Collective Argumentation in the Primary Mathematics Classroom: Towards a Community of Practice

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This paper explores the nature of Collective Argumentation talk in the primary classroom. Interpersonal, intrapersonal and discursive data collected from three Collective Argumentation classrooms is analysed within a framework which recognises the linguistic, psychological and cultural nature of classroom talk. Findings suggest that Collective Argumentation talk functions to assist students to view the development of mathematical knowledge as occurring within their own community of discourse. Suggestions for employing talk as the basis of a classroom community of practice are provided.

Of recent interest to researchers is the view that students learn within a community of practice, i.e., a community in which participants assist each other to become full participants in the educational practice of the classroom (Forman, Stein, Brown, & Larreamendy-Joerns, 1995). In the domain of History, Seixas (1993) highlighted tensions related to the nature of historical investigation, interpretation and debate that teachers face in carrying knowledge outside of the scholarly community and into the school classroom. Bereiter (1994) in dealing with misconceptions, methodology and authoritative text in science education urged teachers to extend knowledge within the classroom by engaging students in a 'progressive discourse' based on a set of quasi-moral disciplinary commitments. Lampert (1990) argued that 'disciplinary virtues' need to be employed in reconceptualising a classroom mathematical culture where students are assisted in viewing knowledge as emerging from their local 'community of discourse'.

Promoting cognitive development through synthesising scholarly discursive practice and the pragmatic voice of the classroom is a common theme shared by the above authors. Preliminary research reported recently by the present authors (see Brown & Renshaw, 1995) found that positioning Year 6 students' discourse within a Collective Argumentation framework (see Brown, 1994) promoted mathematical understanding and the development of higher mental processes within students.

Collective Argumentation

In the spirit of Mikhail Bakhtin (see Todorov, 1984) Collective Argumentation may be said to be a discursive 'speech genre' within the 'social language' of the academic discipline of mathematics. Incorporating Miller's (1987) principles of cooperation within Vygotsky's (1978) notion of mediated social interaction as the means of facilitating cognitive development, Collective Argumentation gave form and structure to students' collaborative ways of doing and talking about mathematics. A key word structure - Represent, Compare, Explain, Justify, Agree and Validate - created a space within the classroom where personal and disciplinary voices could meet. It also enabled a classroom culture to develop where students' dialogue was influenced by core disciplinary values.

The apparent congruence between the goals of academic discourse and the quality of talk experienced within the Collective Argumentation classroom prompts one to consider such a classroom as a community of practice analogous to the mathematical community of discourse. However, before such a claim can be justified further research into the constitutive elements of Collective Argumentation talk needs to be conducted. It is the aim of this paper to provide insights into what these constitutive elements may be by examining cognitive, interpersonal and discursive evidence taken from three different Collective Argumentation classes over a four year period.

Analysing Classroom Talk

Following Mercer's (1995) paradigm for analysing the quality of talk within a classroom, research into Collective Argumentation talk needs to be focused at three levels.

Firstly, at the linguistic level, classroom talk is examined as text. This analysis is focused at ascertaining what types of 'speech acts' (propositions, explanations, justifications, requests, consensual statements, etc.), 'discourse exchanges' (negotiations, submissions, dominations, frustration's, etc.) and 'topic foci' (content, process, extracurricular, etc.) take place. Secondly, at the psychological level, classroom talk is investigated as thought and action. The focus here is on the dialogic nature of the interaction between participants, that is, the "I"/"other" relationship that is being generated. How is the communicative relationship contributing to students' mutual understanding, group membership, social connectedness and mathematical identity? In other words, what kind of 'ground rules', i.e., implicit norms and expectations (Mercer, 1995), is the interaction displaying and what level of reasoning (concrete, intermediate, abstract) is being made visible?

The third level of analysis is what Mercer (1995) calls the 'cultural' level. The focus here is on those principles of educated discourse that are made evident in classroom talk. For example, the principles of 'reflection', 'generalisability', 'objectivity', 'consistency', 'consensus' and 'recontextualisation' which are core elements of Collective Argumentation. These principles are, to a greater or lesser degree, considered by others such as Bereiter (1994) and Lampert (1990) to be constitutive elements of scientific and mathematical discourse.

Analysing Collective Argumentation Talk

Linguistic Analysis: Interpersonal Plane

At the linguistic level we see the content of Collective Argumentation talk centring on a specific type of speech act which Kruger and Tomasello (1986) refer to as 'transacts'. Transacts are spontaneously produced verbal behaviours that clarify, critique, refine, extend, justify or paraphrase a student's point of view or the point of view of another and may be said to fall into three major categories - statements, questions and responses. In a comparative analysis with conventional collaborative talk employing a correlated t test (see Brown & Renshaw, 1995), the content of Collective Argumentation group talk displayed a significantly higher proportion of transacts than did talk generated by conventional groups [33.3% as compared to 23.1%, t (5) = 3.8011, p < .006], with requests for clarification, justification and elaboration of ideas directing the function of group discourse.

The content of Collective Argumentation talk, therefore, resembles what Mercer (1995) refers to as 'exploratory talk', i.e., students' collaborative talk which foregrounds and facilitates the development of reasoning. Requests for clarification, justification and elaboration would also seem to be constitutive elements of talk associated with collaborative inquiry in the Computer Supported Intentional Learning Environments (CSILE) which experts have favourably linked to the scientific community of inquiry (see Hakkarainen, 1995).

Psychological Analysis: Intrapersonal Plane

At the psychological level, two-thirds of independent problem solving protocols of students who had employed Collective Argumentation talk in their groups displayed a mature quality of thinking on a novel problem task, whereas only one-third of the students who had experienced conventional collaborative talk displayed such understanding. Further examination of protocols suggested that the voluntary employment of higher mental functions such as hypothesising, setting and monitoring subgoal achievements and empirically validating outcomes were the features that most distinguished the problem solving efforts of the Collective Argumentation students from the efforts of the conventional collaborative students.

Although no measures of the 'ground rules' that students employ when engaging in Collective Argumentation talk were taken during this particular study, further exploratory research (Brown, 1996) provides a number of insights. A modification of repertory grid technique (Kelly, 1955) was used to investigate the constructs that 10 Year 7 students used to describe doing maths with others (teachers, peers, teacher-aides, etc.) in a Collective Argumentation classroom. The grid was administered and initially analysed on a whole group basis. Table 1 displays the category types generated by the 120 bi-polar constructs elicited from students.

Table 1: Bi-polar constructs by type and as a % of total constructs elicited.

Type	%
Efficacy	30.00
Interactive	22.50
Communication of Meaning	17.50
Competence	16.67
Other	13.33

As can be seen from Table 1, as a group Collective Argumentation students perceived doing maths within the classroom from a perspective that highlighted 'efficacy' (will others help me succeed), 'interactional style' (will others co-operate), the 'communication of meaning' (will an understanding with others be established) and 'competence' (will others have the ability).

These results suggest that students learning within a Collective Argumentation classroom perceive doing maths with others differently to children operating in more conventional classrooms. For example, Stodolsky, Salk and Glaessner (1991) found that fifth grade students' viewed their 'competence' and 'efficacy' in learning mathematics to be framed by 'dependence' (i.e., I can't learn math without teacher instruction). These authors concluded that such views were displayed because these students saw math as an individual performance rather than mastery oriented subject, such as social studies, where the same students evidenced views related to student interaction and elaboration. The fact that Collective Argumentation students viewed maths in terms related to 'communication' and 'interactional style' as well as 'efficacy' and 'competence' would suggest that they view doing math with others (peers, teachers, etc.) as an important feature of mastering mathematical concepts. More specifically, one could say that the quality of communication displayed in classroom interaction was a salient feature of Collective Argumentation talk for these students.

However, suggesting that Collective Argumentation students value quality communication in the classroom provides little insight into the implicit norms and expectations (ground rules) that are necessary for students to take account of in order to successfully participate in such communication. To do this, one must examine classroom discourse itself.

Linguistic and Psychological Analysis: Discursive Plane

A 15 minute segment of a video-taped math lesson in a Collective Argumentation Year 6 classroom was transcribed for analysis. This segment was chosen because it occurred in the Communal Validation part of the lesson where individual students and groups of students interact with the teacher in the presentation and validation of problem solving methods and solutions.

Context and Method: The children had been working in groups representing, comparing, explaining, justifying and agreeing on ideas related to the following problem: 'Jack can clean a room in 10 minutes and Jane can clean the same room in 15 minutes. What fraction of the room will be cleaned in 1 minute if both Jack and Jane work together?' The discourse that followed this group work was analysed according to the framework employed by Forman, et al. (1995) for analysing teacher and student contributions to the function of classroom talk. This framework requires that classroom talk be classified into conversational turns (i.e., student-turn or teacher-turn) with each turn often containing multiple utterances and ending where there is a change in speaker.

Ninety-nine conversational turns were coded according to the following criteria: (a) 'Request-for-answer': a turn in which the speaker asks another speaker to provide specific information without elaboration; (b) 'Request-for-explanation': a turn in which the speaker asks another speaker to elaborate on a statement previously given; (c) 'State-answer': a turn in which the speaker provides a specific answer; (d) 'Explanations': a turn in which justifications or rationales for a point of view are given; (e) 'Restatements': a turn where a speaker repeats what another has spoken; (f) 'Expansions': a turn where a speaker adds to or completes another's statement; (g) 'Rephrasing': a turn where a previous statement is modified but the meaning remains the same; and (h) 'Evaluations': a turn where a speaker makes a statement about the accuracy, conceptual correctness, completeness or relevance of a previous utterance (Forman, et al. 1995).

Results and Discussion: The results of the coding procedure are displayed in Table 2.

Table 2: Conversational turns as a % of total turns by type and agent.

Type	**Teacher %**	**Students %**
Request-for-answer	12	09
Request-for-explanation	05	06
State-answer	00	17
Explanation	00	16
Restatement	04	00
Expansion	04	03
Rephrasing	02	04
Evaluation	03	05
Other	05	05
Total	35	65

As can be seen in Table 2, the students in this Collective Argumentation class generated more conversational turns than did the teacher. They also matched the teacher with requests for answers and requests for explanations. This finding is inconsistent with the Initiation-Response-Evaluation conversational framework that characterises traditional classroom talk, where the teacher mainly asks the questions and provides requests for explanations (Forman, et al. 1995). These results suggest that the students in this Collective Argumentation classroom share control with the teacher of discussion topics and the direction that thought and action take in the discourse of this lesson. They also suggest that the students share with the teacher an interest in the establishment of joint understanding. A striking example of students sharing in the control of the direction of classroom discourse is provided in the following extract.

A group of students (Damien and Lauren) was presenting their thinking about the problem to the class. They had drawn two representations on the blackboard: one organising the problem information into boxes with the problem question occupying a separate box; the other, a drawing of a room complete with bed, window, wardrobe and door. Lauren was presenting her group's ideas by referring to the room diagram:

Teacher: (To class) Is talking about wardrobes, clothes and beds helping us to work out a solution to the problem? Are there other people who would like to say something? (Expansion)
Student: What fraction of the problem did you get? (Request-for-answer)
Damien: Well we are not working with fractions, sort of. (State-answer)
Student: Why did you set the information in the problem up like that and not use it? Why did you set the information out like that when you didn't use it? (Request-for-answer)
Damien: What? (Request-for-explanation)

Teacher: Why did you set the information in the problem up like that if you didn't use it? (Restatement)
Damien: Well we did. Well we are. (State-answer)
Teacher: Would anyone like to add to the reasoning process? Damien and Lauren have taken us so far. Is there anyone who can take us the next step forward? The next step forward to a solution. (Expansion)
Greg: You would probably divide the room up into five. (Explanation)

Although it was the teacher who initially cast doubt over the effectiveness of Damien and Lauren's thinking, it was a student who took up this invitation and directed the discussion to the topic of fractions by requesting an answer. Dissatisfied with Damien's answer, again it was a student who directed attention back to the problem information, as represented by Damien, by requesting an answer. The teacher reinforced the direction this discussion was taking by restating the question when Damien sought an explanation. Taking up the teacher's invitation Greg proceeded to provide an explanation of how the room diagram could be viewed in terms of fractions.

An example of students sharing in the teacher's interest in establishing joint understanding is provided in the following extract which came towards the end of the lesson. A group of students (Emma, Pauline and Nicholas) had presented their representation of the problem to the class along with their thinking about the solution method:

Teacher: Who can understand Emma's and Pauline's and Nicholas's way of doing it? Does it make sense? (Request-for-answer)
Lauren: (To group) So are you saying that together they can clean 5/30's in a minute? (Request-for-answer)
Emma: Yes. (State-answer)
Student: Can you please go over it and explain it right from the beginning? (Request-for-explanation)
Emma: So we divided the room up into 15 parts for Jane because she took 15 minutes to clean the whole room and Jack took..... we divided his into 10 parts and we took 1 minute. (Explanation)
Student: What's that there (pointing to the diagram on the board)? (Request- for-answer)
Teacher: While this group is mapping out the finer points, if you understand the problem can you find someone in the room who doesn't understand the problem and share it with them. (Class breaks up into group discussions with children who understand, explaining to those who don't understand. These discussion groups continue even after the recess bell informs the children that it is time for lunch.)

This extract starts with the teacher emphasising the expectation that the class be able to make sense of explanations. The students take up this obligation by requesting answers and explanations from the group concerning the nature of the solution and the solution method. The teacher lives up to this obligation, not by explaining the solution and the solution method to the class, but by inviting students who understand to share with those who don't understand. The students display their interest in attaining joint understanding by voluntarily continuing their group discussions after the recess bell (a phenomenon rarely observed in conventional classrooms).

In the 15 minute segment, the students provided all the answers which is consistent with the I-R-E framework and all of the explanations which is inconsistent with traditional classroom talk. This suggests that these students view themselves as playing a major role in the development of ideas within the classroom. By providing multiple opportunities for the students to provide answers and explanations the teacher set up the conditions for student ideas to be expressed in increasingly abstract mathematical terms. The following excerpt occurred after the students had been assisted by the teacher to negotiate the meaning of the problem question : 'What fraction of the room will be cleaned in 1 minute if both Jack and Jane work together?'

Joanne: (To group) Could you please explain why you divided (unable to be heard). (Request-for-explanation)
Emma: Yeah, because Jane took 15 minutes to clean the room so we divided the room up into 15 parts and... (Explanation)
Teacher: That will tell you what? (Request-for-answer)
Emma: How many minutes... (State-answer)
Nicholas: She will take 1/15 of the room. (Expansion)
Teacher: She will clean 1/15 of the room in? (Request-for-answer)
Nicholas: One minute. (State-answer)
Teacher: So Jane can clean 1/15 of the room in 1 minute. (Restatement)
Emma: And Jack will clean 1/10 of the room in 1 minute. (Expansion)
Teacher: And Jack can clean 1/10 of the room in 1 minute. (Restatement)
Emma: And so to find out how much that would be altogether, and 1/15 and 1/10 don't add together so we find their closest factor (lowest common denominator) which is 30. So we added them together 2/30 and 3/30 and we got 5/30. That's how much they took 1 minute to clean.... 5/30's of the room. (Explanation)

At Joanne's request, Emma attempts to link the group's representation of the problem (a rectangle divided into 15 parts) with the requirements of the problem question. However, she is unable to see beyond the idea that 15 parts equals 15 minutes. Nicholas provides an expansion on Emma's thinking (She will take 1/15 of the room), but struggles to make the necessary linkage until the teacher rephrases Nicholas's expansion in the form of a request for an answer. Nicholas makes the linkage in his answer and this linkage is restated by the teacher. Emma is then able to make the necessary linkages herself and finishes by explaining the group's solution to the problem in abstract mathematical terms (i.e., 1 minute to clean 5/30 of the room). The class then discusses the answer in terms of equivalent fractions and Emma finally proclaims the group's answer to the problem as being '1/6 in 1 minute'.

As can be seen from Table 2 the teacher provided the majority of restatements, expansions and rephrasings in this segment of the lesson. This finding coupled with the fact that the teacher provided no answers or explanations suggests that the teacher facilitated conceptual development within the classroom by assisting students to reconceptualise their everyday thinking about the problem in the language of mathematics. The teacher expanded, restated and rephrased students' ideas by employing phrases such as 'working out a solution', 'the reasoning process', 'understanding', 'mathematical symbols' and 'sharing ideas'. Such teacher language established the conditions for the emergence of increasingly general mathematical concepts. By making statements such as 'Would anyone like to add to the reasoning process?', 'Does it make sense?', and 'Are there other people who would like to say something?' the teacher invited students to enter the discourse and assisted them to appropriate the disciplinary norms for sharing and evaluating knowledge within the mathematical classroom. The fact that the students engaged in conversational turns classified as expansions and rephrasings is evidence that they were indeed adopting the social norms of mathematical discourse as modelled by the teacher.

It is interesting to note that the students made more evaluations than the teacher. However, teacher evaluations tended to serve a different function. This is illustrated in the following excerpt. A group of students (led by Michelle) had presented their thinking about the problem to the class. This thinking was procedural in nature and centred on summing 10 and 15 and then dividing by 2 (a common strategy used by students when attempting to solve this problem).

Teacher: (Referring the group back to the problem question) What fraction of the room will they both clean if they both work together. Do you think that you have really answered the question? (Evaluation)
Teacher: (To another group of children) Emma does your group want to come out and have a go? (Request-for-answer)
Emma: Yes. (State-answer)

Teacher: (To class) Remember if you want to ask something then ask. (Rephrasing)

Michelle: We would like to revise our answer. Find out..... (Evaluation)

As can be seen in the above excerpt the teacher's evaluation of the group's explanation was phrased in the form of an invitation to Michelle's group to reflect upon the relevance of their thinking rather than in the form of an explicit statement about correctness. This type of evaluation was employed exclusively by the teacher during this segment of the lesson and suggests that the teacher was more interested in having the students conceptualise the problem and apply specific procedures to hypotheses, than in having the students adopt a procedure driven approach to the problem. However, Michelle's evaluation refers explicitly to the answer and a need to revise it. The teacher assisted this group to adopt a different approach to the problem by inviting them to stay at the blackboard and work with Emma's group whose problem solving approach was conceptually driven.

Psychological and Cultural Analysis: Discursive Plane

What are the 'ground rules' that drive Collective Argumentation talk in this classroom? Participants speech indicated that they valued quality talk in social interaction. The above excerpts display that participation in such talk requires from participants (teacher and students) commitments to: (a) shared control of the content of discussion and the direction which thought and action take in discourse; (b) shared establishment of joint understanding; (c) shared agreement about the way that evidence can be brought to bear on ideas; (d) shared willingness to revise ideas when there is good reason to do so; (e) shared interest in progressing knowledge from the everyday to the scientific; (f) shared co-construction of mathematical knowledge; and (g) shared communal evaluation of knowledge. These commitments reflect the quasi-moral commitments that define a mathematical community of discourse as conceptualised by Bereiter (1994) and Lampert (1990).

At the cultural level of analysis, these commitments reflect the principles of educated discourse that invite students to adopt sociocultural ways of reconceptualising the doing of and thinking about mathematics. Through comparing representations, the students were able to *generalise* and *reflect* on their ideas within a context of group membership. Explanations and justifications provided opportunities for students to *objectify* ideas and to incorporate *consistency* into their thinking. Expansions, rephrasings and evaluations provided opportunities for students to attain *consensus* and to attempt *reconceptualisations* within a context that promoted communal attachment.

In summary, the three studies indicate that the principles of Collective Argumentation talk ('reflection', 'generalisability', 'objectivity', 'consistency', 'consensus' and 'recontextualisation) assisted students to display mature thinking when solving a novel problem (Brown & Renshaw,1995), assisted students to value quality talk in social interaction (Brown, 1996) and assisted students in the above classroom discourse to advance their thinking from the everyday to the scientific.

Conclusion

Quality talk in mathematics classrooms need not be a rare event. This paper has shown that the features of Collective Argumentation provide the social context in which students are able to appropriate forms of talking and thinking which are analogous to the broader mathematical community of discourse. Collective Argumentation classrooms, therefore, can be referred to as communities of practice analogous to the mathematical community of discourse. Further research employing linguistic, psychological and cultural levels of analysis along the interpersonal, intrapersonal and discursive planes of operation needs to be conducted to specify the links between the classroom, Collective Argumentation talk and the discourse of the mathematical community of practice.

The insights provided in this paper, however, do offer guidance to teachers interested in transforming their classrooms into communities of practice. Firstly, at the linguistic level, authoritative texts (textbooks and the teacher's voice) need to be viewed as providing a platform for inquiry so that scholarly works may be seen by students as active contributions to the generation of knowledge through metadiscourse. Secondly, at the psychological level, classroom talk needs to reflect scholarly criteria for evaluating discourse if the development of higher forms of conceptual development is to take place. Thirdly, at the cultural level, the social resources of the classroom need to be reconceptualised in terms of assisted participation guided by disciplinary commitments if the search for meaning and understanding is to be facilitated at the local level. Finally, Collective Argumentation offers teachers a pedagogical structure to influence their practice in classrooms so that students may be assisted to view what they learn as having meaning and value in society.

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