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Teachers Using Dialogue to Support Science Learning in the Primary Classroom

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Abstract
The importance of using dialogue as a pedagogical tool to enhance student learning in science has been widely recognised in research literature. Effective classroom dialogue is dependent upon teaching which successfully engages students in critical thinking and deep learning, requiring many teachers to think and work differently in science education. To understand the implications of such pedagogy for teaching practice, it is vital to determine how teachers presently consider and enact the role of dialogue in their science teaching. The study discussed in this paper examines how four primary teachers think about and use dialogue to develop scientific thinking and understanding in their primary classrooms. The study was conducted with teachers working in an inner city, primary school in Melbourne, Australia. Data sets included in-depth, semi-structured interviews conducted with the participant teachers, along with three classroom observation sessions recorded with small groups in each participant teacher's classroom. A talk analysis framework, informed by existing literature, was developed and applied to the classroom observation data. Key findings emerged which identified the teacher as critical to the development of effective dialogue, determining the degree of time provided for dialogue, the nature of the interactions taking place and the questioning used to both promote student reasoning and also challenge student thinking. The analysis also raises considerations about appropriate expectations of higher level thinking in any given dialogue and supports a position which sees worthwhile value for students in building teacher knowledge and capacity to enact effective dialogue in science.

Keywords Dialogue · Science · Primary teachers · High-level thinking

Introduction

It is now widely recognised that effective classroom dialogue, enacted by both teacher and student, improves student learning of science particularly when teachers use dialogue as a key pedagogical

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tool in their classrooms. When used effectively, dialogue has been shown to develop student reasoning, leading to higher order thinking and educational gains (Mercer and Littleton 2007; Wells 2015). However, research also indicates that, while dialogue is highly regarded by teachers, it tends to be taken for granted and can be an under-examined factor of both teacher education and practice (Edwards-Groves and Hoare 2012). There is also a concern that many teachers do not have a good grasp of how dialogue can contribute to such higher order learning and consequently many teachers lack strategies to use talk to best effect (Mercer et al. 2009). The goal of this research was to identify how primary teachers think about and use dialogue in primary classrooms to promote science learning.

Defining Dialogue

Dialogue can be understood as a tool or strategy that enables participants to take their thinking to a higher level, improving knowledge with a focus on discovering new understandings and developing greater insights (Mercer and Dawes 2014). Dialogue, unlike conversation, is a process of inquiry, requiring a participant to reflect on their own thoughts and that of the other participants (Lipman 2003). According to Bohm (2013), in dialogue, participants momentarily suppress their own opinions to focus and consider the opinions of others. Barnes (2010) used the terminology of 'talk' in the same way dialogue has been employed, suggesting that 'talk' is not about responding with the right answer but encouraging active learning and thinking, developing a student for the world in which they live. Barnes (2010) also argued that effective dialogue allows participants to experience diverse ways of thinking and as a consequence develop deeper understandings. Similarly, Gee (2004) referred to dialogue as something that develops meaning, involving the use of language to not only convey one's understandings but also to construct understanding.

Dialogue therefore enables students to make sense of their world and assists in the development of their intellectual capabilities (Mercer and Littleton 2007; Wells 2015). A classroom featuring effective dialogue is capable of developing rich and deep understandings of concepts, promoting and extending students' higher order thinking and encouraging communication proficiency (Alexander 2008; Dickinson and Porche 2011; Mercer and Littleton 2007; Wells 2009). A classroom lacking dialogue might therefore deny the teacher access to students' beliefs and their level of understanding, impacting negatively on future planning for learning (Alexander 2008).

The Relationship Between Dialogue and Science Learning

Research indicates that the key to developing students' understanding of scientific concepts is through dialogue (Loxley et al. 2017; Mercer and Hodgkinson 2008; Scott 2008). A variety of terms, e.g. dialogue, discourse and talk, appear in research literature expressing a key idea that students require time to talk in order to build meaning from information and experiences in science education (Edwards-Groves and Hoare 2012; Loxley et al. 2017; Mercer and Hodgkinson 2008; Scott 2008). Mercer (2016) highlights the importance of teachers providing opportunities where they model and provide explicit information which enables their students to develop the skills needed to interact and develop collective thinking with their peers. Effective dialogue provides such opportunity.

Effective dialogue also plays an important role in the development of scientific literacy, a valued outcome of science learning. Scientific literacy is recognised as the goal and purpose of science education and is viewed as a broad concept which de Boer (2000) defined as the 'science' that citizens need to function effectively in the world. Scott and Ametller (2007) suggested that the

priority for science teachers should be in assisting the student to think and talk like a member of the science community. Barnes (2010) stated that functioning in the twenty-first century requires people who can think for themselves and make informed decisions about their world, referring to students as active learners, that is, learners who involve themselves fully in their learning. Such students might be described by Mitchell et al. (2009) as 'good learners' being those who use metacognitive strategies, such as asking questions, while checking when they do not understand. The important role dialogue plays in the scientific literacy classroom must be acknowledged and fully understood by the teacher who must also be equipped to teach the appropriate communication skills (Dobber and van Oers 2015).

The vital role dialogue plays in science learning can be summarised using the three main arguments of Dobber and van Oers (2015) as to why dialogue is necessary for science learning:

1. Dialogue assists students to build understanding, improve critical thinking and test new thinking.
2. Dialogue assists students to form a realistic, workable view of science.
3. Dialogue enables students to become scientifically literate—a necessity in the twenty-first century.

Implementing Classroom Dialogue—Creating the Right Conditions

To be meaningful, dialogue in science must be interactive. Scott (2008) suggests that dialogue within a science classroom must involve both student and teacher, and therefore becomes dialogic. Students must therefore be taught communicative skills that allow for the effective use of language so they can fully engage in their learning environment (Dobber and van Oers 2015). Effective learning remains inaccessible to students who lack the language skills to negotiate, reason and co-construct meaning with others (Jackson 1987). Littleton et al. (2005) suggested that it is within this community of inquiry that students learn to engage with others, making meaning of their learning. The teacher plays an important role in facilitating the use of dialogue by establishing an environment conducive to talk, constructing ground rules for interaction with others, modelling values and behaviours, and orchestrating who talks and when (Alexander 2008). Mercer and Dawes (2008) suggested that jointly constructed and mutually agreed ground rules for student dialogue must be established between the teacher and students in order to create a talk that involves reasoning and higher order thinking. Such ground rules might include:

- Constructive and critical engagement
- Participation by all
- All ideas and opinions are treated with respect
- Ideas can be challenged by others
- Challenging must be justified
- Decisions are made only after consultation with all participants
- Knowledge is shared to allow for reasoning

Mercer and Littleton (2007) believe that successfully creating such conditions relies upon a teacher's knowledge of science content, their knowledge of language, and their ability to apply a varied use of dialogue to promote learning. However, Mercer et al. (2009) also suggest that teachers lack a deep level of understanding about dialogue and few have strategies to

implement effective talk in their classrooms. While talk is an essential tool for teachers, the literature suggests that nurturing effective talk that is dialogic in nature is not easy for teachers.

The Role of the Teacher in Facilitating Effective Dialogue in Science

Teachers express their desire to inspire active learners; however, they are not always sure what this entails. According to Barnes (2010), facilitating dialogic talk in the classroom is difficult and teachers require much knowledge and skill. Godinho and Shrimpton (2003) stated that dialogue which promotes higher order thinking, such as exploratory talk, is dependent on three elements: firstly, the students' awareness of the discussion process; secondly, the teacher's ability to support students; and lastly, a classroom climate that supports collaborative inquiry. Mercer and Littleton (2007) suggest teachers use four strategies to increase the quality of student talk:

- use high-level thinking: encourage student ideas
- respond to student responses
- use open-ended questions and
- encourage student responses before giving feedback

These strategies however are not always prevalent in science classrooms and rely on teachers developing particular skills and awareness to nurture and create conditions conducive to dialogue such as creating different styles of communication, dialogic patterns and the development of high-level questioning skills.

A skilful science teacher will move between different styles of communication to achieve the intended learning (Scott 2008). Mortimer and Scott (2003) developed an approach to teaching called the communicative approach outlining the different styles a teacher might utilise in order to facilitate learning for their students. Depending on the purpose of the lesson, the teacher may use an interactive, dialogic, non-interactive or authoritative approach. In order to create a meaningful talk that is necessary for effective science learning, teachers need to move between dialogic and authoritative approaches to teaching (Mercer and Dawes 2014).

High-level questioning skills are also required of teachers working to facilitate effective dialogue in the science classroom. For genuine inquiry into a topic, students require the ability to ask and answer questions. Teachers' facilitation of this by the use of questions that require high-level thinking is recommended to enhance student use of reasoning and evaluation (Hardman 2008). As suggested by King (2002), unless teacher support is given, students will not enter into dialogic talk or exploratory talk on their own. Low-quality student dialogue can be attributed to poor-quality questions from teachers (Tofade et al. 2013). Research based on the traditional initiation, response, feedback (IRF) talk pattern, often used by teachers, found that teachers predominantly used closed questions during discussions with their students (Hardman 2008). Kawalkar and Vijapurkar (2011) proposed that lower cognitive and closed-ended teacher questions, used to evaluate student knowledge rather than encourage dialogue, must be replaced by higher cognitive and open-ended questions such as those used in an inquiry-based science classroom.

The attainment of scientific skills and knowledge through the use of dialogue is therefore primarily dependent on the classroom teacher's understandings about and implementation of skills in relation to dialogic patterns. Classroom dialogic patterns are determined by teacher decisions about the purpose and intentions of a lesson. Therefore, to understand more about the role of dialogue in science education, it is essential to explore teachers' intentions for using dialogue and identify how they attend to or enact these intentions in their classroom teaching.

Method

The research discussed in this article set out to identify how teachers think about and use dialogue in their classroom to promote science learning. A qualitative approach was used to examine teacher thinking and also explore the alignment of this thinking with teaching practice. Although the study was predominantly qualitative in nature, a small amount of quantitative data were analysed and used to calculate the frequency and types of teacher initiations, feedback and student responses that took place in classroom sessions.

Participants

This study involved both teacher and student participants from one primary school in an inner-city location in Melbourne, Australia. A purposive sampling method was applied to ensure that only those teachers who had specific relevance to the research questions being asked (Becker et al. 2012) were strategically chosen from the teaching staff.

Teachers were chosen based on the following criteria:

1. Had worked at the school for three or more years
2. Had participated in a school-based professional development program on scientific literacy

As a result, four experienced teachers who were considered knowledgeable in the area of scientific literacy were invited to take part. These four teacher participants had recently undertaken professional learning related to developing scientific literacy and were therefore considered to hold some knowledge about promoting scientific literacy in the classroom. All four teachers considered themselves to be a generalist classroom teacher, and each participant was teaching a class from one of the first four year levels of schooling, i.e. foundation (the first year of primary school) to grade 3. Three participant teachers were female and one male. Teaching experience ranged between 5 and 20 years.

Student participants were aged between 5 to 9 years and were selected from the participating teachers' own classes. Four to eight students were recruited from each class with assistance from the classroom teacher to ensure the sessions were purposeful and a mix of both boys and girls were selected. These students were observed working in small group sessions with their classroom teacher within the body of the whole classroom.

Data Collection

The analysis involved two stages:

- Stage 1: individual teacher interviews
- Stage 2: observation notes of teacher and student small group sessions (three sessions per class conducted over a series of weeks)

Stage 1 Data were collected individually from the four classroom teachers via semi-structured interviews to allow teachers to discuss related ideas and concepts. The teachers were encouraged to enter into a conversation on dialogue and scientific literacy and give their own beliefs and experiences. During the interview, the following questions were asked:

- What do you consider as effective classroom dialogue?
- How do you evoke thoughtful reflection in which all students are encouraged to take part?
- How does dialogue create opportunity for students to think and express their ideas during science lessons?
- What factors facilitate effective classroom dialogue in science learning?
- How do you get students to begin to actively engage in substantive dialogue?

The interviews were audio taped and later transcribed. This allowed the researcher to make sense of the data in relation to the interview questions and the research discussed in the literature review.

Stage 2 Data via observations of small group sessions involving both the teacher and four to eight students were collected. Three small group sessions per class were audio recorded and transcribed. The observation sessions were part of regular classroom work and took place within the learning space. Each of the four classes was using an inquiry process to explore the concept of 'sustainability' at the time.

Data Analysis

Data were analysed applying discourse analysis, informed by existing literature, which enabled investigation into both teacher and student language. In both teacher interviews and classroom observation data sets, teachers' perceptions and actions were analysed to identify strategies employed that promote student dialogue and science learning. In the observations, teacher and student talk were analysed to identify various discourse styles within initiation, response and feedback (Sinclair and Coulthard 1975). An in-depth analysis of the acts made within the IRF talk pattern was conducted (Hardman 2008). As previously stated, although the study was predominantly qualitative in nature, a small amount of quantitative data were analysed and used to calculate the frequency and types of teacher initiations, feedback and student responses. A talk analysis was devised to explore the dialogic patterns that evolved during the sessions. This framework was derived from the work of several researchers: Hardman (2008); Smith (2013); Zhai and Tan (2015). Tables 1 and 2 provide the codes used to analyse the data and definitions of each code.

The coding used to analyse teacher talk during classroom observations was adapted from a study conducted by Hardman et al. (2003) on literacy and numeracy in primary classrooms.

Student responses were analysed using coding adapted from Smith (2013). Details of this coding framework are listed in Table 2.

The data analysis also enabled a consideration of the alignment between teacher intentions and the reality of teaching practice.

Results

Teacher Beliefs About the Role of Dialogue in Science Teaching

During the interviews, all four teachers spoke about dialogue in contemporary science teaching being used first and foremost to establish student engagement, evoke an emotive response and explore ideas and beliefs within an inquiry approach. The belief that scientific concepts were developed through dialogue was also evident in all the teacher interviews. All teachers stated

Table 1 Coding framework used to analyse teacher talk during observations

Code	Definition of code
Teacher check	Teacher checks with a student if this is what they mean or if they are alright with the conversation
Clue	Teacher supplies the student with a clue
Comment	Teacher makes a comment about what is being said, comments on a student's response
Direct	Teacher directs the conversation, moves the conversation on
Evaluation	Teacher supplies the student with an evaluation of their response
Teacher question	Teachers asks a question
Nomination	Teacher nominates a student to talk or respond
Repeat	Teacher repeats a student's response
Prompt	Teacher prompts a student to respond
Reply	Teacher gives a short reply, one or two words
Starter	Teacher starts a conversation, sets the scene

that recent professional development had enabled a shift in personal thinking that had led them to believe scientific understandings were built upon and deepened when students engaged in deep–talk with their peers and teachers. One teacher stated that dialogue was 'invaluable in terms of moving the students beyond their own perspectives towards a more scientific viewpoint'. The importance of having knowledge of students' thinking was discussed by all teachers. One teacher suggested that, through dialogue, 'Teachers can gain insight into their [students'] thinking'. Building knowledge of what students were thinking was seen as vital for preparing lessons and ensuring effective dialogue. All four teachers believed that they now taught science in a way that enabled them to use dialogue to engage student interest and encouraged students to reflect upon their personal thinking and learning.

Teacher Beliefs About the Nature of Dialogue in Science Education

Higher Order Thinking

The teachers believed that dialogue, as opposed to other forms of classroom talk, enabled a change in student thinking. One teacher stated that dialogue enabled students to enter into 'a different level of thinking, a deeper level of thinking'. Most of the teachers proposed that having an open mind to ideas was necessary for students when participating in dialogue in order to challenge one's thinking.

Table 2 Coding framework used to analyse student talk during observations

Code	Definition of code
Reply	Student replies with a yes or no or with a one or two word response
Statement	Students make statements or declarations whereby they express facts or opinions
Explanation	Student provides an explanation of how or why it is so
Reasoning	Student provides reasoning, may suggest what may happen next. Provides evidence to support a proposition or position. May justify using scientific reasons
Challenge	Student challenges, rebuts or contests another's position. May supply an alternative explanation
Open question	Student asks a question that is designed to stimulate further discussion or provide information
Closed question	Student asks a question that is designed to elicit short, unelaborated responses

The notion that dialogue had depth and required higher order thinking was a key idea that appeared in all four of the teacher interviews. Classroom dialogue was viewed as an opportunity for students to openly share their own ideas, build on each other's ideas and knowledge and broaden and change their thinking.

Sustained Interactions

Teachers did not merely view dialogue as being substantive in regard to thinking and meaning but also in terms of length or duration, that is, its ability to be ongoing. Teachers acknowledged that if dialogue was to broaden thinking, then time was needed for ideas to be shared, considered, challenged and deepened. One teacher stated that dialogue is when students 'build on or further develop what the previous person has just said', thus deepening the thought process.

Teacher Beliefs About Role of the Teacher as a Dialogue Facilitator

The belief that the teacher plays a significant role in developing dialogue within a science classroom arose in all of the teacher interviews. When speaking about the role of the teacher, the terms facilitator and scaffolder were referred to many times throughout the interview transcripts. All four teachers positioned themselves as fellow learners on a journey with their students rather than a person who only gave instructions and held all the answers. One teacher stated 'it's about, as a teacher, leading or facilitating the dialogue'.

Establishing a Conducive Environment

All four teachers believed that the teacher played a key role in developing dialogue in a science classroom. They stated that the teacher must begin by establishing a classroom environment that would enhance dialogue, facilitate conversation and provide a scaffold for students to develop their own thinking. Each teacher spoke about the importance of teachers creating a safe environment that would encourage students to express their feelings and ideas. The teachers also considered that allowing time for their students to talk was vital in ensuring student engagement and ownership of the learning. The teachers spoke about the need to scaffold learning through dialogue when exploring science content; it was important for the teacher to use dialogue to make links between student conceptions and accepted scientific understandings. One teacher emphasised the importance of introducing scientific terminology to students, believing that learning new words empowered the students and enabled them to feel confident when learning something new.

When interviewed, one teacher suggested that good dialogue would involve students talking for 80% of the time with teachers facilitating 20% of the time, thereby allowing students time to interact with each other and build on ideas. The teachers talked about the importance of giving students opportunities to build upon each other's statements and challenge each other.

All four teachers spoke of the need to teach students explicit skills and use effective strategies to enhance dialogue in order to nurture what one teacher called 'little scientists'. They stated that the role of the teacher is to not only model good questioning for students but to encourage their students to ask questions of their peers and teachers to seek clarification and deepen understanding.

Exploring Dialogue in Teaching Practice

Encouraging Student Talk

The interview responses indicated that teachers believed deep thinking would be more likely to occur when students were given time to talk and that allowing their students time to talk was vital in ensuring student engagement and ownership of the learning. The following extract illustrates the type of student-teacher interaction where there was an alignment between such intentions and classroom practice, where the teacher actively encourages students to keep talking and in doing so encourages students to engage in a deeper level of thinking (Table 3).

While all the teachers emphasised the importance of allowing student's time to interact with each other and build on ideas, one teacher had stated a belief that good dialogue would involve students talking for 80% of the time with teachers facilitating 20% of the time, yet this belief was not always consistently reflected in classroom interactions. Data showed that in two classes, the student to teacher speaking ratio were almost 2:1, allowing for many student-to-student talk patterns; however, in the remaining two classes, student and teacher speaking ratios were even, resulting in only teacher-student exchange patterns.

The Nature of Scaffolding

While the teacher speaking ratio was not always in line with teacher beliefs about effective dialogue, further analysis showed that much of this teacher talk was, in fact, used to scaffold students' learning. When examining the teacher talk in two classes where teacher and student talk ratios were mostly even, most utterances made by the teacher in these sessions could be classified as scaffolding, providing prompts, direction, evaluation and repeating what the student had said to provide clarity.

Teacher talk was analysed using the following codes: direct, comment, open question, starter and other, which included closed question, nomination and check (see Table 2). Teacher talk was examined to determine whether they provided the scaffolding suggested by the teachers as necessary to create effective dialogue. The data showed that three out of four teachers most frequently used talk that was categorised as a 'direct' when making extended utterances—that is, the teacher was directing the conversation or moving the conversation on—and this was followed by open-ended questions and comments. The data also revealed

Table 3 Transcript

Speaker	Text
Teacher	What does it mean to you?
S1	Ahh, it means, well when I'm older I know that I can sustain, I can make changes to the world.
Teacher	You can make changes to the world. Hmm, what I loved yesterday was hearing some people's words like 'confident'. Do you feel confident about making changes?
S1	Yes, I feel really confident.
Teacher	That's so powerful is not it! How are you feeling about this task?
S2	Well I was feeling like, what do the hats [de Bono's Thinking Hats] mean? And I was thinking that when you type some of the stuff up, I built on what other people are saying and I added onto them and then they added on to me.
Teacher	And why is it [dialogue with other students] important to you?
S2	Because they could give me new ideas and I could share my ideas with them.

that three out of the four teachers mainly asked open-ended questions as opposed to closed. Two out of the four teachers did not ask questions that required students to use meta-analysis, which is reasoning or evidence to support an argument.

The transcript below is an example of a teacher shifting the level of conversation from everyday knowledge to a scientific perspective. The teacher clarified the definition of nutrition for the group and this encouraged one of the students to then make a link between nutrition and exercise (Table 4).

Much teacher talk about fostering deep thinking and encouraging students to move to a different level of thinking appeared in all twelve of the observations. One teacher encouraged their students to think more deeply using 'why' and 'how' open questions and made direct pleas to provide 'reasons', such as 'Why is that important?', 'How does that relate to us?' and 'How does that happen?'

One teacher explicitly directed the students with their thinking in terms of going deeper. The teacher constantly prompted the students to think more deeply and build upon other ideas and thoughts in order to create what they called 'good dialogue'. Examples of such teacher prompts included 'We want to explore a new idea, so hopefully deepening what you are thinking', 'Can I extend what you are saying?' and 'So who could build on from what Hamish has said?' The transcript below (Table 5) gives evidence of a teacher prompting one of the students to think more deeply and produce reasoning:

Teacher Practice and the Nature of Student Dialogue

All teachers valued the role of dialogue in promoting deeper student thinking. While evidence of deeper thinking occurred in a majority of the observations across the four-year levels (11 out of the 12 sessions recorded evidence of either reasoning and/or challenges), the data showed that the use of these response types was low overall. Students made statements 47% of the time, followed by explanations 33%, replies 13%, reasoning 5% and challenges only 0.9% of the time when talking. The results showed that, during the 12 observations, more than half the students' responses were low-level responses, such as replies and statements. The following extract shows evidence of higher level thinking where the student initially responded to the teacher with an explanation and then responded using reasoning (Table 6).

Two out of the four teachers did not ask questions that required students to use meta-analysis, that is, reasoning or evidence to support an argument as seen in the previous example. However, reasoned responses from students were recorded in both of these classrooms. Questions that prompted meta-analysis were used by two of the teachers with very different

Table 4 Transcript

Speaker	Text
S1	I've seen that some people do not even want to be nutritional; they stay in bed for 3 years and do not get out.
Teacher	Is nutrition about not exercising? Or is nutrition about those food groups that were mentioned earlier?
S2	Yes and well nutrition can link to exercising because you need to eat nutritional food to have energy to exercise.
Teacher	So is nutrition about the food you eat and whether or not you lie in bed all day? Exercise is not nutrition. Nutrition is the food?
S2	Yes, that sounds right.

Table 5 Transcript

Teacher	Why would researching an animal help sustain our life, or sustain the Earth?
S1	Well maybe if like they are getting extinct, getting endangered, you can know what to do, how to look after them.
Teacher	I like that you bought in that word endangered. Tell me more about it.
S1	Endangered is like, let us say, like one animal dies and then they keep killing that type of animal. It's like a food chain, one animal dies and then they keep killing that breed of animal and then they start again with another type and then they get extinct and umm (pause).
Teacher	Can we go a bit deeper or can we build on what we are saying about endangered animals, obviously they have classifications that's what we call classifications on whether animals are extinct or endangered do you think those classifications help scientists decide what to research?
S1	Um yes because like if you do not know what to research it's a bit hard to think, then if you find something new to research you can get new information and then you can put it on the Internet or put it in books or whatever and you can show the world what this animal is. What it eats how much time it sleeps for and what not.

responses from students. One class recorded reasoning while the other mostly statements and explanations.

Despite the low frequency of responses using meta-analysis, the data provided examples of students' responses categorised as challenges. The following extract (Table 7) shows evidence of a student challenging another student:

The results showed that in three out of the four classrooms, students made statements the majority of the time when speaking, followed by explanations as the second most frequent response type. Students, although making statements and replies most of the time, which might be considered fairly low-level thinking, also responded using many explanations during the observations. The previous extract shows evidence of a student challenging the thinking of another student, while stimulating further thoughts from a third participant. The initial question posed by the teacher was critical in sparking these interactions. However, challenges made by students did not always stimulate further thinking or use of reasoning in other students; many challenges were followed by statements.

Responses using reasoning mostly came from the students who spoke most frequently and also spoke at length. However, utterances recorded in another class found that responses using reasoning came from a student who spoke for the least number of turns and did not record long utterances. The following extract shows evidence of students using reasoning. Student 1, as seen in the transcript below, recorded some of the longest utterances in her class and made

Table 6 Transcript

Speaker	Text
Teacher	So you said scientists research important things and you said diseases, sicknesses and living things, you are saying we research these things and it is important because they help to sustain human life. Can we build on that any further about sustaining human life, living things, sicknesses and illnesses?
S1	Yeah so, I was going to say that human life, well it's like dominoes, if one person gets the disease and then they cough on someone else, then they will catch the disease and then and then they might like sniff on someone else or something and it keeps going on. (Explanation)
Teacher	So, what should scientists research about that, about passing on disease?
S1	Well maybe about how they should research, they should research like um like, like a medicine or something, um so like the disease is not so catchy like you get it in your old age or something and it's not like if someone coughs on you, you get the disease. (Reasoning)

Table 7 Transcript

Speaker	Text
Teacher	Some people say if it's raining you should move under a tree. What do you think?
S1	You could use a big leaf or something.
S2	I disagree because sometimes there are little holes and even in the big leaves the water pressure is too much and the water still drops on you. (Challenge)
S3	Or if there's lots of wind, you can be holding it and the leaf can blow away.

several responses deemed as reasoning, while student 2 did not speak often or record long utterances yet also used reasoning when responding (Table 8).

During the observations, one class of students asked three to four times as many questions as the students from other year levels and almost three times as many open-ended questions than closed questions. These open questions often resulted in an explanation being made by their classmates; however, no reasoning occurred within this class.

Discussion

Dialogue as a Resource for Student Achievement

For dialogue to effectively support student learning, the learning environment and the nature of the interactions which take place are essential considerations. Many researchers argue that collaborative talk is a key tool in enhancing student achievement (Alexander 2008; Mercer 2016; Scott 2008; Wells 2009). Such research places great importance on the role of the teacher in creating an environment that is conducive to talk and where students are encouraged to take part in and extend their thinking. The teachers in this case study viewed dialogue as an important feature in the teaching and learning of science. They defined dialogue as classroom talk that enabled their students to take their thinking to a higher level and achieve a deeper understanding of scientific concepts. These common beliefs were shared by the four teachers and were translated into practice in different ways. However, each teacher displayed traits of dialogic teaching and their students displayed elements of dialogic thinking.

Teacher Talk Prompted a Range of Student Responses

Analysis of the 12 observations showed some evidence of high-order thinking, dialogic talk and deep learning in the joint construction of scientific understanding. This research highlights that classroom dialogue entails a range of student responses from low-order thinking to high-

Table 8 Transcript

Speaker	Text
S1	Well I agree and disagree and well I disagree because like if everyone lives like there will not be room for everyone in the world because then it will just be like the person will have another baby and then they will grow up and then they'll have a baby and it will get too full and crowded.
S2	Sustain, well we have medicine to sustain people because if we did not have medicine it would not keep on going they would just die.

order thinking, consisting of reply, statement, explanation, reasoning and challenge. All year levels produced low- and high-order responses forming a bell curve effect overall.

This finding has implications on the expectation regarding the amount of higher-level thinking in any dialogic session. Alexander (2008); Nystrand et al. (2003); and Wells (2009) suggest that rich dialogic talk is seldom experienced in current educational contexts. It may be considered quite reasonable for a dialogic session to contain larger amounts of mid-level thinking responses such as statements and explanations with less responses consisting of replies, reasoning and challenges. Mercer and Dawes (2014) proposed that teaching involves all four communicative approaches (Mortimer and Scott 2003) and therefore, such dialogue, while involving a range of responses, may still be considered dialogic. While teachers expected that dialogue would lead to deep thinking, research (as previously cited) suggests that this is not always a realistic expectation.

Teacher Questioning Scaffolds Students' Learning

The important role teachers' play in developing dialogue and scientific understandings is evident in the literature and in the beliefs and actions of the teachers examined within this case study. Although teachers spoke more often than they suggested was appropriate in creating effective dialogue, further analysis showed that much of this teacher talk was, in fact, used to scaffold students' learning. The data revealed that these teachers used more open-ended questions than closed and asked a range of questions that prompted students' higher-order responses such as to explain, use meta-analysis or apply their learning.

A Relationship Between Extended Talk Turns and Higher Order Thinking

The literature shows that, when given time to talk, students are more likely to enter into dialogue. The teachers in this case study believed that giving a student time to talk was important in promoting higher-order thinking. This finding shows that, although half of the teachers spoke as often as their students, teacher talk was mostly used to scaffold the students, thereby enhancing dialogue. During the students' longest utterances, high-level thinking responses of reasoning occurred in three out of the four classrooms, suggesting that time impacts positively on dialogue in regard to higher-level thinking.

The Relationship Between Teachers' Beliefs and Practice

A review of the literature reveals that a gap exists in contemporary science teaching between theory and practice. When interviewed, the teachers stated that their role was that of facilitator and scaffolder of learning and the majority of talk should be allocated to the students and their ideas. However, although the teachers appeared to have sound knowledge of dialogue and its benefits to learning, responses from students did not always correlate with teacher actions as was evident when teachers used questions that required meta-analysis. The teachers in this study spoke about the importance of using scientific language as part of the dialogue in science lessons but such language was not always promoted during the dialogue sessions. The teacher's use of communicative approaches was difficult to monitor as the observations made were of a small aspect of the science lesson rather than the entire lesson. The gap between teachers' knowledge and practice surrounding dialogue remains apparent in classrooms around the world (Alexander 2008; Nystrand et al. 2003; Wells 2009) and within this study.

Conclusion

Effective classroom dialogue often requires teachers to think and work differently. In science, this may require teachers to reconceptualise their role in science education moving from a traditional authoritarian style to a student-centred dialogic style. The teachers at this school had undertaken professional learning in the area of science learning and teaching and, as a consequence, believed that their role in this process was that of a facilitator of learning or a co-learner. This thinking guided their actions and the nature of the interactions that took place between teacher and student.

While talk is widely regarded as 'the most important tool for guiding the development of understanding and for jointly constructing knowledge' (Mercer and Hodgkinson 2008 p. xi), this research has emphasised the complexity of implementing effective classroom dialogue. Creating such talk is intricate; research shows that effective talk which produces higher order thinking remains uncommon in most classrooms around the world (Alexander 2008, 2013; Nystrand et al. 2003; Wells 2009, 2015). That said, the teachers in this case study provided opportunities for dialogic teaching and dialogic talk and the study provides clear evidence of joint dialogue being used in an attempt to develop understandings in science.

The research highlights the importance of contemporary practice which aims to promote higher order thinking and an understanding of scientific concepts. This begins with teacher knowledge of the skills and strategies required to implement and support sustained talk and a manner of thinking to accommodate and promote such practices. This research offers a realistic expectation of the achievement of high-order thinking in a primary science classroom and reminds all educators that deep understanding requires many different levels of talk to produce student responses that feature reasoning and critical thinking which lead to higher level thinking.

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