Eurasia Journal of Mathematics, Science & Technology Education, 2016, **12**(12), 2991-3003
doi: 10.12973/ eurasia.2016.02318a

The level and quality of accountability talk in the science lessons

Abraham Motlhabane
University of South Africa, SOUTH AFRICA

•*Received 10 February 2016*•*Revised 28 April 2016* •*Accepted 14 May 2016*

Teachers are actively encouraged to plan their lessons such that there is maximum classroom talk, namely accountability talk. However, many lessons do not display sufficient accountability talk. This study attempted to better understand the level and quality of accountability talk in six science lessons. The study aimed to provide teachers with insight into the level and quality of accountability talk during the lessons. Video recording was used to record the lessons. Videotapes were transcribed for analysis. An accountability talk rubric was used to measure the extent to which the classroom talk was accountable to learning community, accurate knowledge, and rigorous thinking. The results showed high levels of talk associated with accountability to accurate knowledge compared to accountability to rigorous thinking and accountability to learning community.

Keywords: accountability talk, classroom talk, science, lessons

INTRODUCTION

Classroom talk has drawn an increasing interest among educators and researchers as it has come to be viewed as a rich lens for analysing the role of student-teacher interaction in teaching and learning (Wolf, Crosson & Resnick, 2005). This follows from the notion that learning is both individual and social, in that "all higher mental functions are internalised social relationships" (Vygotsky, 1986). When learning is seen as interactive, it is more appropriately defined as participation in social exchange rather than solely as an acquisition of knowledge (Rogoff, 1995). Some of the features of the more productive interactions include a focus on building students' capacity to think and reason, as well as on sustained interactions between teachers and students over a sequence of several question-and-answer exchanges (Hackling, Smith and Murcia, 2010). It is through rigorous interactions that students incorporate ways of thinking and behaving that foster the knowledge, skills and dispositions needed to support transfer to other situations that require independent problem-solving (Anderson et al., 2001). Notably, the more informal atmosphere and opportunities for more interaction among students.

Correspondence: Abraham Motlhabane,
UNISA, University of South Africa, Preller street, 0003 Pretoria, South Africa
E-mail: motlhat@unisa.ac.za

Their teacher and peers can promote positive social interactions and a healthy learning environment that is conducive to meaningful inquiry and collaborative learning.

The fact 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) implies that through talking, both student engagement and teacher scaffolding are required to support the development of an individual's capacity to think and acquire knowledge. In fact, scaffolding strategies support the participation of individual students by allowing participation by proxy, directly calling on the students for responses to keep them engaged in the activity (Marriage, 2001). The teaching of science and accountability talk is embedded on practical activities. Through these activities, students gain practical experiences and can give purpose to classroom discussion. Thus teachers should support the development of students' understanding and build scientific inquiry (Hackling et al., 2010).

State of the literature

- Classroom talk, namely accountability talk is a necessary element of any classroom lesson.
- Teachers need to plan lessons such that there is maximum classroom talk, by incorporating activities that will spark more accountability talk.
- Reflecting should be part of the teacher's lesson planning.

Contribution of this paper to the literature

- There is much to be learned about classroom talk if teachers are aware of what and how their lessons were presented.
- Reflections on the part of the teacher about his lessons may be a step towards improving the teaching methodology.
- Presenting lesson episodes through a video may assist in analysing the talk moves in a lesson.

Previous studies have shown that through meaningful inquiry and collaborative learning science ideas can be talked into existence. Hence in the context of this study, talk involves talking science in an accountable way; this can be referred to as accountability talk.

Although a number of studies have been conducted on different types of classroom talk (cumulative talk, disputational talk, accountability talk and exploratory talk). There is a paucity of research on the level and quality of talk referred to as accountability talk in the science classroom. Hence the study explored the level and quality of talk in the science lessons. Specifically the dimensions of accountability talk, namely accountability to learning community (ALC), accountability to accurate knowledge (AAK) and accountability to rigorous thinking (ART) was explored.

As adapted from Wolf et al., (2005), the first dimension, 'accountability to learning community', has two categories, namely teacher's linking (T:L) and student's linking (S:L). The former measures to what extent the teacher explicitly links different students' ideas while the latter measures how students link ideas from different people.

The categories for the second dimension, 'accountability to accurate knowledge', include 'asking for knowledge (T:K)' and 'providing with knowledge (S:K)'. The category 'asking for knowledge' measures the extent to which teachers press the students to support their ideas with evidence based on the text, and the category 'providing with knowledge' measures the extent to which students support their ideas based on the text.

The third and last dimension of accountability talk include 'asking for rigorous thinking (T:Th)' and 'providing with rigorous thinking (S:Th)'. The former measures to what extent the teacher presses the students to explain their thinking while the latter measures to what extent students explain their thinking.

Accountability talk conversations do not spring spontaneously (Yoon, Bennett, Mendez, & Hand, 2010) from students' mouths. It takes time and effort to create a classroom environment in which this kind of talk is a valued norm. It requires teachers to guide and support student participation. The most effective teaching method to enhance talk makes use of discussion and probing questions to encourage

students to develop understanding (Newton & Newton, 2000). Teachers create the norms and skills of academically productive talk in their classrooms by modelling appropriate forms of discussion and by questioning, probing, and leading conversations. For example, teachers may press for clarification and explanation, require justifications of proposals and challenges, recognise and challenge misconceptions, demand evidence for claims and arguments, or interpret and 're-voice' students' statements. Over time, students are expected to carry out each of these conversational 'moves' themselves in peer discussions. Once the norms for conversation within the classroom have been established, accountability talk practices are jointly constructed by teachers and students, working together towards rigorous academic purposes in a thinking curriculum (Michaels & O'Connor, 2010).

The role of the teacher should be directed at modelling talk so that it becomes more scientific (Thwaite & McKay, 2013). For example, the teacher can engage the students in the talk of and about science. Experimentation that is interesting to the students can be used in this regard. In the process of experimentation students can be helped to question claims about scientific issues. The teacher should model the talk so that students can investigate, question, and draw conclusions about science topics (Rennie, Goodrum & Hackling, 2001).

Talk moves (Chapin, O'Connor, & Anderson, 2003) such as re-voicing, restating, add on and wait time are regarded as productive in enhancing the level and quality of accountability talk. Re-voicing allows the teacher to interact with the student who is unclear. For example, the teacher can repeat what the student said: "So you say an ammeter measures the current?" While, restating involves asking one of the students to restate what the other student has said, for example, "Can you repeat what he just said in your own words"? The advantage of restating is to teach students to learn to listen and make sense of what other students are saying, thus encouraging students to apply their own reasoning to someone else's. The add-on talk move encourages other students to agree or disagree or add other comments, for example, "Who can add some ideas to this discussion"? The add-on talk move helps in prompting more input to the discussion. Wait time is about allowing time, for example 5-10 seconds after asking a question to allow the students to think about the question so that they can respond appropriately.

Recognising that accountability talk plays an important role in the teaching of science, the study explored some answers to the question:

What is the level and quality of accountability talk that took place in the six practical lessons conducted by the teachers to their peers?

The study sought to add to the existing research that aims to improve scientific inquiry and more student participation through accountability talk. Hence, the article was written to give readers a picture of the level and quality of accountability talk in the science lessons.

THEORETICAL FRAMEWORK

The constructivist and sociocultural theories of education (Shepardson & Britisch, 2001) emphasise that students must engage in hands-on activities, make observations and have social interactions with peers and teachers in order to learn effectively. The constructivist theory of learning refers to encouraging students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing (Vygotsky, 1986). Constructivism promotes social and communication skills by creating a classroom environment that emphasises collaboration and exchange of ideas (Vygotsky, 1986). Students must learn how to articulate their ideas clearly as well as to collaborate on tasks effectively by sharing

in group projects. Students must therefore exchange ideas and so must learn to 'negotiate' with others and to evaluate their contributions in a socially acceptable manner. Sociocultural theories (Vygotsky, 1986) argue that learning is a culturally embedded and socially meditated process in which discourse plays a primary role in the creation and acquisition of shared meaning-making. The key feature of the sociocultural perspective (Tharp & Gallimore, 1988) is that higher-order functions develop out of social interaction. Engaging students in hands-on activities includes students doing experiments, handling apparatus, taking measurements, recording data, making observations and thinking about what they are doing by making conclusions and deductions. Through participation in activities that are hands-on and require cognitive and communicative functions, children are drawn into the use of the functions in ways that nurture and scaffold them. Thus scientific inquiry is necessitated by the type of environment where children can observe, ask questions, seek answers, make discoveries, and justify their decisions (DuVall, 2001). Social interaction is a primary means of promoting individual reasoning (Piaget, 1978). Like Piaget, Vygotsky supports the intersection between individual development and social relations. The social environment is responsible for framing that permits a child to move forward and continue to grow. Accordingly, Vygotsky (1986) argues that one of the most important components of scaffolding is the engagement of children in interesting and culturally meaningful problem-solving activities.

METHODOLOGY

The study used a mixture of qualitative and quantitative approaches to explore the level and quality of accountability talk. The research population consisted of 48 Advanced Certificate in Education second-year science in-service teachers in one of the South African universities. The project involved teachers learning from each other in terms of how to improve their teaching practice. Teachers were requested to divide themselves into six groups of eight members. Each group of teachers prepared a 45-minute lesson on Ohm's law. One of the group members volunteered to present the lesson to the rest of the group. This means that the other group members were now students. The teachers were provided with all the necessary equipment and materials. Video was used as a central data collection instrument. A reason for this (Pirie, 1996) was that videotaping a classroom phenomenon is likely to be "the least intrusive, yet most inclusive way of studying the phenomenon". The flexibility of videotaping for collecting aural and visual information was very useful. Video was able to capture rich behaviour and complex interactions and it allowed me to re-examine data again and again (Clement, 2000). It extended and enhanced the possibilities of observational research by capturing moment-by-moment unfolding, subtle nuances in speech and non-verbal behaviour (Martin, 1999). To ensure reliability and validity of the data, the transcribed videos of lessons were given to the teachers for verification and all videotaped lessons were viewed by all the teachers. In addition to viewing the lessons on video, the teachers were interviewed on their views about watching their own lessons.

A multi-phase analytical model adapted from the methodology developed by several mathematics educators at Rutger's University (Powell, Francisco, & Maher, 2003). Russ (2006) followed the same model for the study entitled 'A framework for recognising mechanistic reasoning in student scientific inquiry'. The model proceeds in three phases as illustrated below.

Phase one: Attentively viewing and describing video data

The first step in the analysis was to watch each video thoughtfully several times. In order to stay focused on the research question, both the printed and the soft copy

of the rubric were available for the purpose of engaging in accountability talk. During the viewing the researcher carefully focused on the dimensions of accountability talk as depicted in the rubric. The purpose of this stage was be to become familiar (Powell et al., 2003) with the content of the videos without trying to interpret the content. Since the video data of the lessons presented was dense and lengthy, the data was analysed to help make sense of it. To do so, the video was divided into 30-second time intervals and then the process of 'stop, watch, and describe' was followed for each interval. As Powell et al. (2003) propose, the researcher tried to ensure that "the descriptions are indeed descriptive and not interpretative or inferential" and that they remained both simple and factual. The process of observing strict time intervals was very helpful in that it forced the researcher to attend to each individual dimension of accountability talk. This phase was especially helpful for analysing the dimensions of accountability talk. Through attentively watching and describing the data, it was possible to become familiar with the video and with the dimensions in each of the six lessons.

Phase two: Transcribing the video data

In each of the 45-minute lessons the researcher transcribed the videos and audio recorded data into written form. Completed transcripts used in the analysis included the teacher presenting the lesson to his/her group members. The utterances and important non-verbal cues were transcribed. Transcription of video data has several benefits for research. As Tuminaro (2004) points out, constructing a written record, like phase one of the methodology, also requires the researcher to watch the video several times and attend to the focus of the study. In this case , it helped the researcher to become more familiar with the data, including potentially important subtle details. The written record made it easier to study the dimensions of accountability talk in depth or to compare across all dimensions. As Powell et al. (2003) note, "The production of transcripts and the physical, static rendering of a research session affords researchers opportunities for extended, considered deliberations of talk and noted gestures […] with transcript data, one can consider more than momentarily the meaning of specific utterances". Transcript data may also give researchers who are unfamiliar with the data faster access to the content of the discussion than watching the entire video.

Phase Three: Coding the video data

The data was coded so that themes for video analysis could be identified. In this phase of analysis, the transcript data was coded line-by-line and the rubric indicated in Table 1 below was used in the analysis.

Powell et al. (2003) describe this process when "researchers write commentary that discusses and justifies the identified material". Through coding and memo-ing it was possible for the researcher to be precise and articulate about the dimensions of accountability talk. Although the analysis of the data began with some "deductive or a priori codes" (Powell et al., 2003), part of the objective of this work was to develop codes that were appropriate for identifying level and quality of talk in the six lessons. Three codes were derived from the data, namely accountability to learning community (ALC), accountability to accurate knowledge (AAK), and accountability to rigorous thinking (ART).

First, categories of the ALC, that is, teacher's linking (T:L) and student's linking (S:L) were coded. The purpose of ALC was to measure the degree to which the teachers and students made consistent efforts to ensure that all participants understood the ideas and positions shared during the whole-group discussion. This dimension also measured the extent to which the teachers and students made

Table 1. Category of accountability talk

Category (Rubric)	Description	Talk moves*
	Accountability to Learning Community (ALC)	
Teacher's linking (T: L)	To what extent does the teacher explicitly link different people's ideas?	• John, did you hear what Ann just said? Can you repeat that in your own words? • Who agrees / disagrees with what Ann just said? • Who wants to add on to what Ann just said?
Student's linking (S: L)	To what extent does the student explicitly link different people's ideas?	• I want to add on to what Ann said … • I agree with you because …
	Accountability to Accurate Knowledge (AAK)	
Asking for knowledge (T: K)	To what extent does the teacher press the students to support their ideas with evidence based on the text?	• How do you know that? • Can you give me some examples? • Where did you find that information? • Can you show me which part of the text tells you that information? • What do you mean?
Providing with knowledge (S: K)	To what extent do the students support their ideas with evidence based on the text?	• I know that because it says here …
	Accountability to Rigorous Thinking (ART)	
Asking for rigorous thinking (T: Th)	To what extent does the teacher press the students to explain their thinking?	• Why do you think that? • Can you explain that more? • Say more about that.
Providing with rigorous thinking (S: Th)	To what extent do the students explain their thinking?	• I think because …

Adapted from Wolf et al. (2005)

efforts to link contributions to one another so that the discussion could build on ideas within the learning community. To receive a high score on the rubrics for this dimension, whole-group discussion would have to demonstrate that the teachers/students were listening attentively, paraphrasing, and building ideas upon one another's contributions.

Second, the categories of the AAK, that is, asking for knowledge (T:K) and providing with knowledge (S:K), were coded. The purpose of AAK was to measure the degree to which the teachers and students ensured that the participants provided specific and accurate knowledge as evidence to back up their contributions. In other words, this dimension captured the level of "commitment to getting the facts right" in the lesson discussion. To receive a high score on rubrics for this dimension, whole-group discussion would have to demonstrate that the teachers pressed for accurate knowledge by asking participants to support their contributions, and that the students, in turn, supported their contributions.

Lastly, the categories of ART were coded, namely, asking for rigorous thinking (T:Th) and providing with rigorous thinking (S:Th). The purpose of ART was to measure the degree to which the speakers were asked to explain their thinking by using rational strategies to present arguments and by drawing logical conclusions. This dimension also measured the degree to which the students explained their thinking. To receive a high score on rubrics for this dimension, classroom talk would have to demonstrate that the students were pressed to explain thinking for their claims, and the students would have to explicate their reasoning in ways appropriate to the discipline.

Ethical issues

Informed consent was obtained from all the teachers who participated in this study. This was done before the lessons were recorded. The teachers were made to understand fully what it means to participate in the study, that their voices and body images will be captured and that they consent to the intended uses of the recorded images. They were informed that they had the right to withdraw at any time during the study if they feel uncomfortable.

RESULTS AND DISCUSSION

The categories for each dimension of accountability talk were carefully considered when recording the talk moves. First, talk moves for ALC, that is, teacher's linking (T:L) and student's linking (S:L) were highlighted and recorded in the transcript. These were followed by the talk moves in the dimension AAK, that is 'asking for knowledge (T:K)' and 'providing with knowledge (S:K)'. Lastly, the talk moves in the dimension ART were recorded, that is, 'asking for rigorous thinking (T:Th)' and 'providing with rigorous thinking (S:Th)'. Constructing a detailed account of the video transcript (coding) and a corresponding graphs of those codes helped in identifying critical moments that guided the interpretation of the rest of the data. The categories in each dimension and the talk moves in each lesson were calculated and the SPSS software was used to compute the mean scores and standard deviations. Talk moves for each category were quantitatively captured and recaptured to ensure accuracy (Table 2).

In Table 2, L1–L6 represent the lessons. Different colours were used to highlight the talk moves in the six-written transcript. The talk moves were counted and

Table 2. Talk moves in each category

Dimensions of Accountability talk	Lessons **Categories Talk moves**	L 1	L 2	L 3	L 4	L 5	L 6	Total	Mean	Standard Deviation
Accountability to Learning Community (ALC)	Teacher's linking (T:L)	-	-	-	-	-	-	-	-	-
	Student's linking (S:L)	-	-	-	-	-	-	-	-	-
Accountability to Accurate Knowledge (AAK)	Asking for knowledge	11	19	6	25	10	8	79	13.17	7.305
	Providing with knowledge	10	17	12	23	9	7	78	13	5.97
Accountability to Rigorous Thinking (ART)	Asking for rigorous thinking	-	1	-	9	3	-	13	2.17	3.54
	Providing with rigorous thinking	-	2	-	2	3	-	7	1.17	1.33

recounted for accuracy. The mean and standard deviation were calculated.

Figure 1 depicts a comparison in talk moves in the dimension Accountability to Accurate Knowledge (AAK). The categories in this dimension are 'Providing knowledge' and 'Asking for knowledge'.

The results show a higher level of talk moves (23 talk moves) relating to providing knowledge in lesson 4, while lesson 6 registered a lower score (7 talk moves) in the same category. With reference to asking for knowledge, lesson 4 recorded a higher score (25 talk moves) while lesson 3 registered a lower score (6 talk moves).

The graph in Figure 2 shows a comparison in means between the two categories of the dimension Accountability to Accurate Knowledge (AAK), that is, 'Asking knowledge' and 'Providing knowledge'.

The mean scores for 'Asking knowledge' and 'Providing knowledge' were compared. The mean score for 'Asking knowledge' was 13.17 while for 'Providing knowledge' was 13. The difference between the two means was only 0.17. In principle the difference was significantly very low. This means that the extent to

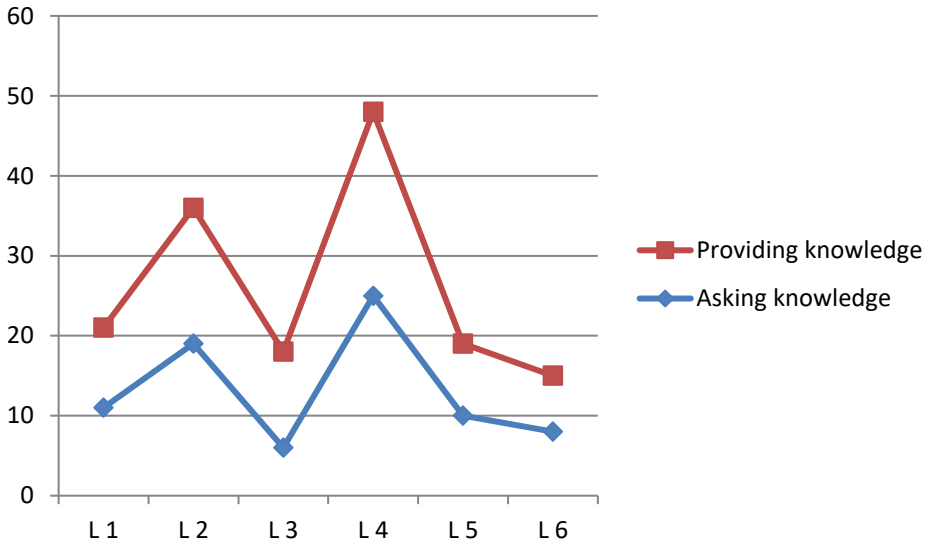

Figure 1. 'Providing knowledge' versus 'Asking knowledge'

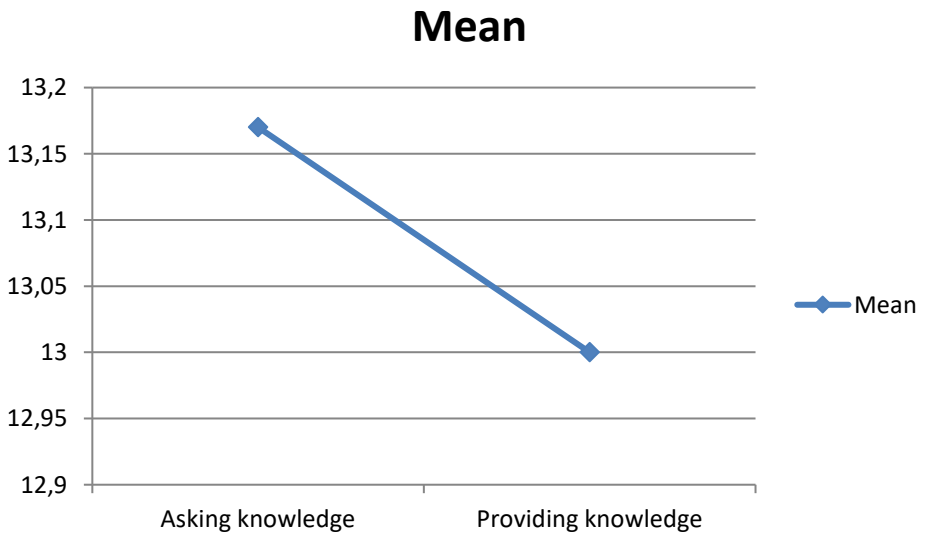

Figure 2. Mean scores 'Asking knowledge' versus 'Providing knowledge'

which the teacher probed students to support their ideas was nearly the same as the extent to which the students supported their ideas with evidence. The reason for this is that the teacher would ask the question and the peer-teachers responded. On few occasions, the teacher answered his own question. An example of the talk moves is indicated below.

Teacher: What is this? (Referring to a voltmeter)
Student: It is a voltmeter.
Teacher: What does it measure?
Student: It measures the potential difference between two points.
Teacher: What is potential difference?
Student: The work done in moving a positive charge from one point to another.
Teacher: What is the unit for potential difference?
Student: Volts.
Teacher: What is this? (Referring to an ammeter)
Student: It is an ammeter.

In the above example, the teacher asked for knowledge on the voltmeter and the students provided the knowledge by answering the questions asked by the teacher. Most of the questions asked "What?". However, students provided specific and accurate knowledge as evidence to back up their contributions and there was a "commitment to getting the facts right" in the lesson discussion. During the talk teachers did not press for accurate knowledge by asking students to support their contributions; furthermore they asked students to support their contributions. Hence the quality of talk was compromised. Questions like "How?" "Give some examples?" and "What do you mean?" did not feature in the lessons. To enhance the quality of talk, more talk could have been initiated through probing for more from the students.

The graph in Figure 3 shows that the talk moves in the dimension Accountability to Rigorous Thinking (ART) were noted. The categories in this dimension are 'Providing with rigorous thinking' and 'Asking for rigorous thinking'.

The talk moves in all six lessons were compared under the categories 'Providing with rigorous thinking' and 'Asking for rigorous thinking'. From the six lessons, lesson 4 shows a higher level of talk moves in terms of 'Providing with rigorous thinking' and 'Asking for rigorous thinking'. In lessons 1 and 2, the talk moves relating to providing with rigorous thinking and asking for rigorous thinking was insignificant. Examples of talk moves in this category are indicated below.

The teacher refers *the students to the table of the results on the worksheet.*
Teacher: what do you think will be the relationship between the potential difference and current? Do you think the resistance will be the same? Think about the graph.
Student: The graph will be the straight line.

In the example above the teacher asks the students to interpret the recorded results from the experiment. The students are asked to deduce the relationship between the potential difference and the current from the data obtained. Students were asked to make deductions from the recorded experimental data on potential difference and current. The students were asked to explain their thinking by drawing logical conclusions. Probing students to explain their thinking would have led to more in terms of proving with rigorous thinking. Questions like, "Why do you think that?" "Can you explain that more?" and "Say more about that" could have made for more interesting talk.

The graph in Figure 4 shows a comparison in means between the two categories of the dimension Accountability to Rigorous Thinking (ART), that is, "Asking for rigorous thinking" and "Providing with rigorous thinking".

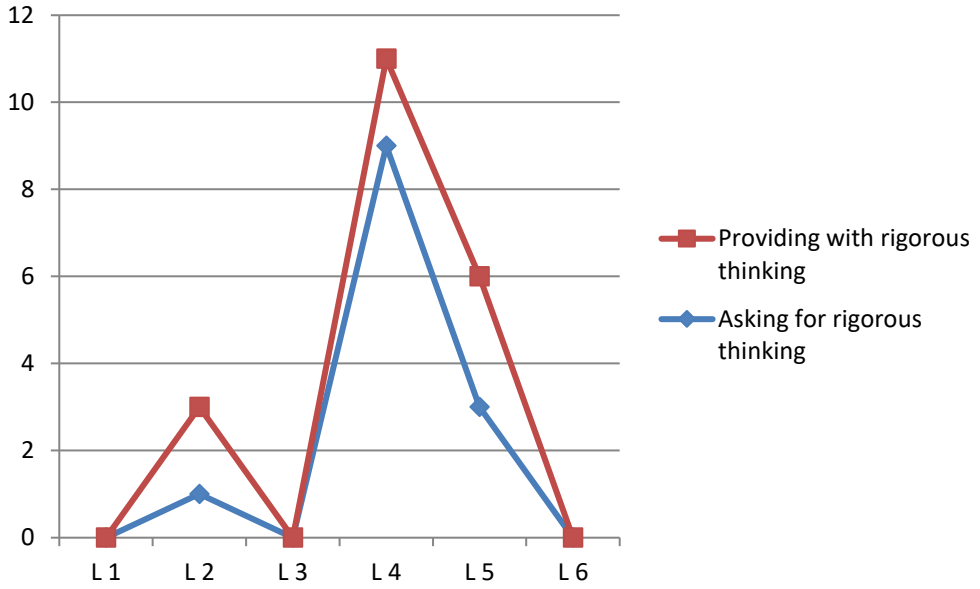

Figure 3. Talk moves, 'Providing with rigorous thinking' versus 'Asking for rigorous thinking'

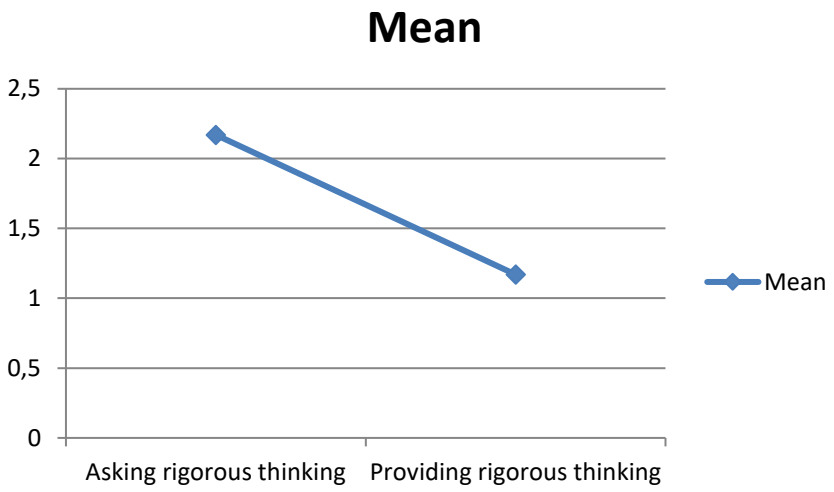

Figure 4. Mean scores 'Asking for rigorous thinking' versus 'Providing with rigorous thinking'

In comparing the mean scores for asking for rigorous thinking and providing with rigorous thinking the following emerged: the mean score for 'Asking for rigorous thinking' was slightly higher at 2.17 compared to 1.17 for 'Providing with rigorous thinking'. This suggests that the extent to which the teacher probed the students to explain their thinking was higher compared to the extent to which the students explained their thinking.

In Table 3 the talk moves in each dimension is summarised. The two categories in each dimension as shown in Table 2 were added for each lesson. The mean and standard deviation were calculated for each dimension taking into consideration the six lessons.

Table 3. Summary of the talk moves

	Talk moves in lessons L1-L6							
Dimension of Accountability Talk	L1	L2	L3	L4	L5	L6	Total	Mean	Standard deviation
Accountability to-Learning Community (ALC)	-	-	-	-	-	-	-	-	-
Accountability to Accurate Knowledge (AAK)	21	36	18	48	19	15	157	26.17	12.98
Accountability to-Rigorous Thinking (ART)	3	-	11	6	-	20	3.34	4.46	

The results show that there were no talk moves in the dimension Accountability to Learning Community (ALC). This implies that in all the lessons there was no linking of ideas either between the students themselves or between the teacher and the students. However, a significant number of talk moves was noted in the dimension Accountability to Accurate Knowledge (AAK), while the talk moves in the dimension Accountability to Rigorous Thinking (ART) recorded a lower number of talk moves

Interviews with teachers

Before the teachers could be interviewed, the lessons were discussed with teachers so that they can reflect on their lessons. The interview with teachers indicated that they learned a lot from the lessons and discussions about the lessons presented. Their comments ranged from "the idea of videotaping lessons was wonderful" to "I had an opportunity to see myself presenting a lesson and it was a learning experience". The comments showed that teachers were excited about the feedback they received and were hoping to improve their future lessons.

EDUCATIONAL IMPLICATIONS

Teachers need to increase the student's capacity to think and reason through actively involving them in talking during the lesson presentation. Involvement of learners may be through a more engaged interaction between the teachers and the learners and between learners themselves. In the context of this study, being engaged refers to making an effort to participate through talking in the classroom. Participation can be in different forms. For example, asking questions that provokes and prompt learners to give responses. Different questioning techniques can be combined to elicit learner's responses. Activities can be planned such that they capture the interest of the students. For example, experimentation can be incorporated and students can take a lead in the planning and execution of the experiments. They can be given roles and responsibilities such as recording, making deductions and presenting the findings of the experiments. Other activities can include making predictions before the experiment is performed. This can lead to more talk as learners can compare the findings of the experiments with their predictions. In this way, talking that is associated with being accountable can be stimulated. For example, learners can listen to one another and to the teacher and build ideas and arguments.

For the classroom talk to be accountable to the learning community (Michaels & O'Connor, 2010), students should listen to one another and to the teacher, so that they can use and build on one another's ideas. Students and teachers should paraphrase and expand upon one another's contributions. If teachers or students are not sure if they understood each other, they should make an effort to clarify. Teachers and students should challenge every claim during the lesson. Students should move the argument forward, sometimes with the teacher's help, sometimes on their own.

The talk in a classroom is accountable to accurate knowledge (Michaels & O'Connor, 2010) if there are consistent signs in such classrooms that both students and teacher consider themselves responsible for the accuracy and truth of their claims. We should see many instances in which students make specific reference to their classroom community's previous 'findings' to support their arguments and assertions. Topics that they have studied together in the past should be referred to in later discussions, where relevant. The learning community builds on the knowledge it has collectively acquired.

Accountability to rigorous thinking should involve students building a line of argument. Making coherent and compelling arguments requires linking together claims and evidence (facts) in a logical, coherent, and rigorous manner. When classroom talk is held to rigorous thinking standards, students and teachers should consistently push for clear statements of claims (positions, explanations, or predictions) and sound reasoning in backing up those claims with evidence. Teachers and students examine evidence critically, knowing that just having accurate facts is not, in and of itself, enough (Michaels & O'Connor, 2010).

CONCLUSION

The study aimed to provide teachers with insight into the level and quality of accountability talk in their lessons. Six lessons were studied. The challenge remains in the implementation of ideas learnt. The results confirm the finding of Yoon et al 2010 that accountability talk does not happen spontaneously. It is through repeated efforts that accountability talk can be elicited.

The recommendation derived from this study is that, teachers should constantly reflect on what and how they teach so that they are aware of the mistakes they make and work upon them. This will help in improving the approach on each lesson and maximise classroom accountability and conversations.

Based on the results of this study, the study suggests that teachers should make use of good questioning techniques to elicit accountability talk responses. Similarly, teachers should constantly monitor their own talk and that of learners in the classroom. Thus, the teaching and learning of science in the classroom may be improved if teachers reflect upon their own lessons. The opportunity given to teachers to view and reflect on their talk actions and that of the learners on video was a step in the right direction. The lessons learnt from this study can be used to inform teacher's classroom practice. The analysis of the quality and level of accountability talk should be considered as a lens to monitor the classroom interactions so that teachers can improve future lessons.

REFERENCES

Alexander, R. (2006). *Towards dialogic teaching*. York, UK: Dialogos.

Anderson, R. C., Nguyen-Jahiel, K., McNurlen, B., Archodidou, A., Kim, S. & Reznitskaya, A. (2001). The snowball phenomena: Spread of ways of talking and ways of thinking across groups of children. *Cognitive and Instruction,* 19, 1–46.

Chapin, S.H., O'Connor, C., & Anderson, N.C. (2003). From classroom discussions: Using Math talk to help students learn. Grades 1-6. Sausalito, CA: Math Solutions

Clement, J. (2000). Analysis of clinical interviews: foundations and model viability. In: A. E. Kelly, & R. Lesh (Eds.), *Handbook of research data design in mathematics and science education* (pp. 547–589). Mahwah, NJ: Lawrence Erlbaum Associates.

DuVall, R. (2001). Inquiry in science: From curiosity to understanding. *Primary Voices K-6*, 10 (1), 3–9.

Hackilng, M., Smith, P. & Murcia, K. (2010). Talking science: Developing a discourse of inquiry. *Teaching Science*, 56 (1), 17–22.

Marriage, T. V. (2001). Features of an interactive writing discourse: Conversational involvement, conventional knowledge, and internalization in 'Morning Message'. *Journal of Learning Disabilities,* 34, 172–196.

Martin, L. C. (1999). *The nature of the folding back phenomenon within the Pirie–Kieren theory for the growth of mathematical understanding and the associated implications for teachers and learners of mathematics*. Unpublished doctoral dissertation, University of Oxford, Oxford, UK.

Michaels, S & O'Connor, M.C. (2010). For Classroom Conversation That Works. Institute for Learning, University of Pittsburgh.

Newton, D.P. & Newton, L. D. (2000). Do teachers support causal understanding through their discourse when teaching primary science. *British Educational Research Journal*, 26 (5), 599–613.

Piaget, J. (1978). *Success and understating.* London: Routledge & Kegan Paul.

Pirie, S. E. B. (1996). *What are the data? An exploration of the use of video-recording as a data gathering tool in the mathematics classroom*. Paper presented at the Sixteenth Annual Meeting of the International Group for the Psychology of Mathematics Education—North America, Florida State University, Panama City.

Powell, A.B., Francisco, J.M., & Maher, C.A. (2003). An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. *Journal of Mathematical Behavior*, 22, 405 – 435.

Rennie, L. J., Goodrum, D. & Hackling, M. (2001). Science teaching and learning in Australian schools: Results of a national study. *Research in Science Education,* 31, 455–498.

Rogoff, B. (1995). Observing sociocultural activity on three planes: Participatory appropriation, guided participation, and apprenticeship. In J. V. Wertsch, P. Del Rio & A. Alvarez (eds), *Sociocultural studies of the mind*. (pp. 139–163). Cambridge, UK: Cambridge University Press.

Russ, R.S. (2006). A framework for recognizing mechanistic reasoning in student scientific inquiry. Unpublished doctoral dissertation. University of Maryland, College Park.

Shepardson, D.P. & Britsch, S. J. (2001). The role of children journals in elementary schools' science activities. *Journal of Research in Science Teaching,* 38 (1), 43–69

Tharp, R. G. & Gallimore, R. (1988). *Rousing minds to life: Teaching, learning, and schooling context. Cambridge*, UK: Cambridge University Press.

Thwaite, A. & McKay, G. (2013). Five-year-olds doing science and technology: How teachers shape the conversation. *Australian Journal of Language and Literacy,* 36 (1), 28–37.

Tuminaro, J. (2004). A cognitive framework for analyzing and describing introductory students' use and understanding of mathematics in physics. Unpublished doctoral dissertation, University of Maryland, College Park.

Vygotsky, L. S. (1986). *Thought and language*. Cambridge, MA: The MIT Press.

Wolf, M., Crosson, A., & Resnick, L. (2005). Classroom Talk for Rigorous Reading Comprehension Instruction. *Reading Psychology* (26), 27-53.

Yoon, S., Bennett, W., Mendez, C. & Hand, B. (2010). Setting up conditions for negotiation in science. *Teaching Science*, 56 (3).

◈⊙◈