turn 9). At this point, Holly made sure she had understood Tara correctly (*clarify*, turn 10) and, in the process of explaining to Tilly, Holly rephrased Tara's idea to improve the way it was expressed (*reframe*, turn 10). It was at this point that Holly began to change her communicative approach, moving from the Interactive-Dialogic style she used to elicit the students ideas to being more Interactive-Authoritative in order to emphasise a key idea. Holly retained this communicative style when she used Detective Doug (turn 11) to summarise the students' ideas (*refocus*, turn 12) and conclude the interaction.

Key Finding 6.29

The students were able to make significant contributions to the discussion in Lesson 3 when given time to think and Holly and the students supported each other to articulate their ideas.

In Lesson 3, Holly's communicative approach became more Interactive-Authoritative when she wanted to emphasise a key idea. She used the *clarify*, *reframe* and *refocus* discourse moves to achieve this.

The next excerpt (Figure 6.9) shows how a little later in the discussion the students helped Tilly to resolve her problem by helping her to identify what had bitten her. Holly also took the chance (as the teacher and also as the puppet) to clearly explain what behaviour was appropriate in the natural environment and to reinforce the scientific point of view.

Turn	Utterances	Coding
1.	P:Tilly: Yes, Joss?	Asks another student for his/her ideas.
2.	**S:Jos: Um.. if you move that book, it might look like one of those insects up there.** [S:Jos is referring to the insect that bit Tilly and he indicates a chart on the whiteboard that has a range of insects on it]	
3.	P:Tilly: Oh, I think you might be right. Look at all those mini beasts, Joss. I didn't see that before. Oh! And I think I can see what bit me. Oh, there it is, Doug, I can see it. And, ooh, it is brown and it's got six legs and it's got this horrible piercing thing at the back of it. And… and its body has got little lines across it. Oh, let me see who is sitting nicely, Miss Holly? Oh, let me see. Susie, what do you think, can you see it? 'Cause I can't read but I can certainly see it up there. What is it called?	Directed question, open-ideas question. Open-description question.
4.	**S:Sus: An earwig.**	
5.	P:Tilly: Could you maybe point to it for me? [Susie moves to point to the chart on the wall]	
6.	P:Tilly: But don't let it bite you!! Oh yes, Susie, that is what it was. So what is it called again, Susie?	
7.	**S:Sus: It's an earwig.**	
8.	P:Tilly: An earwig. Oh, that's what it was, Doug, it was an ear-wig. So I need to make sure I don't go near them anymore. And it must… it must have been defending itself, maybe like what Tara said. Maybe it was scared of me and I need to watch what I'm doing when I go outside, Miss Holly.	Refocus. *(Puppet-teacher interaction)*

| 9. | T: I think you do, Tilly. That's a good lesson for all of us to learn, that when we do go outside and play in our backyards or we go for a walk in the bush somewhere, we need to be very careful where we are walking so that we don't tread on little creatures' homes or disrupt them because they might get protective or defensive and they might try to bite us because they are so scared. | Refocus. *(Change from Interactive-Dialogic to Interactive-Authoritative)* |

Figure 6.9: Lesson 3 - the teacher reiterated the key ideas using prompt and scaffold, clarify, reframe, *and* refocus.

In the above excerpt (Figure 6.9), Tilly asked Joss (S:Jos) to share his ideas and he referred her to a chart of insects so she could identify what had bitten her (turn 2). Tilly found the insect and asked Susie (S:Sus) to read what it was called (turns 3-7). In concluding the discussion, Tilly summarised what she had learned from the students (*refocus*, turn 8) and then Holly clearly reiterated the key messages (*refocus*, turn 9) and drew the threads of the conversation together. In doing so she adopted a more Interactive-Authoritative style once more.

Key Finding 6.30

In Lesson 3, Holly would resume control of the interaction by utilising a more Interactive-Authoritative approach when explaining and reinforcing the key understandings of the topic. She used the *refocus* discourse move to summarise and consolidate the discussion.

In the next part of the discussion, Holly wanted to know more about what the students had learned from their own schoolyard safari and she used the puppet Detective Doug to move the discussion on to more explicit talk about the features of the snails, ants and worms they had found. This provided an opportunity for Holly to probe the students' understandings and to ask them to describe and explain their observations, see Figure 6.10 below.

Turn	Utterances	Coding
1.	P:Doug: Joss, what's something you learnt?	Directed question, open-ideas question.
2.	**S:Jos: Um.. it's about the ant's, because we went out there and we left some sugar and we found a few ants. And we actually got 'em and had to put them into the um.. things** [interrupted]	

3.	**S:1: Petri dish.**	
4.	**S:Jos: um.. petri dish. And there's a picture of the ants up there.**	
5.	P:Doug: Ooh, yes, I can see the ant up there, the picture. Yes, aha. And can you tell me anything more that you noticed about the ants, like what features it might have had.. how many legs or wings?	Elaborate, open-description question.
6.	**S:2: Three body parts and six legs.**	
7.	P:Doug: Three body parts and six legs.	Teacher restate.
8.	**S:3: And they move antennas.**	
9.	P:Doug: And they move it's antennas and [interrupted]	Teacher restate.
10.	**S:3: All ways.**	
11.	P:Doug: All ways? And do you know why they move their antennas?	Clarify. Teacher uptake, open-explanation~reason question.
12.	**S:3: To talk.**	
13.	P:Doug: To talk? Just like I'm talking to you now?	Clarify.
14.	**S:3: Yes.**	
15.	P:Doug: Oh! Ooh, Miss Holly, that's unusual. They have antennas but we don't have antennas and we talk with our mouths. Tara, what did you notice?	Directed question, open-description question.
16.	**S:Tar: I noticed.. I mean, I learnt that a snail has a foot and I didn't know that before.**	
17.	P:Doug: Oh. Does it look like your foot?	Teacher uptake, closed question.
18.	**S:Tar: No.**	
19.	P:Doug: No? And what does this foot do then?	Clarify. Teacher uptake, open-description question.
20.	**S:Tar: It helps the snail to move.**	
21.	P:Doug: Ah-hah. Is there anything else that maybe helps it move that you know of? Does it use anything else?	Teacher uptake, open-description question. Prompt and scaffold, closed question.
22.	**S:Tar: Its body, it slimes across.**	
23.	P:Doug: Ahh, slimes across things. Mmm. Wow!	Teacher restate.

Figure 6.10: Lesson 3 - the teacher sought explanation and probed the students' ideas further.

In turns 1-14 of Figure 6.10, Detective Doug (P:Doug) focused initially on eliciting the students' observations of the small animals and insects they had investigated and then

on seeking some explanation of their observations. This interaction began with Joss (S:Jos) describing how he had collected ants in a petri dish (turns 2-4) and was continued by Student 2 (S:2) and Student 3 (S:3) when they responded to Detective Doug's request to say more about the features of an ant (*elaborate, open-description* question, turn 5). Detective Doug asked Student 3 to explain why ants moved their antennae (*teacher uptake*, *open-explanation~reason* question, turn11) and he responded that the ants use their antennae to talk (turn 12). Detective Doug concluded the interaction by drawing a comparison between the way that ants talk and the way that people talk (turn 15).

In the next part of the excerpt (turns 15-23 in Figure 6.10), Detective Doug turned to Tara (S:Tar) to find out what she had discovered and in this interaction he engaged her further by probing for more explicit information. The interaction began with Tara stating that she had found out that a snail has a foot (turn 16). Once again, Detective Doug used *teacher uptake* (turns 17, 19 and 20) and *prompt and scaffold* (turn 21) as a way to find out more (Video footage, 26/8/2009).

This excerpt (Figure 6.10) shows how Holly used Detective Doug to focus initially on eliciting the students' observations and then on engaging them further by using discourse moves such as *elaborate*, *teacher restate*, *clarify*, *teacher uptake* and *prompt and scaffold* to probe for more explicit information or for deeper thinking. The use of these teacher discourse moves generated two conversation threads, one 12-turn structure involving Joss, Student 2 and Student 3 (P-S:Jos → P-S2→ P-S3→ P-S3→ P-S3→ P-S3) followed by a nine-turn structure involving Tara (P-S:Tar→ P-S:Tar → P-S:Tar → P-S:Tar → P).

In Lesson 3, the analysis shows that there is no evidence of Holly's use of *wait time* but there were four instances of discourse moves that were coded as *extended thinking time*.

Key Finding 6.31

In Lesson 3, Holly used the puppets to find out what the students had learned and to probe their understandings by asking questions that seek elaboration and explanation. The teacher discourse moves she used included *elaborate*, *teacher restate*, *clarify*, *teacher uptake*, *prompt and scaffold*, and *reframe*. Holly did not use *wait time* in this lesson but there were four instances of *extended thinking time*.

Communicative approach

Lesson 3 differed from previous lessons in that the style of interaction altered during the course of discussion. Whilst the interaction remained predominantly Interactive-Dialogic as Holly used the puppets to review the students' experiences and ideas from the earlier phases of the investigation, there was a shift to a more Interactive-Authoritative style when she gave an explanation of an ants' colony (turns 10 and 12 in Figure 6.12; turn 9 in Figure 13). Such a shift in the style of interaction is consistent with the form of discourse required in the Explain phase where the instructional purpose is to introduce and develop the scientific explanation of the science phenomenon that is the focus of the investigation. This type of discussion requires the teacher to initially use an Interactive-Dialogic approach (Mortimer & Scott, 2003) to recall the students' experiences, ideas and explanations related to the phenomenon; followed by a more Interactive-Authoritative approach (Mortimer & Scott, 2003) as the teacher uses questioning to develop the scientific view. When eliciting the students' ideas and explanations, Holly utilised *open-ideas* questions and *clarify* and *restate* discourse moves. When she began to probe the students' thinking she used more *open-description* and *open-explanation~reason* questions and a greater range of discourse moves, including *elaborate*, *teacher restate*, *clarify*, *teacher uptake*, and *prompt and scaffold.*

Key Finding 6.32

The communicative approach in Lesson 3 was initially Interactive-Dialogic, as Holly and the students reviewed their experiences and ideas from the Engage and Explore phases. An Interactive-Authoritative style of interaction became evident when Holly wished to make key ideas explicit or to provide an explanation.

Proportions of teacher and student talk

While Holly continued to utilise a large percentage of the talk in Lesson 3 (67%), the level of student contributions had increased (33%) compared to previous lessons.

Key Finding 6.33

In Lesson 3, Holly utilised about 67% of the talk time and the students utilised 33% in whole-class substantive discussion.

The students' role

In Lesson 3, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

There were 17 *elaborated utterances* in Lesson 3. This is a significant increase compared to previous lessons and suggests that the students were keen to engage in the discussion and were growing accustomed to Holly's requests for further information and elaboration. The example below (Figure 6.11) shows two of the student's contributions that have been coded as *elaborated utterances* (turns 10 and 12). This segment builds on from the previous excerpt in Figure 6.14 where Tara shared her understandings about snails.

Turn	Utterances	Coding
1.	P:Doug: Yes, Shelly?	
2.	**S:She: It uses its slime to help it.**	
3.	P:Doug: It uses its slime. Is that why they leave these funny sticky marks when they've finished going past you?	
4.	**S:She: Yes.**	
5.	P:Doug: Ah!	
6.	**S:She: And they leave a trail so um.. so they can.. it's like a trail.**	
7.	P:Doug: It's like a trail. Yes, Kane.	
8.	**S:Kan: And they leave the slime so they can make their**	

	way back without getting lost.	
9.	P:Doug: Oh! So you think it helps find how to get back home? Oh. Remi?	
10.	**S:Rem: Um.. they've also.. not only does slime help them to get away, the foot helps them and if they're scared they just go into the shell or they can.. the.. their foot can push them along.**	Elaborated utterance. Explanation.
11.	P:Doug: Ahh, their foot pushes them. And so when they're scared like Tilley's been scared, she doesn't have a shell, but they can go into their shell? Mm-hmm. Keith?	
12.	**S:Kei: The snail has a foot that has muscles inside them, that's how it helps them.. that's why one foot helps it move. But we have um.. two legs so we can help it move. But we don't have lots of muscles inside our legs, oh, we have some, but we have more muscles inside our arms.**	Elaborated utterance. Explanation.
13.	P:Doug: Ahhh, do we? And we've got two legs and two feet and they only have one. Good.	

Figure 6.11: Lesson 3 - the students provided elaborated utterances as they explained and built on each other's ideas.

In Lesson 3, the students continued to build on each other's ideas. In the above excerpt (Figure 6.11), first Shelly (S:She) suggested that the snails' trail of slime helped them (see turns 2-6) and then Kane (S:Kan) explained that snails leave a trail of slime "so they can make their way back without getting lost" (turn 8). Next, Remi (S:Rem) added that snails can use slime to get away and that they also have a foot to push them along and shells to hide in (*elaborated utterance* and *explanation*, turn 10). Keith (S:Kei) then explained how the muscles in the snail's foot helps it move and he attempted to differentiate between this and the muscles in his own legs (*elaborated utterance* and *explanation*, turn 12).

Quality of student talk

In Lesson 3, 60% of the students' responses were coded for *description*, 11% as *unistructural* and 49% as *multistructural*, and 40% were coded for *explanation*.

Holly was pleased with the level of interaction in this lesson. In the Post Lesson 3 interview, she said that she had noticed that some of the more reticent speakers in the class had begun to participate more frequently (PL 3 interview, 1/10/2009). She had found a greater range of students were more willing to share their ideas, that they

wished to speak more frequently, and they gave more detailed responses (PL 3 interview, 1/10/2009).

> They're not just expecting a one answer type question… I think they are expecting me to [ask] 'Well, what more can you say?' and because they expect me to ask for a bit more they are willing to give a bit more. Before I would go 'Oh, that's a great answer' and give a more evaluative response and they tended to think they needed to say one thing. Whereas now they are expecting me to ask for more and … it's almost coming out of their mouth before I even say 'Can you tell me anymore?' They keep putting their hands up repeatedly rather than only one time. (PL 3 interview, 1/10/2009)

Holly had also noticed the students seemed to articulate their ideas more clearly and that they would build on each other's ideas (PL 3 interview, 1/10/2009). In addition, they tried to use the appropriate scientific terminology and they often helped one another to articulate particularly tricky words (PL 3 interview, 1/10/2009). She had found that the students were generally more supportive of one another during discussions and that they valued the chance to share their ideas. She said that the students had named these discussions "sharing time" and had come to understand that this was a safe environment in which to share ideas and listen to one another (PL 3 interview, 1/10/2009).

> I think they're more patient, they're waiting their turn more, they're not interrupting other people as much and I think they are definitely listening and looking at the person and listening to what they have to say. The whole atmosphere is definitely more like a sharing thing rather than them just giving me information. It's more sharing and listening to what everybody has to say and valuing everybody's contribution. … and they talk to each other. … They feel safe but I think they also feel really good because they know that they've said good things and they feel pleased with themselves. (PL 3 interview, 1/10/2009)

Holly was confident that the students could easily sustain science conversations and, in fact, their capacity to do so resulted in their science lessons becoming a little longer (PL 3 interview, 1/10/2009).

Lesson 3 summary

Lesson 3 was an Explain lesson for the Schoolyard Safari topic. In this lesson, Holly wanted to elicit the student's initial ideas and shared experiences from the Engage and Explore phases so as to develop a reasonable response to the problem under investigation and then she wanted to make sure the scientific ideas and explanations were made explicit. To achieve this she utilised an Interactive-Dialogic style of interaction to elicit the students' ideas and then she shifted to a more Interactive-Authoritative style when she wanted to make particular ideas explicit.

At the start of the discussion, when the communicative approach was Interactive-Dialogic, Holly used the puppets to ask *open-ideas* questions and she employed a range of teacher discourse moves (*teacher restate*, *clarify*, *teacher uptake*) to maximise the interaction with individual students and to help them to link their ideas to the problem. In addition, when she wanted to highlight important ideas she used simple teacher discourse moves (*teacher restate* and *clarify*), which resulted in longer teacher-student exchanges (e.g. T-S→ P-S→ P-S→ P-S→ P-S→ P).

Later on in the discussion, when the interaction became more Interactive-Authoritative, Holly used the puppets to probe the students understandings by asking more *open-description* and *open-explanation~reason* questions in conjunction with a range of teacher discourse moves (*elaborate*, *teacher restate*, *clarify*, *teacher uptake*, and *prompt and scaffold*) that supported the students to articulate and elaborate on their

ideas. Holly also used *refocus* to summarise the students' ideas and consolidate the discussion. Managing the discourse in this way resulted in longer chains of teacher-student interaction (e.g. T-S→ T-S→ T-S→ T-S→ T-S→ T). Additionally, while Holly used Thinking Time (*extended thinking time*) several times throughout the lesson, she did not use *wait time*.

Although Holly and the puppets continued to utilise most of the talk time, there were many more elaborated students' responses in this lesson than in previous lessons. In addition, the students continued to build on each other's contributions and their responses were predominantly comprised of higher order descriptions and explanations.

Mid-intervention: Holly's beliefs, knowledge and practice

On the third PL day in August 2009, the teachers participating in the professional learning intervention were asked to review their management of classroom discourse during the implementation of the initial science topic. For Holly, this related to the Schoolyard Safari topic referred to in Lessons 2 and 3 of this case study.

Knowledge about managing classroom discourse

The data collected from the review showed that Holly had made several changes to the way that discussion was conducted in her class. This included utilising teaching strategies that were supportive of sustained conversations, and providing teacher responses that fostered the students' interaction. In Lesson 2, Holly had introduced the Sharing Circle as a strategy that would support the students to participate in whole-class discussions (PLD 3: Review, 24/08/09). Previously, when the students had gathered on the mat to have a discussion, they would sit as one large group facing the teacher. However, when they used the Sharing Circle the students and the teacher sat in a circle around the edges of the mat so that they could face each other as they spoke. Holly had introduced the Thinking Thumb as a way for the students to indicate that they wished to speak. This meant that instead of raising their hands the students

would simply keep their hands in their laps and hold up their thumb when they had something to add to the discussion.

Holly found the Sharing Circle seating format and the Thinking Thumb strategy made it easier for the students to attend to each speaker. It also seemed to facilitate the students' interactions which had increased in length (PLD 3: Review, 24/08/09). "Better discussions [were] happening", the students were "sitting and listening to each other more", "waiting their turn and not moving around as much" (PLD 3: Review, 24/08/09). While Holly considered the students' lengthier discussions were a positive outcome, she also found it was "sometimes hard to stop the flow of conversation" in order to complete the remainder of the science lesson (PLD 3: Review, 24/08/09).

Overall, Holly felt that the quality of the students' conversation had improved (PLD 3: Review, 24/08/09). In Lesson 2, she had also endeavoured to develop a more interactive form of discourse with the students (PLD 3: Review, 24/08/09). She thought that she utilised questioning better and that she asked the students to elaborate on their ideas so that they had begun to share more of their understandings (PLD 3: Review, 24/08/09). Holly had also noticed that she was becoming more consistent in offering feedback (IRF, Mortimer & Scott, 2003) instead of evaluative answers (IRE, Mehan, 1979) when she responded to students' ideas (PLD 3: Review, 24/08/09). In the Post Lesson 2 interview, Holly had commented on her increased understanding of the way a teacher can impact the quality of classroom talk and how this had helped her to pay more attention to the kinds of responses that she gave the students.

> [Previously] I think I tended to evaluate the person's answer. You say 'Wow, that's fantastic' and because they're little [students] you tend to do that a lot. You know, 'What a great answer'. But I didn't realize that that cuts off the person from maybe extending their answer. So, now I try and say 'Can you give me a bit more about that?' or 'Can you tell me a bit more?' or 'What do you think about this?' And so I will ask them another question rather than just say 'That's great' and look for somebody else to answer a question. So, I am trying to get more information in a conversation from that one child rather than going round to the next child… to sort of get a little bit more of a meaningful conversation from that one child. And I think it gets them to think a bit harder as well. So they come up with the first answer and then when I say 'Can you tell me a bit more about that?' they then have to really take a minute to think about it and expand on their answer. I think that is actually making them think a lot more about the kind of answers they need to give. (PL 2 interview, 18/8/2009)

Holly also thought she had used more *wait time* during class discussions (PLD 3: Review, 24/08/09) and while she had begun to use *extended thinking time* and she had the perception that she used *wait time* there was no objective evidence of this in the videos from Lessons 1-3.

The review completed on the PL Day 3 also asked that the teachers rate the extent to which they had been able to develop a classroom culture that was supportive of productive talk. The teachers had to rate (0-100%) the extent to which they had developed five characteristics of productive classroom talk (Alexander, 2008) and five ground rules for effective talk (Mercer, 2008). With regard to the characteristics of productive classroom talk (Alexander, 2008), Holly indicated that she was most successful in creating a classroom culture to do with talk that was *supportive* (90%), *collective* (80%) and *reciprocal* (80%) and she thought these aspects of classroom talk were also the most improved. The reasons she gave for this were that she had "provided a feel good environment", developed "more effective questioning", and involved the students more in shaping the direction of the lessons in the Engage stage of the inquiry (PLD 3: Review, 24/08/09). Holly also indicated that, thus far in the professional learning intervention, she had had less success at developing classroom talk that was *cumulative* (70%) and *purposeful* (70%) and she identified the *cumulative* characteristic as being the most difficult to establish. She said the students found it hard to explain 'why' and to build their ideas into lines of thinking (PLD 3: Review, 24/08/09).

Regarding the ground rules for effective talk (Mercer, 2008), Holly indicated that she was most successful in creating a classroom culture in which everyone shared and listened to each others' ideas (80%), spoke one at a time (80%), and respected each others' opinions (80%) (PLD 3: Review, 24/08/09). However, she had had less success at getting the students to give reasons to explain their ideas (70%) or to resolve their disagreements (70%) (PLD 3: Review, 24/08/09).

Knowledge about using puppets

The review undertaken on the third professional learning day also invited the teachers to reflect on their use of puppets during the implementation of the initial science topic. Holly found that using the puppets at all stages of the inquiry process had been effective (PLD 3: Review, 24/08/09). She had used the puppets to set the context for the investigation and to build the students' interest during the Engage lessons (PLD 3: Review, 24/08/09). In the Post Lesson 3 interview, Holly also reported that she had used the puppets to recreate the context for the investigation and to remind the students of the puppet's problem (PL 3 interview, 1/10/2009). Since introducing them into her science lessons, Holly had found that the students were "definitely engaged and motivated to talk to the puppets" and that they "loved science day and looked forward to seeing the puppets" (PLD 3: Review, 24/08/09). In fact, Holly had noticed an immediate and positive impact on the students after introducing the puppets for the first time in Lesson 2 and she was encouraged by their keenness to share their ideas (PL 2

interview, 18/8/2009). "I think using the puppets actually helps… they really liked to talk to the puppets" (PL 2 interview, 18/8/2009).

At this point in the professional learning intervention, Holly also reported that she had found managing the whole-class discussion with two new puppets and her own role as the teacher was a complex undertaking (PLD 3: Review, 24/08/09). However, in the Post Lesson 2 interview, she also stated that she was keen to work on this further since she enjoyed using the puppets and she felt that the level of student interaction had increased.

> I think I am getting better each week. I still feel a bit self-conscious and I don't think I have really perfected the voices because sometimes I start using a high voice and then a low voice for the different dog. But, yeah, it's getting more comfortable within my own class; I would probably feel a bit embarrassed in front of anybody else at the moment still. And the thing is the kids just love the puppets and even if I am a bad puppeteer they still love the puppets. So, I am gaining in confidence. I am just not a natural puppeteer like some people might be. (PL 2 interview, 18/8/2009)

Key Finding 6.36

Holly had found that the students were immediately engaged by the puppets and motivated to talk to them. At the mid-intervention review, Holly reported that she had used the puppets effectively at all stages of the inquiry process, particularly during the Engage phase and also in the Explain phase.

At this point in the intervention, Holly found juggling the roles of two new puppets as well as the teacher was complex and, while she enjoyed it and was gaining in confidence, she still felt self-conscious as a puppeteer.

Following PL Day 3, data was gathered from two more of Holly's science lessons. Lesson 4, filmed a few weeks after PL Day 3 in October, was an Engage lesson for a new teacher-authored topic called Lifecycles and Lesson 5, filmed in November, was an Explain lesson for the same topic. The data from video, classroom observation and follow up interviews are presented in the next part of this chapter.

Lesson 4, post Professional Learning Day 3

The lesson

This lesson was carried out soon after PL Day 3 and was the first lesson in a new topic called Lifecycles. While reflecting on the Schoolyard Safari topic completed the previous term, Holly realised that the students had some misconceptions about the life cycles of insects and small animals.

> A lot of the students didn't realize that life cycles can be different for different creatures. They think an egg just becomes an ant, or that an insect retains its form like a human baby that grows bigger as it moves into adulthood. For some insects that's what happens but for a lot of them they actually go through different stages. (PL 3 interview, 1/10/2009)

Consequently, Holly decided to extend the students' understandings by creating her own topic about the lifecycles of small animals and insects. The topic, Lifecycles, addressed science concepts related to the Living Things strand of the science syllabus (MCEETYA, 2006). It aimed to develop the students' conceptual understandings about the life cycles of butterflies, silk worms and frogs; to relate these to the human life cycle; and to compare how each life cycle changes over time.

In developing the topic, Holly planned to draw on several story books that related to the animal theme. The first was *The Very Hungry Caterpillar* (Carle, 2003), which follows the process of metamorphosis as a caterpillar turns into a butterfly. Holly also used the caterpillar puppet associated with the story to set up a problem for the students to investigate.

Lesson 4 was entitled *Metamorphosis* and was an introductory lesson in the Engage phase of the Lifecycles topic. The purpose of this lesson was to engage the students' interest in lifecycles, to ascertain their prior knowledge, and to elicit their questions about the topic. The lesson involved: a whole-class discussion to introduce the topic and set the context for the investigation; reading and discussing the stimulus text, *The Very Hungry Caterpillar*; viewing a DVD about the metamorphoses of tadpoles, dragonflies and caterpillars; and group work to sequence photos of the life cycles seen on the DVD.

The data analysis for this lesson centred on the whole-class discussion that arose from the interaction with the puppets during the initial introduction to the topic and from the interaction with Holly following the reading of *The Very Hungry Caterpillar*.

The setting

In planning for this lesson, Holly had to not only create a new scenario to use with the puppets when she introduced the topic but she also had to develop the personality and voice for the new caterpillar puppet that she wanted to use with this topic. In this instance, Holly used the colourful caterpillar puppet associated with the text *The Very Hungry Caterpillar* (Carle, 2003) and created a character called Katy Caterpillar. Like Tilly, the puppet that was central to the Schoolyard Safari topic, Holly portrayed Katy as a young and naïve character in the hope that the students would feel more confident to share their ideas with someone less knowledgeable than themselves (PL 4 interview, 11/11/2009). The scenario that Holly had devised to set the scene for the new Lifecycles topic centred on Katy who had asked Detective Doug for his help.

> Detective Doug had found Katy Caterpillar in the garden and she was sad and lonely and couldn't understand where all her friends had gone and she was also becoming very, very hungry all the time. And so he [Detective Doug] thought he would bring Katy to school and maybe the children could help solve the problem of what happened to Katy's friends and why she was hungry and what all these fluffy things [were] that were hanging in the trees. (PL 4 interview, 11/11/2009)

In the initial part of the discussion in Lesson 4, Holly used Detective Doug and Katy Caterpillar to make links to the previous topic, Schoolyard Safari and to set up the new problem for the students to solve. Subsequently, she read the stimulus text, *The Very Hungry Caterpillar*, and then in the follow up discussion she elicited the students' more detailed understandings about the metamorphosis of a caterpillar into a butterfly.

As in Lessons 2 and 3, when the discussion commenced Holly and the students sat facing each other in the Sharing Circle in the mat area of the classroom. Holly was on a chair at the top end of the circle and four students were seated on the couch directly opposite her (Video footage, 26/10/2009). The remaining 16 students sat cross legged on the mat around the sides of the circle (Video footage, 26/10/2009). Either Holly or

269

the puppets nominated the speaker and the students were expected to use a Thinking Thumb to indicate that they wished to speak (Video footage, 26/10/2009).

Key Finding 6.37

Holly used the puppets in Lesson 4 to set the scene for the new topic and to elicit the students' initial understandings. She introduced a new puppet in this lesson, which she portrayed as a naïve character so as to make the students feel more confident to share their ideas.

Holly and the students continued to use the Sharing Circle and the students used a Thinking Thumb to indicate that they wished to speak.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In Lesson 4, the first part of the discussion was predominantly driven by *open-ideas* questions when Detective Doug and Katy set the problem for investigation and elicited the students' initial ideas. The second part of the discussion, which followed the reading of the text *The Very Hungry Caterpillar*, was driven by a mixture of *open-ideas* and *open-description* questions as well as some *open-explanation~reason* questions. Additionally, some *closed* questions were asked when the discourse move *teacher uptake* was used.

The analysis showed that Holly and the puppets asked a total of 30 initiating questions in this discussion. Of these questions, 15 (50%) were classified as *open-ideas*; eight (27%) were classified as *open-description*; four (13%) were classified as *open-explanation~reason*; and three (10%) were *closed* questions.

Teacher discourse moves

In Lesson 4, Holly wanted to capture the students' interest in the new topic by introducing them to the new puppet and by seeking their help to solve her problem. Holly had been working on her use of questioning during discussions and in this lesson she wanted to focus on eliciting the students' ideas about life cycles and metamorphosis so that she could gain a clear understanding of their prior knowledge (PL 4 interview 11/11/2009). Two excerpts are taken from the discussion in this lesson. The first shows how Holly drew on the naïve and inexperienced qualities of the new puppet to elicit a student's ideas and make them explicit, and the second shows how she followed up ideas and maintained a line of questioning.

Detective Doug commenced the discussion by introducing Katy Caterpillar (Puppet Katy or P:Katy) to the students. Once she had told them about the problem with her missing friends and how she felt so hungry all the time, Katy asked the students if they could explain what was happening. In the excerpt below (Figure 6.12), Katy asks Alison (S:Ali) for her ideas.

Turn	Utterances	Coding
1.	Puppet Katy (P:Katy): Alison, what do you think?	Initiating question, open-ideas question. Directed question.
2.	**S:Ali: I've got an answer where they might be. Um.. are.. are your friends caterpillars?**	
3.	P:Katy: Yeah, they're all caterpillars like me. Lots of different colours.	
4.	**S:Ali: Maybe they have.. have to.. they have gone into cocoons and they're wrapped around in the tree and then after a little when they come out of their cocoons they turn into butterflies. So they're not really hiding but they're..**	
5.	**S: flying**	

6.	**S:Ali: ..like that on the wall and that's what a butterfly looks like.** [Alison points to the wall behind her and shows Katy a picture of what a butterfly looks like].	
7.	P:Katy: Oh, so.. so you think that my friends are going in a what? A cocoon?	Clarify.
8.	**S:Ali: Yeah, and then that's called a life cycle. You'll be.. you'll be a caterpillar and then you'll go in a cocoon and then after a little while when you've stayed in the cocoon you'll turn.. um.. if that happened to you, if you were real, you'll turn into a butterfly.**	
9.	P:Katy: Oh, so is a cocoon sort of like a house?	Clarify. Teacher uptake.
10.	**S:Ali: Yeah.** [Alison nods her head in agreement]	
11.	P:Katy: Oh. And.. and who builds my.. who builds the cocoon that I might go in?	Clarify. Teacher uptake.
12.	**S:Ali: You.** [Alison points to Katy]	
13.	P:Katy: Oh! I'm going to build a cocoon?	Clarify.
14.	**S:Ali: Yep.**	
15.	P:Katy: And is that what those fluffy yellow things and brown things might be in the trees?	Clarify. Teacher uptake.
16.	**S:Ali: Yes.** [Alison nods].	
17.	P:Katy: Oh, so you think my friends are all hiding inside them?	Clarify. Teacher uptake.
18.	**S:Ali: Yep.** [Alison nods].	
19.	P:Katy: Oh, and.. and.. and.. and I'm going to come out looking like that poster on the wall?	Clarify.
20.	**S:Ali: Yes.** [Alison nods].	
21.	P:Katy: Oh wow! That's pretty beautiful. Oh, that would be special.	

Figure 6.12: Lesson 4 - the teacher used the less knowledgeable puppet to elicit a student's ideas and explanations.

In this excerpt (Figure 6.12), first Alison checked that Katy's friends were caterpillars (turn 2) and then suggested that they had made cocoons in the trees so that they could transform into butterflies (turn 4). Subsequently, Holly used Katy as the less knowledgeable participant in the discussion to ask Alison a series of closed questions which served to make her ideas explicit (*clarify,* in turns 7, 9, 11, 13, 15) as well as to elicit further information (*teacher uptake*, turns 15 and 17).

By setting Katy up as the less knowledgeable speaker and the using simple discourse moves (*directed question*, *clarify*, *teacher uptake*) to make the student's ideas explicit and incorporate them into the discussion, Holly was able to sustain quite a long and productive chain of teacher/puppet-student exchange (P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P). Holly utilised a similar pattern of interaction several times in Lesson 4.

Key Finding 6.39

Holly set up a puppet as less knowledgeable in order to elicit a student's ideas and make them explicit. She used simple teacher discourse moves (*clarify* and *teacher uptake*) to build on the interaction and sustain quite a long and productive teacher/puppet-student interaction of 19 turns.

In the next excerpt (Figure 6.13), Holly used a range of teacher discourse moves to elicit what the students knew about the process of metamorphosis. This segment of the discussion follows on from the text reading of *The Very Hungry Caterpillar*.

Turn	Utterances	Coding
1.	T: OK, what changes did the caterpillar have to go through to become a butterfly? What changes, Jack?	Initiating question, open-ideas question.
2.	**S:Jac: The egg and the caterpillar, then the cocoon, then he was a butterfly.**	
3.	T: That was the cycle.. the process that it went through, but what changes did the caterpillar have to do? Like what's a caterpillar look like and compared to the butterfly? What sort of had to happen? What changes, Brigid?	Recast the question. Asks for other ideas.
4.	**S:Bri: Well, um.. he um.. kept on eating stuff and then he ate a leaf and then he um.. got a little bit more fatter and then he turned into a cocoon. That's the kind of changes I thought.**	
5.	T: That you think. Anything else that you'd like to add to that?	Elaborate.
6.	**S:Bri: Um.. and then they put a little hole in it and then it turned into a butterfly.**	
7.	T: OK. What about you, Alison, what do you think the changes that go from a caterpillar to a butterfly?	Acknowledge only. Asks for other ideas.
8.	**S:Ali: I think that it was in an egg and then the egg hatches and then the caterpillar has to eat a lot of food otherwise it can't make the cocoon and then it made the cocoon, made a little hole, popped into the cocoon**	

	and stayed there for two or more weeks. And then after a little while he.. he turned into a um.. he turned into a butterfly and then the butterfly lays eggs and then it does it all again.	
9.	T: But what.. but how is the caterpillar and butterfly sort of different? How are they different? What happened to.. what kind of changes did they make? Lyle?	Recast the question. Asks another student for his/her ideas.
10.	**S:Lyl: The caterpillar doesn't have any wings and the butterfly does.**	
11.	T: The caterpillar doesn't have any wings and the butterfly does. So does that mean that um.. how.. where do you think the wings might have come from?	Teacher restate. Teacher uptake.
12.	**S:Lyl: Um.. from the mum, its mums' wings.**	
13.	T: You think from the.. from the mum, OK.	Teacher restate.

Figure 6.13: Lesson 4 - the teacher elicited and followed up on ideas while maintaining a line of questioning.

In this excerpt (Figure 6.13), Holly asked about the physical changes that the caterpillar went through to become a butterfly (initiating question, *open-ideas* question, turn 1). When Jack (S:Jac) responded by describing the process of metamorphosis more generally (turn 2), Holly adjusted her questioning (*recast the question*, turn 3) to help the students think about the changes in physical features that occurs as a caterpillar becomes a butterfly. Subsequently, she needed to reiterate her questions twice more (turns 7 and 9) with first Brigid (turns 4 and 6) and then Alison (turn 8) giving more details about the process of metamorphosis. Ultimately, Lyle (S:Lyl) stated "The caterpillar doesn't have any wings and the butterfly does" (turn 10) and this gave Holly the chance to focus the discussion more on the physical changes the caterpillar needs to undergo to become a butterfly.

While Holly's initial question about the physical changes that the caterpillar went through to become a butterfly was not explicitly answered in this session, she realised from the students' responses that this was a level of detail that could be explored more fully during the Lifecycles topic (PL 4 interview, 11/11/2009). What is interesting about this interaction is that Holly maintained her line of questioning and did not settle for the first response the students gave. She maximised her interactions with individual students by asking them to elaborate on what they had to say and she moved on to seek other ideas when she felt the exchange was no longer productive. Whilst this produced longer chains of interaction with multiple participants (T-S1→ T-S2→ T-S2→

T-S3→ T-S4→ T-S4→ T), the discussion was valuable as the students' ideas were explored in more depth. The teacher discourse moves used in this chain of interaction included: *recast the question*, *asks for other ideas*, *elaborate*, *acknowledge only*, *teacher restate*, and *teacher uptake*.

In Lesson 4, the analysis shows that there is no evidence of Holly's use of *wait time* or of discourse moves that were coded as *extended thinking time*.

Key Finding 6.40

Holly maintained her line of questioning and did not settle for the first response. She maximised her interactions with students by asking them to elaborate on their ideas and she moved on to seek other ideas when she felt the exchange was no longer productive. This produced an extended chain of teacher/puppet-student interaction comprising 13 turns. Holly did not use *wait time* or *extended thinking time* in Lesson 4.

Communicative approach

The discussion in Lesson 4 was initially characterised by a high proportion of *open-ideas* questions and subsequently by a mixture of *open-ideas*, *open-description* and *open-explanation~reason* questions. Even with such a range of questions, the communicative approach would be classified as Interactive-Dialogic (Mortimer and Scott, 2003) as Holly was seeking the students' initial ideas and explanations about lifecycles. This is an appropriate form of interaction for an Engage lesson when the teacher wishes to determine the students' existing ideas about a new topic. In this lesson, Holly asked *open-ideas* questions to elicit the students' ideas and she mostly used the discourse moves *clarify* and *teacher uptake* to maximise her interactions with each student. She also asked some *open-description* and *open-explanation~reason* questions to find out how much the students knew about the process of metamorphosis and when she needed to adjust her questioning Holly used *recast the question*, *asks for other ideas*, *elaborate*, *acknowledge only*, *teacher restate*, and *teacher uptake*.

Key Finding 6.41

In Lesson 4, an Engage lesson, Holly utilised an Interactive-Dialogic communicative approach to help the students to share their ideas.

Proportions of teacher and student talk

In Lesson 4, there was a significant change to the proportions of teacher and student talk. While Holly continued to manage the talk, the level of her contributions had decreased (35%) and the level of student contributions had significantly increased (65%) in whole-class substantive discussion compared to previous lessons.

Key Finding 6.42

In Lesson 4, the students utilised far more of the talk time (65%) and Holly utilised far less (35%) compared to whole-class discussions in previous lessons.

The students' role

In Lesson 4, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

In Lesson 4, there were eight *elaborated utterances* and the students continued to build on each other's ideas and to generate cumulative talk (Alexander, 2006).

Quality of student talk

The students' responses in the discussion were mostly coded for *explanation*. In total, 54% were coded as *explanation*; 25% were coded as *description,* 4% as *unistructural* and 21% as *multistructural*; and 21% were coded as *reasoning*.

Key Finding 6.43

There were eight *elaborated utterances* in Lesson 4. Fifty-four per cent of the students' responses were coded as *explanation*; 25% as *description* (4% as *unistructural*, 21% as *multistructural*) and 21% were coded as *reasoning*. The students' talk continued to be cumulative.

In the Post Lesson 4 interview, Holly stated that she was very pleased with level of student participation in the discussion, and she commented on the quality of their contributions and the relevant questions that they asked (PL 4 interview, 11/11/2009).

> I feel very confident in science that they [the students] are willing to share and they enjoy sharing. I think that science time is one of the best times where they are communicating with each other and are supportive of each other's ideas. No-one feels uncomfortable in sharing because it's not like I'm ever putting that pressure on them, it's up to them but most of them are responding very freely. (PL 4 interview, 11/11/2009)

Lesson 4 summary

Lesson 4 was the first Engage lesson for the new topic, Lifecycles, and Holly used the puppets to engage the students in the topic and to explore their prior knowledge. In this lesson, Holly utilised an Interactive-Dialogic style of interaction and at the start of the discussion she used *open-ideas* questions in conjunction with discourse moves such as *clarify* and *teacher uptake* to elicit the students' initial ideas and maximise her interactions with each student. This resulted in quite long and productive teacher-student exchanges (e.g. P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P-S→ P).

Later in the discussion, when she wanted to explore what the students knew about the process of metamorphosis in more depth and she needed to adjust her questioning, Holly utilised *open-description* and *open-explanation~reason* questions and discourse moves such as *recast the question*, *asks for other ideas*, *elaborate*, *acknowledge only*, *teacher restate*, and *teacher uptake*. This also resulted in longer chains of teacher-student interaction (e.g. T-S1→ T-S2→ T-S2→ T-S3→ T-S4→ T-S4→ T). Holly did not use *wait time* or *extended thinking time* in this lesson.

In this lesson, the students were very engaged by the interaction with the puppets and they utilised most of the talk time. They continued to give elaborated responses, which were comprised predominantly of explanations and higher order descriptions.

Lesson 5, post Professional Learning Day 3

The lesson

Lesson 5 was videoed in November, approximately four weeks after Lesson 4. This lesson was entitled Where is Katy and was the first lesson in the Explain phase of the Lifecycles topic. The purpose of the lesson was to give the students the opportunity to explain their understandings and for Holly to make the scientific ideas about lifecycles explicit. The lesson was comprised of: a whole-class discussion to find out what the students had learned from the activities in the Explore phase and how their findings might resolve the initial problem and an explicit discussion about metamorphosis; group work, with students comparing what is the same or different about the life cycles of three different small animals or insects; and a whole-class discussion, where groups report their findings.

In the whole-class discussion at the start of the lesson, Holly used the puppets to review and expand on the initial problem and to find out what the students had learned. Following this Holly guided the discussion to focus more explicitly on the process of metamorphosis (Video footage, 13/11/2009). The data analysis for this lesson was focused on this initial whole-class discussion.

The setting

In the initial part of the discussion in Lesson 5, Holly added to the scenario previously played out with Katy Caterpillar in Lesson 4. In this lesson, Katy seemed to have disappeared and Detective Doug and Tilly had returned so that the students could explain to them what they had learned about lifecycles that would help to solve Katy's problem and figure out where she could have gone. In the second part of the discussion, Holly used Detective Doug to initiate a discussion that explored more deeply what the students had learned about the lifecycles of butterflies, silk worms and frogs during the Engage and Explore phases of the investigation. Holly had planned for Detective Doug to invite her back into this part of the discussion so that she could explain some key understandings about the process of metamorphosis.

As in previous lessons, Holly and the students were seated on the mat in the Sharing Circle facing one another, with Holly seated on a chair at the top end of the circle and four students seated in the couch opposite (Video footage, 13/11/2009). The remaining 16 students were seated on the mat around the sides of the circle (Video footage, 13/11/2009). Holly or the puppets continued to nominate the speaker and the students used a Thinking Thumb to indicate that they wished to speak (Video footage, 13/11/2009).

Key Finding 6.44

Holly used the puppets to expand on the initial problem in Lesson 5 and to find out what the students had learned during the Engage and Explore phases that would resolve the problem. Later in the discussion, Holly used the puppets to invite her (as the teacher) to explain the process of metamorphosis.

Holly and the students continued to use the Sharing Circle and the students used a Thinking Thumb to indicate that they wished to speak.

The teacher's role

The transcript of this lesson was analysed for the communicative approach taken as well as for the teacher's use of questioning and discourse moves.

Teacher questioning

In the first part of the discussion, when the Detective Doug and Tilly were eliciting the students' ideas, the interaction seemed to be directed by questions that were classified as *open-ideas* and *open-description*. As the students began to explain what they thought had happened to Katy some questions were classified as *open-explanation~reason*. In the later part of the discussion, when Holly began to make the ideas about metamorphosis explicit, there were more questions classified as *open-explanation~reason*.

The analysis of this discussion showed that Holly and the puppets asked a total of 32 initiating questions. 14 (44%) of these questions were classified as *open-*

explanation~reason; eight (25%) were classified as *open-ideas*; seven (22%) were classified as *closed* questions; and three (9%) were *open-description* questions.

Key Finding 6.45

In the whole-class discussion in Lesson 5, Holly asked a total of 32 initiating questions, of which approximately 50% were *open-explanation~reason* questions and 50% were either *open-ideas* questions or *closed* questions.

Teacher discourse moves

In Lesson 5, Holly wanted as much as possible to use the puppets to initiate the discussion and to ask questions as she felt that the students enjoyed helping the puppets to solve their problems by sharing what they knew (PL 5 interview, 27/11/2009). She had also been trying to develop the way she utilised the interaction between the puppets and how they invited her, as the more authoritative teacher voice, into the discussion (PL 5 interview, 27/11/2009). Two excerpts are taken from the discussion in this lesson. The first shows how Holly used both puppets to elicit the students' understandings and the second shows how Holly used Detective Doug to invite her into the conversation to make the scientific ideas explicit.

The discussion commenced in Lesson 5 with Tilly reviewing the students' learning experiences from the Lifecycles topic and then Detective Doug linking this to Katy Caterpillar's initial problem and her subsequent disappearance. The interaction below (Figure 6.14) begins with Lyle (S:Lyl) sharing his ideas about the lifecycle of a caterpillar.

Turn	Utterances	Coding
1.	P:Tilly: Yes, Lyle?	Asks another student for his/her ideas.
2.	**S:Lyl: We also learned about the life cycle of a caterpillar and how it grows into a butterfly.**	
3.	P:Tilly: Ahh! And.. and where did the caterpillar come from? Do you know where the caterpillar came from to start with?	Open-description question.

4.	**S:Lyl: An egg on the branch.**	
5.	P:Tilly: It was an egg. Mmm [interrupted]	Teacher restate.
6.	**S:Lyl: And then it goes.. and then when it hangs on a branch it turns into a cocoon and then it gets darker and then as soon as the butterfly puts a hole in the cocoon and then it breaks out.**	
7.	P:Tilly: Wow, Lyle! Did you hear that, Doug? These kids know lots of things about life cycles and they've found lots of information that I think can help Katy the Caterpillar. Have you seen her lately, Doug?	Acknowledge only. *(Puppet-puppet interaction, links to the initial problem)*
8.	P:Doug: Well, actually I haven't seen her. She seems to have disappeared in the garden as well. And I've been looking and looking and I keep seeing those strange things that we realised they were cocoons hanging in the trees and I'm trying to work out which one might be Katy. And I go up and talk to them and I'm wondering if she can hear me but I still can't find out which one she is. But maybe when she comes out as a butterfly, because that's what we worked out was going to maybe happen, then she might be able to find me and come fluttering past and say 'Hi, Doug' and show me what she looks like now. Yes, Brigid, have you got something to share?	*(Expands on the context of the initial problem)* Asks for other ideas.
9.	**S:Bri: Yeah. Umm.. and there were another life cycle, there was a silk worm life cycles.**	
10.	P:Doug: Ahh, a silk worm. And mmm.. is the silk worm like a worm or is it.. is it like a caterpillar, or… what does it look like?	Teacher restate. Clarify, open-description question.
11.	**S:Bri: It looks like a caterpillar.**	
12.	P:Doug: It looks like a caterpillar, does it?	Clarify.
13.	**S:Bri: Yeah.**	
14.	P:Doug: Ahh. Yes, Alison?	Asks another student for his/her ideas.
15.	**S:Ali: And you know how um.. your friend Katy the Caterpillar she might not be.. you might have to call her something else because she's not a caterpillar anymore. You might have to call her like 'Katy** [Interrupted]	
16.	**S: 'Katy the Butterfly'.**	
17.	**S:Ali: … something the Butterfly'.**	
18.	P:Doug: Oh, that's true. I never thought about that. I call her 'Katy Caterpillar' but is she going to stay as a caterpillar, everyone?	Checks for consensus, closed question.
19.	**Ss: No.**	
20.	P:Doug: No. Oh, so she might become 'Katy the Butterfly'. Mmm, oh dear, I'll have to remember to call her… maybe that's why she's not answering when I call her because I'm calling 'Katy Caterpillar' and she might be already changing into a butterfly. Yes, Lyle?	Teacher restate. Asks another student for his/her ideas.

21.	**S:Lyl: When you go and look in the garden in the branches she might not even be there. She might already turned into a butterfly.**	
22.	P:Doug: Oh, what makes you say that? How do you know that she might have already done that?	Open-explanation~reason question.
23.	**S:Lyl: Because um.. sometimes it takes a day for the cocoon to um.. go to a butterfly.**	
24.	P:Doug: Oh, so you're saying it might have already happened?	Clarify.
25.	**S:Lyl: Yeah.**	
26.	P:Doug: So she might already be out there and I'm calling 'Katy Caterpillar'. Oh, I might have to go back to the garden today and start calling 'Katy Butterfly'. Yes, Luke?	Teacher restate. Asks another student for his/her ideas.
27.	**S:Luk: Well, if you're saying 'Katy Caterpillar' or 'Katy Butterfly', how will she hear when she's in the cocoon?**	
28.	P:Doug: Well, that's a good point too, I'm not really sure if she can hear me in the cocoon, so that's important, too, to remember. You might be right, Luke, I might be calling her and she might still be in the cocoon but she might not be able to hear me. Yes, Tania?	Evaluate. Asks another student for his/her ideas.
29.	**S:Tan: Where is she?**	
30.	P:Doug: Well, that's what I said, I'm not sure because I haven't seen her. So she's in the garden somewhere but I'm not sure which cocoon she might be in or, as Lyle said, she might already be out.	Refocus.

Figure 6.14: Lesson 5 - the teacher used the puppets to elicit student's ideas and resolve the problem.

In this part of the discussion (Figure 6.14) Lyle (S:Lyl) mentioned that the students had learnt about the lifecycle of a caterpillar (turn 2) and by probing further (turn 3) Tilly was able to elicit a concise description of the metamorphosis of the caterpillar from him (turns 2, 4 and 6). At this point, Detective Doug joined the discussion (turn 7) and he updated the students with regard to Katy's disappearance (turn 8).

A little later, Alison (S:Ali in turns 15 and 17) initiated a chain of interaction about the need to change Katy's name to Katy Butterfly since she was no longer a caterpillar. Detective Doug asked if the rest of the class agreed with this idea (*checks for consensus - teacher asks class to indicate who agrees with an idea*, turn 18) and he went on to elicit ideas from first Lyle (S:Lyl in turns 21-25) and then Luke (S:Luk in turn 27) who added to Alison's idea and developed this chain of interaction further. Finally,

Detective Doug responded to Tania's query regarding Katy's whereabouts (S:Tan in turn 29) by reiterating the students ideas and drawing this segment of the discussion to a close (*refocus*, turn 30).

In this excerpt of the discussion (Figure 6.18), Holly used a range of teacher discourse moves (*teacher restate, asks for other ideas, clarify, checks for consensus, evaluate, refocus*) to develop the interaction between the puppets and the students. As a result, the puppets were able to sustain a long chain of interaction with the students, helping them to articulate their understandings and to develop a reasonable response to Katy's problem. The use of these teacher discourse moves generated a chain of teacher/puppet-student interaction comprising six links. The first two links, each comprised of six-turn structures, involved Lyle and Brigid (P1- S:Lyl → P1-S:Lyl→ P1-S:Lyl → P1; P2-S:Bri→ P2- S:Bri → P2- S:Bri); the next involved Alison and the class (P2-S:Ali→ P2-Group→ P2); the fourth, also comprised a six-turn structure, involved Lyle (P2- S:Lyl → P2- S:Lyl → P2- S:Lyl → P2); and the final two links involved Luke and Tania (P2-S:Luk→ P2; P2-S:Tan→ P2).

Key Finding 6.46

Holly used the puppets in Lesson 5 to help the students to articulate their understandings and to develop a reasonable response to the initial problem. She developed and sustained a long and productive chain of teacher/puppet-student interaction using a range of teacher discourse moves, including: *teacher restate*, *asks for other ideas*, *clarify, checks for consensus*, *evaluate*, and *refocus*.

The second excerpt from Lesson 5 highlights the turning point in the discussion, when the talk became less Interactive-Dialogic and more Interactive-Authoritative (Mortimer & Scott, 2003). In this part of the discussion, Holly wanted to ensure that the students understood that 'metamorphosis' referred not only to the changes in body shape of a developing animal or insect but also to the stages of development of their lifecycles. This excerpt follows on from the previous interaction in Figure 6.14 and begins with Detective Doug inviting Holly into the discussion, see Figure 6.15.

Turn	Utterances	Coding
1.	P:Doug: Oh, Miss Holly, we're getting lots of questions but I know there's something that you wanted to ask the boys and girls because you mentioned to me before that there was a special word that you thought the children might have heard about because they've been learning about lifecycles. And it means 'lifecycles', but you're not sure whether they can remember or that they have heard what that word might be. And it's a special word that we can use that means the word 'lifecycle'. Mmm.. let me have a look. I can see lots of Thinking Thumbs coming up now. Maybe they have heard it when they were doing some of the work you set for them. Mmm. … Hayes?	*(Puppet to teacher interaction)* Moves on.
2.	**S:Hay: Is the word metamorphosis?**	
3.	P:Doug: Mmm… let me say that, 'met-a-mor-pho-sis'. Is that right, Hayes?	Teacher restate. Clarify.
4.	**S:Hay: Yes.**	
5.	P:Doug: Is that what you were going to say, Shelly? [S:She nods] Oh. 'Metamorphosis', is that the word, Miss Holly?	*(Puppet hands over to teacher)*
6.	T: Yes, it was actually, Doug. And well done, Hayes. 'Metamorphosis' was the brand new word that I was hoping to talk to you about today because 'metamorphosis' is actually another word that we can use for 'lifecycle'. And I'm just going to put Tilly down for a second. [T puts puppet on the chair next to her] OK, I've got the word 'lifecycle' here. [T points to the word on the white board behind her] But I've also got the word 'metamorphosis' and 'metamorphosis' is another term that we use that can mean the 'lifecycle'. And when we're talking about 'metamorphosis' and 'lifecycle', what are we actually talking about? I know that we've said that caterpillars turn into butterflies, but what's actually happening? What is the process, do you think, that's actually happening? Alison?	Initiating question, open-explanation~reason.
7.	**S:Ali: They're changing.**	
8.	T: They're changing. What's changing?	Teacher restate. Initiating question, open-explanation~reason.
9.	**S:Ali: The um.. whatever the insect is or small animal.**	
10.	T: Are they changing their voice?	Teacher uptake.
11.	**S:Ali: No, they're changing their body shape. Well, they might change, like if a bee turned into something they might not make the "bzzzz" sound.**	
12.	T: Ah! So they're basically changing their body shape and that's right. They are changing their form, like their body shape.	*(Turning point in the discussion)* Teacher restate.

	[T puts the word 'form' onto the whiteboard] And there's something else important about a lifecycle. Lyle?	Evaluate. Reframe scientifically. Asks another student for his/her ideas.
13.	**S:Lyl: Um.. it changes by their cocoon what they're in.**	
14.	T: The ah.. so, like they're changing inside the cocoon? Is that what you mean?	Clarify.
15.	**S:Lyl: Yes.**	
16.	T: They are changing inside the cocoon. But what's happening? And I know Tara was sort of doing a… [T draws a circle in the air with her finger] …with her hands. What does that sort of mean? What's sort of happening? Brigid?	Teacher restate. Recast the question. Prompt and scaffold. Recast the question.
17.	**S:Bri: Its flowing, its flowing around.**	
18.	T: It is flowing. But what's sort of flowing? What is the thing? What's flowing? Tara?	Teacher restate. Teacher uptake. Recast the question.
19.	**S:Tar: Um.. it's called a flow chart.**	
20.	T: It is a flow chart. It is called a flow chart, that's right. Luke?	Evaluate. Teacher restate. Asks another student for his/her ideas.
21.	**S:Luk: Its going around in a circle and that's why it's called a cycle.**	
22.	T: It is going around in a circle and, yes, that's why we call it a cycle. Shelly?	Teacher restate. Evaluate. Asks another student for his/her ideas.
23.	**S:She: It happens all over again.**	
24.	T: It does happen all over again. And yes, Alison?	Evaluate. Teacher restate. Asks for other ideas.
25.	**S:Ali: It's like their life changing.**	
26.	T: That's right, it's like their life changing and we call that the stages of development. So they're not only changing their form, their body shape, but they're changing in their development, in their whole life. They're going from young up to adulthood.	Evaluate. Teacher restate. Reframe scientifically.

Figure 6.15: Lesson 5 at the turning point in the discussion, the puppets invited the teacher's input.

In this excerpt (Figure 6.15) Holly used Detective Doug to draw her into the discussion (turns 1 and 5) so that she could explain the ideas associated with the word 'metamorphosis'. In this instance, Holly highlighted the word 'metamorphosis' by using Detective Doug to articulate the word slowly (turn 3) and also by writing it on the whiteboard (turn 6). Then she began to find out how much the students knew by asking them to explain the process of 'metamorphosis' (turn 6). Initially, Alison gave quite a simple response saying 'They're changing' (turn 7). By working on this idea and asking further questions (*teacher restate,* turn 8; *teacher uptake*, turn 10), Holly was able to support Alison to articulate a key message that she wished to emphasise - that small animals or insects can change their body shape during the process of metamorphosis (turns 9 and 11). Holly then endorsed and rephrased what Alison had said (*teacher restate*, *evaluate* and *reframe scientifically*, turn 12).

Subsequently, another chain of interaction about metamorphosis emerged (turns 13 to 25) where Holly used a range of questions and discourse moves to probe the students' ideas (*teacher restate*, *clarify*, *recast the question*, *prompt and scaffold*, *evaluate,* turns 14, 16, 18, 20, 22, 24). In doing so, she was able to work on the students' ideas and guide them to make a second key message explicit - that 'metamorphosis' also refers to the stages of development that a small animal or insect undergoes in their lifecycle (turn 26). When the students had shared their ideas, Holly once again endorsed and rephrased what they had said to make the key messages clear (*evaluate*, *teacher restate* and *reframe scientifically,* turn 26).

Holly's use of the teacher discourse moves *evaluate* and *reframe scientifically* (turn 12, Figure 6.19) marked a turning point (Mortimer & Scott, 2003; Scott & Amteller, 2007; Scott, et al., 2007) in the discussion as she moved from an Interactive-Dialogic form of interaction to a more Interactive-Authoritative style (Mortimer & Scott, 2003). Where she had initially been accepting of the students' many ideas in the earlier phases of the investigation, in this Explain lesson she had become more particular about making the correct or scientifically accepted idea explicit. As the discussion progressed Holly used these discourse moves several times (turns 12, 20, 22, 24, 26).

In Lesson 5, the analysis shows that there was no evidence of Holly's use of *wait time*. However, there was one instance of *extended thinking time*.

Key Finding 6.47

In Lesson 5, Holly used the puppets to invite her into the discussion so that she could work on the students' ideas and explanations in order to make key messages explicit. She would rephrase and endorse the students' ideas so that the correct or scientifically accepted ideas were heard. She used a range of teacher discourse moves to achieve this, including: *teacher restate*, *clarify*, *recast the question*, *teacher uptake*, *evaluate*, *reframe*, *prompt and scaffold*, *reframe scientifically*. By working the discussion in this way, Holly was able to generate several productive chains of interaction that built upon each other. There was one instance of *extended thinking time*, but no instances of *wait time*.

Communicative approach

The interaction in Lesson 5 differed from Lesson 4 in that there were fewer *open-ideas* questions and more *open-explanation~reason* and *closed* questions asked. This is consistent with the form of discourse required in the Explain phase when the teacher adjusts the interaction to ensure the scientific ideas are made explicit. In this lesson, Holly used an Interactive-Dialogic style of interaction when she used the puppets to review the students' initial ideas, experiences and explanations about lifecycles from the Engage and Explore phases of the investigation. To achieve this she asked a mixture of *open-ideas, open-description* and some *open-explanation~reason* questions and she used teacher discourse moves that would maximise her interactions with the students, including *clarify* and *teacher restate*.

Later in the discussion, when she explained the process of metamorphosis and she wanted to make her message explicit, Holly adjusted her communicative approach to a more Interactive-Authoritative style. When this occurred, she asked more *open-explanation~reason* questions and utilised teacher discourse moves that helped to focus the discussion, including *elaborate*, *teacher restate*, *clarify*, *teacher uptake, evaluate, reframe scientifically, recast the question, and prompt and scaffold.*

Key Finding 6.48

In Lesson 5, an Explain lesson, Holly initially utilised an Interactive-Dialogic communicative approach when she used the puppets to help the students to review their experiences and ideas from the Engage and Explore phases. When Holly explained the process of metamorphosis, a more Interactive-Authoritative style of interaction was evident.

Proportions of teacher and student talk

In Lesson 5, the proportions of teacher and student talk reverted to the ratios seen in earlier lessons where Holly utilised a large percentage of the talk time (77%) and the level of the student contributions was reduced (23%) in whole-class substantive discussion.

Key Finding 6.49

In Lesson 5, Holly utilised about 77% of the talk time and the students utilised 23% in whole-class substantive discussion.

The students' role

In Lesson 5, a measure of the quality of student talk was derived from the analysis of the number of students' elaborated utterances and the complexity of the students' responses.

Elaborated utterances

In Lesson 5, there were five *elaborated utterances* and the students continued to generate cumulative talk (Alexander, 2006) by building on each others' ideas.

Quality of student talk

The students' responses to whole-class discussion were mostly coded as *explanation*. In total, 67% were coded as *explanation*; and 33% were coded as *unistructural description*.

Lesson 5 summary

Since Lesson 5 was an Explain lesson for the Lifecycles topic, Holly wanted to elicit the student's initial ideas and explanations from the Engage and Explore phases in order to develop a reasonable response to the problem under investigation and she also wanted to make the scientific ideas about lifecycles explicit. Consequently, she utilised an Interactive-Dialogic style of interaction to elicit the students' ideas and then she adjusted this to an Interactive-Authoritative approach when she wanted to make particular ideas explicit.

In the first part of the discussion, when the communicative approach was Interactive-Dialogic, Holly used the puppets to ask a mix of *open-ideas* and *open-description* questions as well as some *open-explanation~reason* questions to elicit the students' ideas and explanations to do with the problem. Holly also used a range of teacher discourse moves (*teacher restate, clarify, asks for other ideas, checks for consensus, evaluate, refocus*) to maximise the interaction with the students. This generated a complex chain of teacher/puppet-student interaction which was made up of several links, each comprising a number of turns (e.g. [P1-S:Lyl → P1-S:Lyl → P1-S:Lyl → P1] → [P1-P2-S:Bri → P2-S:Bri → P2-S:Bri] → [P2-S:Ali → P2-Group → P2] → [P2-S:Lyl → P2-S:Lyl → P2- S:Lyl → P2] → [P2-S:Luk → P2] → [P2-S:Tan → P2]).

In the second part of the discussion, when the communicative approach became more Interactive-Authoritative, Holly used the puppets to probe the students understandings further and then to invite her (as the teacher) to explain some key ideas about the process of metamorphosis. To do this she asked more *open-explanation~reason* questions and used a range of teacher discourse moves (*teacher restate, clarify*, *teacher uptake*, *recast the question*, *prompt and scaffold*, *evaluate*, and *reframe scientifically*) to work on and probe the students ideas in order to make key messages

explicit. The teacher discourse moves *evaluate* and *reframe scientifically*, which Holly used several times in this part of the discussion, can be seen as indicators of a more Interactive-Authoritative style. Holly did not use *wait time* or *extended thinking time* in this lesson.

While Holly and the puppets utilised most of the talk time in this lesson, the students continued to give elaborated responses and to build on each other's ideas. Their responses were predominantly comprised of explanations and some descriptions.

Post intervention: Holly's beliefs, knowledge and practice

On the final professional learning day (PL Day 4) in November 2009, the teachers participating in the professional learning intervention were asked to complete a questionnaire that captured data to do with: teacher beliefs about teaching science; teacher confidence with teaching science; teacher knowledge about managing classroom discourse; teacher knowledge about questioning; and, teacher knowledge about using puppets.

Beliefs about teaching science

From the data collected from the final teacher questionnaire, it was evident that Holly had become more focused on discourse. The first two most important characteristics of effective science teaching practice that Holly identified were to do with classroom discourse, and the classroom environment. She believed that questioning and classroom discussion facilitated students' greater engagement and deeper understandings of science ideas. She considered that discussion assisted students to "make sense of their ideas and apply them to their world", to "undo [their] misconceptions", and to learn from their peers and the teacher (Final teacher questionnaire, 16/11/09). She also believed that "effective extended conversations" were essential to effective primary science teaching so that the "teacher facilitates students to make sense of their ideas", and that the appropriate communicative approach should be matched to each stage of the inquiry process (Final teacher questionnaire, 16/11/09).

Holly also believed that effective primary science teaching practice was supported by classroom management that provided a "safe and comfortable environment" (Final teacher questionnaire, 16/11/09). She also identified several other characteristics of effective science teaching practice which confirmed the beliefs she had articulated prior to the professional learning intervention. This included: teaching "appropriate, relevant and meaningful science lessons or topics" that students can "relate to their world"; "students understanding and participating in investigative processes"; using "the 5E model so students can construct their own understanding"; and "facilitating and supporting students to learn science concepts and how to apply them" (Final teacher questionnaire, 16/11/09).

Key Finding 6.51

Holly believed that questioning and classroom discussion facilitate students' greater engagement and deeper understandings of science ideas; that extended conversations were essential to effective science teaching so that the teacher can help students to make sense of their ideas; and, that the appropriate communicative approach should be matched to each stage of the inquiry process.

Holly believed that effective primary science teaching was supported by classroom management that provided a safe and comfortable environment. Additionally, she confirmed her initial beliefs that effective primary science teaching included: investigating science topics that are relevant and are appropriate to the students' learning needs and interests; students understanding and participating in investigative processes; using the 5Es model of inquiry to help students construct their own understanding; and, teachers supporting students to learn new science concepts and how to apply them.

Confidence with teaching science

The data collected from the final teacher questionnaire showed that Holly felt an increased confidence for 'Engaging students' interest in science' (initially rated as 'Confident' and subsequently as 'Very confident') (Final teacher questionnaire, 16/11/09). She continued to rate herself as 'Confident' for 'Managing discussions and interpretation of science activities' and 'Explaining science concepts' (Final teacher questionnaire, 16/11/09). Holly also indicated a slight decrease in confidence for

'Developing [students'] literacy skills needed for learning science' (initially rated as 'Very confident' and subsequently as 'Confident') (Final teacher questionnaire, 16/11/09).

The final mean scale score for confidence with teaching science strategies for all of the teachers involved in the professional learning intervention was 4.21/5, which is greater than the mean confidence scale score of 3.88 for a group of *Primary Connections* trial teachers who had participated in five days of professional learning and taught some *Primary Connections* units (Hackling & Prain, 2005). In comparison, Holly's final mean scale score for confidence with teaching science strategies was 4.3/5, which was greater than the mean scale scores for either of these groups of teachers.

Key Finding 6.52

Following the PL intervention, Holly remained a confident teacher of primary science, particularly for engaging students' interest in science and for managing discussions and developing interpretations of observations. Her final mean scale score for confidence with teaching science was 4.3/5.

Beliefs about being an effective manager of classroom talk

The data from final teacher questionnaire showed that although there was some adjustment to how she rated her self-efficacy with some aspects, Holly continued to believe she was an effective manager of classroom talk. More particularly, the data showed that Holly had a greater level of self-efficacy for responding to students' answers in ways that maintain and promote further discussion (initially rated 3/5 and subsequently rated 4/5) (Final teacher questionnaire, 16/11/09). In addition, Holly had maintained a high level of self-efficacy (rated 4/5) against 11 other aspects of managing classroom discussions (Final teacher questionnaire, 16/11/09).

However, the data also showed that Holly had a slightly lower level of self-efficacy for establishing an appropriate classroom climate (initially rated 5/5 and subsequently 4/5) and for using wait time (initially rated 4/5 and subsequently 3/5) (Final teacher questionnaire, 16/11/09). This may indicate that Holly had come to understand the

complexities involved in constructing a classroom environment that is supportive of substantive discussion. Furthermore, while she had use *extended thinking time* during whole-class discussion, she did not use *wait time*, which she may have found to be rather more difficult to incorporate into her practice than she had anticipated.

The final mean scale score for being an effective manager of classroom talk for all of the teachers involved in the professional learning intervention was 4.09/5. In comparison, Holly's final mean scale score was 3.92/5, which is slightly less than the mean scale scores for the group of teachers involved in the professional learning intervention.

Key Finding 6.53

Holly continued to believe that she was an effective manager of classroom talk. Her level of self-efficacy for responding to students' answers in ways that maintain and promote further discussion increased. However, she indicated a slightly lower level of self-efficacy for establishing an appropriate classroom climate and for using *wait time*, which may indicate that she had come to understand the complexities involved in constructing a classroom environment that is supportive of substantive discussion and the difficulties related to incorporating *wait time* into her practice. Her final mean scale score for being an effective manager of classroom talk was 3.92/5.

Knowledge about managing classroom discourse

The data collected from the final teacher questionnaire showed that Holly's understandings of how to manage classroom discourse that facilitates students' learning in primary science lessons centred on the communicative approach used, as well as teacher questioning and teacher discourse moves. In the final teacher questionnaire (16/11/09), Holly's response to questions about what good classroom discussion looked like in a science lesson centred on how teachers manage discussion. She considered that good discussion would look different at different stages of the inquiry process, but that for the Engage and Explore stages the communicative approach would be Interactive-Dialogic (Final teacher questionnaire, 16/11/09). Holly thought there would be opportunities for students to provide "extended answers" to teacher questions and that teachers would use discourse strategies such as "pause and wait" to give students time to think about what they wanted to say (Final

teacher questionnaire, 16/11/09). When responding to students contributions to discussion, Holly felt teachers should provide "feedback rather than evaluative responses" (Final teacher questionnaire, 16/11/09). She also thought that good discussions were characterised by teachers using "probing, open-ended questions" and "maybe some closed questions in the Explain stage" (Final teacher questionnaire, 16/11/09).

In the Post Lesson 4 interview, Holly stated that she had begun to use more probing questions and she was unwilling to settle for the students' first response. She felt the students were quite comfortable with her requests for elaboration because she would always respond positively to what they could offer. Consequently, they would add to their contributions if they could but they also knew that it was quite acceptable to say "I can't think of anything else" (PL 4 interview, 11/11/2009). Additionally, she noted that the students did not feel like they had to know the right answer or have a lot to say before they could share what they thought (PL 4 interview, 11/11/2009).

> I've noticed a couple of boys who at the beginning of the year wouldn't have said anything and now they are responding. And one of them is a particularly bright boy but he's never been keen to share his opinions and views, but in science he actually does a bit more. So I think he does feel a bit more confident. He's one of these children, I think, that is too nervous to say anything just in case he's wrong and so would rather say nothing. Whereas, I think, in science he feels that it's OK and if it's not a hundred per cent right it doesn't matter and so he's more willing to have a go. There are a few children who are more willing to have a go. … and I think that's got to do with that whole environment … that they feel comfortable, and part of that I think is having the puppets there. They're sort of fun and sometimes it's like 'Well, the puppets don't know the answer to that so then that's OK for me not to know.' So, I think that helps as well. (PL 4 interview, 11/11/2009)

Later in the Post Lesson 5 interview, Holly also reflected on her use of questioning and the way that she managed whole-class discussions and she thought that these had changed for the better (PL 5 interview, 27/11/2009).

> With my questioning techniques, I'm definitely not trying to be evaluative in my answers. I am trying to elicit more responses and ask more questions or repeat their answers to validate what they're saying and to make sure that I've got it right and that the other children understand. And I'm giving them a bit more time if they are

> not saying something … and [I'm] saying 'Well, have a bit more Think Time and I'll come back to you'. And I'm just making sure that everybody's having a chance to be heard. … Previously, I think I probably would have cut them off more and thought we need to get onto the next part [of the lesson], whereas now I really value the discussion session more than I probably used to and I realise the importance of it… Sometimes it goes on longer than it used to but that's because I value it and I can see the importance of it and the children really enjoy that time. (PL 4 interview, 11/11/2009)

In the Post Lesson 5 interview, Holly also commented on the way that the conversations in science seemed to flow and retain their focus because the discussion was planned and purposeful (PL 5 interview, 27/11/2009). She felt she knew how to guide the talk and which questions would elicit key ideas (PL 5 interview, 27/11/2009).

> You've got to know where you're going and where you're heading and what the outcomes are that you want to achieve. … I try and pre-plan a lot of the questions. … This Lifecycle topic I wrote myself and I wrote the kind of questions that I wanted to ask. So I think it's important to have those ideas in your head. … I need to have an outcome or a process that I want to achieve and in a way you're sort of guiding them [the students] to head to that. So there is a purpose. Otherwise, what was the point of the whole thing? And did they understand that conceptual outcome that you were trying to achieve? … So you've sort of got to steer them in a way and guide them by your questioning techniques. (PL 5 interview, 27/11/2009)

Holly commented that the students' capacity to sustain science focused conversations had developed over the course of the professional learning intervention. She found that the students were always willingly to contribute to discussions, they seemed to be more engaged, and the numbers of students participating and the frequency of their participation had increased (PL 5 interview, 27/11/2009). Holly thought the students were happy to participate in discussions because they had a common understanding of the conventions for talking in science and because an environment had been created where they felt it was safe to express their ideas (PL 5 interview, 27/11/2009).

Holly had also noticed that her focus had changed when it came to behaviour management. She stated that once she would have felt obliged to reprimand students if they appeared to be inattentive during class discussions because she would have

considered their behaviour was disruptive (PL 4 interview, 11/11/2009). Over time, she had come to realise that whilst these students might look like they are not engaged, often they are listening because they are able to answer her questions and make valuable contributions to the discussion (PL 4 interview, 11/11/2009).

> In the past I think I would've picked them up on those things, not really notice whether they were paying attention or not but just that they were fiddling and that's not the right thing to do. Whereas, now I'm sort of listening to what they're saying more and I think 'Well, they are engaged, they are giving me answers. So what if they're fiddling with their shoelace because it's not disturbing anybody else. Why am I going to stop my lesson to do that [reprimand them]?' … It's just more disruptive for the rest of the class if I do that. ... While they're doing that they are actually thinking about things. … You can sort of still see their brain ticking over with all these thoughts and if I do say something to them about their shoe, well, I'll probably stop that brain process happening, you know, their thoughts about the topic. (PL 4 interview, 11/11/2009)

Key Finding 6.54

Holly considered good discussion looked different at different stages of the inquiry process but for the Engage and Explore stages the communicative approach would be Interactive-Dialogic. She thought teachers should ask "probing, open-ended questions" as well as some closed questions in the Explain stage".

Holly felt students should be given the chance to give "extended answers" and teachers should use "pause and wait" to give them time to think. She thought teachers should provide students with feedback rather than give evaluative responses.

She felt that she had begun to value the discussion part of the lesson more and that her use of questioning and management of discussions had improved. She thought the discussions retained their focus because they were planned and purposeful, she knew how to guide the talk, and which questions would elicit key ideas.

Holly felt that a safe and friendly environment for discussion had been created, which had given the students the courage to share their ideas even if they were not correct and she had come to realise that often students who appear to be inattentive are in fact listening and can make valuable contributions to the discussion.

Knowledge about using puppets

In the final teacher questionnaire, Holly reported that she had used the puppets to engage and motivate the students and to set the scene for the new topic of inquiry (Final teacher questionnaire, 16/11/09). During the early phases of the inquiry, she used the puppets to ascertain the students' prior knowledge and in the latter phases to

find out what they had learned (Final teacher questionnaire, 16/11/09). When Holly reflected on the final lesson, she thought that she had made better use of the puppets, not only in eliciting the students ideas at the start but more particularly at the turning point (Mortimer & Scott, 2003; Scott & Amteller, 2007; Scott, Ametller, Dawes, Kleine, Staarman, & Mercer, 2007) of the discussion when there was a need to be more explicit and the style of interaction needed to change (PL 5 interview, 27/11/2009). In this instance, she used Detective Doug to invite her back into the discussion so that she could resume her role as the teacher and provide a clear explanation of 'metamorphosis' (PL 5 interview, 27/11/2009).

Holly noticed that the students became very engaged and motivated when she used puppets in her science lessons and that they were participating in "longer more productive" discussions and "more confident and keen to share" their ideas (Final teacher questionnaire, 16/11/09). She thought the puppets provided "a safe, comfortable environment" for class discussions, especially since "the puppets were less knowledgeable than the students" (Final teacher questionnaire, 16/11/09). In the Post Lesson 5 interview, Holly explained that if she played on the puppets' naïvety, using them to ask most of the questions, the students were likely to share their ideas and to give more detailed explanations (PL 5 interview, 27/11/2009). Holly would also use the puppets to ask the students the meaning of particular words or phrases as a way to reinforce particular concepts or terminology (PL 5 interview, 27/11/2009).

> I was using the puppets to elicit their [the students'] knowledge and understanding and I tried asking for more explanation and the children actually gave quite long detailed explanations. …They weren't just giving simple one sentence answers or one word answers. They were actually giving quite an explanation to the puppets as if they were explaining the whole purpose and what was happening in the life cycle to teach the puppets. (PL 5 interview, 27/11/2009)

Since using puppets in her science lessons, Holly had modified not only the way that she managed whole-class discussions but also her questioning technique and the way that she responds to students' ideas (Final teacher questionnaire, 16/11/09).

At the end of the professional learning intervention, the teachers were asked to identify any difficulties they had encountered in using puppets. Holly found that introducing puppets into a lesson, transitioning between the puppet personalities, and developing the interaction between the teacher and the puppets were complex aspects to manage. Even so, she still rated herself as confident with using puppets in her science teaching and she felt that the students were very engaged and motivated by the puppets. Holly also noted that the puppets were able to elicit conversation from all the students, including the reluctant ones, and that they promoted a comfortable environment for conversation.

Key Finding 6.55

In the early phases of inquiry, Holly used the puppets to set the scene for the new topic, to engage the students and to ascertain their prior knowledge. In later phases, she used the puppets to find out what they had learned. In Lesson 5, Holly felt that she had made better use of the puppets, not only in eliciting the students' ideas at the start of the lesson but more particularly when she used them to invite her to resume her role as the teacher and give an explanation.

Holly felt confident with using the puppets and she believed the students were very engaged and motivated by them. She used the puppet's lack of knowledge to elicit more ideas and explanations from the students. Holly thought that the puppets had facilitated the development of a safe and comfortable environment for discussion and, as a consequence, the students were keen to share their ideas and to participate in longer, more productive discussions.

Holly found introducing puppets into a lesson, transitioning between the puppet personalities, and managing the teacher-puppet interaction were challenging.

Participation in the professional learning intervention

Holly had elected to be involved in the *Discourse Project* because *s*he was particularly keen to participate in some professional learning that focused on developing classroom discourse and teacher questioning techniques as she doubted her capacity to support her students to participate in substantive conversations. Additionally, she was particularly interested in learning how to use puppets to make her lessons more engaging. "I had never used puppets in my teaching and I had always had a fear of them and so I thought maybe it's time to get outside my comfort zone and take on a challenge" (PL 3 interview, 1/10/2009).

I've often thought … am I really asking the right questions to elicit the answers I really want to get? And so that was a focus for me, to really make sure that I'm giving the children the opportunity to give me the answers that I really want to hear. And learning about the communicative approaches… has really brought it to my attention again. And the way you manage the classroom in relation to positioning and other things like that. So I've changed that in science and that's made a big difference as well. .. Just the whole atmosphere, it's created a really nice, comfortable, enjoyable environment to work in during the science lesson. The students just love the dog puppets and they're just such a big hit with my Year 2 class. They might just be at that nice age that they really, really are into it. … And I'm looking forward to whatever year I get next year so that I can introduce those new children to the puppets and do the same thing again. And yeah, I just feel that it's made the science special and it's really engaged the students. (Final teacher interview, 27/11/09)

When introducing a new science topic, Holly found that it was important to develop a scenario that gave a background context in which to set the problem for the students to solve. She thought that this provided a believable purpose for their investigation and increased the students' enjoyment of science lessons.

There wouldn't be one student in my class who wouldn't like science… and a lot of that's to do with the puppets and that initial engagement when the puppets come [out] …they're just excited to see the puppets and what they're going to say this week or what they're going to do or what the story is going to be. … I think it's being able to create a little bit more of a context, using the puppets as a story base. … I've always used a lot of literature and maybe I'd read a story but this is creating and making up some scenario, which I wasn't doing before. And I think that makes it a little bit more interesting and a little bit more relevant as to why we're doing the topic. The story might be made up, but to the kids there seems to be a purpose for why we're now investigating this topic. Whereas beforehand, I might have just said 'We're going to learn about magnets'. Now the kids are learning and they'll say they're learning because of Tilly or Doug or something like that. So there seems to be a little bit more of a purpose as to why we're doing that topic and it's a bit more meaningful. (Final teacher interview, 27/11/09)

Holly felt that she would like to continue to develop the way that she responded to students' questions. She also wished to increase her skills in handling the puppets and in transitioning from one character to the next in the course of discussions (Final

teacher questionnaire, 16/11/09). In addition, Holly was keen to support other teachers in her school to use puppets in science.

In the Final teacher interview (27/11/09), Holly volunteered some feedback about her experiences in the professional learning intervention.

> I've really been pleased that I put my hand up to be involved in the project … it's been a really good experience for me. Apart from doing the *Primary Connections* professional learning, I think it's probably the most rewarding project that I've actually been in. It's allowed me to be really reflective and I really can see how I've implemented and made changes to how I'm teaching, more so than some other PD's [professional development sessions] and things that I've been to. I really feel that I've immersed myself in it and its really benefitted me as a teacher and I think it will continue to, especially the questioning part of it. I feel that's been invaluable, and just taking up the challenge, now I don't mind using puppets.
>
> And I can just see the difference in the quality of the conversations that I have with my students now compared with what I got last year, I can see there's a difference. And for me, if I can get other teachers to see that difference that would just be great… for other teachers to get the rewards that I've received from doing this course. I'm very conscious now in all my discussions of the questioning techniques that I'm using and all that sort of thinking to extend the conversation and make it more productive. (Final teacher interview, 27/11/09)

Key Finding 6.56

Holly became involved in the professional learning intervention because she wanted to develop her understanding and use of discourse and questioning techniques so that she could better support her students to participate in substantive conversation. She was also keen to learn how to use puppets to make her lessons more engaging.

As a consequence of participating in the intervention, Holly thought she had developed a greater level of comfort and confidence in using the puppets and she saw how much more engaged her students became when she used the puppets to create a context for science investigations. Additionally, Holly had come to understand the conventions that support substantive class discussion and she was confident that she could use teacher questioning and responding techniques to develop extended and productive conversations with her students. Holly was motivated to continue to develop her skills in using puppets and developing substantive discourse and she was keen to share her understandings with other teachers at her school.

Summary

This chapter explored Holly's involvement in the professional learning opportunity and the impact this had on the way that she used puppets and managed discussions in science. Key findings have highlighted the contextual factors, beliefs and understandings that may influence her teaching and also how she managed class discussions in practice. As Holly worked on her use of puppets and her management of class discussions over the course of the professional learning intervention, it is very likely that her initial beliefs and knowledge informed her practice and, as the intervention progressed, that her practice subsequently began to inform her beliefs and knowledge.

Teacher beliefs and knowledge

Beliefs about teaching science

Over the course of the professional learning intervention, many of Holly's beliefs about using an inquiry approach to teaching science and supporting students' to construct their own understandings remained constant (KF 6.51) but her ideas about the role of discourse in science teaching began to expand. At the start of the intervention, she believed that inclusivity was important and that each student should have their turn to speak or answer a question because they were entitled to give their ideas (KF 6.7). She also believed that teacher questioning and class discussions supported students to share their thinking and to develop a common set of ideas (KF 6.4).

Subsequently, Holly began to talk about how teachers could help students to make sense of their ideas via discussion and that extended conversations were essential to effective science teaching (KF 6.51). She came to believe that teacher questioning and class discussions also facilitated students' greater engagement and deeper understanding of science ideas and that this was achieved by matching an appropriate communicative approach to each phase of inquiry (KF 6.51). In addition, Holly believed it was important to set up a supportive classroom environment in which the students felt safe to articulate their ideas (KF 6.51).

Assertion 6.1

As Holly engaged in the professional learning intervention, she began to believe that as well as giving students the opportunity to speak, teachers need to think carefully about the questions they ask, how they match their style of interaction to the phase of inquiry, and how the classroom culture for talk supports students' participation in discussion.

Confidence to teach science

Holly commenced the professional learning intervention a confident teacher of primary science (KF 6.5). She increased her confidence with engaging students' interest in science and for managing discussions and developing interpretations of observations (KF 6.52).

Assertion 6.2

As a consequence of her involvement in the professional learning intervention, Holly further developed her confidence for managing class discussions.

Beliefs about being an effective manager of classroom talk

Holly believed she was an effective manager of classroom talk (KF 6.6; KF 6.53) and at the end of the intervention she reported an increased level of self-efficacy for responding to students' answers in ways that maintain and promote further discussion of the science ideas (KF 6.53). At the start of the professional learning intervention, Holly reported a high level of self-efficacy for establishing an appropriate classroom climate for classroom talk (KF 6.6), however, later in the intervention she indicated a slightly lower level of self-efficacy for this aspect and for using *wait time* (KF 6.53).

Assertion 6.3

Through the professional learning process, Holly began to understand the complexities involved in constructing a classroom environment that is supportive of substantive discussion and the difficulties related to incorporating *wait time* into her teaching practice.

Knowledge about managing classroom discourse

Holly considered it was important to create a comfortable and non-threatening classroom environment that is supportive of students' participation in discussion (KF 6.7). She thought that inclusivity was important and that each student should have their turn to speak or answer a question because they were entitled to give their ideas (KF 6.7). At the start of the professional learning intervention, the students in Holly's class were expected to raise their hands when they wished to speak and they sat in a pod shape facing Holly (KF 6.9). Following the first two PL days, Holly introduced the Sharing Circle and the Thinking Thumb into her class discussions and she thought that these strategies had facilitated the students' interactions because they listened to each other more and their responses had increased in quality as well as in length (KF 6.35).

Mid-way through the intervention, Holly indicated that she had been most successful in creating a classroom culture to do with talk that was *supportive, collective,* and *reciprocal* (KF 6.35). She also thought she had been slightly less successful at getting the students to give reasons to explain their ideas or resolve their disagreements or to develop classroom talk that was *cumulative* and *purposeful* (KF 6.35). However, the analysis of the discussions from Lesson 2 onwards showed that the students did build on each other's ideas and that their talk became increasingly cumulative (KF 6.24; KF 6.34; KF 6.43; KF 6.50). Similarly, evidence from the post lesson interviews indicated that Holly did plan class discussions and that she became increasingly clear about how she should steer the discourse to reach the specific outcomes for each lesson (KF 6.54).

Assertion 6.4

Holly developed a greater understanding of classroom conventions that are supportive of students' participation in discussion and she was able to identify the development of *collective, supportive,* and *reciprocal* characteristics of talk in her class discussions before she recognised the *cumulative* and *purposeful* aspects.

Holly thought that teachers should be encouraging and accepting of students' responses to their questions (KF 6.7). Consequently, at the start of the professional

learning intervention she appeared to focus on ensuring all the students had their say, which resulted in a (teacher-nominated) *turn taking* style of interaction (KF 7.11; KF 7.20). Mid-way through the intervention, when given the opportunity to observe how *turn taking* limited the students' ability to elaborate on their ideas in discussion, Holly began to understand that students should be given the chance to give extended answers and that teachers' responses should provide students with feedback (IRF, Mortimer & Scott, 2003) (KF 6.35). As a result, she thought that she needed to develop a more interactive form of discourse by asking questions that allowed the students to elaborate on their ideas (KF 6.35).

Assertion 6.5

Holly came to understand the impact a teacher has on their students' contributions to discussion and the need for teachers to make room in the discussion for students' to participate and to make more elaborated contributions.

At the start of the professional earning intervention, Holly thought that teacher questioning should be differentiated to correspond with each phase of the inquiry process (KF 6.7). Later on she was able to elaborate on this idea, stating that in the Engage and Explore phases the communicative approach should be Interactive-Dialogic, where teachers asked open-ended questions, and that in the Explain phase teachers needed to adjust their questioning to probe students' ideas and to use closed questions to highlight scientific ideas (KF 6.54).

Assertion 6.6

Holly showed a deeper understanding about how teachers should use the questioning and discourse moves to match their communicative approach to the phase of inquiry.

Throughout the professional learning intervention, Holly consistently articulated the idea that teachers should use *wait time* during class discussions as she felt this gave the students' time to think and encouraged their participation (KF 6.7; KF 6.35; KF 6.54). While Holly thought she had used *wait time*, there was no evidence in the video

footage of what Rowe (1972) referred as to *Wait Time 1* (the pause after a teacher utterance) or *Wait Time 2* (the pause after a student utterance) (KF 6.14; KF 6.21; KF 6.31; KF 6.40; KF 6.47). However, from the mid-way point in the intervention Holly did begin to use the Thinking Time strategy, which was considered a form of *wait time* in this study (KF 6.31; KF 6.47).

Assertion 6.7

While, Holly consistently stated that teachers should use *wait time* to give the students' time to think and she used Thinking Time in her practice, she did not seem to understand how to implement *Wait Time 1* and *2* in her teaching.

Knowledge about using puppets

Holly began the professional learning intervention with no experience of using puppets in her teaching (KF 6.8). However, the professional learning days provided opportunities for the teachers to plan the implementation of science topics incorporating the use of puppets. Consequently, Holly developed an understanding of how to use the puppets in the Engage phase to set the scene and engage the students in the new topic, to present a problem for them to investigate, and to ascertain their prior knowledge (KF7.39; KF 6.55). In the Explain phase, Holly learned to use the puppets to expand on the initial problem and to find out what the students had learned during the Engage and Explore phases that would resolve the problem (KF 6.55). Ultimately, Holly reported that she had been able to use the puppets effectively at all stages of the inquiry process (KF 6.36).

Additionally, Holly learned how to develop the personality and voice for each of the three puppets she used, as well as the skill to physically manipulate them (KF 6.18; KF 6.37). She also found that portraying one of the puppets as a naïve, clueless character helped the students to feel knowledgeable and more confident to share their ideas and explanations (KF 6.37). Towards the end of the intervention when her skills were more developed, Holly also used the puppets to invite her to re-enter the discussion in order to draw on the more authoritative voice of the teacher to give an explanation or make a science idea explicit (KF 6.44).

When Holly initially introduced two dog puppets into her lessons, she noticed that the students were immediately engaged by them and were motivated to talk to them (KF 6.36). Ultimately, she found the puppets facilitated the development of a safe and comfortable environment for discussion and that all the students were more willing to share their ideas, to listen to one another and to participate in longer, more productive discussions (KF 6.54; KF 6.55).

Over the course of the intervention, Holly felt her confidence with using the puppets increased (KF 6.36; KF 6.55). However, she also found introducing the puppets into the lesson, juggling the interaction between the teacher and two puppets, and transitioning from one personality to another was challenging (KF 6.36; KF 6.55).

Assertion 6.8

Holly's capacity to use puppets to support class discussions and primary science investigations developed significantly as a consequence of her involvement in the professional learning intervention. She developed an understanding about how to use puppets to promote a safe environment for students to participate in longer, more productive discussions and how to use the puppets in all phases of inquiry. While Holly's confidence with using the puppets increased considerably, she also identified several challenges that she continued to work on.

Teacher practice

Communicative approach, teacher questioning, and teacher discourse moves

Over the course of the professional learning intervention, Holly developed a deeper understanding about how to use teacher questioning and discourse moves to develop an Interactive-Dialogic style of interaction in Engage lessons (KF 6.15; KF 6.22; KF 6.41) so as to capture the students' interest in the topic and to elicit their existing ideas. In the early stage of the professional learning intervention, Holly asked *open-ideas* and *open-description* questions that were appropriate to the Engage phase (KF 6.10). However, because she utilised a (teacher-nominated) *turn taking* pattern of interaction (Initiation-Response-Restate or I-R-R) (KF 6.11; KF 6.20), Holly's responses effectively shut down the interaction with the students and this impacted on the quality of their contributions to the discussion (KF 6.17). As the intervention progressed, Holly began to utilise a greater range of teacher discourse moves to elicit the students' ideas and

make them explicit (KF 6.20; KF 6.21; KF 6.27; KF 6.30; KF 6.39; KF 6.46; KF 6.47). She maintained her line of questioning and maximised her interactions with students by asking them to say more, and she moved on to seek other ideas when she felt the exchange was no longer productive (KF 6.40; KF 6.47). By working the discussion in this way, Holly was able to sustain quite long and productive chains of teacher-student interaction (KF 6.21; KF 6.46; KF 6.47) and the quality of the students' contributions increased (KF 6.24; KF 6.34; KF 6.43; KF 6.50).

In Explain lessons, Holly progressively became more adept at using teacher questioning (KF 6.26; KF 6.45) and discourse moves to explain the science phenomenon that was the focus of the investigation. She did this by first reviewing what the students had learned during the Engage and Explore phases that might help to resolve the problem (KF 6.27; KF 6.46), and then by exploring the students' understandings in more depth so as to make the scientific ideas explicit (KF 6.30; KF 6.47). In the first part of the discussion, when she wanted to review what the students had learned, Holly used an Interactive-Dialogic approach (KF 6.32; 6.48) where she asked *open-ideas* questions (KF 6.26; KF 6.45) and used a range of discourse moves (*teacher restate*, *clarify*, *teacher uptake*, *extended thinking time*, *checks for consensus*, *evaluate*, and *refocus*) to maximise the interaction with individual students and to help them to link their ideas to the problem (KF 6.27; KF 6.46). She used other discourse moves to reshape students' ideas (*clarify*, *reframe, refocus*), to explain and reinforce key understandings (*elaborate*, *teacher restates*, *clarifies*, *teacher uptake*, *prompt and scaffold*, *reframe*), and to summarise the discussion (*refocus*) (KF 6.29; KF 6.30; KF 6.46). In the latter part of the discussion, when she wanted to probe the students' understandings and to make the scientific ideas explicit, she used a more Interactive-Authoritative approach (KF 6.29; KF 6.30; KF 6.32; KF 6.48) where she asked more *open-description* and *open-explanation~reason* questions (KF 6.26; KF 6.45) and used a complex range of discourse moves (*teacher restate*, *clarify*, *recast the question*, *elaborate*, *teacher uptake*, *evaluate*, *reframe*, *prompt and scaffold*, *reframe scientifically*) to work on the students' ideas, rephrasing some and endorsing others, so that the correct scientific ideas were heard (KF 6.31 KF 6.32; KF 6.47). By managing the discussion in this way, Holly developed and sustained long and productive chains of teacher-student interaction in both parts of the discussion.

Students

The students' participation in class discussions and the quality of their contributions changed quite markedly over the course of the professional learning intervention. The very short, simple responses that were typical of their contributions in the initial lesson (KF 6.17) changed very quickly in subsequent lessons to become increasingly more elaborate responses that built on the ideas of others, generating cumulative talk (Alexander, 2006) (KF 6. 24; KF 6.34; KF 6.43; KF 6.50). Similarly, the quality of the students' responses changed over the course of the intervention and they progressively gave more complex descriptions, explanations and reasons (KF 6.17; KF 6.24; KF 6.34; KF 6.43; KF 6.50).

Assertion 6.9

Holly's management of class discussion became increasingly sophisticated as she aligned her use of teacher questioning and discourse moves with the purposes of the Engage and Explain lessons. While there is no direct evidence, it is likely that this change to her practice and the positive impact that it had on the quality of the students' contributions would have also impacted her beliefs and knowledge.

Conclusion

As Holly participated in the professional learning intervention, she developed her pedagogical content knowledge for using puppets and managing discussions and this positively impacted the quantity and quality of her students' contributions to class discussions in science. Such an outcome may well have been facilitated by the supportive school context in which she worked, by Holly's own background in science, and her confidence and experience as a primary science teacher.

CHAPTER 7: CROSS CASE ANALYSIS & DISCUSSION

Introduction

This study explored the impact of a professional learning intervention on teachers' beliefs and knowledge about discourse and how they utilised teacher questioning, teacher discourse moves, and communicative approaches to orchestrate sustained conversations in their science lessons. This chapter explores the similarities and salient differences between the three case studies and examines how each of the teachers responded to the professional learning intervention with regard to their beliefs, knowledge and practice. The themes that emerged from this analysis and data interpretation resulted in the construction of general assertions which inform the conclusions presented in the final chapter.

The professional learning intervention impacted on the teachers' beliefs, knowledge, and practice in different ways and such an outcome is consistent with the social constructivist and sociocultural perspectives taken by this study. Both of these perspectives maintain that individuals develop subjective meanings of their experiences via interaction with others and that, in order to interpret the settings of the participants, the research needed to focus on the interactions and the specific contexts in which the teachers worked. With such an orientation to research, it is also important that, as the Researcher, I acknowledge my interpretation of the teachers' and students' interactions and their classroom contexts is filtered through my own beliefs and experiences of classroom teaching.

This chapter interprets the findings of the research with reference to the literature and the conceptual framework that guides the study and, subsequently, articulates how the study has developed new knowledge about the ways that teachers use discourse to deepen students' understandings in primary science lessons. Figure 7.1 below provides a visual representation of the conceptual framework that has guided this study.

Classroom culture for talk

Teacher's beliefs

Teacher's practice

Teacher's knowledge

Teacher's use of questioning and discourse moves

Teacher's communicative approach

Opportunities for students' sustained engagement with a discourse of inquiry

Development of the discourse required for effective science inquiry

Student reasoning and learning
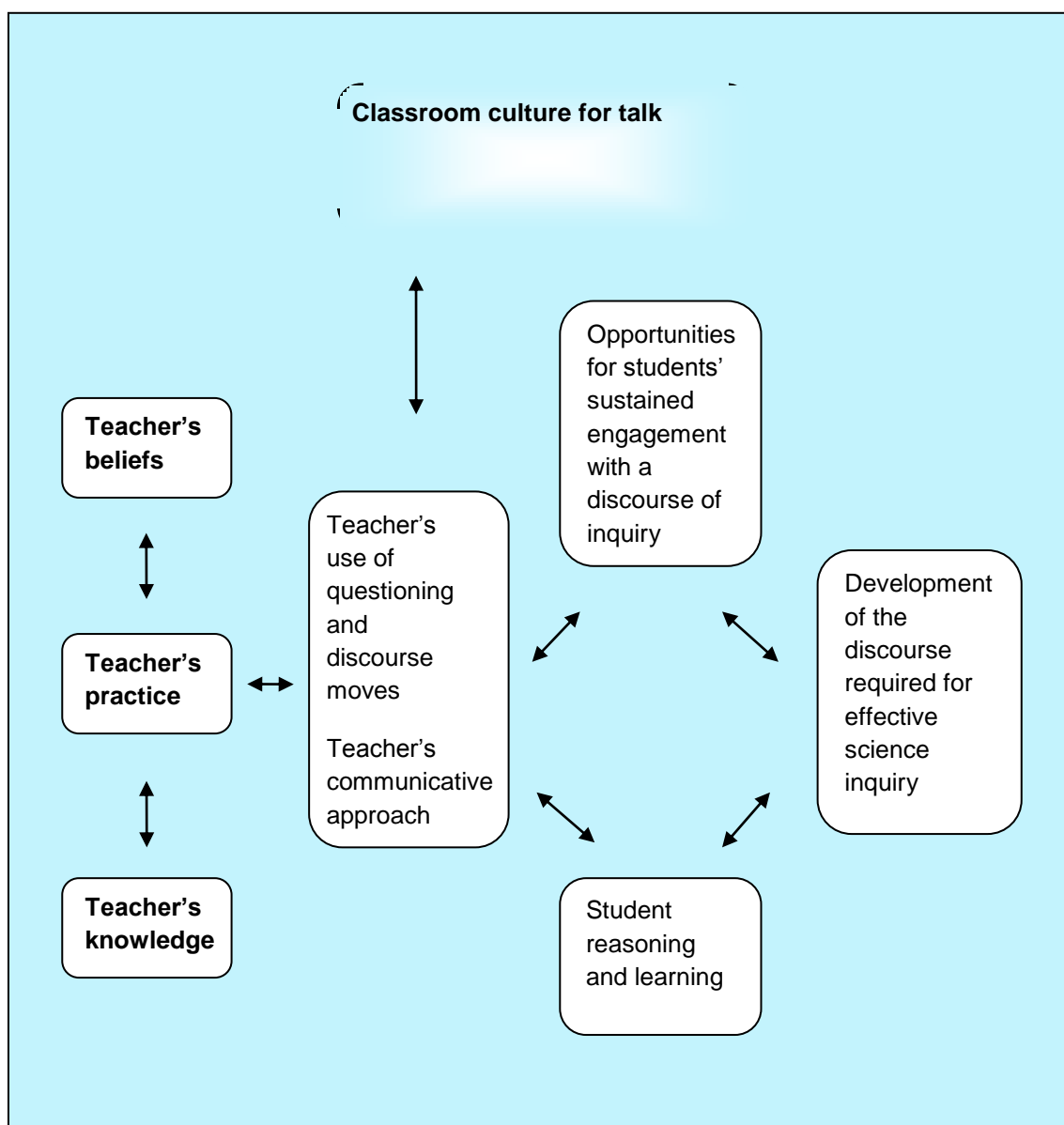
Figure 7.1: A conceptual framework for this study.

Three different contexts

Given the social constructivist and sociocultural perspective taken by this study, it is important to recognise that the contexts in which the case study teachers worked would have influenced the outcomes of the professional learning intervention. The intervention involved advanced teacher professional learning that was suited to confident teachers of primary science. A cohort of 12 teachers was recruited from government and independent schools in the Perth metropolitan area of WA and five of

these teachers volunteered to participate in case studies. Given the richness of the data collected, it was ultimately decided that only three case studies (Penny, Ben and Holly) would be developed. An overview of the key contextual aspects for each case study is outlined below in Table 7.1.

Table 7.1: An overview of teaching contexts.

Aspects	Penny	Ben	Holly
Teacher's qualifications & science background	Undergraduate degree in Library studies, Graduate Diploma in Education	Bachelor of Education (Primary)	Bachelor of Science, Graduate Diploma in Education Extensive experience as a researcher in Botany
Teaching experience	More than 7 years Science Co-ordinator Mentor teacher in science (WA DoE)	First year in a substantive position Science Co-ordinator	10 years Science Co-ordinator
Experience with using an inquiry approach	In science	A school focus and used in most curriculum areas	In science
Experience with *Primary Connections*	Completed teacher professional development in implementation of *PC* Well experienced with using *PC* resources *PC* professional learning facilitator	Had not completed teacher professional development in implementation of *PC* Limited experience with using *PC* resources Had not used the 5Es inquiry learning model	Completed teacher professional development in implementation of *PC* Well experienced with using *PC* resources *PC* professional learning facilitator
School	Eastbrook Primary School (EPS)	Wildlake Community School (WCS)	Southport Primary School (SPS)
Sector	Government, WA Department of Education	Non-government, independent	Government, WA Department of Education
ISCEA value (mean 1000)	863 20% Indigenous students	1155	955 8% Indigenous students
NAPLAN results in 2009	Students in Year 7 were significantly below the national average in each domain	Students in Year 3 tend to be above or close to the national average in each domain	Students in Year 3 tend to be close to the national average in each domain
Class	23 students, Year 6/7	23 students, K/PP	22 students, Year 2/3

Table 7.1 (above) shows that the teachers had a range of teacher qualifications with Ben having attained a Bachelor of Education and Penny and Holly holding a post

graduate diploma (KF 4.1; KF 5.1; KF 6.1). Holly also had a strong science background with her undergraduate degree in Science and extensive work experience in Botany (KF 4.1). Both Penny and Holly had been teaching for more than seven years (KF 4.1; KF 6.1) and while Ben was only in his first year in a substantive teaching position, he had also completed a three year internship at WCS (KF 5.1). All of the teachers were familiar with the inquiry approach to teaching and learning, and Holly and Penny used the 5Es inquiry learning model (Hackling et al., 2007) in science (KF 4.4; KF 5.1; KF 6.4). Both Holly and Penny had attended teacher professional development in the use of the *Primary Connections* (AAS, 2005) curriculum resources and had used them for some time (KF 4.1; KF 6.1). Additionally, they had both trained as *Primary Connections* professional learning facilitators and were accustomed to providing professional learning for other teachers (KF 4.1; KF 6.1). Ben had not attended teacher professional development in the use of the *Primary Connections* (AAS, 2005) curriculum resources, had limited experience with using the resources, and had not used the 5Es inquiry learning model (KF 5.1).

The case study teachers taught differing year levels with Ben teaching Kindergarten/Pre-Primary students, Holly teaching Year 2/3, and Penny teaching Year 6/7 (KF 4.3; KF 5.3; KF 6.3). They also taught in quite different schools. Although Penny and Holly both taught in WA government schools (KF 4.2; KF 6.2), their contexts differed in that Penny's school (EPS) served students experiencing greater levels of socio-economic disadvantage and higher numbers of Indigenous students than Holly's school (SPS). Additionally, Ben taught in a non-government independent school (WCS) that served students who mostly came from above average socio-economic circumstances, where none of the student population is Indigenous, and the school adopted a social constructivist approach to teaching and learning (KF 5.2). These differences highlight the unique contexts in which the teachers worked and suggest that the findings of the study would be relevant to schools from similar contexts.

The impact of the professional learning intervention on teachers' beliefs, knowledge and classroom practice

Several themes emerged from the data concerning the development of the teachers' beliefs and knowledge about students' learning of science and classroom discourse and their practices of using communicative approaches in class discussions. These themes related to: effective science teaching and learning; establishing a supportive classroom environment for talk; the use of questioning, discourse moves and communicative approach in whole-class discussions; and, the use of puppets to facilitate whole-class discussions. The development of each teacher's beliefs and or knowledge is discussed in relation to each theme and, where appropriate, this is then linked to the development of their teaching practice. Some general assertions are then developed for each theme.

Theme 1: Teachers' beliefs about effective science teaching and learning

In this section, a summary of each of the teacher's beliefs about effective science teaching and learning is presented and assertions about their beliefs are developed. The subsequent discussion highlights the similarities and differences between the teachers' beliefs as well as the influence of the professional learning intervention on those beliefs. Finally, a general assertion is given.

Penny's beliefs

Throughout the professional learning intervention, Penny maintained her beliefs about effective science teaching. She believed that a hands-on, inquiry approach to teaching science was an effective way to increase students' conceptual understandings (KF 4.4; KF 4.45) and that eliciting the students' initial understandings was an important step in developing investigations that were student-centred (KF 4.4; KF 4.45). Penny also believed that it was important to develop the students' understandings by modelling and scaffolding the skills for investigation (KF 4.4) and that inquiry-based science teaching and learning should be integrated with literacy (KF 4.4).

Assertion 7.1

Penny's beliefs were consistent with a constructivist approach to teaching and learning and reflected the inquiry approach to teaching science used by the *Primary Connections* program that had been adopted by her school.

Penny believed it was important to use a hands-on, inquiry approach to teaching science; to develop investigations that were student-centred; to provide opportunities for students to develop the skills for investigation; and that science should be integrated with literacy. These beliefs were reinforced over the course of the professional learning intervention.

Ben's beliefs

Similarly, Ben retained a number of his beliefs about effective science teaching that he had articulated at the start of the professional learning intervention. He believed that it was important for science teaching to be emergent, explorative and student-centred (KF 5.4; KF 5.44). He also believed that teachers should plan investigations that align with students' interests and questions, and that the learning should be engaging, contextualised, hands-on, and connected to the students' real life and place-based experiences (KF 5.4; KF 5.44). Later in the intervention, Ben began to believe that differentiating the phases of inquiry was an important characteristic of inquiry-based science teaching and learning (KF 5.44), and that utilising a more authoritative communicative approach in Explain lessons enabled him to synthesise the students' ideas concisely using the correct scientific language and to present coherent scientific explanations at the end of the learning experience (KF 5.41).

Assertion 7.2

Ben's beliefs were consistent with a constructivist approach to teaching and learning, which reflected the pedagogical stance taken by his school.

He believed that science teaching should be emergent, explorative and student-centred and that that investigations should be connected to the students' real life experiences, driven by their questions, and that they should be hands-on. These beliefs were reinforced over the course of the professional learning intervention.

As the professional learning intervention progressed, Ben also came to believe that it was important to differentiate his teaching approach according to the phase of inquiry.

Holly's beliefs

Holly's beliefs about using an inquiry approach to teaching science and supporting students to construct their own understandings also remained constant over the course of the professional learning intervention (KF 6.4; KF 6.51). She believed that it was important to develop the students' capacity to use the investigative processes, to interpret data and make judgements, and to apply new science concepts (KF 6.4; KF 6.51). Holly also believed that science investigations should engage the students' curiosity and cater to their interests, developmental levels and learning needs (KF 6.4; KF 6.51), and that science should be integrated into a range of curriculum areas such as literacy (KF 6.4).

Assertion 7.3

Holly's beliefs were consistent with a constructivist approach to teaching and learning and reflected the inquiry approach to teaching science used by the *Primary Connections* program that had been adopted by her school.

She believed in an inquiry approach to teaching science, that investigations should be student centred, engaging, and appropriate to the students' learning needs. She also believed that it was important to develop the students' capacity to use the investigative processes and to construct their own understandings, and that science should be integrated with other curriculum areas such as literacy.

These beliefs were reinforced over the course of the professional learning intervention.

Discussion about Theme 1

Effective science teaching

Each of the teachers retained their beliefs about teaching science that they had articulated at the start of the professional learning intervention. They shared a common belief about the key elements of effective science teaching, namely that it was achieved via a hands-on, inquiry approach where the teacher supported the students to construct their own understandings; and that investigations should take account of the students' interests, current understandings and real life experiences, as well as their developmental levels and particular learning needs (Assertion 7.1; Assertion 7.2; Assertion 7.3). These beliefs are consistent with a social constructivist view of learning which holds that learners actively construct knowledge and derive personal meaning

from their shared experiences by drawing on their prior knowledge, and by interacting with their teachers, peers and environment (Bybee, 1997; Driver et al., 1994).

Penny and Holly believed that it was important to explicitly model and scaffold the skills of investigation for the students (Assertion 7.1; Assertion 7.3), which reflected the approach taken by the *Primary Connections* program used by their schools. On the other hand, Ben believed in a more emergent, explorative approach (Assertion 7.2) where the focus of the teaching is more naturally led by the interests of the children, which corresponds well with an early childhood context. Further, Holly believed that it was important to not only develop the students' capacity to use the investigative processes but also to show them how to interpret data, make judgements, and apply the new science concepts that they had learned (Assertion 7.2). Penny and Holly also articulated a belief that inquiry-based science teaching and learning should be integrated into a range of curriculum areas, particularly literacy (Assertion 7.1; Assertion 7.3). This finding is consistent with a sociocultural approach to teaching and learning where students are exposed to the scientific view and encouraged to develop their understandings of scientific concepts and procedures to use as tools for problem-solving. From this perspective, learners are seen to be enculturated into the practices of a scientific community and to learn through cognitive apprenticeship (Traianou, 2007).

Although Ben was familiar with an inquiry approach to teaching, he had limited experience of using the *Primary Connections* program and had not used the 5Es learning model with its discrete phases of inquiry (KF 5.1). Later in the intervention, he came to believe that inquiry-based science teaching and learning was well supported by the different and specific phases of inquiry (Assertion 7.2). This is consistent with Brickhouse (1990) as well as Clark and Peterson (1986) who assert that teachers' behaviour and actions influence the continual development of their beliefs and personal theories. Clark and Peterson (1986) also suggest that teacher beliefs are reinforced or adapted according to the evidence gained from their experiences in classroom and school contexts. Given this, it is highly likely that this development in Ben's beliefs resulted from his involvement in the professional learning intervention together with the opportunities that he had to view and reflect on his practice and the practice of other

teachers, to interact with colleagues, and to plan and implement several investigations with his students over a period of time.

General Assertion 1

The teachers in this study shared a set of common beliefs to do with utilising an inquiry approach to teaching science that involved student-centred investigations in which the teacher supported students to construct their own understandings. Two of the teachers believed that it was important to explicitly model and scaffold the skills for investigation for the students and the other believed in a more emergent, explorative approach which was consistent with the teaching approach he used with his Kindergarten/Pre-Primary children.

The teachers' beliefs about teaching science were confirmed as they participated in the professional learning process. Later in the intervention, one of the teachers came to believe that it was important to differentiate his teaching approach according to the phase of inquiry.

Theme 2: Teachers' beliefs, knowledge and classroom practice to do with developing a supportive classroom environment for talk

In this section, a summary of each teacher's beliefs, knowledge and classroom practice relating to developing a supportive classroom environment for talk is presented and assertions are developed. Subsequently, the discussion highlights the similarities and differences between their beliefs, knowledge and practice and how this changed as a result of the teachers' participation in the professional learning intervention. Ultimately, two general assertions about the development of the teachers' beliefs, knowledge and practice to do with developing a supportive classroom environment for talk are given.

Penny's beliefs and knowledge

Over the course of the professional learning intervention, Penny maintained her beliefs about developing a supportive classroom environment for talk (KF 4.4; KF 4.45). At the start of the intervention, she stated that it was necessary to create a safe and supportive environment for classroom discussion so that the students felt comfortable to share their thinking and to challenge each other's ideas without the fear of being told they were wrong (KF 4.7). She thought that it was important for all the students to know that their ideas were worthy and that less confident students would be supported to share their ideas by participating in small group discussions (KF 4.7). Later in the

intervention, she also highlighted the role of the teacher in facilitating the discussion and supporting the students to build on each other's ideas (KF4.48).

At the start of the intervention, Penny believed she was an effective manager of classroom talk, particularly for establishing an appropriate classroom climate, encouraging and supporting students to ask questions, and being effective in engaging most of the students in responding to questions (KF 4.6). While she maintained her belief that she was an effective manager of classroom talk, she indicated a slightly lower level of self-efficacy for each of these aspects later in the intervention (KF 4.47).

Mid-way through the intervention, Penny indicated that she had been most successful in creating a classroom culture to do with talk that was *collective* (90%) and *reciprocal* (80%). In contrast, she had been less successful at developing classroom talk that was *cumulative* (70%), *purposeful* (70%) or *supportive* (60%) (KF 4.31). In spite of this perception, the data shows that the students' talk was cumulative (KF 4.23; KF 4.30; KF 4.38; KF 4.44). In fact, Penny consistently utilised an Interactive-Dialogic approach which enabled the students to share their ideas (KF 4.14; KF 4.21; KF 4.28; KF5.36; KF 4.42). In addition, the data shows that in the Explain lessons (Lessons 3 and 5) the discussions were purposeful as Penny utilised a set of planned focus questions to drive the discussion (KF 4.24; KF 4.39), and in the final Engage lesson (Lesson 4) she had planned a scenario to set the scene for a new topic and to present a problem for the students to solve (KF 4.33).

Penny's classroom practice

The students in Penny's class raised their hands when they wanted to speak during discussions and they sat in a pod formation on the floor facing her (KF 4.9; KF 4.17; KF 4.24; KF 4.33; KF 4.39). At the midpoint of the intervention, Penny reported that she had focused on developing the students' use of speaking and listening conventions (KF 4.31) and she thought that she had been most successful in creating a classroom culture in which students spoke one at a time (90%), respected each other's opinions (90%), and shared and listened to each other's ideas (80%) (KF 4.31). However, she also thought she had been less successful at getting the students to give reasons to explain their ideas (60%) or to resolve their disagreements (50%) (KF 4.31).

Assertion 7.4

Penny's perception of her success in developing substantive talk in her class may have been coloured by the sometimes challenging context in which she worked and by her growing understanding of what was actually involved in developing a classroom culture that supported productive talk.

At the start of the professional learning intervention, Penny believed and understood that a safe and supportive classroom environment facilitated student participation in discussion. As she participated in the intervention, she came to understand the role of the teacher in facilitating student participation in substantive talk.

At the midpoint of the intervention, Penny was able to identify the development of *collective* and *reciprocal* characteristics of talk in her class discussions and only later on in the intervention did she recognise the *supportive*, *cumulative* and *purposeful* aspects.

As she engaged in the professional learning process, Penny understood more clearly the importance of first establishing and then developing the students' use of speaking and listening conventions that are supportive of substantive talk. While Penny thought her students had used these conventions successfully, she also thought they needed more support to know how to explain why or to resolve their disagreements.

Ben's beliefs and knowledge

Over the course of the professional learning intervention, Ben did not articulate any particular beliefs about the classroom environment or the development of a classroom culture that is supportive of discourse although he did believe he was an effective manager of classroom talk, particularly for establishing an appropriate classroom climate (KF 5.6; KF 5.46). At the start of the intervention, he stated that he thought a good classroom discussion was the product of an open, safe and caring environment (KF 5.47). He thought that good discussion looked like a conversation, with open dialogue and all members of the class interacting and contributing ideas (KF 5.7; KF 5.47). Ben also thought that a student-centred classroom fostered interaction; that the learning should be driven by the student's ideas; and the students should be given time to investigate and to deepen their understandings (KF 5.7). This student-directed focus was an intrinsic part of the Reggio Emilio inspired approach to teaching and learning at WCS and seemed a natural fit with the young children in Ben's class (KF 5.2).

At the midpoint of the intervention, Ben was very confident that he had created a classroom culture to do with talk that was *collective* (100%), *reciprocal* (100%), *supportive* (100%), and *cumulative* (100%) (KF 5.30). However, he considered that he

had been less successful at creating a classroom culture to do with talk that was *purposeful* (70%), i.e. when teachers plan and steer classroom talk with a specific outcome in view (KF 5.30).

Ben's classroom practice

When Ben managed his whole-class discussions, he worked with the students to develop substantive talk but he also focused explicitly on developing their understandings and use of the conventions for talk. This dual focus was clearly evident in each lesson as he supported the students to articulate their ideas in one turn, then prompted them to take responsibility for using the conventions for talk in the next (KF 5.9; KF 5.17; KF 5.24; KF 5.32; KF 5.38). As the professional learning intervention progressed, Ben adjusted his expectations of the students and asked them to take more responsibility for using the different conventions for talk, e.g. sharing speaking turns, staying on topic, remembering how to ask questions (KF 5.17; KF 5.24; KF 5.32; KF 5.38) and finding a space in the discussion to talk (KF 5.32; KF 5.38). At the midpoint of the intervention, Ben reported that he had been successful at keeping the students on topic during the discussion, and thought that sitting in a circle formation and using a Thinking Thumb had helped them to stay focused (KF 5.30). He also believed that his class discussions had improved because he devoted time to them (KF 5.30). Additionally, Ben was very confident that he been most successful in creating a classroom culture in which the students shared and listened to each other's ideas (100%), gave reasons to explain their ideas (100%), respected each other's opinions (90%), asked "why" when they disagreed (90%), and spoke one at a time (80%) (KF 5.30).

Holly's beliefs and knowledge

Like Ben, Holly did not articulate any particular beliefs at the start of the intervention about the classroom environment or the development of a classroom culture that is supportive of discourse. She thought that inclusivity was important and that each student should have their turn to speak or to answer a question because they were entitled to give their ideas (KF 6.7). Later in the intervention, Holly articulated a belief that effective primary science teaching was supported by classroom management that provided a safe and comfortable environment (KF 6.51).

At the start of the professional learning intervention, Holly believed she was an effective manager of classroom talk, particularly for establishing an appropriate classroom climate (KF 6.6); however she indicated a slightly lower level of self-efficacy for this aspect later in the intervention (KF 6.53).

Mid-way through the intervention, Holly indicated that she had been most successful in creating a classroom culture to do with talk that was *supportive* (90%), *collective* (80%) and *reciprocal* (80%) (KF 6.35). She also believed she had been slightly less successful at developing classroom talk that was *cumulative* (70%) and *purposeful*

(70%) (KF 6.35). However, the analysis of the discussions from Lesson 2 onwards showed that the students did build on each other's ideas and that their talk became increasingly cumulative (KF 6.24; KF 6.34; KF 6.43; KF 6.50). Similarly, evidence from the post lesson interviews indicated that Holly did plan class discussions and develop scenarios to introduce new science investigations and that she became increasingly clear about how she should steer the discourse to reach specific learning outcomes for each lesson (KF 6.54).

Holly's classroom practice

At the start of the intervention, the students in Holly's class were expected to raise their hands when they wanted to speak and they sat in a pod shape facing Holly (KF 6.9). Following the first two professional learning days, Holly changed her practice when she introduced the Sharing Circle and the Thinking Thumb into her class discussions (KF 6.18). She thought that these strategies had facilitated the students' interactions because they listened to each other more and their responses had increased in quality as well as in length (KF 6.35). Holly continued to implement and develop the students' use of these speaking and listening conventions as the professional learning intervention progressed (KF 6.25; KF 6.37; KF 6.44). Mid-way through the intervention, Holly indicated that she was most successful in creating a classroom culture in which everyone shared and listened to each other's ideas (80%), spoke one at a time (80%), and respected each other's opinions (80%) and that, up to that point, she had been less successful at getting the students to give reasons to explain their ideas (70%) or to resolve their disagreements (70%) (KF 6.35).

Assertion 7.6

At the start of the intervention, Holly understood that a safe and supportive classroom environment facilitated student participation in discussion. She thought that every student should have the opportunity to share their ideas and give their views. As she engaged in the professional learning process, Holly began to believe that teachers need to also think about the way they manage classroom discourse in order to sustain a safe culture for talk.

At the midpoint of the intervention, she was able to identify the development of *collective*, *supportive*, and *reciprocal* characteristics of talk in her class discussions and later on she recognised the *cumulative* and *purposeful* aspects.

Holly developed a greater understanding of the speaking and listening conventions that are supportive of substantive talk and student participation in whole-class discussion and early on in the intervention she adjusted her practice to reflect this. She also came to understand how to support the students to use these conventions successfully.

Discussion about Theme 2

A supportive classroom environment for talk

As they participated in the professional learning intervention, the teachers' beliefs and understandings about developing a supportive classroom environment for talk were both reinforced and extended. Over the course of the intervention, each of the teachers maintained their beliefs and understandings about the importance of developing a safe and supportive classroom environment to facilitate substantive talk and students' participation in discussion (Assertion 7.4; Assertion 7.5; Assertion 7.6). In his review of the research, Alexander (2006) described a public and confident culture around talk as one where students both listened and expected to be listened to, and they felt confident that their mistakes would be viewed as a way into learning rather than a matter of shame or embarrassment. Similarly, the teachers in this study considered inclusivity was an important aspect of a supportive classroom environment and they thought their students should understand that everyone's ideas were worthy and that each class member had the right to contribute ideas to discussion without the fear of being told they were wrong (Assertion 7.4; Assertion 7.5; Assertion 7.6). As the intervention progressed, Penny and Holly also came to believe and/or understand the important role of the teacher in managing classroom discourse to sustain a safe culture for talk (Assertion 7.4; Assertion 7.6).

Self-efficacy for managing classroom climate

At the start of the intervention, each of the teachers believed that they were effective managers of classroom talk, particularly for establishing an appropriate classroom climate (Assertion 7.4; Assertion 7.5; Assertion 7.6) and Penny also believed she was effective in engaging most of the students in responding to questions (Assertion 7.4). However, both Penny and Holly indicated a slightly lower level of self-efficacy for these aspects later in the intervention (Assertion 7.4; Assertion 7.6). This adjustment may have come about as Penny and Holly developed their understandings of substantive talk and the sort of classroom climate required to sustain it (Assertion 7.4; Assertion 7.6).

Recognising characteristics of dialogic teaching

Alexander (2006) regards dialogic teaching as an important part of a repertoire of classroom talk and he considers it fundamental to facilitating students thinking and learning. Mid-way through the professional learning intervention, the teachers were invited to rate the extent to which they had been able to develop a classroom culture that was supportive of productive talk according to Alexander's (2006) five principles of dialogic teaching, that is: *collective*, *reciprocal*, *supportive*, *cumulative*, and *purposeful*. At that time, the teachers were able to easily identify the *collective* (when teachers and children address learning tasks together) and *reciprocal* aspects (when teachers and children listen to each other and share ideas) of classroom talk (Assertion 7.4; Assertion 7.5; Assertion 7.6), most probably because these aspects were characteristic of their teaching and discourse practices prior to the professional learning intervention. Ben and Holly were also able to easily identify the *supportive* aspect (when children articulate their ideas freely without fear of embarrassment) of classroom talk in their class discussions (Assertion 7.5; Assertion 7.6). However, at the midpoint of the intervention, Penny found this more difficult to recognise in her more challenging Year 6/7 class (Assertion 7.4).

Additionally, Ben readily identified the *cumulative* aspect (when teachers and children build on each other's ideas and chain them into lines of thinking) of classroom talk in his class discussions (Assertion 7.5), while both Penny and Holly were less able to recognise this in spite of the data showing that their students' talk was becoming

increasingly cumulative (Assertion 7.4; Assertion 7.6). Alexander (2008) found the *cumulative* aspect of dialogic teaching was more difficult for teachers to achieve because it is dependent on their subject knowledge as well as their knowledge of their students' understandings and learning needs. However, given that this data was collected mid-way through the intervention and there is evidence of cumulative talk in both classrooms, it is likely that Penny and Holly simply did not have a well-developed understanding of the *cumulative* aspect of dialogic teaching to be able to recognise it at that point in time.

Finally, each of the teachers found it more difficult to identify the *purposeful* aspect (when teachers plan and steer classroom talk with a specific outcome in view) of classroom talk in their practice at the midpoint of the intervention (Assertion 7.4; Assertion 7.5; Assertion 7.6). This aspect emphasises the need for teachers to plan whole-class discussions so that they have secure "conceptual map" of the lesson's subject matter to help guide the discussion so as to achieve the desired learning outcomes for any particular lesson (Alexander, 2006, p. 31). When working with teachers in the United Kingdom, Alexander (2008) also found the *purposeful* aspect of dialogic teaching was more difficult for teachers to achieve. However, while the teachers in this study did not initially recognise the *purposeful* aspect, the data showed that both Penny's and Holly's class discussions were increasingly purposeful (Assertion 7.4; Assertion 7.6). Once again, it is possible that Penny and Holly did not have a well-developed understanding of the *purposeful* aspect of dialogic teaching to be able to recognise it at that point of the intervention. Whereas a lesser focus on purposeful talk in Ben's classroom may well be explained by his more student-directed approach to teaching and learning, which might be considered better suited to the learning of his young students (Assertion 7.5). It is also possible that, at that midpoint of the professional learning intervention, Ben was working out how to strike the balance between the kinds of student-led learning experiences that he was accustomed to providing and the more intentional, adult-led approaches required for purposeful dialogic teaching. Intentional teaching (Epstein, 2007) fits between the extremes of student-led and adult-led approaches to learning, so that the instruction might be initiated from by the students' interests and questions but it is ultimately shaped via teacher-student interactions to reach predetermined learning outcomes. Given this, it becomes clear that incorporating a more teacher-led and purposeful approach to

teaching signified a considerable change for Ben, not only to his practice but also to his beliefs and knowledge about effective teaching and learning in the early years.

Speaking and listening conventions that support substantive talk

From the start of the professional learning intervention, Ben understood the importance of establishing speaking and listening conventions that are supportive of substantive talk (i.e. Sharing Circle, Thinking Thumb; sharing turns to speak, staying on topic, asking questions, finding a space in the discussion to talk, listening to one another) and student participation in whole-class discussion (Assertion 7.5). He also demonstrated that he had a good understanding of what these conventions were and how to support his students to use them (Assertion 7.5). Additionally, by the midpoint of the intervention, Ben was very confident that he had successfully established Mercer's (2008) five ground rules for effective talk in his class (i.e. we share our ideas and listen to one another; we talk one at a time; we respect each other's opinions; we give reasons to explain our ideas; and, if we disagree we try to ask "why").

Although Penny and Holly had clearly established speaking and listening conventions in their classrooms at the start of the intervention, they came to understand the importance of focusing on conventions that were more supportive of substantive talk and student participation (Assertion 7.4; Assertion 7.6). Consequently, when Holly adjusted the speaking and listening conventions used in her class (i.e. implementing the Sharing Circle and Thinking Thumb) and supported her students to use them in class discussions (Assertion 7.6), she showed that she had substantially increased her understandings about how to manage class discussions. In addition, at the midpoint of the intervention, Holly was confident that she had successfully established three of Mercer's (2008) ground rules for effective talk with her class (i.e. we share our ideas and listen to one another; we talk one at a time; and, we respect each other's opinions). Both Ben and Holly had commented that the Sharing Circle and Thinking Thumb strategies helped the students to participate and to stay focused on the topic of discussion. In his review of the research, Alexander (2006) also found that physical layout, student organisation, routines and rules for classroom talk set up a positive culture for talk and helped to focus students' attention and engagement. He found teachers were able to achieve the *collective*, *reciprocal* and *supportive* aspects of a

dialogic classroom quite quickly when they specified guidelines for classroom talk that their students could use and understand (Alexander, 2008).

While Penny did not alter the speaking and listening conventions used in her classroom (i.e. students sit facing the teacher, raise hands to speak), she did focus more explicitly on reinforcing their use and, as a result, she too increased her understandings about how to manage class discussions (Assertion 7.4). In addition, at the midpoint of the intervention, Penny was confident that she had successfully established three of Mercer's (2008) ground rules for effective talk with her class (i.e. we share our ideas and listen to one another; we talk one at a time; and, we respect each other's opinions).

Engle and Conant (2002) point out that in an environment which fosters productive disciplinary engagement, the students are accountable for their ideas and that they know how to disagree and how to respond to alternative points of view. Both Holly and, more particularly, Penny, found that they needed to spend more time establishing the final two of Mercer's (2008) ground rules for talk (i.e. we give reasons to explain our ideas; and, if we disagree we try to ask "why"). This suggests that developing explanations for their ideas and asking "why" if they disagreed with each other was less obvious in the culture for talk that existed in Penny's and Holly's classrooms at the midpoint of the intervention. These two ground rules may have been more difficult to achieve not only because it takes time to change the speaking and listening practices of a class and for the students to become accustomed to the processes of dialogic interaction, but also because explaining their ideas and asking "why" requires greater intellectual engagement on the part of the students. Furthermore, the research does show that the types of questions teachers ask dictates the quality of learning (Morgan & Saxton, 1991) and that teachers need to ask higher order questions (i.e. *open-explanation~reason* questions) that promote reasoning in order to elicit students' thinking and develop their capacity to reason (Koufetta-Menicou & Scaife, 2000; Erdogan & Campbell, 2008). Consequently, Penny and Holly may not have been able to establish the final two of Mercer's (2008) ground rules for talk simply because they were still developing their capacity to manage classroom discussions and to use questioning and discourse moves to elicit the students' deeper thinking.

General Assertion 2

The teachers reinforced their beliefs and understandings that a safe, supportive and inclusive classroom environment facilitates substantive talk and students' participation in discussion. They gained a deeper understanding of substantive talk and of the complex role of the teacher in managing classroom discourse to sustain a culture for talk. The teachers' capacity to recognise the characteristics of effective dialogic teaching (*collective*, *reciprocal, supportive cumulative* and *purposeful*) in their class discussions was dependent on their understanding of those aspects and some aspects of dialogic teaching proved harder for teachers to achieve when they had to make significant changes to their beliefs and knowledge.

The teachers developed a greater understanding of the speaking and listening conventions that are supportive of substantive talk and how to support their students to use them and to be accountable for their use during class discussions. Some of Mercer's (2008) ground rules for talk were harder to establish (giving reasons to explain ideas; and, asking 'why' when disagreeing) than others (sharing ideas, listening to each another; taking turns to talk; and, respecting each other's opinions) because they took time, they required a degree of familiarity with dialogic interaction as well as greater intellectual engagement on the part of the students, and they required an increased capacity to ask questions that elicit students' deeper thinking on the part of the teacher.

The teachers' capacity to achieve change in the students' use of speaking and listening conventions and to develop a classroom culture that was supportive of dialogic teaching and interaction was either facilitated or constrained by their classroom context and/or by the broader school context in which they worked.

Theme 3: Teachers' beliefs, knowledge and practices to do with the use of questioning and teacher discourse moves, and adjusting their communicative approach

In this section, a summary of each teacher's beliefs, knowledge and classroom practice to do with the use of questioning and teacher discourse moves and adjusting their communicative approach is presented and assertions are developed. The subsequent discussion highlights the similarities and differences between the teachers' beliefs, knowledge and practice and how this changed as the professional learning intervention progressed. Finally, a general assertion is presented that captures the development of the teachers' beliefs, knowledge and practice to do with the use of questioning and teacher discourse moves and adjusting their communicative approach.

Penny's beliefs and knowledge

Initially, Penny did not articulate any particular beliefs about the use of teacher questioning and discourse moves or communicative approaches in whole-class discussion. However, as the professional learning intervention progressed she began to believe that opportunities for planned and purposeful class discussions and the teacher's skilful use of questioning were important characteristics of effective science teaching practice (KF 4.45).

From the outset, Penny maintained that teachers needed to know how to use questioning to engage students in discussion, to ascertain their understandings and misconceptions in the beginning phases of inquiry and to find out what they had learned in the later phases (KF 4.7). At the end of the intervention, she reinforced these ideas when she reported that she had been able to vary her use of questioning and discourse moves in discussions to suit the instructional focus of Engage and Explain lessons (KF 4.48).

At the start of the intervention, Penny believed that she was an effective manager of class discussions particularly for using *wait time*, encouraging and supporting students to ask questions, engaging most students, and using questioning to identify students' prior knowledge and initial science understandings (KF 4.6). While she retained this belief, she indicated a slightly lower level of self-efficacy later in the intervention for asking open and closed questions to suit the purpose of discussion; responding to students in ways that support the effective discussion of ideas; drawing on her rich knowledge of science to ask the right questions; and being able to sustain discussions in order to thoroughly discuss science ideas (KF 4.47).

Assertion 7.7

At the start of the learning intervention, Penny understood that teachers needed to know how to use questioning to engage students in discussion and to find out what they know. As she participated in the professional learning process, she began to believe that opportunities for planned and purposeful class discussions and the teacher's skilful use of questioning were important aspects of effective science teaching.

Penny also developed a greater understanding about how to differentiate teacher questioning and discourse moves to suit the instructional focus of Engage and Explain lessons.

While Penny retained her belief that she was an effective manager of classroom talk, she adjusted this perception as she developed a deeper understanding of the complexities of managing and developing substantive whole-class discussions.

Penny's classroom practice

As she participated in the intervention, Penny developed both her understandings about how to manage classroom discourse as well as her capacity to do this effectively in class discussions. In the first Engage lesson (Lesson 1), Penny's interaction with the students alternated between substantive talk as she elicited their ideas and procedural talk as they wrote their ideas on the IWB (KF 4.11). While she did ask a few *open-idea*s questions (KF 4.10), she mostly used a limited range of teacher discourse moves (*teacher restate* and/or *evaluate*), which resulted in short teacher-student exchanges (T-S-T). Sometimes she also used *elaborate* or *clarify*, which extended the teacher-student interaction slightly (T-S → T-S) (KF 4.11). In the last Engage lesson (Lesson 4), Penny asked a greater number of *open-ideas* and *open-description* questions (KF 4.11) and began to use a greater range of teacher discourse moves to support the students to express their ideas clearly and to use appropriate terminology (KF 4.19). She frequently used the teacher discourse moves *teacher restate* or *clarify* to repeat and/or clarify a student's idea so that the class could hear it again, and she often used *evaluate* when she praised a student's response before moving on to ask for other ideas (KF 4.19). Penny would also work on or explore a student's idea by asking further questions and using teacher discourse moves such as *teacher uptake*, *wait time, extended thinking time, prompt and scaffold*, and *reframe* to help them to articulate or develop their idea (KF 4.19; KF 4.35). Periodically, she used *refocus* to summarise the students' ideas and this helped them to develop more cumulative talk (Alexander, 2006) (KF 4.35). Utilising teacher discourse moves in this way generated teacher-student

interactions that ranged from three-turn structures (T-S-T) to progressively longer interactions involving four-turn (T-S →T-S) and six-turn structures (T-S →T-S →T-S →T-S →T-S) and, ultimately, some longer stretches of cumulative talk (KF 4.19; KF 4.35).

As the professional learning intervention proceeded, Penny also demonstrated a deeper understanding of how to adjust her communicative approach during class discussions (KF 4.48). She used an Interactive-Dialogic style in Explain lessons when she helped the students to review their observations and to articulate their ideas for future investigations. Then she shifted her approach to a more Interactive-Authoritative style as she led the students to develop explanations and reasons for their results (KF 4.28; KF 4.42). Penny became increasingly adept at using teacher questioning and discourse moves to help the students interpret her focus questions and to develop explanations and reasoning. She would help students to interpret an *open-explanation~reason* question by initially asking *open-description* and *closed* questions and using teacher discourse moves such as *prompt and scaffold, extended thinking time, wait time,* and *refocus* to shape their response (KF 4.26; KF 4.27). Penny also used the teacher discourse moves *clarify*, *prompt and scaffold*, *wait time* and *teacher uptake* to support the students to articulate their ideas (KF 4.26; KF 4.41) and she used *teacher uptake, teacher restate, evaluate, refocus, prompt and scaffold, reframe* to reinforce particular ideas and make key ideas explicit (KF 4.26; KF 4.41). Additionally, she frequently used *wait time* and *extended thinking time* in Explain lessons (Lessons 3 and 5) in order to give the students some time to think (KF 4.26; KF 4.27; KF 4.41). By consistently working the discourse in this way, the teacher-student interactions in Explain lessons increased from three-turn structures (T-S-T) to more four- (T-S →T-S) and six-turn structures (T-S →T-S →T-S) and some that were longer (KF 4.26; KF 4.27; KF 4.42). In addition, the talk became progressively cumulative (KF 4.23; KF 4.30; KF 4.38; KF 4.42; KF 4.48).

Penny's students

At the beginning of the professional learning intervention, the students' responses in whole-class discussions were typically quite short (KF 4.16) but over time they progressively developed more elaborated responses and generated more cumulative

talk (Alexander, 2006) (KF 4.23; KF 4.30; KF 4.38: KF 4.44). Additionally, the quality of their responses in Explain lessons increased over the course of the intervention as Penny supported the students to give more complex descriptions, explanations and reasons (KF 4.30; KF 4.44).

Assertion 7.8

Penny developed her understandings about how to differentiate the management of classroom discourse in Engage and Explain lessons and this was evident in her practice.

In Engage lessons, Penny utilised an Interactive-Dialogic communicative approach and she began to ask an increased range of *open-ideas* and *open-description* questions and to use a greater range of teacher discourse moves to: support the students to express their ideas clearly and to use appropriate terminology; work on and explore the students' ideas; support the students to develop their ideas; and to summarise the students' ideas.

In Explain lessons, Penny became more adept at adjusting her communicative approach from an Interactive-Dialogic style, when the students reviewed their findings and considered ideas for future investigations, to a more Interactive-Authoritative style, when she led the students to develop explanations and reasons for their results. She learned to help the students interpret *open-explanation~reason* questions by initially asking *open-description* and *closed* questions and using teacher discourse moves to shape their response. She also learned to use an increased range of teacher discourse moves to: support the students to articulate their ideas; reinforce particular ideas; make key ideas explicit; and give students time to think.

As Penny adjusted her practice, her students' contributions to discussion became increasingly elaborated and progressively cumulative and they gave more complex descriptions, explanations and reasons.

Ben's beliefs and knowledge

Throughout the professional learning intervention, Ben maintained his belief that discussion was an effective tool for science teaching (KF 5.4; KF 5.44) and that students accessed knowledge via social interaction (KF 5.4; KF 5.7; KF 5.47). He believed discussion that was facilitated by the teacher and that incorporated quality questioning was a valuable tool for examining students' ideas in order to find out what they know and what they need to know next (KF 5.4; KF 5.44). Additionally, as he participated in the professional learning process, Ben strengthened his belief that he managed class discussions effectively (KF 5.6; KF 5.46).

At the start of the intervention, Ben stated that he thought teachers should know something about how to manage class discussions. He thought they needed to know how to listen to students and how to give them time to think, and how to reword a question in order to get them to say more (KF 5.7). At the midpoint of the intervention, he reported that he had focused on using *wait time* to give the students a chance to think, and on asking the students to elaborate on their ideas (KF 5.30).

Over the course of the intervention, Ben increased his understanding about how to adjust his communicative approach during discussions in different phases of an investigation. Early on, he was unsure whether he varied his communicative approach to match the instructional purpose or phases of inquiry (KF 5.6) but he thought he varied his style of interaction by asking open-ended questions at the beginning of an investigation and then asking more focused questions to direct the learning as the investigation continued (KF 5.7). Later in the intervention, Ben came to believe that identifying the phase of inquiry was an important characteristic of inquiry-based science teaching and learning (KF 5.44). Ben also believed that as an effective manager of classroom talk he was able to adjust his communicative approach to match the instructional purpose of the phases of inquiry (KF 5.46). He stated that he had varied his communicative approach by: asking for more information from the students; exploring their ideas more thoroughly; seeking explanations in the early phases of an investigation; and, being more "directional" by asking more guiding questions during the later phases (KF 5.47).

Assertion 7.9

From the outset, Ben had a developed understanding of how to manage many aspects of whole-class discussions. He reinforced his beliefs and understandings regarding: the social construction of knowledge; the use of discussion as a tool for science teaching; and the use of effective questioning techniques to explore students' ideas. In addition, Ben believed that he became a more effective manager of class discussions.

As he participated in the intervention, Ben began to believe that it was important to adjust his communicative approach to match the instructional purpose of different phases of an investigation and he increased his understandings about how to utilise a more authoritative approach in discussions in the later phases.

Ben's classroom practice

From the early stages of the professional learning intervention, Ben demonstrated a developed understanding of how to utilise an Interactive-Dialogic communicative approach during Engage lessons. He was adept at orchestrating teacher questioning and discourse moves to encourage the students' participation and to elicit their ideas and questions about the investigation. Ben asked *open-ideas* and some *open-explanation~reason* questions to elicit and explore the students' ideas (KF 5.10; KF 5.18; KF 5.33) and then he worked on their responses using a range of teacher discourse moves. He often used *teacher restate* and *clarify* to ensure he understood what the students had to say (KF 5.11; KF 5.19; KF 5.34), and he asked further questions and used *teacher uptake*, *clarify,* and *elaborate* when he wanted to explore their ideas (KF 5.11; KF 5.19; KF 5.34). Ben also used *wait time* after he had asked a question in order to give a student time to think (KF 5.11; KF 5.19; KF 5.34). This form of *wait time*, the pause after a teacher utterance, was referred to by Rowe (1972) as *Wait Time 1*. Ben used *reframe* to rephrase the students' ideas (KF 5.11; KF 5.19; KF 5.34) and *reframe scientifically* to model appropriate scientific language (KF 5.11; KF 5.34). He also used *refocus* as a way to gather the groups' collective thoughts and to summarise the students' ideas at the end of the discussion (KF 5.19; KF 5.34). Ben orchestrated the flow of the discussion by asking *directed questions* and using *acknowledge only* to accept an idea without exploring it or *moves on* to initiate a new phase of discussion (KF 5.11; KF 5.19; KF 5.34). Working the discourse in this way generated many teacher-student interactions comprising three- (T-S-T) and four-turn structures (T-S →T-S), as well as some six- (T-S →T-S →T-S) and eight-turn structures (T-S →T-S →T-S→T-S) (KF 5.11; KF 5.19; KF 5.34). When Ben explored a student's idea by asking probing questions even longer teacher-student interactions were generated (KF 5.11; KF 5.19).

As he participated in the professional learning process, Ben became more explicit in the way that he talked about the scientific ideas in Explain lessons (KF 5.27; KF 5.41). In the initial Explain lesson (Lesson 3), he utilised an Interactive-Dialogic approach which was very similar to the style of interaction seen in the previous Engage lessons (KF 5.26). He asked some *open-description* questions to elicit the students' observations, a combination of *open-ideas* and *open-explanation~reason* questions to work on their explanations, and *closed* questions to clarify their ideas and to shape the

discussion (KF 5.25). He used similar teacher discourse moves to those used in previous lessons, specifically: *teacher restate*, *clarify*, and *wait time* to support the students to think about and articulate their ideas; *teacher uptake,* and *reframe* to develop their explanations; *refocus* to draw together or summarise the students' ideas; *evaluate* to endorse particular ideas; and *directed questions*, *ignore* and *acknowledge only* to manage the interaction (KF 5.26). However, in this initial Explain lesson, his communicative approach became only slightly more authoritative when he endorsed some of the students' ideas (KF 5.27).

In the later Explain lesson (Lesson 5), Ben started by using an Interactive-Dialogic communicative approach but there was a noticeable shift to a more Interactive-Authoritative style when he wanted to make key ideas explicit or to support the students to develop explanations (KF 5.41). When Ben wanted to elicit the students' experiences and observations he utilised an Interactive-Dialogic approach (KF 5.41) where he asked *open-description* and *open-ideas* questions and used teacher discourse moves such as *teacher restate, clarify,* and *elaborate* to help the students articulate their ideas (KF 5.39; KF 5.40). Ben's approach became more Interactive-Authoritative (KF 5.41) when he wanted to make the science ideas explicit. He asked more *open-explanation~reason* and *closed* questions and used teacher discourse moves such as *teacher uptake, prompt and scaffold* to develop the students' explanations; *evaluate, reframe,* and *refocus* to endorse particular ideas and summarise the students' thinking; and *directed questions*, *ignore* and *acknowledge only* to orchestrate the interaction (KF 5.39; KF 5.40).

Ben's students

From early on in the professional learning intervention, the students in Ben's class consistently participated in quite lengthy interactions during discussions, often giving elaborated responses (KF 5.16; KF 5.23; KF 5.29: KF 5.37; KF 5.43) and generating cumulative talk (Alexander, 2006) by building on each other's ideas (KF 5.23; KF 5.29: KF 5.37; KF 5.43). The quality of the students' responses remained consistently high as they gave simple and complex descriptions and explanations in the Engage and the Explain lessons (KF 5.16; KF 5.29: KF 5.37; KF 5.43).

Assertion 7.10

Ben was accustomed to using an Interactive-Dialogic communicative approach in discussion and at the start of the intervention he did not adjust this in Explain lessons. His Interactive-Dialogic approach aligned well with the purposes of the lessons in the Engage phase, where he asked *open-ideas* and some *open-explanation~reason* questions and used a range of teacher discourse moves to: clarify and explore the students' ideas; give students time to think; rephrase the students' ideas; model appropriate scientific language; summarise the students' ideas; and orchestrate the flow of the discussion.

As Ben participated in the professional learning intervention, he demonstrated an increased understanding of how to adjust his communicative approach so that scientific ideas were made explicit. In the final Explain lesson, he utilised an Interactive-Dialogic approach to elicit the students' observations where he asked *open-description* and *open-ideas* questions and used teacher discourse moves to help the students articulate their ideas. He then utilised a more Interactive-Authoritative approach where he asked *open-explanation~reason* and *closed* questions and used teacher discourse moves to: develop the students' explanations; endorse particular ideas; summarise the students' thinking; and to orchestrate the interaction.

Over the course of the learning intervention, the students' contributions to discussion remained of a consistently good quality, their responses were often elaborated and they were able to generate cumulative talk and to consistently provide simple and complex descriptions and explanations.

Holly's beliefs and knowledge

As she participated in the professional learning process, Holly's beliefs and understandings about the role of discourse in science teaching began to expand. At the start of the intervention, she believed that teacher questioning and class discussions supported students to share their thinking and to develop a common set of ideas (KF 6.4). Subsequently, she developed a greater understanding of the role of the teacher in substantive discussions and she came to believe that teachers could help students to make sense of their ideas via discussion and that extended conversations were essential to effective science teaching (KF 6.51).

At the beginning of the intervention, Holly thought that teachers should be encouraging and accepting of students' responses to their questions (KF 6.7) and she seemed to focus on ensuring all the students had their say, which resulted in a (teacher-nominated) *turn taking* style of interaction (KF 6.11; KF 6.20). Mid-way through the intervention, after she was given the opportunity to view her teaching practice, Holly observed how *turn taking* limited the students' ability to elaborate on their ideas in

discussion and she came to understand that they should be given the chance to give extended answers and that a teacher's responses should provide students with feedback (IRFRF) (Mortimer & Scott, 2003) (KF 6.35). Consequently, early on in the intervention, Holly decided she needed to develop a more interactive form of discourse by asking questions that allowed the students to elaborate on their ideas (KF 6.35). Ultimately, Holly thought that she had developed her use of teacher discourse moves by giving the students the opportunity to give "extended answers", using strategies that gave them time to think, and providing feedback rather than evaluative responses (KF 6.54). More generally, she thought that her class discussions retained their focus because they were planned and purposeful, and that her use of questioning and management of discussions had improved because she knew how to guide the talk and she knew which questions would elicit key ideas (KF 6.54).

Throughout the professional learning intervention, Holly consistently articulated the belief that teachers should use *wait time* during discussions as she felt this gave the students' time to think and encouraged their participation (KF 6.7; KF 6.35; KF 6.54). While Holly thought she had used *wait time*, there was no evidence in the video footage of what Rowe (1972) referred as to *Wait Time 1* (the pause after a teacher utterance) or *Wait Time 2* (the pause after a student utterance) (KF 6.14; KF 6.21; KF 6.31; KF 6.40; KF 6.47). However, from the midpoint of the intervention, Holly increasingly used Thinking Time which the class came to recognise as a legitimate 'pause and think' strategy and was considered a form of *wait time* (coded as *extended thinking time*) in this study (KF 6.27; KF 6.31; KF 6.47).

At the start of the intervention, Holly believed that she was an effective manager of class discussions, however, she felt less confident that she could respond to students' answers in ways that maintained and promoted further discussion of science ideas (KF 6.6). Later in the intervention, Holly retained her belief that she was an effective manager of class discussions and her self-efficacy for responding to students' answers in ways that maintain and promote further discussion of science ideas had increased (KF 6.53). However, she also indicated a slightly lower level of self-efficacy for establishing an appropriate classroom climate and for using *wait time*. This may indicate that she had come to understand the complexities involved in developing an

environment that is supportive of substantive talk and the challenges related to adjusting her discourse practice (KF 6.53).

From the outset, Holly also thought that teacher questioning should be differentiated to correspond with each phase of the inquiry process (KF 6.7). Later on she elaborated on this idea, stating that in the Engage and Explore phases the communicative approach should be Interactive-Dialogic where teachers asked open-ended questions and that in the Explain phase teachers needed to adjust their questioning to probe students' ideas and to ask closed questions so as to highlight scientific ideas (KF 6.54). As the intervention progressed, Holly also came to believe that teachers should adjust the communicative approach they used in discussion according to the phase of the investigation (KF 6.51).

Assertion 7.11

As Holly engaged in the professional learning process, she developed a greater understanding of the role of the teacher in building substantive discussions and she came to believe that teachers could help students to make sense of their ideas via discussion and that extended conversations were essential to effective science teaching.

Holly also came to understand the impact a teacher has on their students' contributions to discussion and the need for teachers to make room for students to participate and to make more elaborated contributions.

Holly developed her understanding of how to use teacher questioning and discourse moves to develop the students' use of discourse and to manage discussions. She consistently stated that teachers should use *wait time* to give students the time to think and she used Thinking Time in her practice. However, she did not seem to understand *Wait Time 1* and *2* or use this in her practice.

While Holly retained her belief that she was an effective manager of classroom talk, she revised her perception of this as she came to understand the complexities involved in constructing a classroom environment that is supportive of substantive discussion and the challenges related to adjusting her practice.

As she participated in the professional learning process, Holly deepened her belief and demonstrated an increased understanding about how teachers should adjust their use of questioning and teacher discourse moves so as to match their communicative approach to each phase of inquiry.

Holly's classroom practice

Over the course of the learning intervention, Holly developed a deeper understanding about how to use teacher questioning and discourse moves to develop an Interactive-Dialogic style of interaction in Engage lessons (KF 6.15; KF 6.22; KF 6.41) so as to capture the students' interest in the topic and to elicit their existing ideas. In the early stage of the intervention (Lesson 1), Holly asked a large number of *open-ideas* questions and some *open-description* questions, which were appropriate to the Engage phase (KF 6.10). However, as previously stated, she also utilised a *turn taking* pattern of interaction (Initiation-Response-Restate or I-R-R) whereby she continually used the teacher discourse move *teacher restate* to repeat each student's response and then, without further interaction, she moved on to ask other students for their ideas (KF 6.11; KF 6.20). By managing the discourse in this way, Holly effectively shut down the interaction, thus limiting not only the kinds of responses that the students could give but also the quality of their contributions (KF 6.17). However, Holly asked a greater range of questions as the intervention progressed, including *open-ideas*, *open-description* and open-*explanation~reason* questions (KF 6.19; KF 6.38), and she began to utilise an increased number of teacher discourse moves to elicit the students' ideas and make them explicit. When she wanted to probe a student's ideas she used teacher discourse moves such as *directed question*, *teacher restate*, *teacher uptake*, *reframe*, and *evaluate* (KF 6.21) and she used simple teacher discourse moves such as *clarify* and *teacher uptake* to build on the interaction (KF 6.39). When Holly needed to maintain her line of questioning she used *acknowledge only*, *recast the question,* and *asks for other ideas*. If she wanted to maximise her interactions with the students she used *elaborate, teacher restate, teacher uptake* to get them to say more and she moved on to seek other ideas when she felt the exchange was no longer productive (KF 6.40). By working the discussion in this way, Holly was able to sustain quite long and productive chains of teacher-student interaction (KF 6.21; KF 6.46; KF 6.47) and the quality of the students contributions increased (KF 6.24; KF 6.34; KF 6.43; KF 6.50).

In Explain lessons, Holly progressively became more adept at using teacher questioning and discourse moves to explain the science phenomenon that was the focus of the investigation (KF 6.26; KF 6.45). She did this by first reviewing what the students had learned during the Engage and Explore phases that might help to resolve the problem (KF 6.27; KF 6.46), and then by exploring the students' understandings in

more depth so as to make the scientific ideas explicit (KF 6.30; KF 6.47). In the first part of the discussion, when she wanted to review what the students had learned, Holly used an Interactive-Dialogic approach (KF 6.32; 6.48) where she asked *open-ideas* questions (KF 6.26; KF 6.45) and used teacher discourse moves such as *teacher restate*, *clarify*, *teacher uptake*, *extended thinking time*, *checks for consensus*, *evaluate*, and *refocus* to develop and maximise the interaction with individual students and to help them to link their ideas to the problem (KF 6.27; KF 6.46).

In the latter part of the discussion, when she wanted to probe the students' understandings and to make the scientific ideas explicit, Holly used a more Interactive-Authoritative approach (KF 6.29; KF 6.30; KF 6.32; KF 6.48). She asked more *open-description* and *open-explanation~reason* questions (KF 6.26; KF 6.45) and used a complex range of teacher discourse moves to work on the students' ideas, rephrasing some and endorsing others, so that the correct scientific ideas were heard. More particularly, Holly used: *clarify*, *reframe, refocus* to reshape students' ideas; *elaborate*, *teacher restates*, *clarifies*, *teacher uptake*, *evaluate*, *reframe*, *prompt and scaffold*, and *reframe scientifically* to explain and reinforce key understandings; and, *refocus* to summarise the discussion (KF 6.29; KF 6.30; KF 6.31 KF 6.32; KF 6.47). By orchestrating the discussion in this way, Holly developed and sustained long and productive chains of teacher-student interaction in both parts of the discussion.

Holly's students

The students' participation in class discussions and the quality of their contributions changed quite markedly over the course of the intervention. The very short, simple responses that were typical of their contributions in the initial lesson (KF 6.17) changed very quickly in subsequent lessons to become increasingly more elaborated responses that built on the ideas of others, generating cumulative talk (Alexander, 2006) (KF 6.24; KF 6.34; KF 6.43; KF 6.50). Similarly, the quality of the students' responses changed over the course of the intervention and they progressively gave more complex descriptions, explanations and reasons (KF 6.17; KF 6.24; KF 6.34; KF 6.43; KF 6.50).

Assertion 7.12

Holly's management of class discussion became increasingly sophisticated as she aligned her use of teacher questioning and discourse moves with the purposes of the Engage and Explain lessons.

In Engage lessons, she utilised an Interactive-Dialogic communicative approach when she asked an increased range of *open-ideas*, *open-description* and *open-explanation~reason* questions and employed a more complex set of teacher discourse moves to: probe the student's ideas; build on the interaction; maintain her line of questioning; maximise the interaction; and close off the interaction when it was no longer productive. This is in stark contrast to the way that she managed the discussion in the initial Engage lesson where she utilised a (teacher-nominated) *turn taking* pattern of interaction which limited the quality of the talk.

In Explain lessons, Holly learned to use an Interactive-Dialogic communicative approach to review the students' findings and she asked *open-ideas* questions and used a range of teacher discourse moves to maximise the interaction and help the students to link their ideas to the problem. Then, she adopted a more authoritative approach in order to probe the students' understandings and ensure the scientific ideas were made explicit. She asked a greater number of *open-description* and *open-explanation~reason* questions and used teacher discourse moves to: reshape and draw together the students' ideas; explain and reinforce key understandings; and summarise the discussion.

As Holly adjusted her practice, the students' contributions to discussion became increasingly more elaborated and cumulative, and they progressively gave more complex descriptions, explanations and reasons.

Discussion about Theme 3

The role of discourse in science teaching

The teachers' beliefs and understandings about the role of discourse in science teaching were either reinforced or expanded as they participated in the professional learning intervention (Assertion 7.7; Assertion 7.9; Assertion 7.11). At the start of the intervention, the teachers believed that discussion was an effective tool for science teaching, particularly for fostering students' participation, sharing ideas, and ascertaining what students know (Assertion 7.7; Assertion 7.9; Assertion 7.11). Thinking about discussion in this way gives emphasis to the inclusive and democratic aspects of classroom talk. Such an emphasis was clearly evident in Holly's initial Engage lesson (Lesson 1) when she focused on ensuring all the students had their say and a (teacher-nominated) *turn taking* style of interaction developed. The *turn taking* pattern of interaction was comprised of Initiation-Response-Restate (I-R-R), where the teacher asked a question (Initiation), listened to a student's answer (Response), and

restated (Restate) their response. While the I-R-R response looks similar to other three-turn structures such as the I-R-E (Mehan, 1979) and the I-R-F (Sinclair & Coulthard, 1975) described in the research, it is in fact less productive. The I-R-E (Initiation-Response-Evaluate) pattern of interaction identified by Mehan (1979) represents a teacher-student exchange where the teacher asks a question (Initiation), listens to a student's answer (Response), and assesses the correctness of the response (Evaluate). While this is not conducive to exploring and developing students' ideas it does provide some limited form of feedback to the students. A more productive three-turn structure, described by Sinclair and Coulthard (1975), is the I-R-F (Initiation-Response-Feedback) pattern of interaction. In this exchange the teacher asks a question (Initiation), listens to a student's answer (Response), and provides constructive feedback (Feedback) to the student. However, the *turn taking* or I-R-R pattern of interaction seen in Holly's first discussion produced short teacher-student exchanges, where the students gave very short, simple responses and Holly simply restated their response before moving on. While this form of interaction served to quickly elicit many of the students' ideas, it did not provide them with any feedback and, like most triadic dialogue (Lemke, 1990), served to shut down the interaction and the chance for the students to talk through their ideas. Lemke (1990) maintains that teachers miss an opportunity to gauge students' real understandings or misunderstandings about a topic when the students are not given the chance to talk through their ideas. However, given the opportunity to view her lesson as well as other examples of effective practice, Holly quickly changed the way that she interacted with her students. Thus, while it is important for teachers to foster the inclusive and democratic aspects of classroom talk, it is also important that they recognise what substantive conversation is, what the benefits are for their students, and how they can achieve this in their practice.

From the outset of the learning intervention, Ben believed that teachers can guide discussions and explore students' ideas and understandings by using skilful questioning to find out what they know and what they need to know next (KF 5.4; KF 5.44). Considering discussion in this light places a greater emphasis on using classroom talk as a tool for deeper thinking and on the role of the teacher in developing and sustaining 'talking for thinking'. Although Holly believed and Penny understood that teacher questioning and class discussions were important in fostering students' participation, ascertaining their understandings, and supporting them to share their

thinking (Assertion 7.7; Assertion 7.11), it was not until later in the intervention that they really came to believe and understand the role of the teacher in planning discussions and using questioning to guide and develop substantive talk. In the mid and later parts of the intervention, Penny's and Holly's increased beliefs and understandings about the teacher's role in developing substantive talk and the intentional use of talk as a tool for teaching and learning were matched by their more skilful management of discussions and by an increase in both the level of participation and the quality of their students' contribution to discussion (Assertion 7.8; Assertion 7.12). This outcome reinforces existing research which highlights how teacher beliefs about teaching and learning affect their likeliness to enhance student learning (Levitt, 2001). What is more, teachers' beliefs are enacted in their classroom practice (Pajares, 1992; Peterman, 1993; Tobin, 1993) and the decisions teachers make in their practice are dependent on their beliefs (Brickhouse, 1990; Pajares, 1992; Pomeroy, 1993).

Self-efficacy for managing class discussions

At the start of the professional learning intervention, each of the teachers believed that they were effective managers of class discussions (Assertion 7.7; Assertion 7.9; Assertion 7.11). As they participated in the intervention, Ben reinforced this belief while Penny and Holly came to believe that they were slightly less effective as managers of class discussions (Assertion 7.7; Assertion 7.9; Assertion 7.11). Once again, it seems that when Penny and Holly were given the chance to view and reflect on the video footage of their own and other teachers' class discussions, they began to understand the complexities involved in managing substantive discussions and the challenges related to changing their practice. This resulted in them revising their beliefs about the effectiveness of their own practice (Assertion 7.7; Assertion 7.11).

Matching the communicative approach to the phase of inquiry

Over the course of the professional learning intervention, each of the teachers generally increased their beliefs and knowledge about matching their communicative approach to different phases of inquiry. Mortimer and Scott (2003) argue that students internalise the science ideas and science language articulated on the social plane of the classroom via a process of appropriation, and that by working through the different phases of an investigation teachers can provide opportunities for students to articulate

their everyday understandings about science phenomenon and to work through a range of experiences to develop those understandings. Thus, Mortimer and Scott (2003) maintain that it is important for teachers to be able to adjust their communicative approach from the Engage and Explore phases, when they may have used an Interactive-Dialogic approach to elicit the students' ideas and observations, to a more authoritative one in the Explain phase when they need to develop the scientific view.

At the start of the intervention, Penny did not articulate any particular beliefs about the need for teachers to adjust their communicative approach according to the phase of inquiry (Assertion 7.7). However, later on she demonstrated an increased understanding of how to vary her use of questioning and discourse moves in discussions to suit the instructional focus of Engage and Explain lessons (Assertion 7.7). Similarly, while Holly initially stated that it was important for teachers to adjust their questioning to suit the phase of the inquiry, she developed an increased belief and articulated a clearer understanding of how teachers do this (Assertion 7.11) as she participated in the professional learning process. Ben, on the other hand, initially understood how to adjust his questioning technique to initiate and to focus the learning over the course of an investigation but was unsure that he varied his communicative approach to match the phases of inquiry (Assertion 7.9). As the intervention progressed, Ben came to believe that it was important to adjust his communicative approach to suit the instructional purpose of a lesson and he increased his understandings of how to use a more authoritative approach in the later phases of inquiry (Assertion 7.9).

It would seem that the teachers had very little difficulty in maintaining an Interactive-Dialogic approach during the discussions in Engage lessons as this style of interaction is probably quite similar to the communicative approach they would normally have used in class discussions. The more complex adjustment to the teachers' communicative approach was required in the Explain lesson after they had led the students to review their ideas and observations from their experiments in the Engage and Explore phases. At this turning point in the discussion (Mortimer & Scott, 2003; Scott & Amteller, 2007; Scott, et al., 2007; Scott, et al., 2006), the teachers needed to guide the students to develop explanations about the scientific phenomenon under investigation and to do this they needed to draw on a more authoritative approach to highlight certain ideas

and to downplay or 'close off' others (Scott & Amteller, 2007) so that the scientific ideas were progressively made more explicit. In this instance, it seems that Penny and Holly were most able to achieve an Interactive-Authoritative shift in their communicative approach in the Explain lessons, perhaps because this was already a part of their interactive repertoire and they were accustomed to working with the discrete phases of the 5Es model of inquiry (Hackling et al., 2007).

However, Ben initially found this shift in communicative approach more difficult to achieve and there may have been several factors associated with teacher belief and knowledge that contributed to this. Ben may not have perceived there was a reason to change his practice given his students participated in whole-class discussions effectively and the quality of their talk was good (Assertion 7.10). Also, such a change to his practice might well have necessitated that his class discussions were more deliberately planned and intentional (Epstein, 2007), so that they were guided by a series of questions that would lead the talk to a specific outcome. Given that Ben did not use the 5Es model (Hackling et al., 2007), preferring instead to let the students' investigations develop from their evolving questions and explanations, this may have been too much of a cultural shift for him to make in the first instance. Additionally, he may not have adjusted his communicative approach in the initial Explain lesson because he was not familiar with the discrete phases of inquiry (KF 5.1). It is also possible that in the early stages of the intervention, Ben may have lacked the domain specific knowledge (Alexander, 2006; Scott et al., 2007) required to resolve the range of students' ideas and to focus the discussion on the validated science idea. However, after further opportunities to view and reflect on his own and other teachers' practice and to interact with colleagues involved in the professional learning intervention, Ben did utilise a more Interactive-Authoritative communicative approach in the final Explain lesson (Lesson 5) (Assertion 7.10).

General Assertion 3

The teachers shared a common set of beliefs that discussion was an effective tool for science teaching, particularly for fostering students' participation, sharing ideas, and ascertaining what students know. Some of the teachers increased their beliefs and understandings about the teacher's role in planning discussions, using questioning to guide and develop substantive talk, and the intentional use of talk as a tool for teaching and learning.

Each of the teachers demonstrated an increased belief and understanding about the importance of adjusting their questioning and discourse moves to suit the instructional focus of Engage and Explain lessons. One of the teachers, who was accustomed to using an explorative teaching approach and did not see the need to vary his communicative approach, did not adjust his beliefs until after he had developed his understandings of the instructional purpose of each phase of inquiry.

Planning class discussions

A key feature of the professional learning intervention was that the teachers were given the opportunity to collaborate in planning how they would use whole-class discussions to introduce and develop new topics of investigation. Thus, the teachers had to develop a scenario to introduce the topic in the Engage phase that presented a problem for the students to solve, and they had to script a series of questions that would guide the initial discussion about the topic. Engle and Conant, (2002) believe that problematising the learning like this facilitates students productive disciplinary engagement by encouraging students to: engage in the learning; ask questions; propose ideas; and challenge each other's ideas. The teachers involved in the professional learning intervention also had to plan the discussion for the Explain phase of the investigation so that their questions led students to develop explanations for their ideas and findings from the Engage and Explore phases. Developing a series of lessons so that the learning is 'stretched-out-in-time' (Scott, et al., 2007), permits teachers to explore the students' everyday views about science phenomenon and to provide subsequent learning experiences that allow the students to continue to investigate new concepts and to talk through their developing ideas. Erdogan and Campbell (2008) also found that when teachers use guided discussions they can help students to develop their conceptual understandings by building on their previous experiences and diagnosing and refining their ideas. The kind of work that is done by teachers in class discussions to help their students build their ideas into 'coherent lines of thinking' relates to the *cumulative* aspect that Alexander (2006) identified as essential to dialogic teaching. For

Penny and Holly, planning whole-class discussions in this way helped them to develop more purposeful discussions so that they were more effective in the way they used teacher questioning to develop and shape the discussion with their students, and they developed more cumulative talk (Assertion 7.8; Assertion 7.12).

A variety of teacher questions

As the teachers participated in the learning intervention, they began to work on developing their use of teacher questioning and discourse moves in class discussions. At the start of the intervention, Ben demonstrated a well-developed understanding of how to use teacher questioning in conjunction with a sophisticated range of teacher discourse moves to elicit, explore and probe his students' ideas during Engage and Explain lessons (Assertion 7.10). Consequently, the students in Ben's class were able to provide elaborated responses and to develop cumulative talk (Alexander, 2006) from early on in the intervention, and they were able to consistently provide higher-order descriptions and explanations (Assertion 7.10).

In contrast, Penny and Holly asked appropriate questions to elicit their students' ideas in the early part of the intervention but they also utilised a limited range of teacher discourse moves to explore the students ideas more thoroughly (Assertion 7.8; Assertion 7.12). This resulted in the development of short teacher-student exchanges and restricted the opportunities for students to give elaborated responses or to develop cumulative talk (Assertion 7.8; Assertion 7.12). The research shows that this lack of follow-up and exploration of students' responses is associated with teachers controlling the discourse and ensuring that the content of the lesson is 'covered' (Nystrand, 1997). And further, that by using a limited range of classroom talk, teachers control not only the content of the lesson but also the events that play out in the classroom (Alexander, 2006; Koufetta-Menicou & Scaife, 2000; Rop, 2002). It is quite possible, particularly given the challenging class that Penny worked with, that both Penny and Holly managed the discourse in this way so as to maintain control of the class and to get things done. However, as discussed previously, Holly also managed the discourse in this way to ensure each student was given an opportunity to speak. Levitt (2001) argues that the way in which teachers implement teaching and learning is mostly dependent on their beliefs and if they do not value shared interactions as a tool for

learning they may manage discourse in a way that inhibits student interaction and impedes the inquiry process. Ultimately, it is clear that as long as Penny and Holly were focused on managing the discourse to retain control of the class or to ensure everyone had their say, they were less likely to foster the kind of interaction that would allow them to explore their students' ideas and to develop cumulative talk.

The research also shows that teachers facilitate students' active inquiry when they ask a greater number of open-ended questions (Koufetta-Menicou & Scaife, 2000) that stimulate productive activity in the inquiry process (Elstgeest, 1985). In the initial phase of analysis, the data showed that the teachers tended to ask open or closed questions; that they asked questions to elicit descriptions, explanations or reasoning; and that they asked initiating questions to commence an interaction or to maintain the momentum of the discussion (Hackling, et al., 2011). Thus, the analysis subsequently centred on the types and purposes of initiating questions that the teachers asked and this included: *closed* questions, which elicited only a limited number of response options; *open-ideas* questions, which elicited a range of students' ideas; *open-description* questions, which elicited description of an observation or an event; *open-explanation~reason* questions, which elicited an explanation as to why something happened or a reason to justify a claim.

Ultimately, the data showed that each of the teachers asked *open-ideas* questions to 'open up' (Erdogan & Campbell, 2008) a discussion in the Engage phase so as to find out what their students knew about a topic (Assertion 7.8; Assertion 7.10; Assertion 7.12). They also asked *open-ideas* questions in the Explain phase to elicit the students' predictions about what might happen or how they might find out more about a particular phenomenon when planning new investigations for the Elaborate phase (Assertion 7.8; Assertion 7.10; Assertion 7.12). The data also showed that the teachers asked an increased number of *open-description* questions in Explain lessons in order to elicit the students' responses regarding their observations of a phenomenon or to describe what had happened. The teachers also asked more *open-explanation~reason* questions in the Explain phase to elicit the students' explanations about why something occurred or to elicit a reason that justified a claim about how it may have happened (Assertion 7.8; Assertion 7.10; Assertion 7.12). Typically, the teachers asked *closed* questions in order to seek clarification about something that a student had said, to refocus the discussion

by drawing together a range of students' ideas, or to manage the flow of the discussion (Assertion 7.8; Assertion 7.10; Assertion 7.12). What is more, they asked significantly more *closed* questions in the Explain phase when they wished to shape the discussion so as to make the science ideas explicit (Assertion 7.8; Assertion 7.10; Assertion 7.12).

Like Ben, Penny and Holly began to use the range of questions described above to probe their students' ideas and to help them to think more deeply about their investigations (Assertion 7.8; Assertion 7.10; Assertion 7.12). This probing pattern of interaction became progressively more apparent in class discussions in the Explain phase but it was also evident in some Engage lessons when the teacher wanted to explore the students' initial understandings more carefully. When the probing sequence was utilised, the teacher typically asked *open-ideas* (and some *open-description*) questions to initiate the discussion about a phenomenon but then followed up with *open-description* questions and then *open-explanation~reason* questions to prompt the students to think about why something had happened. In this sequence, the teachers would also ask *closed* questions to support the students to reach an answer to an explain question, thus shaping the discussion and narrowing the range of ideas for the students to focus on. This is similar to the Socratic questioning approach described by Chin (2007). It is also consistent with the research which found that teachers who utilised high levels of constructivist teaching practices asked more open-ended questions than any other type, and they balanced open-endedness by using closed questions to focus students' thinking as they carried out their investigations (Erodgan & Campbell, 2008). A good example of the probing sequence is evident in Penny's final Explain lesson (Lesson 5) when she led students to answer an *open-explanation~reason* question about the importance of heat in the germination process by asking *open-description* and *closed* questions (KF 5.41). In this instance, the students were able to develop explanations for the way their seeds had developed and to reason about the conditions that facilitated the germination process (KF 5.41).

One of the key functions of teacher questioning is to promote students' learning and Koufetta-Menicou and Scaife (2000) found a strong correlation between teachers' use of open-ended and higher-order questions and students' metacognitive awareness. Koufetta-Menicou and Scaife (2000) classified questions as lower- or higher-order according to their cognitive demand. They regard lower-order questions as those that

require students to recall information, describe elements, or identify simple relationships between variables (Koufetta-Menicou & Scaife, 2000). In this study, the teachers asked many *open-description* questions, which required the students to make literal statements about their observations and to make links to what they had seen or measured. Typically, the students provided either a unistructural response (Biggs, 2003; Biggs & Collis, 1982), where they reported on one aspect or feature (e.g. growth or a single process), or a multistructural response (Biggs, 2003; Biggs & Collis, 1982) where they reported on two or more aspects or features and any change or difference between those features. For example, in the Engage phase of inquiry, the students might have recounted a personal experience, given a literal description of objects that may have been used to stimulate the discussion, or described processes that were linked to the topic being explored. In the Explain phase, they might have included observations they had made about an experiment or science related task.

Koufetta-Menicou and Scaife (2000) considered higher-order questions are those that call for students to make and justify judgements, arguments or explanations, to develop hypotheses, or to make predictions and draw conclusions. In this study, the *open-explanation~reason* questions the teachers asked during the probing sequence were considered higher-order questions as the students were required to give an explanation as to why something had happened or how something might happen in the future. The students were also encouraged to provide some supporting reason or justification for their explanation which made recourse to a science idea, and this was more cognitively demanding for them. The younger students in Ben's Kindergarten/Pre-Primary class frequently gave explanations for their observations of different phenomena and towards the end of the professional learning intervention they also provided some supporting reasons (Assertion 7.10). Similarly, once Holly began to focus her use of teacher questioning, the students in her Year 2/3 class gave an increasing number of explanations for different aspects of their investigations and, on occasion, they could also provide some reasons (Assertion 7.12). However, the Year 6/7 students in Penny's class were able to provide explanations for their observations from the outset and later in the intervention they could also give reasons for their explanations when Penny supported them to interpret her questions (Assertion 7.8).

Koufetta-Menicou and Scaife (2000) argue that teachers cannot assume that teaching has been effective in developing higher-level thinking unless they ask higher-order questions and, in general, this may be a useful way to help teachers to think more carefully about and to differentiate their use of questioning. However, as Chin (2007) pointed out, it is also necessary for teachers to pay attention to how a series of different types of questions can work in combination to achieve higher-level thinking. While *open-description* and *closed* questions might appear to fit Koufetta-Menicou's and Scaife's (2000) lower-order classification, it is useful to note that they are very important in the probing sequence as they demand that students develop explanations and reasons for their findings based on their observations and experiences. Additionally, it should be recognised that answering *open-description* questions may well be an appropriate learning outcome for young children and, when considered in this light, the lower-order label is less useful. A simple visual representation of the probing sequence that teachers used to support their students to develop explanations and reasons is given below in Figure 7.2. It shows how the teachers might ask *open-ideas* questions to elicit the students' ideas and predictions; then *open-description* questions, which call for the students to draw on observations derived from their experiments or experiences of science related tasks; followed by more cognitively demanding *open-explanation~reasoning* questions, which call for the students to think about the explanations and scientific reasons for their observations.
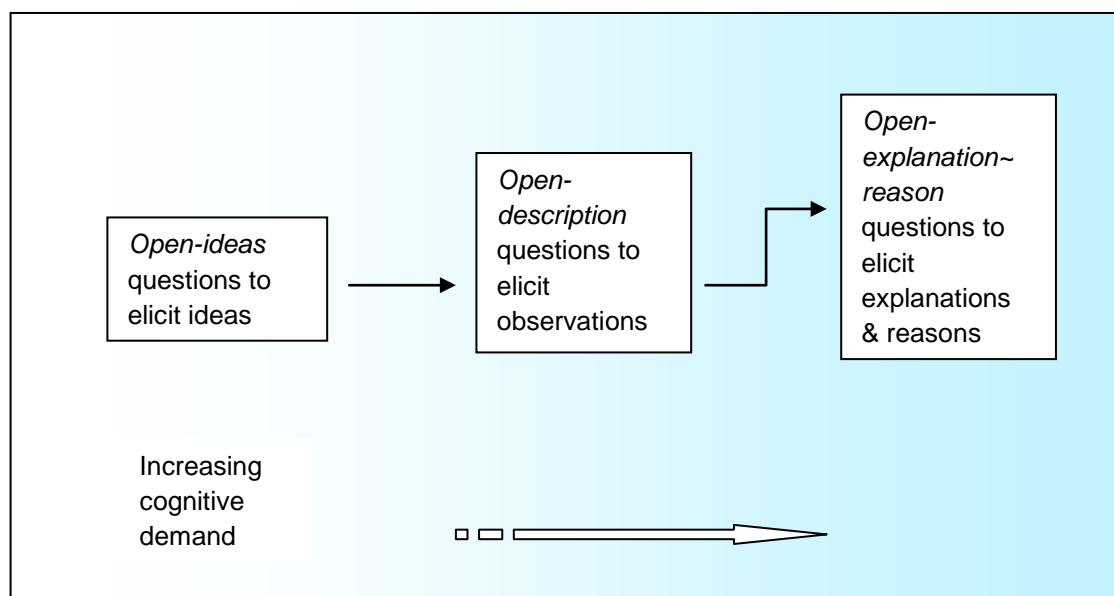
Figure 7.2: The probing sequence, teachers asked questions of increasing cognitive demand to support students to develop explanations and reasons.

A repertoire of teacher discourse moves

While it is important for teachers to pay attention to how they use questions in whole-class discussions, Nystrand (1997) argues that it is also important that they pay attention to students' answers and what they do with those answers. In this study, the teachers developed a repertoire of teacher discourse moves which they used to support their questioning and to differentiate their management of class discussions during different phases of an investigation. The teachers utilised the teacher discourse moves in subtly different ways and they also used individual discourse moves in multiple ways. Further, they were inclined to marry particular types of teacher discourse moves and questions, depending on the discourse strategy they wished to employ and the communicative approach required for the instructional focus of the lesson and phase of investigation.

In the Engage phase, when the teachers wanted to open up the discussion about a new topic, they utilised an Interactive-Dialogic communicative approach whereby they asked predominantly *open-ideas* and *open-description* questions, and fewer *open-explanation~reason* questions. In addition, they combined an increasingly sophisticated range of teacher discourse moves to initiate and build the interaction, to explore and develop the students' ideas and their use of scientific language, and to manage the discourse. The teachers initiated and built up the interaction by: supporting the students to articulate and clarify their ideas (*teacher restate, clarify*); building on the students' ideas (*clarify*, *teacher uptake*); maximising the interaction with individual students (*elaborate, teacher restate, teacher uptake*); and, endorsing the students' responses (*evaluate*). The teachers investigated and developed the students' ideas by: exploring (*teacher uptake*, *wait time, extended thinking time, prompt and scaffold; or teacher uptake*, *clarify,* and *elaborate*) and probing their ideas (*directed question*, *teacher restate*, *teacher uptake*, *reframe*, and *evaluate*); maintaining a line of questioning (*acknowledge only*, *recast the question, asks for other ideas*); giving the students time to think (*wait time, extended thinking time*); and, summarising the students' ideas (*refocus).* The teachers developed the students' ideas and use of language by supporting them to use appropriate terminology and rephrasing their ideas (*reframe*); and, modelling appropriate scientific language (*reframe scientifically*). Additionally, the teachers managed the discourse by orchestrating the flow of the discussion (*directed question, acknowledge only, moves on*).

In Explain lessons, the teachers utilised an Interactive-Dialogic communicative approach when they wanted the students to review their observations and results from the activities carried out in the Engage and Explore phases of investigation. They asked *open-ideas* and *open-description* questions and they used teacher discourse moves to initiate and build the interaction by: supporting the students to articulate their ideas (*clarify*, *prompt and scaffold*, *wait time* and *teacher uptake;* or *teacher restate, clarify,* and *elaborate*); and, maximising the interaction and helping the students to link their ideas to the problem (*teacher restate*, *clarify*, *teacher uptake*, *extended thinking time*, *checks for consensus*, *evaluate*, and *refocus*). When the teachers wanted the students to develop explanations and reasons for their results they adjusted their communicative approach to a more Interactive-Authoritative style where they asked more *open-description, closed* and *open-explanation~reason* questions, and they used teacher discourse moves to: develop the students' ideas and use of language by shaping the students' responses (*prompt and scaffold, extended thinking time,* and *refocus*); give the students some time to think (*wait time* and *extended thinking time*); reshape and accumulate the students' ideas (*clarify*, *reframe, refocus*); and, develop cumulative talk and summarise the students' ideas (*refocus*). In addition, the teachers ensured the scientific ideas were made explicit by: reinforcing particular ideas and making key ideas explicit (*teacher uptake, teacher restate, evaluate, refocus, prompt and scaffold, reframe*); and, explaining and emphasising key understandings (*elaborate*, *teacher restates*, *clarifies*, *teacher uptake*, *evaluate*, *reframe*, *prompt and scaffold*, *reframe scientifically*).

The teachers also focused on incorporating *wait time* into their discourse practice. At the start of the intervention, Ben and Holly had understood that teachers needed to give students the time to think during discussions (Assertion 7.9; Assertion 7.11) and Penny believed that she was effective in using *wait time* (KF4.6). However, the data from Lesson 1 showed that neither Holly nor Penny had used *wait time* in their practice. At the midpoint of the intervention, Ben reported that he had focused on using *wait time* (KF 5.30) and his consistent use of Wait Time 1 and, to a lesser extent, Wait Time 2 (Rowe, 1972) and *extended thinking time* was evident in the video footage from Lessons 1-5 (KF 5.13; KF 5.19; KF 5.26; KF 5.34; KF 5.40). Similarly, Penny reported that she had used *wait time* (Wait Time 1) (Rowe, 1972) and *extended thinking time* successfully (KF 4.31) and this was also evident in her practice, more so in the Explain lessons (Lessons 3 and 5) (KF 4.19; KF 4.26; KF 4.41). Holly also reported that she

had used *wait time* and while she had begun to use Thinking Time (coded as *extended thinking time*) (KF 6.31; KF 6.47) there was no evidence in the video footage that she had used Wait Time 1 or Wait Time 2 (Rowe, 1972) in her discourse practice (KF 6.14; KF 6.21; KF 6.31; KF 6.40; KF 6.47).

The literature shows that this responsive way of working and managing the discourse is typical of classrooms that generate productive interactions in whole-class discussions. Researchers have described how productive interactions are achieved when teachers are receptive to a range of students' ideas and they use questioning to prompt and challenge the students' thinking and reasoning (Chin, 2007; Erodgan & Campbell, 2008; Koufetta-Menicou & Scaife, 2000). The research also highlights how teachers can support and develop students' interactions when they use discourse moves that ask for clarification or elaboration and when they use wait time (Rowe, 1972; Tobin, 1987) or strategies such as Thinking Time (Alexander, 2006) and 'practicing quietness' (van Zee, Iwasyk, Kurose, Simpson & Wild, 2001), which provide spaces in the discourse for the students to think and make sense of their ideas. Alexander (2006) finds dialogic classroom interactions can be used to provoke students' thinking and he underscores the importance of asking authentic questions that engage with what students think and know. Similarly, Collins' (1982, in Nystrand, 1997) describes a process of 'uptake' (coded as *teacher uptake* in this study), which highlights how teachers can develop authentic and productive interactions with their students when they ask questions that draw on the ideas the students contribute to discussion. Ultimately, by making room for the students to participate in the discussion and encouraging them to articulate, elaborate on and clarify their ideas, the teachers in this study supported their students to be accountable for their thinking. In addition, they orchestrated the conversation so that the students' contributions formed cohesive chains of interaction much like the I-R-F-R-F (Initiation-Response-Feedback-Response-Feedback) pattern of interaction described by Mortimer and Scott (2003). For Penny and Holly, this marked a significant change to their beliefs, knowledge and practice and is evidence that they had responded positively to the feedback they had gained from working with their students and from their engagement with the professional learning process.

It was evident from the analysis of the transcripts of the class discussions that the teachers in this study employed discourse moves in many ways to achieve productive interaction in their classrooms. Furthermore, as they developed their repertoires, the teachers' use of discourse moves became increasingly sophisticated and complex. The codes generated from the analysis of the transcripts, which were developed for this study and for the larger *Discourse Project*, has highlighted a range of possible discourse moves that teachers can draw on to orchestrate the talk in their classrooms. Refer to Appendix 1 for the full set of the codes relating to teacher questioning, teachers discourse moves and the quality of student talk.

In Table 7.2, I have shown how the codes relating to teacher discourse moves can be loosely categorised according to their purpose, for example, whether they can be used to initiate interaction, open up or build the talk, and to close off the talk or move the discussion on. As discussed previously, the discourse moves can be used in conjunction with one another to achieve a range of purposes. Furthermore, some discourse moves can be categorised in multiple ways, for example, *wait time* and *extended thinking time* can be used to help initiate interaction but they are equally useful in opening up discussion and building talk. Similarly, a *turn taking* pattern of interaction might serve to close off substantive discussion, but it can be also used to initiate interaction by eliciting many students' ideas at once.

Table 7.2: Categorising teacher discourse moves according to their purpose.

Teacher discourse moves used to initiate interaction	
Directed question	Teacher directs a question to a named student.
Turn taking (teacher nominated)	Teacher nominates one student after another to respond without calling for elaboration or explanation of their ideas.
Wait Time	Teacher pauses for greater than "one and two" (WAIT time) after asking a question (WT1) or after a student's response (WT2).
Extended Thinking Time	Teacher extends thinking time using strategies other than Wait Time, e.g. Think-Pair-Share, Thinking Time, writing a draft, other.
Recast the question	Teacher does not receive an answer or receives an unsuitable response and rephrases the question.
Teacher discourse moves used to open up or build the talk	
Teacher restates	Teacher repeats or restates what has been said.
Restate/clarify	Teacher asks a student to restate so audible to class or to clarify what was said.
Reframe	Teacher rephrases a student answer to improve expression.

Reframe scientifically	Teacher rephrases student answer to correct science.
Elaborate	Teacher asks for elaboration of a response (to say more about it).
Prompt and scaffold	Teacher provides cues before or after a question to prompt/scaffold student's responses.
Refocus	Teacher summarises to consolidate and refocus the discussion.
Teacher uptake	Teacher asks a follow-up question that includes (builds on) part of a previous answer.
Checks for consensus	Teacher asks the class to indicate who agrees with an idea.
Teacher discourse moves used to close off the talk or to move on	
Ignore	Teacher ignores a student response.
Acknowledge only	Teacher just acknowledges a student response with no further interaction.
Evaluate	Teacher indicates whether an answer is correct or incorrect.
Asks for other ideas	Teacher asks for other (different) ideas.
Moves on	Teacher asks a question which changes the focus of discussion.

Clearly, teachers who are armed with a good repertoire of discourse moves as well as the knowledge of how to orchestrate discussion to achieve cumulative talk are more likely to achieve the kind of whole-class interaction needed to engage students in substantive discourse or 'talking for thinking'. A visual representation of some of the discourse moves teachers might draw on to respond to students' ideas is given below in Figure 7.3 (Hackling, Smith & Murcia, 2011)[1]. It shows how a teacher might ask an initiating question and then use wait time to give students time to think before nominating someone to respond. Once a student has responded, the teacher can select from a range of discourse moves to: provide further wait time, thus allowing time for the class to consider the student's response; ignore the response and allow the student's idea to fade away; acknowledge the student's response without further interaction; evaluate the response by indicating whether it is correct or incorrect; ask the student to clarify what they have said; ask the student to elaborate on their response; or ask other students for their ideas. Clearly, some discourse moves serve to close off the interaction (*ignore*, *acknowledge only*, and *evaluate*) and others open up the discourse and invite further interaction (*wait time*, *clarify*, *elaborate*, and *asks for other ideas*). Once a particular chain of interaction has achieved its purpose or has

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[1] This paper presents findings that were common to this thesis as well as to the *Discourse Project*.
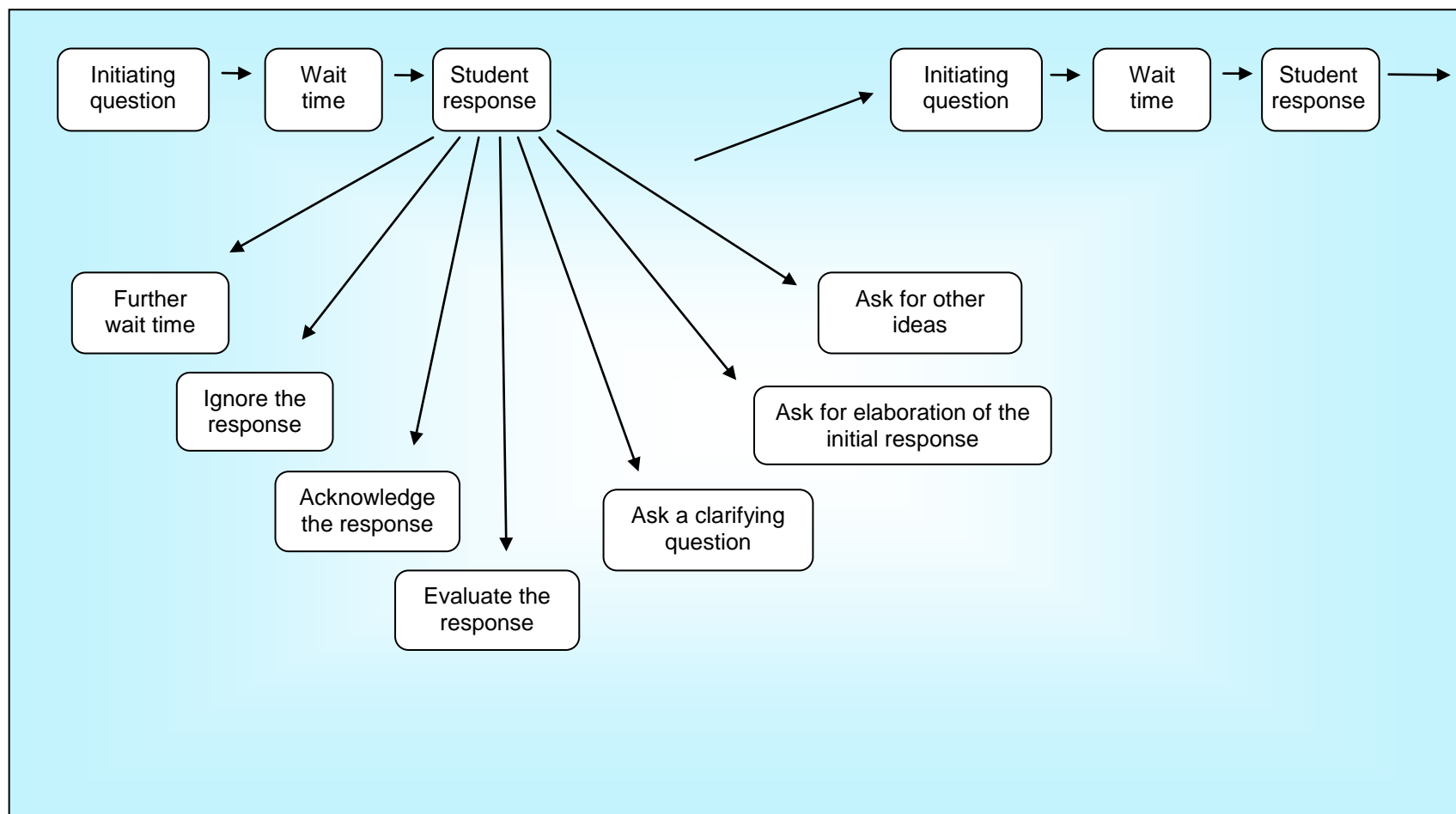
Figure 7.3: The complexities of discourse interactions (Hackling, Smith, Murcia, 2011).

been exhausted, the teacher can go on to ask another initiating question and to draw on other discourse moves to build and shape the interaction.

Students' increased engagement in substantive discussions

Alexander (2006) argues that both student engagement *and* teacher intervention is necessary to develop students' capacity to think and to learn. Additionally, Morgan and Saxton (1991) found that the types of questions teachers ask and the ways that they respond to their students' in discussion significantly influences not only the culture for talk in the classroom but also the degree of student engagement and learning. In this study, when they aligned their communicative approach and use of teacher questioning and discourse moves with the purposes of the Engage and Explain lessons, the teachers facilitated the students' participation in discussion (Assertion 7.8; Assertion 7.10; Assertion 7.12). Consequently, the students were able to provide increasingly elaborated responses and they were able to build on each other's ideas to generate cumulative talk (Alexander, 2006) (Assertion 7.8; Assertion 7.10; Assertion 7.12). Additionally, the data show that the quality of the students' contributions to discussion increased and they were able to give progressively more complex descriptions, explanations and reasons (Assertion 7.8; Assertion 7.10; Assertion 7.12). Given the increase in the students' substantive contributions to discussion and cumulative nature of their talk, this suggests that each of the case study teachers had successfully created a context for learning which supported their students' productive disciplinary engagement (Engle & Conant, 2002).

The sociocultural perspective of learning holds that individual understanding (intramental activity) is developed via the social experience of language use (intermental activity) (Mercer et al., 2004) and that meanings are negotiated and socially constructed in the context of activity and community via a process of enculturation (Traianou, 2007). In this instance, when the teachers interacted with their students in whole-class discussions, they not only worked on developing the students' ideas and understandings of science but they also worked on helping them to interpret their findings and on developing their acquisition and use of scientific language (Gee, 2004), thus fostering their ability to talk science (Lemke, 1998). While, there may not be direct evidence that students had appropriated ideas from the social to the individual plane (Vygotsky, 1978), there is evidence to suggest that this is so given the

quantitative and qualitative data gained about the students' increased participation and the improved quality of their talk.

General Assertion 4

Over the course of the professional learning intervention, the teachers increased their capacity to use teacher questioning and discourse moves to elicit, explore and probe their students' ideas in class discussions. Initially, some of the teachers asked appropriate questions to elicit the students' ideas, however, they only used a limited range of teacher discourse moves. This meant that they missed the opportunity to explore the students' ideas and they prevented the students from elaborating on their ideas, thus inhibiting the development of cumulative talk.

As they participated in the professional learning process, the teachers began to plan whole-class discussions, which helped them to conduct more purposeful discussions, to manage the discourse more effectively, and to develop cumulative talk. Additionally, they developed their capacity to adjust their questioning to fit the instructional focus of a lesson or phase of inquiry and they became more adept at using a sequence of questions to probe the students' ideas and to help them to develop explanations and reasons for their findings. The teachers also extended the repertoire of discourse moves they used to support their questioning and to differentiate their management of class discussions during different phases of inquiry.

As a result of their involvement in the professional learning intervention, all of the case study teachers increased their understandings and developed their practice of using teacher questioning and discourse moves to adjust their communicative approach so as to match the instructional focus of the lesson and phase of investigation. Consequently, their students participated more readily in discussion, they gave increasingly elaborated responses and generated cumulative talk, and they were able to give progressively more complex descriptions, explanations and reasons.

Theme 4: Teachers' knowledge and practice of using puppets in their science lessons

In this section, a summary of each teacher's knowledge and classroom practice to do with the use of puppets in science lessons is presented and assertions about their knowledge and practice are developed. The subsequent discussion highlights the similarities and differences between the teachers' knowledge and practice, how this changed as the professional learning intervention progressed, and a general assertion is presented.

Penny's knowledge and practice

At the start of the professional learning intervention, Penny had limited experience of using puppets in her teaching (KF 4.8). The intervention provided opportunities for the participating teachers to develop skills of using puppets and, subsequently, Penny presented two large puppets called Lucy and Charlie to the class. She characterised the puppets as teenage twins and she portrayed Lucy as less knowledgeable and quarrelsome character and Charlie as more knowledgeable and curious. However, Penny found it quite difficult to manage both puppets at once and so she only used Lucy in the second Engage Lesson (Lesson 2) to help to set the scene for a new topic and to elicit the students' ideas (KF 4.32; KF 4.49). Ultimately, Penny did not use the puppets in any subsequent lessons (KF 4.32).

While Penny had initially found most of the students were engaged by the puppets and the weaker students were motivated to talk to them, there were also some of her Year 6/7 students who were not won over by them (KF 4.32). Later in the intervention, when she had reflected on the impact the puppets had on student engagement and talk, Penny thought the students had humoured her and were not really very engaged in the discussion (KF 4.49). She also reported that she had stopped using the puppets as she felt that they did not add to the classroom discourse and she was worried that the personas she had created would reinforce gender stereotyping (KF 4.49).

Additionally, Penny had found it difficult to manipulate two puppets at once, to stay in character, and to adjust her voice as she took on each role (KF 4.32; KF 4.49). She found it awkward to sustain classroom discussion when she used the puppet (KF 4.20; KF 4.49) and she felt self-conscious when she was being filmed (KF 4.20). In spite of this, Penny indicated that her level of confidence for using puppets in her science teaching was okay (KF 4.49).

Assertion 7.13

Penny's attempt to use a puppet in her science lessons was moderately successful and she developed an understanding about the importance of developing an appropriate persona for the puppets. Ultimately, she stopped using the puppets because she found it difficult to convince all of her upper primary students to buy into the interaction. While Penny identified several challenges with using puppets and she did not develop her capacity to use puppets during this professional learning opportunity, she regarded herself as being confident with using puppets in her science teaching.

Ben's knowledge and practice

Ben had some experience of using puppets at the start of the professional learning intervention (KF 5.8). As he participated in the intervention, Ben reported that he had briefly introduced two puppets to small groups of his students as they worked on activities in the Explore phase of an investigation (KF 5.31). At the midpoint of the intervention, he reported that he was more comfortable with using just one puppet at a time and that he wished to develop more confidence with using the puppets before he used them with his whole class (KF 5.31).

Ultimately, Ben did not use the puppets in any lessons associated with the professional learning intervention and he gave several reasons for this. He stated that he had found it difficult to find a reason to use the puppets in whole-class discussions (KF 5.31; KF 5.48) because he thought his class used discourse well and there was little need for the puppets to assist in this process (KF 5.31). He also felt that the puppets took away from the focus of the lesson and were distracting (KF 5.48). Ben said that he had difficulty establishing a connection between the students and the puppets and he thought that the puppets replaced rather than complemented his role in the discussion (KF 5.48). Given the lack of use, he thought the puppets had made very little impact on the level of student engagement or talk in his class (KF 5.48). At the end of the intervention, Ben indicated that his level of confidence for using puppets in science teaching was okay (KF 5.48).

Holly's knowledge and practice

Holly began the professional learning intervention with no experience of using puppets in her teaching (KF 6.8). However, as she participated in the intervention, she developed an understanding of how to use the puppets in the Engage phase to set the scene and engage the students in a new topic, to present a problem for them to investigate, and to ascertain their prior knowledge (KF7.39; KF 6.55). Holly also learned to use the puppets in the Explain phase to expand on the initial problem and to find out what the students had learned during the Engage and Explore phases that would resolve the problem (KF 6.55). In addition, she learned to use the puppets to probe the students' understandings by asking questions that seek elaboration and explanation, to make science ideas explicit, and to highlight important ideas in the discussion (KF 6.28; KF 6.31; KF 6.47). Ultimately, Holly reported that she had been able to use the puppets effectively at all stages of the inquiry process (KF 6.36).

Holly also learned how to develop the personality and voice for the three puppets she used, as well as the skill to physically manipulate them (KF 6.18; KF 6.37). She initially introduced the class to two small dog puppets called Detective Doug and Tilly. Holly portrayed Detective Doug as a knowledgeable, dependable character who loved to investigate problems and she used him to present problems for the students to solve and to help her to develop the investigation. She characterised Tilly as a young, scatterbrained little dog that seemed to always find trouble, and, when planning the context for the investigation in Lesson 2, Holly created a problem for the students to solve that centred on Tilly's misadventures. Later in the intervention, when planning a new topic, Holly decided to base the problem for investigation on another young and naïve character called Katy Caterpillar. Holly found that portraying two of the puppets as naïve, clueless characters helped the students to feel knowledgeable and more confident to share their ideas and explanations (KF 6.37; KF 6.39). Additionally,

towards the end of the intervention when her skills were more developed, Holly learned to use the puppets to invite her to re-enter the discussion so she could give an explanation (KF 6.44; KF 6.47). This allowed her to draw on the more authoritative voice of the teacher to make the science ideas explicit.

When Holly initially introduced two dog puppets into her lessons, she noticed that the students were immediately engaged by them and were motivated to talk to them (KF 6.36). Ultimately, she found that all three puppets facilitated the development of a safe and comfortable environment for discussion and that all the students were more willing to share their ideas, to listen to one another and to participate in longer, more productive discussions (KF 6.28; KF 6.39; KF 6.47; KF 6.54; KF 6.55).

Over the course of the intervention, Holly felt her confidence with using the puppets increased (KF 6.36; KF 6.55). However, she also found introducing the puppets into the lesson, juggling the interaction between the teacher and two puppets, and transitioning from one personality to another was challenging (KF 6.36; KF 6.55).

Assertion 7.15

Holly's capacity to use puppets to support class discussions and primary science investigations developed significantly as a consequence of her involvement in the professional learning intervention.

Holly learned how to use the puppets at different phases of inquiry in order to: set the scene at the start of a new investigation and to present a convincing problem for the students to solve; and, in latter phases, to draw on the authoritative voice of the teacher to present the scientific view.

She also learned to use the puppets to: highlight important ideas; encourage more elaborated responses; probe the students' ideas; and, elicit explanations.

In addition, Holly developed an understanding about how to use puppets to promote a safe environment for students to participate in longer, more productive discussions. She developed her understanding of how to create believable personas for the puppets and how to build rapport between the puppets and the students.

While Holly's confidence with using the puppets increased considerably, she also identified several challenges that she continued to work on.

Issues arising from using puppets in science

While developing the use of puppets was not the main purpose of the professional learning intervention, it did provide an opportunity to investigate how the use of puppets could facilitate classroom discourse. The development of the teachers' knowledge for using puppets in their science investigations was varied and several issues were highlighted as a result of their work with the puppets during the intervention.

The teachers' receptivity to the puppets depended to an extent on how well received they thought the puppets would be by their students and how much value they would add to discussions and the learning context in general. This was particularly evident in the case of Penny who worked with a challenging Year 6/7 class and who was focused on establishing and encouraging her students to use speaking and listening conventions. Penny found quite early on that when she attempted to introduce the puppets to her class the students did not find them believable and, consequently, they did not engage very well with them (Assertion 7.13). It is quite probable that the puppets would have appeared less convincing to Penny's students and this would have made it harder for them to suspend their disbelief and buy into a learning event that centred on the puppets. Ben, on the other hand, did not feel that the puppets would add any value to whole-class discussions in his Kindergarten/Pre-Primary class (KF 5.31; KF 5.48) and after an initial attempt he chose not to persist with their use (Assertion 7.14). However, when Holly introduced the puppets to her Year 2/3 class she found that her students were very interested and engaged by them and that the puppets facilitated the development of longer, more productive discussions (Assertion 7.15). This is consistent with Simon et al. (2008) who found that when teachers used puppets in their science lessons their students' contributions to class discussions were enhanced. Holly also found that the puppets assisted in establishing a safe, supportive classroom environment for talk (Assertion 7.15).

It became apparent that the teachers also needed to have a degree of confidence as a performer to use the puppets effectively and some of the teachers were challenged by this. When they initially started to use the puppets in their science lessons, the teachers commented on their self-consciousness (KF 4.20; KF 4.49) or desire to further

develop their confidence with using the puppets (KF 5.31; KF 6.36). However, they ultimately rated themselves as confident with using the puppets at the end of the professional learning intervention (Assertion 7.13; Assertion 7.14; Assertion 7.15).

Using puppets to introduce and develop science investigations

As they worked with the puppets, Penny and Holly came to understand how to develop a convincing scenario that would provide a context for a new topic of investigation and the means for the puppets to present the problem for the students to solve. They also realised that is was necessary to spend time developing believable voices and personas for the puppets (Assertion 7.13; Assertion 7.15) and they did this with varying degrees of success. The teachers tended to characterise one puppet as knowledgeable and responsible and another as less knowledgeable and naïve. This meant that they could develop a problem for the students to solve based around the misadventures of the less knowledgeable, more naïve puppet and use the more knowledgeable puppet to present the problem and to work with the teacher to develop the investigation. While Holly found that the students in her class were very willing to interact with all of the puppets, she noted they felt confident to share their ideas and opinions with the naïve and less knowledgeable puppets (Assertion 7.15). These observations are consistent with the findings of Simon et al. (2008) who found that portraying puppets as less knowledgeable characters in need of the students' help provided the opportunity for the students to be the 'expert' and gave them the confidence to articulate their thinking and reasoning. Simon et al. (2008) reported that they also presented puppets as 'experts' who set up problems for the students to solve and they found that these puppets were able to challenge the students' thinking and support them to: develop scientific arguments based on evidence; introduce alternative explanations; challenge conceptions; and, create cognitive conflict. As discussed previously, Holly tended to use the more knowledgeable puppet to present the problem and to work with her to develop the investigation but she preferred to resume her role as the teacher when she needed to use a more authoritative communicative approach to make science ideas explicit.

Over the course of the professional learning intervention, the teachers also came to understand that, in order to build a level of credibility with the puppets and to build a

rapport between the puppets and the students, they needed to develop their skills as a puppeteer (Assertion 7.13; Assertion 7.15). For example, during discussions the teachers needed to learn how to stay in character as they interacted with the students and they needed to ensure a smooth transition between the roles of the puppets and that of the teacher (teacher-puppet, puppet-teacher, and puppet-puppet). All of the teachers found it challenging to manage the roles of two puppets as well as the teacher (KF 4.32; KF 5.31; KF 6.36) and for the brief time that they used them, Penny and Ben ultimately only used one puppet at a time (KF 4.32; KF 5.31). Holly, on the other hand, persisted in learning how to use multiple puppets. She developed believable personas for each puppet and the skills to transition from one puppet to another during discussions. Holly also learned to use the puppets to elicit elaborated responses from the students and to use them effectively at different phases of an investigation (Assertion 7.15). This was particularly apparent in Explain lessons when she used them to draw her into the discussion so that she could use her more authoritative teacher voice to make key ideas explicit (Assertion 7.15).

Holly's efforts to build her capacity with using puppets in science discussions were well rewarded by her students' immediate and increased engagement in discussion, their willingness to participate in extended interactions, and the creation of a positive classroom culture for talk where the students willingly shared and listened to each others' ideas and explanations.

The development of the teachers' understandings and practice of using puppets in science depended on the their receptivity to the puppets and their perception of: how well the puppets would be received by their students; the value that the puppets would add to class discussions; and, how the puppets would contribute to the development of a supportive classroom environment for talk.

Additionally, the success of the puppets was contingent on the teacher's experience and confidence with using puppets, as well as their capacity to develop age-appropriate and believable personas, to manipulate the puppets convincingly, and to manage multiple puppets in conjunction with their role as the teacher.

The puppets added value to whole-class discussions, when the teacher used them to: establish a safe classroom environment for talk; set up convincing investigations; and, elicit elaborated responses and explanations from the students.

It was evident that the puppets positively impacted the students' engagement in discussion when the students were willing to participate in extended interactions, to share their ideas, to listen to one another and to contribute in longer, more productive discussions.

Supporting teachers to achieve productive discourse

The teachers' engagement with professional learning offered via the *Discourse Project* enabled them to successfully develop their capacity to scaffold productive discourse in their primary science classrooms and there were several features of the professional learning that facilitated this. The intervention offered a range of learning events that supported the teachers' learning. They participated in workshops that helped them to increase their content knowledge about the principles of effective classroom discourse and good discussion pedagogy. They engaged in extended professional conversations that helped them to: develop shared understandings and to use a common language about classroom discourse; build their pedagogical content knowledge about the importance of student talk in helping students to think about and extend their understandings of science ideas; and, understand how teacher questioning and responding to students impacts on the development of students' thinking (Hackling et al., 2010). The teachers shared video footage and discussed transcripts of their class discussions that enabled them to view examples of good discussion pedagogy and to consider how different types of questions and ways of responding to students' answers supported sustained conversation (Hackling et al., 2011). As a result of sharing their practice, the teachers developed openness and they seemed to work as a professional learning community (Hackling et al., 2011).

Another important aspect of the professional learning experience was the opportunity for teachers to obtain immediate feedback about their practice. As they began to develop the culture for talk in their classrooms and to implement the *Primary Connections* units they had planned, the teachers gained valuable feedback about their practice from the extent of the students' engagement, their buy-in with the puppets, and the quantity and quality of their contributions to discussion. Furthermore, when the teachers viewed the video footage and participated in follow up interviews about each lesson, they were able to reflect more deeply on the effectiveness of their practice.

As they participated in the professional learning process, the teachers adjusted their beliefs and knowledge as they gained feedback from their practice in what appeared to be a virtuous cycle. This observation is consistent with earlier research which found that the evidence gained from their practice influences the continual development of teachers' beliefs and personal theories (Brickhouse, 1990; Clarke & Hollingsworth, 2002; Clark & Peterson, 1986; Guskey, 1986) and that reflecting on new practices and the student outcomes achieved by those practices is key to changing teacher beliefs (Clarke & Hollingsworth, 2002). In addition, the increase and strengthening of the teachers' beliefs, knowledge and practice that was observed in this study infers their increased pedagogical content knowledge for managing classroom discourse and how this impacts students' learning.

An elaborated theoretical model that has emerged from this study is presented in Figure 7.4. The model adds significantly to the literature by to do with discourse by providing an overview of the variables that impact on the quality of classroom discourse. It shows how teaching and learning as well as the culture for talk are socially situated within the context of the classroom; how the teachers' beliefs and knowledge inform their practice; and, how their practice impacts on whole-class interaction as well as the culture for talk.

The model also suggests that the opportunities for students' sustained engagement with a discourse of inquiry can be increased when the teachers develop their use of questioning and discourse moves and their capacity to adjust their communicative approach, and to differentiate the management of discussions during different phases

of inquiry. Further, that when the teachers work with the discourse in this way, the interactions with their students have the potential to become increasingly productive and the students' reasoning and learning about science significantly enhanced. Ultimately, how teachers set up the culture for talk in their class and how they use questioning and discourse moves to achieve certain communicative approaches in class discussions will impact on the opportunities available for students to reason and to learn in science, and to acquire the discourse needed for effective inquiry in science.
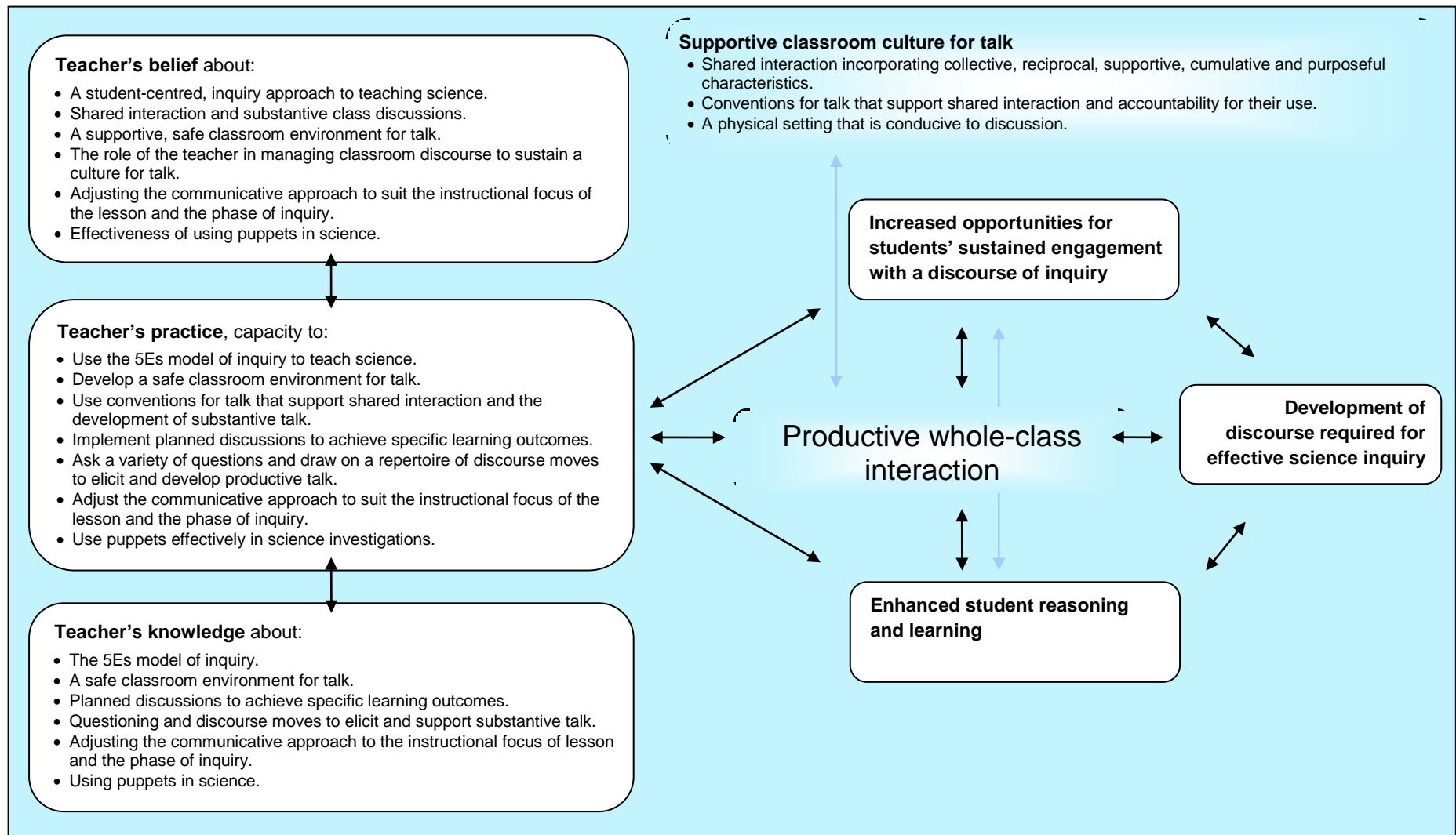
Figure 7.4: An elaborated theoretical model showing the variables impacting on quality classroom discourse.

In Chapter 8, the general assertions that have been developed in this chapter will be used to answer the research questions and will form the basis for the conclusions for this thesis.

CHAPTER 8: CONCLUSIONS AND IMPLICATIONS

Introduction

This study was part of an exploratory research project that focused on the development of teachers' science teaching beliefs, knowledge and practice as they participated in a professional learning intervention which aimed to enhance the use of discourse in primary science lessons. It involved confident teachers of primary science from government and independent schools in the Perth metropolitan area.

Conclusion

The conclusions answer the research questions that were established at the start of this study and are based on the general assertions that were developed in Chapter 7.

Research Question 1: What impact does the professional learning program have on teachers' beliefs about students' learning of science?

The case study teachers involved in the *Discourse Project* shared a set of common beliefs to do with utilising an inquiry approach to teaching science that involved student-centred investigations in which the teacher supported students to construct their own understandings (General Assertion 1). Two of the teachers believed that it was important to explicitly model and scaffold the skills for investigation for the students and the other believed in a more emergent, explorative approach (General Assertion 1).

The teachers' beliefs about teaching science were confirmed as they participated in the professional learning process. However, not all of the teachers were familiar with the 5Es model of inquiry used in the *Primary Connections* curriculum resources (Hackling et al., 2007) and it was not until later in the intervention, that one of the teachers came to believe it was important to differentiate his teaching approach according to the phase of inquiry (General Assertion 1).

Research Question 2: What impact does the professional learning program have on teachers' beliefs, knowledge and practice to do with developing a classroom culture that is supportive of discourse?

The case study teachers reinforced their beliefs and understandings that a safe, supportive and inclusive classroom environment facilitates substantive talk and students' participation in discussion (General Assertion 2). As they shared their practice with each other and participated in extended professional discussions, the teachers gained a deeper understanding of substantive talk and of the complex role of the teacher in managing classroom discourse to sustain a culture for talk (General Assertion 2). This was particularly obvious for one of the teachers when, after participating in the initial professional learning days and gaining feedback about her practice, she began to differentiate between the democratic aspects of classroom talk and substantive talk (Assertion 7.6)

The teachers' capacity to recognise the characteristics of effective dialogic teaching (*collective*, *reciprocal, supportive cumulative* and *purposeful*) (Alexander, 2006) in their class discussions was dependent on their understanding of those aspects (General Assertion 2). Additionally, some aspects of dialogic teaching proved harder for teachers to achieve when they had to make significant changes to their beliefs and knowledge (General Assertion 2). For example, in order to achieve a more purposeful approach to class discussions, it was necessary for one of the teachers to adjust his student-led approach to teaching and learning to the more intentional approach required for purposeful dialogic teaching and this required a significant shift in his beliefs, knowledge and practice. Such a deep and significant change could only have been achieved in a professional learning context where teachers have the opportunity to engage with the focus of the learning over an extended period of time.

As the professional learning intervention progressed, the teachers developed a greater understanding of the speaking and listening conventions that are supportive of substantive talk and how to support their students to use them and to be accountable for their use during class discussions (General Assertion 2). This outcome shows that the teachers' beliefs and understandings about developing a supportive classroom environment for talk had become aligned with their practice.

Some of Mercer's (2008) ground rules for talk were harder to establish (giving reasons to explain ideas; asking 'why' when disagreeing) than others (sharing ideas, listening to each

another; taking turns to talk; respecting each other's opinions) because they took time, they required a degree of familiarity with dialogic interaction as well as greater intellectual engagement on the part of the students, and they required an increased capacity to ask questions that elicit students' deeper thinking on the part of the teacher (General Assertion 2). In addition, the teachers' capacity to achieve change in the students' use of speaking and listening conventions and to develop a classroom culture that was supportive of dialogic teaching and interaction was either facilitated or constrained by their classroom context and/or by the broader school context in which they worked (General Assertion 2).

Research Question 3: What impact does the professional learning program have on teachers' beliefs, knowledge and practice to do with using classroom discourse?

At the start of the professional learning intervention, the teachers shared a common set of beliefs that discussion was an effective tool for science teaching, particularly for fostering students' participation, sharing ideas, and ascertaining what students know (General Assertion 3). Some of the teachers increased their beliefs and understandings about the teacher's role in planning discussions, using questioning to guide and develop substantive talk, and the intentional use of talk as a tool for teaching and learning (General Assertion 3).

Each of the teachers demonstrated an increased belief and understanding about the importance of adjusting their questioning and discourse moves to suit the instructional focus of Engage and Explain lessons (General Assertion 3). Although one of the teachers, who was accustomed to using an explorative teaching approach and did not see the need to vary his communicative approach, did not adjust his beliefs until after he had developed his understandings of the instructional purpose of each phase of inquiry (General Assertion 3).

Furthermore, the teachers increased their capacity to use teacher questioning and discourse moves to elicit, explore and probe their students' ideas in class discussions (General Assertion 4). Initially, some of the teachers asked appropriate questions to elicit the students' ideas; however, they only used a limited range of teacher discourse moves (General Assertion 4). This meant that they missed the opportunity to explore the students' ideas and they prevented the students from elaborating on their ideas, thus inhibiting the development of cumulative talk (General Assertion 4).

374

As they participated in the professional learning process, the teachers began to plan whole-class discussions and this helped them to conduct more purposeful discussions, to manage the discourse more effectively, and to develop cumulative talk (General Assertion 4). Additionally, they developed their capacity to adjust their questioning to fit the instructional focus of a lesson or phase of inquiry and they became more adept at using a sequence of questions to probe the students' ideas (Figure 7.2) and to help them to develop explanations and reasons for their findings (General Assertion 4). The teachers also extended the repertoire of discourse moves (Figure 7.3) that they used to support their questioning and to differentiate their management of class discussions during different phases of inquiry (General Assertion 4).

As a result of their involvement in the professional learning intervention, all of the case study teachers increased their understandings and developed their practice of using teacher questioning and discourse moves to adjust their communicative approach so as to match the instructional focus of the lesson and phase of investigation (General Assertion 4).

When the teachers focused their questioning and paid attention to how they responded to students' answers, they developed sustained conversations and the quantity and quality of the students' contributions to discussion improved. It is likely that this change in the teachers' practice and the positive impact that it had on the quality of the students' contributions would have also influenced the teachers' changing beliefs and knowledge. And, as the professional learning proceeded, the teachers continued to adjust their beliefs and knowledge as they gained positive feedback from their practice (Figure 7.4).

Research Question 4: What impact does the professional learning program have on teachers' knowledge and practice to do with using puppets in science?

The development of the teachers' understandings and practice of using puppets in science depended on their receptivity to the puppets and their perception of: how well the puppets would be received by their students; the value that the puppets would add to class discussions; and, how the puppets would contribute to the development of a supportive classroom environment for talk (General Assertion 5).

Ultimately, the success of the puppets was contingent on the teacher's experience and confidence with using puppets, as well as their capacity to develop age-appropriate and believable personas, to manipulate the puppets convincingly, and to manage multiple puppets in conjunction with their role as the teacher (General Assertion 5). The puppets added value to whole-class discussions, when the teacher used them to: establish a safe classroom environment for talk; set up convincing investigations; and, elicit elaborated responses and explanations from the students (General Assertion 5).

Implications

This section considers the implications of the conclusions for teachers' practice and professional learning, as well as for further research.

Implications for teachers' practice

This research has shown that if teachers are to develop their beliefs, knowledge and practice in relation to effective classroom discourse in science the professional learning curriculum needs to focus on several key aspects. First, teachers need to gain a clear understanding of the inquiry model and the purpose of each phase of inquiry, and how the model is used to guide the implementation of science investigations.

Second, teachers need to know what substantive discourse is, what it looks like in the context of whole-class discussions and how productive discourse significantly improves students' interactions and opportunities for learning. They need to know how to create a classroom culture that is supportive of substantive talk and how to use teacher questioning and discourse moves to generate and manage substantive talk.

Finally, teachers need to know how to match their communicative approach to the instructional focus of the lesson and the phase of inquiry so that they progress the discourse from simply engaging the students and exploring their ideas to supporting them to develop clear explanations and reasons for their findings which are grounded in the canonical ideas of science.

The research has also shown that pedagogical tools, such as puppets, can be used to help establish a supportive classroom culture for talk and to enhance students' engagement and participation in discussion. However, in order to effectively integrate tools such as these into the learning experience, teachers need to develop the skills to master their use. In addition, teachers need to give some consideration to the fit between the pedagogical tools they use and contextual factors such as the age of the students, their interests and their capacity for 'buy in'.

Implications for teacher professional learning

The research has demonstrated that professional learning that is focused on building capacity in teachers needs to be sustained over time and, what is more, the learning needs to take place in the context of teachers' real work – in their classrooms with their students. Learning to use classroom discourse effectively so as to achieve sustainable improvements in students' learning in science is a complex undertaking and the teachers involved in this study needed time to develop their beliefs, knowledge and practice in the context of a supportive professional learning program.

The research has also shown that professional learning providers need to give thought to designing programs that offer teachers multiple opportunities to develop their content knowledge as well as their pedagogical content knowledge. In this case, an action research approach was used and the teachers were able to collaborate to design and plan units of work which they then implemented in their classrooms. Subsequently, they were able to view, reflect on and gain feedback about their own discourse practice and to examine how their interaction supported students' deeper thinking and reasoning and the development of a discourse of inquiry. In fact, the video footage that was captured of teacher practice proved to be a vital tool for professional learning. It not only provided the means for teachers to view and gain feedback about their own practice but it also facilitated their shared practice and provided a rich contextual stimulus for professional conversations, thus enabling the teachers to learn from one another. In addition, the effect of the professional learning was enhanced because the teachers were able to work through two cycles of design, enactment, analysis and reflection, and redesign over the course of the intervention.

Additionally, the research has shown that in order for deep learning to occur, teachers need to work with a skilled facilitator who provides opportunities for them to deepen their understandings of theory and practice by participating in frequent conversations with a consistent group of colleagues. Consequently, professional learning providers need to ensure there are multiple opportunities for teachers to engage in professional conversations where they share their ideas and their practice, and develop common understandings about the focus of the learning. By interacting and working together the teachers build a level of trust and they feel comfortable to de-privatise their practice and to work as a professional learning community.

Ultimately, the research has demonstrated that the combination of these aspects contributed to the overall effectiveness of the professional learning program and enabled the case study teachers to develop their beliefs, knowledge and practice about an aspect of teaching they wished to know more about.

Implications for research

Given that this was an exploratory study into the impact of the professional learning on teachers' beliefs knowledge and practice for a small group of teachers, the generalisability of the findings is limited. However, the findings may be transferable to teachers who work in settings similar to those of the case study teachers and the transferability of the findings may be increased if the research was replicated with a greater number of teachers in a range of different settings.

The detailed analysis and coding of transcripts that was undertaken in this study revealed how teachers combine questioning and discourse moves to build classroom discussions. A greater understanding of the type, function and purpose of teachers' questions as well as of the wide range of discourse moves they can draw on to respond to students has enabled the researchers to clearly identify what is effective discourse practice and what effective teachers do to shape the discourse so as to develop substantive discourse or 'talking for thinking'. The set of codes that were developed to describe such teacher-student interactions will serve as a valuable tool of analysis for future researchers wishing to investigate classroom discourse.

Additionally, the coded transcripts and the video footage of classroom discussions proved to be effective tools for helping teachers to not only reflect on their own practice but also to share and talk about what constitutes good discourse practice during the professional learning process. These codes along with the video footage and professional learning resources developed for this study will be used as the basis for future research and teacher professional learning.

Ultimately, this study has shown that the pedagogical framework and the professional learning model have been successful in developing not only the teachers' beliefs and knowledge about productive discourse but also their capacity to use discourse effectively to increase students' learning in inquiry-based science. Further studies might investigate how changes to the teachers' discourse practice were sustained over time and what impact their improved practice had on students' learning outcomes. Additionally, it would be useful to investigate how these changes to discourse practice have impacted the classroom culture more generally and whether this has also influenced the discourse practice in curriculum areas other than science. Furthermore, it would be useful to understand how the improvements seen in whole-class discourse translate to the student-to-student interactions in both whole-class and small group discussions and whether students are able to manage the talk so that they use 'talking for thinking'.

Final conclusion

Dialogic teaching requires that teachers devote time to talking with and listening to their students so that they can shape their teaching in a way that is responsive to the students' needs and is focused at their cutting edge of learning. For teachers who are time poor, under pressure to just 'get things done' and who have to be accountable for the learning outcomes of diverse groups of students in a range of curriculum areas, devoting extra time to whole-class discussion might not seem essential. However, the teacher's capacity to work classroom discourse to sustain deeper interactions is fundamental to 'talking for thinking' and this study has shown that the students' willingness to engage lifted substantially when their teachers made room for them in the discussion and encouraged them to talk through their ideas. Such an outcome suggests that teachers' efforts would be well rewarded if they adjusted their focus away from just 'getting things done' to a space where taking time to conduct planned, purposeful discussions, which give students' a chance to talk, to listen and

to think through their ideas, is seen as a legitimate and essential element of effective classroom pedagogy.

For most teachers, adopting a dialogic teaching approach requires some change to their teaching practice - for some this may be a matter of fine-tuning their practice while for others this necessitates significant change. In any case, this study has demonstrated that to realise any change in their practice, the teachers also needed to work at the level of their beliefs and knowledge. This was no simple undertaking as it called for change at a deeper level. Such growth is difficult for teachers to achieve without time, support and guidance. Ultimately, schools, their communities and the education systems that teachers serve need to honour this work and to facilitate the kinds of quality professional learning that allow teachers to work at these deeper, more profound levels.

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Appendix 1

Overview of research design: Improving classroom discourse in inquiry-based primary science education

Primary research question

How does participation in an action-research professional learning process impact on teachers' beliefs, knowledge and practice of utilising communicative approaches in primary science teaching?

Secondary research questions

Research Question 1: What impact does the professional learning program have on teachers' beliefs about students' learning of science?

Research Question 2: What impact does the professional learning program have on teachers' beliefs, knowledge and practice to do with developing a classroom culture that is supportive of discourse?

Research Question 3: What impact does the professional learning program have on teachers' beliefs, knowledge and practice to do with using classroom discourse?

Research Question 4: What impact does the professional learning program have on teachers' knowledge and practice to do with using puppets in science?

Phases and stages	Case study data collections	Research Questions	Timeline
Initial data collections	Initial case study interview; Observation (O); Video (V); Interview (I)	Research Questions (RQs) 1-4	May 4 – May 29
Professional Learning (PL) Day 1	Questionnaire (Q)		June 2 & 3
PL Day 2	Q (PL feedback)	RQs 1-4	
Teach first unit			Terms 2 & 3
Engage phase	O, V, I	RQs 2-4	
Explain phase	O, V, I	RQs 2-4	
PL Day 3	Q (PL feedback)	RQs 1-4	August 31
Teach second unit			Term 3 & 4
Engage phase	O, V, I	RQs 2-4	
Explain phase	O, V, I	RQs 2-4	
PL Day 4	Q (PL feedback) Final case study interview	RQs 1-4	November 16

Appendix 2

Timeline for research	
2009	
May May 4-May 29	Presentation of research proposal. Submission of ethics application for case study teachers. Whole cohort: Pre-intervention observation, video & interviews. Case study teachers: Identify and contact potential participants.
June 2 & 3	Professional Learning Days 1 & 2. Whole cohort: Questionnaires, reflection tasks. Data analysis.
June 8-August 7	Case study teachers: Mid-intervention 1 observation, video & interviews. Data analysis.
August 31	Professional Learning Day 3. Whole cohort: Questionnaires, reflection tasks.
September 7-October 16	Case study teachers: Mid-intervention 2 observation, video & interviews.
October 19-November 13	Whole cohort: Post-intervention observation, video & interviews.
November 16	Professional Learning Day 4. Whole cohort: Questionnaires, reflection tasks.
December	Summary of data for Report to ORI, DET, AISWA.
2010	
January to March	Organisation of thesis. Data analysis and reporting on findings for first case study.
April to June	Data analysis and reporting on findings for first case study. Submission of draft of first case study, Chapter Four.
July to September	Data analysis and reporting on findings for second case study.
October to December	Data analysis and reporting on findings for second case study. Submission of draft of second case study, Chapter Five.
2011	
January to March	Data analysis and reporting on findings for third case study.
April to June	Data analysis and reporting on findings for third case study. Submission of draft of third case study, Chapter Six.
July to September	Cross-case analysis.
October to	Submission first draft Chapter 7 – Cross-case analysis.

December	
2012	
January to March	Submission second draft Chapter 7 – Cross-case analysis. Submission third draft Chapter 7 – Cross-case analysis.
April to June	Submission of draft Chapters: One – Introduction & statement of the problem; Two – Literature review; Three – Methodology & data collection.
July to September	Submission first draft Chapter 8 – Conclusions & recommendations.
October to December	Thesis review – self. Thesis review – supervisors. Final review & submission of thesis.

Appendix 3

Initial Case Study Teacher Interview	

Teacher: **Date:**

School: **Year level:**

6. Teachers' beliefs about classroom discourse and students' learning of science

How would you describe your approach to teaching primary science?

What are your reasons for constructing the learning in this way?

How do questioning and classroom discussion help students learn science concepts?

7. Teachers' knowledge about: discourse moves, communicative approaches, questioning technique, and classroom culture; and how these aspects influence opportunities for students' learning science through inquiry

What do you think a teacher needs to know about discussion and questioning techniques that would enable them to facilitate students' learning in primary science lessons?

What kinds of classroom environments foster students' interaction in primary science?

8. a) Teachers' use of communicative approaches and questioning

What do you think are important characteristics of classroom discussions in your science lessons?

b) Teachers' capacity to match these aspects to the phases of inquiry

Do you think your classroom discussions and use of questioning are different at different stages of a science lesson or different phases of a science unit?

9. Teacher's experience of the *Primary Connections* program

Do you use the *Primary Connections* resources? How long have you been using them?

Which professional learning have you completed and when? Are you a facilitator for in-school professional learning for *Primary Connections* or any other programs?

10. Current teaching context

Tell me something about that school you are currently working in.

Where is it located? Which community does it serve? How many students attend the school?

What can you tell me about the cultural and social backgrounds of the students who attend the school? What can you tell me about the focus of the school?

Tell me about your class.

What year level/s are you teaching? How many students and how many boys/girls? What can you tell me about their cultural and social backgrounds and their educational needs?

What conventions have you developed for behaviour management in your class?

What conventions have you developed for managing talk?

Appendix 4

Discourse Project: Initial Teacher Questionnaire

Dear Colleague

Thank you for contributing your expertise to this research and development project which will develop approaches and resources to enhance the quality of classroom talk in primary science. This questionnaire gathers information about your confidence and beliefs about managing classroom discourse. We request your name and school details for follow-up purposes only. Your responses will contribute to our overall picture of classroom talk in primary science teaching. Only the researchers will see your name. No person or school will be identified in any reports of this research.

Please answer this questionnaire honestly and frankly. Respond in the way that it is, rather than portraying things as you would like them to be seen.

Mark W Hackling

ID number

For office use only

Teacher background

Teacher name: _____

Name of School: _____

Which science topics did you teach this year? Please complete the table.

Term 1	Term 2	Term 3	Term 4

What year level is your class? _____

Or, are you teaching science to several classes at Years? _____

About science teaching

- Which do you believe are the three most important characteristics of effective primary science teaching practice?

  ○ _____

  ○ _____

  ○ _____

- What do you believe are the three most important characteristics of inquiry-based science teaching and learning?

  ○ _____

  ○ _____

  ○ _____

Confidence with science teaching

Please rate your confidence with the following aspects of science teaching by ticking the appropriate box after each statement.

VC = Very confident; C = Confident; LC = Limited confidence; NC = No confidence

Please tick INSIDE boxes and not on the line between boxes

Item	Aspect	VC	C	OK	LC	NC
1	Engaging students' interest in science					
2	Managing hands-on group activities in science					
3	Managing discussions and interpretation of science observations					
4	Explaining science concepts					
5	Teaching science processes					
6	Developing literacy skills needed for learning science					
7	Assessing children's learning in science					
8	Using computers and ICTs in science					
9	Using a constructivist model to plan science units of work					

Beliefs about being an effective manager of classroom talk

Please indicate the degree to which you agree or disagree with each of the statements below about managing classroom talk by ticking the appropriate box to the right of each statement:

SA = Strongly agree; A = Agree; UN = Uncertain; D = Disagree; SD = Strongly disagree

Please tick INSIDE boxes and not on the line between boxes

Item	Aspect	SA	A	UN	D	SD
1	I am efficient in establishing a classroom climate in which most students feel confident to give speculative answers to questions					
2	I am effective in posing open or closed questions to suit the purpose and flow of classroom discussions in science					
3	I am able to respond to student answers in ways that help develop an effective discussion of science ideas					
4	I am able to vary the type of classroom talk to match the instructional purpose of the phases of inquiry in science topics					
5	My rich knowledge of science helps me ask the right questions to develop science ideas through discussion					
6	My rich knowledge of science helps me respond appropriately to students' answers to my questions					
7	I use WAIT time effectively as a tool to enhance the quality of classroom discussion in science lessons					
8	I am typically able to respond to students' answers in ways that maintain and promote further discussion of the science ideas					
9	I am effective in encouraging and supporting students to ask questions in my science lessons					
10	I am effective in engaging most students in responding to my questions during science discussions					

11	I am able to sustain discussions so that we thoroughly discuss the science ideas					
12	I am effective in using questioning to identify students' prior knowledge and initial science understandings					

Questioning and classroom talk

- How do questioning and classroom discussion help students learn science concepts?

_____
_____
_____

- What does good classroom discussion look like?

_____
_____
_____

- Do you vary questioning and discussion style at different phases of a science lesson and/or topic? Please explain.

_____
_____
_____

Previous experience with puppets

- Please describe any previous use of puppets **in your teaching** and explain why you used them

_____
_____
_____

The project

- What do you hope to gain from participating in the project?

_____
_____
_____

Appendix 5

<table>
<tr><td colspan="3" align="center">***Lesson Observation Record***</td></tr>
<tr><td>School:</td><td>Teacher:</td><td>Year Level:</td></tr>
<tr><td>Date:</td><td>Time:</td><td></td></tr>
<tr><td colspan="3">Students (total number, M/F, other):</td></tr>
<tr><td colspan="3">Students not to be videoed (non-video, NV), description & location in shot</td></tr>
<tr><td colspan="3">Unit (*Primary Connections,* other):</td></tr>
<tr><td colspan="2">Phase of inquiry:</td><td>Lesson no.:</td></tr>
<tr><td colspan="3">Lesson name:</td></tr>
</table>

Lesson observation protocol

1. Contact teacher to check status of parent permissions and implications for student grouping several days before the lesson observation and video recording. Students without parental consent must be placed out of shot or in another teacher's class.

2. Set-up camera and microphone and conduct sound and light checks. Use a wide angle shot so that the camera does not have to be moved too often to track the teacher. The teacher needs to remain in-shot and also need to include students who respond to questions. Run a dummy recording for 90 minutes to accustom the teacher and students to being recorded prior to the actual lesson that is to be observed and video recorded.

3. Insert the background data about the teacher and lesson in the first two tables prior to commencement of the lesson.

4. As the lesson progresses record codes for the *Instructional setting* in the third table, as:

   WC – whole class; SG – small group; IW – individual work

5. As the lesson progresses record the *Nature of activity* as a phrase that describes the instructional/content focus of the activity (e.g., exploring students' ideas about X, students plant seeds, teacher elicits student observations etc.) for each segment of a lesson that has a given instructional setting.

6. Use ticks in the right hand column of the third table to identify parts of the lesson to be subjected to discourse analysis.

7. Immediately after the lesson, complete the fourth table to give your overall impressions of the teacher's management of classroom discourse and record issues to be followed-up in a post-observation interview in the final table.

<table>
<tr><td colspan="2">Classroom observer:</td></tr>
<tr><td>Reviewer of MP4:</td><td>Editor:</td></tr>
</table>

Time (on video)	**Instructional setting (WC, SG, IW) & nature of activity**	**Analyse ✓**	**Editing**	
			Time	Edit

Classroom culture - openness to inquiry; encouragement of student involvement in public discourse:

Communicative approaches:

Question types:

Use of WAIT time:

Evaluation of student responses:

Events observed in the lesson to be explored in post observation interview:

Appendix 6

Teacher: **Date:**

School: **Year level:**

1. **Questions to open the discussion**

    Tell me about the science lesson that I observed. Did it go as you had planned?

2. **Questions relating to particular phases of the inquiry**

    a) For lessons in the Engage Phase

    How did you engage the students in the topic (inquiry)?

    What prior understandings of the topic did the students' bring to the investigation?

    How did you ascertain what those were?

    b) For lessons in the Explain Phase

    What is the intended learning outcome of the unit and what did you do in the Engage phase to get the children to start to think about the topic?

    What did the students do during the Explore phase to investigate the topic further?

    So in this Explain lesson, how did you support the students to seek out patterns and relationships within their observations and to develop scientific explanations?

    How did you manage to make the science explanation explicit?

    What kinds of literacy products have the students produced to represent their ideas?

3. **Questions relating to communicative approaches and questioning:**

    a) Teachers' use of communicative approaches and questioning

    How would you describe your interaction with the students in this lesson?

    What kinds of questioning did you use?

    What kinds of interaction were you seeking to achieve in this lesson?

    How did you encourage the students to interact?

    b) Teachers' capacity to construct a classroom culture that supports sustained conversations

    What would you say about the level of student participation (numbers of students participating and the frequency with which they participated) in the conversation?

    What kinds of contributions did the students make to the discussion? (Focused on the science

concepts; procedural matters - what do we do now/next)

What kinds of contributions did you make to the discussion? (Managing the discussion, including students; reinforcing use of conventions for talk; building understanding of concepts; other)

What would you say about the students' capacity to sustain science-focused conversations at this point?

Any events from the lesson that were identified for further exploration (see Lesson Observation Record).

Is there anything else that you would like to say about the lesson or about your reflection on the lesson?

Appendix 7

Discourse Project: PL Day 3 Review
Teacher _____   Year group _____
Using puppets to engage students and enhance discourse
What have you been using puppets for?

What has worked well?	Why?
What has been difficult?	Why?

Managing classroom discourse
What strategies have you been working on?

What has worked well?	Why?
What has been difficult?	Why?

Appendix 8

## *Discourse Project: Final Teacher Questionnaire*

Dear Colleague

Thank you for contributing your expertise to this research and development project which is developing approaches and resources to enhance the quality of classroom talk in primary science. This questionnaire gathers information about your confidence and beliefs about managing classroom discourse. We request your name only so that we can match your initial and final questionnaires. Your responses will contribute to our overall picture of classroom talk in primary science teaching. Only the researchers will see your name. No person or school will be identified in any reports of this research.

Please answer this questionnaire honestly and frankly. Respond in the way that it is, rather than portraying things as you would like them to be seen.

Mark W Hackling

ID number

For office use only

Teacher background

Teacher name: _____

Which science topics did you teach this year? Please complete the table.

Term 1	Term 2	Term 3	Term 4

About science teaching

- Which do you believe are the **three** most important characteristics of **effective primary science teaching practice**?

  ○ _____

  ○ _____

  ○ _____

- What do you believe are the **three** most important characteristics of **inquiry-based science teaching and learning**?

  ○ _____

  ○ _____

  ○ _____

Confidence with science teaching

Please rate your confidence with the following aspects of science teaching by ticking the appropriate box after each statement.

VC = Very confident; C = Confident; LC = Limited confidence; NC = No confidence

Please tick INSIDE boxes and not on the line between boxes

Item	Aspect	VC	C	OK	LC	NC
1	Engaging students' interest in science					
2	Managing hands-on group activities in science					
3	Managing discussions and interpretation of science observations					
4	Explaining science concepts					
5	Teaching science processes					
6	Developing literacy skills needed for learning science					
7	Assessing children's learning in science					
8	Using computers and ICTs in science					
9	Using a constructivist model to plan science units					

Please indicate the degree to which you agree or disagree with each of the statements below about managing classroom talk by ticking the appropriate box to the right of each statement:

SA = Strongly agree; A = Agree; UN = Uncertain; D = Disagree; SD = Strongly disagree

Please tick INSIDE boxes and not on the line between boxes

Item	Aspect	SA	A	UN	D	SD
1	I am efficient in establishing a classroom climate in which most students feel confident to give speculative answers to questions					
2	I am effective in posing open or closed questions to suit the purpose and flow of classroom discussions in science					
3	I am able to respond to student answers in ways that help develop an effective discussion of science ideas					
4	I am able to vary the type of classroom talk to match the instructional purpose of the phases of inquiry in science topics					
5	My rich knowledge of science helps me ask the right questions to develop science ideas through discussion					
6	My rich knowledge of science helps me respond appropriately to students' answers to my questions					
7	I use WAIT time effectively as a tool to enhance the quality of classroom discussion in science lessons					
8	I am typically able to respond to students' answers in ways that maintain and promote further discussion of the science ideas					
9	I am effective in encouraging and supporting students to ask questions in my science lessons					
10	I am effective in engaging most students in responding to my questions during science discussions					
11	I am able to sustain discussions so that we thoroughly discuss the science ideas					
12	I am effective in using questioning to identify students' prior knowledge and initial science understandings					

Questioning and classroom talk

- How do questioning and classroom discussion help students learn science concepts?

_____
_____
_____

- What does good classroom discussion look like?

_____
_____
_____

- Do you vary questioning and discussion style at different phases of a science lesson and/or topic? Please explain.

_____
_____
_____

Puppets

- To what extent did you use puppets in your science teaching? What were they used for?

_____
_____
_____

- What difficulties, if any, did you encounter with using puppets?

_____
_____
_____

How confident are you now with using puppets in your science teaching? Indicate by ticking the scale below.

Very confident	Confident	OK	Limited Confidence	No Confidence

- What impact did the puppets have on student engagement and talk?

_____
_____
_____

- How has your participation impacted on your teaching practice?

_____
_____
_____

- How has your participation in this project impacted on the quality of classroom talk?

_____

_____

_____

- What aspects of talking science would you like to work on next?

_____

_____

_____

Thank you for completing this questionnaire. The data will be most valuable.

Appendix 9

Final Case Study Teacher Interview	

Teacher: **Date:**

School: **Year level:**

1. **Reasons for participating in the *Discourse Project***

   What were your initial reasons for participating in the *Discourse Project*? What did you hope to gain?

   Having reached the end of the project, what do you think you have been able to achieve?

2. **Teacher's educational background**

   Tell me something about your school years. What kind of primary and secondary school did you attend? (Government, Catholic, independent; metro, rural, remote; single sex or co-educational; other)

   Can you tell me about your experience of learning science in primary school? What were you like at science?

   Did you pursue science at high school?

   Did you gain any qualifications in science at school/university?

3. **Teaching experiences**

   How many years have you been teaching (up to 2009)?

   Where? What kinds of schools? Which year levels? How long in each position?

   What teaching roles have you taken on? (General class teacher; curriculum co-ordinator, support; administrative; other)

   What sort of experiences have you had as a science teacher?

   How easy is it to teach science at your school? (Access to adequate curriculum resources, materials, support)

   How well do you think your teacher education prepared you to teach primary science? (Confidence, knowledge of science content and processes)

   How do you feel about your preparedness to teach primary science now?

   Is there anything further that you would like to say or to feedback about the Discourse project?

Appendix 10

Codes developed to analyse classroom discourse	
Code	**Definition of code**
Teacher questions	
Closed	Elicits a limited number of response options.
Open - ideas	Elicits ideas. Includes 'What do you think?'
Open - description	Elicits a description. Includes 'What do you see?' 'What happened?'
Open – explanation/reason	Elicits an explanation (why something is so) or a reason to justify a claim (how do you know).
Teacher discourse moves	
Directed question	Teacher directs a question to a named student.
Turn taking (teacher nominated)	Teacher nominates one student after another to respond without calling for elaboration or explanation of their ideas.
Wait Time	Teacher pauses for greater than "one and two" (WAIT time) after asking a question (WT1) or after a student's response (WT2).
Extended Thinking Time	Teacher extends thinking time using strategies other than Wait Time, e.g. Think-Pair-Share, Thinking Time, writing a draft, other.
Recast the question	Teacher does not receive an answer or receives an unsuitable response and rephrases the question.
Teacher restates	Teacher repeats or restates what has been said.
Restate/clarify	Teacher asks a student to restate so audible to class or to clarify what was said.
Reframe	Teacher rephrases a student answer to improve expression.
Reframe scientifically	Teacher rephrases student answer to correct science.
Elaborate	Teacher asks for elaboration of a response (to say more about it).
Prompt and scaffold	Teacher provides cues before or after a question to prompt/scaffold student's responses.
Refocus	Teacher summarises to consolidate and refocus the discussion.
Teacher uptake	Teacher asks a follow-up question that includes (builds on) part of a previous answer.
Checks for consensus	Teacher asks the class to indicate who agrees with an idea.
Ignore	Teacher ignores a student response.
Acknowledge only	Teacher just acknowledges a student response with no further interaction.
Evaluate	Teacher indicates whether an answer is correct or incorrect.
Asks for other ideas	Teacher asks for other (different) ideas.
Moves on	Teacher asks a question which changes the focus of discussion.
Quality of student talk	

Description	Student provides descriptions of objects or events currently being observed or previously experienced. Coded as *unistructural* when one aspect is reported and *multistructural* when two or more aspects are reported.
Explanation	Student provides an explanation of how or why it is so and may include explanations of what is likely to happen next.
Reasoning	Student provides reasoning. Includes some scientific reason to justify an explanation.
Elaborated utterance	Student utterance is greater than 100 characters of transcript.