

Increasing explanatory behaviour, problem-solving, and reasoning within classes using cooperative group work

Robyn M. Gillies · Michele Haynes

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Abstract The present study builds on research that indicates that teachers play a key role in promoting those interactional behaviours that challenge children's thinking and scaffold their learning. It does this by seeking to determine whether teachers who implement cooperative learning and receive training in explicit strategic questioning strategies demonstrate more verbal behaviours that mediate children's learning than teachers who implement cooperative learning only. The study also sought to determine whether students who receive training in explicit questioning strategies demonstrate more explanatory behaviour than their untrained peers, and, as a consequence, do these same students demonstrate more advanced reasoning and problem-solving skills on follow-up reasoning and problem-solving tasks. The study involved 31 teachers in two conditions, the cooperative + strategic questioning condition and the cooperative condition, and two groups of students from each teacher's classroom. The results show that the teachers in the cooperative + strategic questioning condition used significantly more mediating behaviours than their peers in the cooperative condition. The study also showed that the children in these teachers' classes engaged in more elaboration and obtained significantly higher scores on the follow-up reasoning and problem-solving tasks. The study demonstrates the importance of explicitly teaching strategic questioning strategies to children during cooperative learning.

Keywords Cooperative learning · Explanatory behaviour · Problem-solving and reasoning

Importance of talk during cooperative learning

Student-centred approaches to learning place great emphasis on ensuring students are actively involved in their own learning. These approaches to teaching and learning are in

R. M. Gillies (✉) · M. Haynes
School of Education, The University of Queensland, Brisbane 4072, Australia
e-mail: r.gillies@uq.edu.au

contrast to teacher-centred approaches where students have been the passive recipients of knowledge with little control over what and how they learn (Sharan et al. 1999). The channel of communication in teacher-centred classrooms tends to be one-way as teachers talk at students who are required to listen and respond, often reiterating information provided earlier by the teacher (Turner et al. 2002).

In a study of teachers' classroom discourse, Galton et al. (1999) noted that the general pattern of teacher verbal behaviours tended to fall into two categories where teachers asked questions of a factual or closed nature or made statements that required no answers. This behaviour was so entrenched that over a twenty-year period, Galton et al. reported that teachers' propensity to provide students with facts or ideas actually increased from about 57% to over 80% of teachers' total classroom talk.

In high school classrooms it appears that little has changed. McBride et al. (2004) observed that that teacher-talk and text books are still the primary providers of science information while Galton (2002) noted that the teaching of science had changed little over the past twenty years with teacher instruction and demonstration the primary mode for teaching science in secondary schools. Interestingly, when students' attitudes to science were investigated further, Galton found that it was the high attaining boys, a higher proportion of whom opt for science, who registered the most dissatisfaction with their schooling. Galton suggests that much of this dissatisfaction can be attributed to the existing tradition of science teaching which relies very much on a deductive, discovery approach with the teacher expected to guide students towards the discovery of solutions. However, in many classrooms, guided discovery often ends up as teacher direction. Such an approach encourages more dependency on the teacher and less ownership on the part of students for the solution and more student dissatisfaction.

In contrast, student-centred approaches demonstrate that students develop better capacities for problem-solving and reasoning and obtain higher learning outcomes when they are able to interact with others, share ideas, challenge perspectives, and discuss alternative propositions before reaching agreement (Rojas-Drummond and Mercer 2003; Wegerif et al. 1999). Mercer et al. (2004) found that children who were taught to talk and reason together as they participated in inquiry science activities demonstrated significantly better knowledge and understanding of scientific concepts and relevant parts of the science curriculum than students who had not participated in such training. The authors concluded that students can be taught to talk and reason together and apply those skills to the study of science. Furthermore, they found that talk-based activities such as occurs during cooperative group work can be useful in scaffolding the development of reasoning and scientific understanding. Similarly, Gillies and Khan (2008), in a study that investigated the effects of teacher discourse on student discourse, problem-solving and learning in units of work in the social sciences, found that children whose teachers had been taught specific communication skills to challenge their thinking engaged in significantly more elaborative and help-giving behaviours with group members and they obtained higher follow-up scores on a reasoning and problem-solving activity than peers whose teachers had not participated in this training.

Teachers need to teach students how to dialogue together

There is no doubt that children are more interactive and learn more when they have been taught how to communicate as they work on common tasks. Placing students in groups and expecting them to interact does not guarantee that learning will occur (Johnson and

Johnson 1990). It is only when students have been taught how to communicate that the benefits attributed to this approach to learning are realised. In fact, Blatchford et al. (2003) identify preparing and developing student interactional skills as one of four key dimensions in their social pedagogical approach to classroom grouping. This includes not only the skills of learning to communicate effectively through listening, explaining, and sharing ideas but also those skills needed to plan and organise their work that give them the confidence to work more independently of the teacher. Gillies (2003) in a review of five studies on cooperative learning in primary and secondary schools across different subject areas (mathematics, science, English, and social studies) highlighted the importance of training students in the small-group and interpersonal skills needed to work effectively in small groups.

Rojas-Drummond and Zaparta (2004) taught 88 Grade 5 and 6 children to use Exploratory Talk as a linguistic tool for helping them to learn to present and negotiate different points of view, argue in favour of their positions, and make their reasoning explicit as they work on problem-solving tasks together. The results showed that the children who participated in the Exploratory Talk training produced significantly more and better arguments, presented their arguments in a more cohesive and explicit way, and provided more links and supports to sustain their opinions. In so doing they made their reasoning more visible and this had a significant effect on their capacity to solve problems. Similarly, Wegerif et al. (2005), in a review of a number of studies where children participated in the Thinking Together program which taught children how to use Exploratory Talk during their collaborative group experiences, found that the program had similar positive effects on individual reasoning and on the capacity of children to collaborate effectively in groups. In all instances, the success of the program was contingent on teachers explicitly teaching and modelling the use of Exploratory Talk and coaching children in its use during their small group discussions.

Explicit instruction appears to be critical in the successful application of reasoning and problem-solving skills. Reznitskaya et al. (2007) found that students who had received explicit instruction in argumentative discourse during group discussions displayed significantly better knowledge of the argument schema than their peers who had not received such instruction. Similarly, Nussbaum and Schraw (2007) reported that students who received training in the criteria for constructing arguments demonstrated stronger rebuttals and more balanced reasoning than their peers who used a graphic organiser only to assist them to integrate their arguments and counterarguments. In short, it appears that students need to be taught how to engage in reasoned argumentation and teachers play a key role in explicitly teaching these skills if they are to be used effectively during small group discussions.

The teachers' role in promoting student discourse

Teachers induct children into ways of thinking and learning by making explicit how to express ideas, seek help, contest opposing positions, and reason cogently, and in so doing, they are helped to generate new ways of thinking and creating knowledge (Melothe and Deering, 1999; Mercer et al. 1999). Students are receptive to teachers' discourse as it affects how they react to learning and the perceptions they develop about their classroom learning environment (Patrick et al. 2001).

Turner et al. (2003), in a study that investigated students' participation in mathematics lessons in grade 6, found that students were more motivated to learn when their teachers

used language that stressed strong positive affect about learning and conveyed positive expectations to their students. In a follow-up in-depth study that examined the participation of two students in mathematics lessons during sixth- and seventh-grades, Turner and Patrick (2004) reported that students' patterns of participation changed markedly from one year to the next, depending on the encouragement and support they received from their teachers. The authors concluded that teachers' communicative behaviours do affect students' engagement with learning.

In a study that investigated the effects of training teachers in specific communication skills designed to challenge children's thinking and scaffold their learning, Gillies (2004) found that the teachers engaged in more mediated-learning interactions, asked more questions, and made fewer disciplinary comments than their peers who had not participated in the training. Moreover, the children in these teachers' classes modelled many of the responses they gave their teachers in their interactions with each other by providing more detailed help and explanations to other group members. Gillies and Boyle (2006), in a follow-up examination of the types of discourse that the teachers used showed that they used a range of mediated-learning behaviours in their interactions with the children that included challenging their perspectives, asking more cognitive and metacognitive questions, and scaffolding their learning. It has been suggested that children probably learn new ways of thinking and talking by listening to teachers model these types of verbal behaviours in their interactions with their students (Cohen et al. 2002). Furthermore, when teachers are explicit in the types of thinking they want children to engage in, it encourages students, in turn, to be more explicit in the types of help they provide to each other during group discussions.

Webb et al. (2008), in an in-depth investigation of the role of three teachers in supporting students' explanations of their thinking, reported that the greatest amount of correct and complete student explaining occurred in the classroom where the teacher did the most to elicit students' explaining. In this study, the teacher did this by inviting students to explain and elaborate on their explanations, whether their explanations were correct or incorrect and she encouraged this type of behaviour even when the students were working in dyads, independently of the teacher. Webb et al. argued that this teacher, through her behaviour, created a learning context in which all students understood that they were expected to explain their thinking, and it was a willingness to engage in this type of behaviour that was valued.

In a study of four elementary classrooms where teachers had participated in one year of on-site professional development on ways to develop students' algebraic reasoning, Webb et al. (2009) found that when teachers pressed children to explain their thinking, it helped them to clarify their explanations, justify their reasoning and problem-solving strategies, and correct any misconceptions. Moreover, the more teachers probed students' explanations, the more explanations students provided, and the more correct and complete these explanations were, the more they were positively related to achievement scores.

The present study builds on research that indicates that teachers' play a key role in promoting those interactional behaviours that challenge children's thinking and scaffolding their learning. It does this by seeking to determine whether teachers who receive training in explicit strategic questioning strategies demonstrate more verbal behaviours that mediate children's learning than the teachers who did not participate in this training. The study also seeks to determine whether the students who receive training in explicit questioning strategies demonstrate more explanatory behaviour than their untrained peers, and, as a consequence, do these same students demonstrate more advanced reasoning and problem-solving skills on follow-up learning activities.

Methodology

Study design

This is a comparative study of the effectiveness of training teachers to implement specific strategic questioning strategies (discussed below) to challenge students' thinking, problem-solving, and learning during cooperative learning in comparison to teachers who implement cooperative learning who have not received training in the specific strategic questioning strategies. The study involved two cohorts of teachers: the cooperative + strategic questioning condition (Condition 1) and the cooperative condition (Condition 2). The study had two purposes: First, it aimed to examine the differences between the cooperative + strategic questioning condition and the cooperative condition in the discourse that the teachers used to scaffold and challenge students' thinking, problem-solving, and learning. Second, it aimed to examine the effects of these specific strategic questioning strategies on the students' discourse and learning. This study was embedded in classes where teachers were prepared to implement cooperative learning because research by Hertz-Lazarowitz and Shachar (1990) found that when teachers implement cooperative learning, their language is more friendly, personal and supportive of students' learning than when they implement whole-class instruction where their language is more authoritarian, rigid, critical, and impersonal. Moreover, during whole-class instruction, teachers often direct the learning while students are expected to be passive and respond only when required to do so. Building on this finding, Gillies (2006) found that teachers who implement cooperative learning in their classrooms use more mediated-learning interactions and make fewer disciplinary comments and students, in turn, model many of these interactions in their small groups, promoting student interactions and discussion.

Teachers

The study involved 31 middle school teachers from seven schools in a large metropolitan city in Australia who agreed to participate in the study. The participating teachers had 1–21 years of teaching experience; nine of the teachers were male and 22 were female, which is broadly representative of the 1:3 ratio of male to female teachers in the middle-years of schooling. All the teachers were volunteers and many regarded the opportunity to participate in the study as a way of extending their professional knowledge by learning new skills.

Students

Six hundred and fifteen children (males = 306, females = 309; mean age for males = 12.86 years, SD = 12.27 months, mean age for females = 12.68 years, SD = 11.57 months) in the above teachers classrooms participated in the cooperative learning activities their teachers implemented as part of their regular curriculum. Children were randomly assigned by their teachers to 3–4 person groups so that each group was mixed in ability levels (i.e., one high-ability student, 1–2 medium-ability students, one low-ability student based on their performance on the Middle Years Ability Test [MYAT] (Withers et al. 2005). The MYAT is designed to assess the general reasoning ability of students between the ages of 10 and 15 years. It consists of a series of items assessing verbal and numerical reasoning abilities which are independent of specific learning in specific subjects. Previous research has shown that low-ability children

benefit from interacting with high-ability students and high-ability students are not disadvantaged from working in mixed-ability groups (Lou et al. 1996; Webb 1997).

In addition to the mix of abilities in groups, teachers were also asked to ensure that the groups were mixed in gender. While the evidence for gender-balanced groups is not unequivocal, Webb (1984) found that when groups were gender-balanced, the males and females had similar interaction patterns. However, in gender-imbalanced groups, the females' experiences were detrimental to their achievement because in majority-male groups, the females tended to be ignored as males focused their attention on other males. In majority-female groups, the females gave more help to the males than they gave to the females. Two groups of children out of each classroom were audio-taped and because of attrition of group members, complete data are only available on 53 groups.

The cooperative + strategic questioning condition and the cooperative condition

The participating teachers were randomly allocated by school to either the cooperative + strategic questioning condition (Condition 1) or the cooperative condition (Condition 2). All teachers participated in a two-day workshop to provide them with the background knowledge and skills to help them establish small cooperative (i.e., cooperative learning) group activities in their classroom. This included ensuring that the key elements known to facilitate cooperation were embedded in the small group activities. Teachers were asked to ensure that: tasks were structured so that all group members were required to participate; the appropriate interpersonal and small-group skills were taught; students understood they were to facilitate each other's learning; students would be held accountable for their contributions; and, students undertook to monitor their group's progress (Johnson and Johnson 2003). The teachers spent time discussing how they would embed these key elements into their cooperative activities, reflect on the concerns about the implementation of this pedagogical practice in their classrooms, and receive on-going support from their colleagues as they discussed their issues. It was important for teachers to have these discussions because research indicates that teachers will decide for themselves on the value and utility of practices for their classrooms (Antil et al. 1998). Lopata et al. (2003) and Gillies and Khan (2008) found that teachers are more likely to implement cooperative learning when they have participated in staff development designed to provide them with the background knowledge and skills required to implement this approach to learning in their classrooms. Research indicates that teachers can be trained during a two-day workshop to successfully implement specific communication strategies and cooperative group structures in their classes (Gillies 2004, 2006). The workshop also provided the teachers with the background information on positive interdependence theory (Johnson and Johnson 1990) and social (Vygotsky 1978) and individual constructivism (Piaget 1950), the key theoretical perspectives that informed the study. The emphasis was on helping the participating teachers to understand how children construct meaning and create new knowledge when they interact with others (Damon 1984; Doise 1990; Palincsar and Herrenkohl 1999).

In addition to the information that was provided on how to structure cooperative learning activities in the curriculum, the teachers in the cooperative + strategic questioning condition received additional information on how to promote discussion among students during their cooperating group activities. Because of the wide variability in students' needs in many classrooms, teachers were introduced to three different approaches (linguistic tools) to promoting student discussion by teaching them how to ask and answer questions.

The first approach, Collaborative Strategic Reading (CSR) (Vaughn et al. 2001) is designed to enhance students' understanding of text by teaching them to use four strategies that successful readers use to comprehend text. These strategies are: the preview strategy (predict what the passage is about); the click and clunk strategy (clicks represent words that are known and clunks are the unknown words); the get-the-gist strategy (identifying the main idea in a passage); and the wrap-up strategy (students summarise the main theme of the passage in 10 words or less). The teachers were asked to introduce each strategy, one at a time, by modelling it and then providing opportunities for students to practise it until they had mastered all four strategies. The children were also given prompt cards to help them remember the sequence of questions.

The second approach, Ask To Think Tel-Why (King 1997), teaches students to ask a series of questions that are designed to promote higher-level thinking and complex learning. The five types of questions the students are taught to ask are: Review questions ("Describe in your own words..."); Probing questions ("Tell me more about...?"); Hint questions ("Have you considered...?"); Intelligent-thinking questions ("How are ...and ...the same and different?"); and Self-monitoring questions ("Have we covered all the ideas we need to?"). The advantages of these types of questions are that they help students to not only summarise and elaborate on information but also to ask cognitively challenging questions by drawing on previous knowledge and understandings and connecting it to new information and ideas to construct new knowledge. The teachers were asked to model these questions to the students so they understood how they could use them to elicit different types of information. As in the first approach, the children were given prompt cards to help them remember the types of questions they could pose.

The final approach to helping students ask questions was an adaptation of the Cognitive Tools and Intellectual Roles approach that Palincsar and Herrenkohl (2002) used to promote student engagement and collaboration during inquiry-based science instruction. Using a variation of the reciprocal teaching strategies of predicting, questioning, clarifying and summarising (Brown and Palincsar 1988) to help students develop explanations about scientific phenomena, Palincsar and Herrenkohl constructed a set of audience roles, designed to promote discussion during the whole-class reporting-back stage. In the current study, these roles were adapted so that some groups in the audience were responsible for checking on the clarity of the presentation, others were responsible for commenting on the clarity of the group's summary of the findings or potential solutions, and others focused on the relationships among the group's presentation of the topic and the summary of the findings or potential solutions. Teachers were asked to stimulate the whole-class discussion during the report back stage by asking different class members the following types of questions: "What do you think about that point?" "Do you think the reason presented is acceptable?" "Why?"

While the teachers in the cooperative + strategic questioning condition discussed how they would teach the students the different questioning strategies, the teachers in the cooperative condition spent the same length of time discussing how they would embed the key elements of cooperative learning into their lesson plans. The teachers and the author discussed the different units of work the teachers were intending to use, how they could be adapted to enable students to have a variety of cooperative learning experiences, and the resources available in their schools to support this approach to learning.

The teachers in the two conditions were asked to ensure that cooperative group activities were embedded in one unit of work (4–6 weeks) across two terms from their social sciences program. In the middle years, many subjects such as English, drama, social studies, and science are taught as integrated themes rather than different subjects so it is not

unusual to see teachers teaching topics on “Climate change” where they have included aspects of science, social studies, English, drama, and art as a way of helping to engage children’s interests while endeavouring to provide them with a broader and deeper understanding of the topic under discussion. However, in planning the units of work the children were to study, all teachers were asked to use the *Studies of Society and Environment Years 1–10 Syllabus* (Queensland Schools Curriculum Council 2000) as a guide to structuring their activities. This syllabus is not prescriptive but rather provides a framework for planning learning experiences and assessment tasks through which students have opportunities to demonstrate what they know and can do. The syllabus incorporates the cross-curricula priorities of literacy, numeracy, life skills, and has a futures’ perspective so that any unit of work has an integrated curricula approach. Hence, while teachers designed their own units of work, they all used the same principles of planning for the learning experiences that they designed for their students.

Cooperative learning tasks

Teachers in both conditions were provided with information on the types of tasks that would encourage student interaction, problem-solving and learning. This was particularly important because research indicates that students are more likely to interact with each other when they participate in ill-structured tasks that are open and discovery-based where there are no correct answers or set procedures to follow. When students work on these types of tasks they are more likely to share ideas and information as they seek to resolve the problem at hand than when they work on well-structured tasks where there is a set procedure to follow or correct answer to obtain so students have little need to discuss how to proceed. Ill-structured group tasks encourage student interaction and it is this interaction that Cohen (1994) and Cohen et al. (2002) have found is consistently related to follow-up achievement gains.

Procedure

The first author discussed the preliminary testing with the MYAT and the assignment of students to mixed-ability and gender groups with the teachers prior to the commencement of the study. During the two-day workshop (mentioned previously), the teachers received additional information on the background to the study and the procedures for establishing cooperative learning in their classrooms.

The teachers were audio-taped twice during lesson in which they used cooperative learning activities. The audio-taping occurred towards the final two-weeks of each unit of work in which they had embedded cooperative learning. The teachers wore an audio-microphone and they were taped for the full class period (approximately 45 min). Samples of the students’ language from two small groups, chosen randomly, initially, from the pool of groups available in each classroom, were collected during these taping sessions by placing a cassette recorder with a directional microphone on the desk during each recording session. Two groups were chosen from each classroom because previous research has shown that it is possible to obtain a representative sample of the students’ discourse across classes by sampling the discussions of two groups from each class (Gillies 2004, 2006). The same groups were audio-taped at both taping sessions.

Measures

Teachers' verbal behaviours

The observation schedule of the teachers' verbal behaviours was adapted from Hertz-Lazarowitz and Shachar (1990) and modified by Gillies (2004, 2006). The schedule identifies six categories of teacher verbal behaviour that capture the range of behaviours that teachers demonstrate during small group learning. These behaviours include: demonstrating control (i.e., instructing, directing); disciplining (i.e., reprimands directed at students); mediating learning (i.e., paraphrases to assist understanding, prompts, uses questions to challenge and scaffold children's learning; summarises key ideas); encouraging (i.e., praises students, facilitates student interactions); questioning (i.e., generate a short response); and, maintaining learning (i.e., helps students, refers to technical issues on completing the task). These categories of verbal behaviour were coded according to frequency across recorded class session and represent 100% of each teacher's talk during that session. A total of 46.5 h of teachers' verbal behaviours was taped across the two time periods (i.e., 31 teachers were taped twice over a period of 45 min). Two raters, who were experienced in coding discourse, coded a common 3 hs of audiotape. When there were any coding disagreements, the raters reviewed their coding until there was 100% agreement (Table 1).

Students' verbal behaviours

The schedule of the students' verbal behaviours was originally developed by Webb (1992) and modified by Gillies (2004, 2006) and was designed to gather information on the verbal behaviours that students used during the recorded, small-group learning. The schedule identifies five categories of verbal behaviour: Elaborations (i.e., provides detailed help, including reasons and justifications; extends another students' response to make it more substantive); questions (i.e., open and closed); short responses (i.e., provides short response); engages with others around the topic (i.e., affirms another student's response, makes a statement on the topic to extend discussion, engages in sustained exchanges on the topic); and, directions (i.e., gives directions, disciplines another student to focus attention). Students' verbal behaviours were coded according to frequency across the recorded group session. A total of 79.5 h of students' verbal behaviours (i.e., 53 groups were taped for a period of 45 min) was collected across the two time periods. The same two raters (mentioned previously) coded a common 3 h of students' verbal behaviours and inter-rater agreement was 100%.

Table 1 Distribution of the 31 teachers across seven schools

School	Teachers	Condition
1	11	2
2	6	1
3	1	2
4	2	2
5	2	1
6	5	2
7	4	1

Condition 1 = Cooperative + strategic questioning condition;
Condition 2 = Cooperative condition

Thinking about a problem: a reasoning and problem-solving measure

The teachers were presented with an exemplar of the “Thinking about a problem organiser” (Gillies and Khan 2009) that was to be used to assess the extent to which the children were making connections and building understandings between information presented and discussed during their small group activities. The advantage of this exemplar was that it provided a template which allowed the teachers to construct specific problem-solving and reasoning tasks that were based on the units of work the children had been studying.

The criteria for assessing the “Thinking about a problem organiser” were informed by the Anderson et al. (2001) revision of Bloom’s original taxonomy of educational objectives. The revised taxonomy illustrates the relationship between complex kinds of knowledge and cognitive processes so it is possible to construct a matrix to plot the types of reasoning and problem-solving responses the children generated and to determine the level of cognitive complexity demonstrated. For example in the “Thinking about a problem organiser”, students were asked to identify three possible solutions to a problem issue and the possible positive and negative consequences of each solution. As this aspect of the task required the children to compare and contrast their understandings of the topic and demonstrate an understanding of the different consequences, responses at this level were perceived as being more sophisticated than those that required the factual recall. A more advanced task required children to identify their best solution and provide reasons or their choice. As this task required children to synthesise information, they received a score of four on the one to five dimension that was used to assess students’ responses. The final task required children to illustrate how their decision could be effectively communicated (e.g., design a slogan or a poster or logo that communicates the main message). This task required them to think creatively because it involved them in putting elements of the problem together to produce a novel, yet coherent response to the problem and, in so doing, demonstrate how they were thinking metacognitively. In short, a score of one indicated that students had recorded a response at the knowledge review level, a score of three indicated they were connecting information to develop more complex understandings, and a score of five indicated that they were thinking metacognitively about the problem.

Statistical analyses

The overall effects of intervention over two conditions across two time points were evaluated using repeated measure multivariate analysis of variance (MANOVA), which examines both the between- and within-subject effects. In addition to examining whether there were significant differences between the two conditions at two time points in the verbal behaviour of teachers and student groups, a separate MANOVA was carried out at Time 1 and Time 2. While using MANOVA on teacher data, participating teachers were considered as between-subject variables, while the set of verbal behaviours at Time 1 and Time 2 was considered as within-subject variables. For students’ group data, student groups and their group behaviour at Time 1 and Time 2 were also considered as between- and within-subject variables.

Before conducting MANOVA, collinearity of the dependent measures was assessed. Although it cannot be claimed that the measures were truly independent, none of the correlation coefficients were considerably high (Tabachnick and Fidell 2001). Assumptions of normality and homogeneity of variance underpinning the use of MANOVA were investigated. Normality was investigated by examining the variables for skewness and kurtosis, and homogeneity of variance was assessed using the Box M test. The majority of

the variables met the normality and homogeneity requirements with a few variables with modest violation of assumptions. Given the samples sizes, this violation of assumptions to a lower extent is unlikely to affect the validity of the results (Tabachnick and Fidell 2001).

Data on the students' thinking, reasoning, and problem-solving (TPR-S) scores had a hierarchical three-level structure where repeat observations on students were nested within schools and as such the observations could not be regarded as independent of each other. As the continuous TPR-S scores were expected to vary over students and classes, a multilevel modelling approach was taken to analyse the data. A restricted maximum likelihood (REML) procedure was used to estimate the parameters of the model and hence determine if there were significant differences in students' TPR-S scores between the two conditions while accounting for variation between students and between schools. The multilevel model assumes that unobserved variations between students and classes are random rather than fixed (Bickel 2007).

Results

Teachers' verbal behaviours

The means and standard deviations of the teachers' verbal behaviours in the cooperative + strategic questioning condition and the cooperative condition for Time 1 and Time 2 are presented in Table 2.

To determine if there were significant differences in the verbal behaviours of the teachers in the two conditions across time, a Condition by Time multivariate analysis of variance (MANOVA) was conducted with a repeated measure on the last dimension. The MANOVA yielded a significant multivariate effect for Condition, $T^2 = 0.75$, $F(6, 24) = 3.02$, $p < 0.05$, $\eta^2 = 0.43$ and Condition \times Time, $T^2 = 0.82$, $F(6, 24) = 3.29$, $p < 0.05$, $\eta^2 = 0.45$ but not for Time, $T^2 = 0.56$, $F(6, 24) = 2.22$, $p > 0.05$, $\eta^2 = 0.35$. Three

Table 2 Means and standard deviations of the teachers' verbal behaviours in the Cooperative + strategic questioning and Cooperative Conditions at Times 1 and 2

Variable	Time 1		Time 2	
	Cooperative + strategic questioning ($n = 12$)	Cooperative ($n = 19$)	Cooperative + strategic questioning ($n = 12$)	Cooperative ($n = 19$)
Control	19.83	30.21	18.66	20.00
SD	8.53	18.05	4.47	7.26
Discipline	1.00	4.00	1.66	3.10
SD	1.04	3.80	1.77	3.17
Mediates	24.58	22.78	36.83	21.36
SD	7.57	12.41	5.25	13.39
Encourage	11.58	9.74	10.08	9.52
SD	8.83	4.47	5.01	4.24
Question	22.58	35.52	23.33	26.68
SD	12.50	21.87	15.78	17.16
Maintenance	2.58	5.47	3.33	3.63
SD	2.19	3.11	2.64	2.29

univariate results that were significant for Condition: Discipline, $F(1, 29) = 5.66$, $p < 0.05$, $\eta^2 = 0.16$, Mediates, $F(1, 29) = 6.04$, $p < 0.05$, $\eta^2 = 0.17$, and Maintenance, $F(1, 29) = 4.98$, $p < 0.05$, $\eta^2 = 0.15$. Only one univariate result was significant for Condition \times Time: Mediates, $F(1, 29) = 11.81$, $p < 0.01$, $\eta^2 = 0.29$.

In order to determine if there were differences in the teachers' verbal behaviours in the two conditions at Time 1, a separate MANOVA was conducted. There was no significant difference between the conditions for teachers' verbal behaviour, $T^2 = 0.53$, $F(6, 24) = 2.12$, $p = 0.88$, $\eta^2 = 0.35$. Another MANOVA conducted at Time 2 identified significant differences between the two conditions in the verbal behaviours of the teachers, $T^2 = 1.42$, $F(6, 24) = 5.70$, $p < 0.01$, $\eta^2 = 0.58$, permitting an examination of the follow-up univariate results. Only the univariate result for Mediates was significant, $F(1, 29) = 14.43$, $p < 0.001$, $\eta^2 = 0.32$. An examination of Table 2 shows that the teachers in the cooperative + strategic questioning condition engaged in more mediating behaviour than their peers in the cooperative condition at Time 2.

Student groups' verbal behaviours

The means and standard deviations of the students' verbal behaviours in the cooperative + strategic questioning condition and the cooperative condition for Time 1 and Time 2 are presented in Table 3.

To determine if there were significant differences in the verbal behaviours of the students in the two conditions across time, a Condition by Time multivariate analysis of variance (MANOVA) was conducted with a repeated measure on the last dimension (see Table 4).

The MANOVA yielded a significant multivariate effect for Condition, $T^2 = 0.42$, $F(5, 47) = 3.96$, $p < 0.01$, $\eta^2 = 0.30$, Time, $T^2 = 0.85$, $F(5, 47) = 8.04$, $p < 0.001$, $\eta^2 = 0.46$, and Condition \times Time, $T^2 = 0.48$, $F(5, 47) = 4.51$, $p < 0.01$, $\eta^2 = 0.32$. The significant univariate results for Condition were: Elaborate, $F(1, 51) = 9.69$, $p < 0.01$, $\eta^2 = 0.16$ and Short response, $F(1, 51) = 5.90$, $p < 0.05$, $\eta^2 = 0.10$. The significant univariate results for Time were: Short response, $F(1, 51) = 8.87$, $p < 0.01$, $\eta^2 = 0.14$,

Table 3 Means and standard deviations of the students' verbal behaviours in the Cooperative + strategic questioning and Cooperative Conditions at Times 1 and 2

Variable	Time 1		Time 2	
	Cooperative + strategic questioning ($n = 20$)	Cooperative ($n = 33$)	Cooperative + strategic questioning ($n = 20$)	Cooperative ($n = 33$)
Elaboration	12.85	9.30	15.75	9.51
SD	7.40	7.66	6.06	6.04
Question	10.25	11.30	8.65	10.36
SD	4.67	6.14	4.43	4.31
Short response	8.25	12.33	7.50	8.54
SD	3.97	5.83	3.13	4.23
Engages	12.65	10.96	16.10	16.39
SD	8.09	8.12	9.11	7.52
Direction	0.75	0.78	0.90	0.93
SD	1.25	1.02	1.37	1.19

Table 4 Results of repeated measures MANOVA testing for difference between different conditions over time in students' group verbal behaviour

Source of variations	Hotelling's T	F	df	<i>p</i>	Partial Eta-square
MANOVA @ Time1&2					
Conditions (between-subject)	0.42	3.96	5, 47	<0.01	0.29
Time (within-subject)	0.85	8.04	5, 47	<0.001	0.46
Time by Conditions	0.48	4.51	5, 47	<0.01	0.32
Significant univariate results for Condition					
Elaboration		9.66	1, 51	<0.01	0.16
Short response		5.90	1, 51	<0.05	0.10
MANOVA @ Time 1					
Conditions	0.21	2.03	5, 47	0.91	0.18
MANOVA @ Time 2					
Conditions	0.60	6.25	5, 52	<0.001	0.37
Dependent variables					
Elaborate2		18.74	1, 56	<0.001	0.25

and Engages, $F(1, 51) = 9.81, p < 0.01, \eta^2 = 0.16$. No univariate results were significant for Condition \times Time.

In order to determine if there were differences in the groups' verbal behaviours in the two conditions at Time 1, a separate MANOVA was conducted (see Table 4). There was no significant difference between the conditions for students' verbal behaviour, $T^2 = 0.21, F(5, 47) = 2.03, p = 0.91, \eta^2 = 0.18$. Another MANOVA conducted at Time 2 identified significant differences between the two conditions in the students' verbal behaviours, $T^2 = 0.60, F(5, 52) = 6.25, p < 0.001, \eta^2 = 0.37$, permitting an examination of the follow-up univariate results. Only the univariate result for Elaborates was significant, $F(1, 56) = 18.74, p < 0.001, \eta^2 = 0.25$. An examination of Table 3 shows that students in the cooperative + strategic questioning condition recorded more Elaborations than their peers in the cooperative condition.

Thinking, reasoning, and problem-solving (TRP-S)

The multilevel regression model was used to examine the effect of the intervention on students' TRP-S scores while accounting for the nested structure of the data, that is, students within schools across two points in time. Table 5 shows that there was no significant variation among schools ($VC = 0.0174, SE = 0.0306$) but there was a significant variation in repeated observations among students ($VC = 0.2283, SE = 0.0743$). The conditional intra-class correlation coefficient was computed to examine the amount of variation in students' thinking, reasoning, and problem-solving (TPR-S) scores among students. The intra-class correlation coefficient was calculated by dividing the variance component for students by the sum of the variance components for the residual, school, and students. The intra-class correlation was 0.295, indicating un-explained variation among students of approximately 30%. On examining the effect of the intervention on students TRP-S scores, there were significant differences for condition ($p < 0.0001$). The intercept in the fixed part of the model was 2.87, which is the average TPR-S score for all students in

Table 5 Mixed effects of multilevel regression of condition and stanine variables on students' thinking, reasoning, and problem-solving (TRP-S) scores

TRP-S scores				
Fixed-effects	β	SE	<i>p</i> value	95% CI
Intercept	2.8698	0.1855	<0.0001	2.5062 to 3.2334
Condition	−.5678	0.1619	<0.0001	−0.8854 to −0.2503
Random-effects	VC (SE)		95% CI	
Residual	0.5274 (0.0698)		0.4069 to 0.6836	
School	0.0174 (0.0306)		0.0005 to 0.5410	
Student	0.2283 (0.0743)		0.1206 to 0.6836	

β regression coefficient, *SE* standard error, *VC* variance component, *CI* confidence interval

all classrooms. The effect of condition on TRP-S scores was 0.57 less for the cooperative condition than the cooperative + strategic questioning condition.

Discussion

The current study had two aims. First, it aimed to determine whether teachers who were trained in explicit strategic questioning strategies designed to challenge children's thinking and scaffold their learning (cooperative + strategic questioning condition) demonstrate more verbal behaviours that mediate children's learning than teachers who did not participate in this training (cooperative condition). Second, it aimed to determine whether students who are trained in explicit questioning strategies demonstrate more explanatory behaviour than their untrained peers, and, as a consequence, do these same students demonstrate more advanced thinking, reasoning and problem-solving skills on the follow-up TRP-S task. All teachers who participated in the study agreed to embed cooperative learning experiences into a unit of work (4–6 weeks) in social science, once a term for two school terms. In addition, the teacher in the cooperative + strategic questioning condition agreed to teach their students some specific questioning strategies designed to teach them how to ask questions, particularly questions that promote higher-level thinking and complex learning. These questioning strategies were taught to students through the use of teacher modelling and prompting with students having opportunities to practice these questioning strategies as they participated in their cooperative, small groups.

The results show that the teachers in the cooperative + strategic questioning condition used significantly more mediating behaviours than their peers in the cooperative condition. This finding is consistent with a previous study by Gillies and Khan (2009) that found when teachers are trained in specific questioning skills (e.g., King 1997; Palinscar and Herrenkohl 2002; Vaughn et al. 2001) designed to teach children how to ask and answer questions then they, in turn, demonstrate more verbal behaviours that mediate children's learning than teachers who do not receive this training. In the current study, this included asking questions that probed and clarified issues, confronted and challenged discrepancies, and paraphrased and summarised key ideas. In short, the teachers in the cooperative + strategic questioning condition posed questions that both challenged and scaffolded children's higher-level thinking and complex learning. Interestingly, these teachers used

fewer disciplinary sanctions than their peers in the cooperative condition, possibly because of the way they moved around the groups, actively modelling the questioning strategies they were encouraging the children to use. There is no doubt that teachers play a key role in actively promoting discourse among students and encouraging them to explain their thinking (Christie et al. 2009; Gillies and Khan 2008; Kutnick and Berdondini 2009). Hence, providing teachers with the linguistic tools to enable this to happen appears to be critically important if students are to maximise on the benefits attributed to social interaction and learning (Gillies and Khan 2009; Webb 2008; Webb et al. 2009).

Interestingly, the children in the cooperative + strategic questioning condition engaged in more elaboration than their peers in the cooperative condition. It appears that when children are exposed to questions that challenge their thinking and scaffolded their learning, it sensitises them to the importance of responding with more complete and detailed responses than they may have previously given. Wegerif et al. (2005) found that when teachers explicitly teach children to engage in Exploratory talk (an approach to dialoguing together), they demonstrate an increase in well reasoned argumentation over time. Similarly, Reznitskaya et al. (2009) found that when students are taught to engage in Collaborative Reasoning (CR) during group discussions where they learn to adopt different positions on an issue and support their position with reasons and evidence, rebutting alternative ideas, and challenging the positions of others, they learn to acquire enhanced argumentation skills. Moreover, these skills not only enhance learning in the social context in which they are taught but they also transfer to different tasks and contexts, including written tasks. In effect, Wegerif et al. and Reznitskaya et al. maintain that the quality of student discourse and learning can be enhanced when students are explicitly taught how to dialogue together and are provided with opportunities to practice these newly acquired skills in partnership with others. Given that talk is now recognised as more than a means of sharing thoughts but as a social mode of thinking and a tool for the joint construction of knowledge (Mercer and Sams 2006; Mercer et al. 2004), providing students with opportunities to interact productively together may be critically important for the development of their social reasoning and problem-solving skills and learning (Gillies and Khan 2009; Mercer 2008). These are issues that need further investigation.

The thinking, reasoning, and problem-solving (TRP-S) measure that the children completed at the end of each unit of work was designed to determine how they were building understandings, making connections, and demonstrating higher-level thinking about information discussed during their small-group discussions. The results show that there were significant differences between the children in the two conditions with the children in the cooperative + strategic questioning condition obtaining higher TRP-S scores than their peers in the cooperative condition. Teacher intervention in providing guidance in how to ask and answer questions during group work appears to be crucial to helping students understand the importance of engaging in higher-level thinking and providing detailed explanations or elaborations to others (King 2002; Webb and Mastergeorge 2003; Wegerif et al. 2005). In fact, it may have been the lack of explicit and systematic intervention by teachers in the cooperative condition on how to ask and answer questions that contributed to the differences between students in the two conditions in their TRP-S scores (Gillies and Khan 2008).

Limitations

There were two limitations to the current study. First, there were no pre-intervention measures of the teachers' and students' verbal behaviours during cooperative group work.

This was because the teachers had not consistently implemented cooperative learning in their classrooms and they expressed the opinion that they needed to participate in the training offered in order to set the groups up correctly before the research team undertook their investigation. Second, the teachers were volunteers who were interested in embedding cooperative learning into their social science curriculum so they were not randomly selected from a pool of available teachers. The self-selection of teachers into the study limits the generalisations that can be made about teachers' willingness, generally, to implement cooperative learning in their classrooms and use the linguistic tools that challenge and scaffold children's higher-level thinking and complex learning.

Conclusion

The study shows that when teachers are taught how to use different strategic questioning strategies during cooperative learning (cooperative + strategic questioning condition), they use more mediating behaviours that challenge and scaffold students' higher-level thinking and learning than their peers who use cooperative learning only (cooperative condition). The role the teachers in the cooperative + strategic condition played in actively modelling and guiding students use of different questioning strategies, ensured that the children understood the importance of providing detailed and elaborative help to their peers, and it was this enhanced dialoguing that contributed to the higher TPR-S scores obtained by the children in the cooperative + strategic questioning condition. The study demonstrates the importance of explicitly teaching strategic questioning strategies to children during cooperative learning.

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