Learning to co-operate:
Small group interaction in New Zealand elementary mathematics classrooms

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This paper explores the possibilities for cooperative group work in NZ elementary mathematics programmes. It discusses effective tasks and appropriate teacher behaviour for promoting cooperative group work. The paper is based on observations made in eight classrooms of children in the first two years at school in the Wellington city area over terms two and three 1993. In particular it highlights what appear to be key factors of effective small group instruction in mathematics.

Introduction

The official curriculum document, *Mathematics in the New Zealand Curriculum* (1992, p.29) states that students at level one (typically 5-7 year olds) should be, "working co-operatively as part of a group by listening attentively, generating ideas, and participating in reflective discussion". New Zealand elementary classrooms have commonly used small-group instruction for many years. However, given the emphasis in the new curriculum, it is timely to look more closely at what happens during this time in the classroom, and to build up a knowledge of group processes. There is a need to identify key factors leading to this model of instruction being an effective means of enhancing student achievement, encouraging useful relationships with peers, and improving attitudes towards mathematics as a subject.

Writing about cooperative group work has often focused on the merits of different models of grouping. A more fundamental issue is a consideration of how instruction can be improved to facilitate the meaningful acquisition of mathematical ideas. Good and Biddle (1988) warn that small-group instruction, on its own, is unlikely to make the discussion and practice of mathematics more meaningful. It is also not simply a matter of providing less teacher support and encouraging more learner independence (Nickerson, 1988). Good, Mulryan and McCaslin (1992) argue that it is the quality and place of small-group instruction in a mathematics programme that is important. The goal is to help children to learn how to learn and to consider the whole context of learning in the classroom. Good and Biddle argue for the proper implementation of small-group instruction which they define as careful organisation and appropriateness of tasks. Good, Mulryan and McCaslin (1992 p.167) urge caution

Yet to be demonstrated is whether small-group instruction influences the development of critical thinking, students' views of mathematics content and problem solving, students' ability to reason mathematically, and their developing social intelligence.

The value of peer interaction and **Peer interaction patterns**

There is little process data which indicates what happens during small-group instruction, and traditionally the value of peer interaction has been described mainly in terms of the socialisation of behaviour and personality. Possibly this relates to the current analyses, usually of an ethnographic nature, of classroom life which mostly focus on social aspects. The influence of this on the learning of mathematics is often neglected. Cobb (1990) sees this neglect as part of a wider issue of how to coordinate analyses of the construction of mathematical knowledge with analyses of classroom social life.

Some commentators are urging a reconsideration of the value of peer interaction for classroom learning. Webb (1989) identifies the level of interaction as a criterion for judging the success of a cooperative task. However, the nature of that interaction is important if learning of mathematics is to occur. Forman and Cazden (1985) argue for the recognition of the importance of cognition and intellectual learning. A number of commentators (Forman & Cazden (1985), Bennett & Dunne (1992), Thomas (1994) have analysed interaction patterns while children work independently of the teacher. Forman & Cazden argue that to increase the value of learning in a peer contextual setting the number of abstract interactions should be increased and the number of procedural interactions (i.e. those focused on getting the task accomplished) decreased. However, Cobb (1990) points out that abstract and procedural interactions are interdependent, and suggests that one can become the other. For example, problem solving strategies might appear first as social interactional procedures. A recent study in New Zealand school classrooms (Thomas 1994) has found that whilst much of this interaction is task-related, it was more likely to relate to the social demands of the task rather than the cognitive demands of the task.

Effective teacher behaviour

There has been much discussion of the teacher's role in small-group instruction. It is not enough just to set a joint activity. A possible difficulty with this is that much of the classroom practice in NZ elementary mathematics classrooms has been based on a Piagetian perspective as this has been the predominant perspective on peer collaboration. Forman and Cazden (1985) argue that this is only useful where cognitive conflict is evident, and that a Vygotskian perspective may be more useful in situations where mutual guidance and support are evident. Such a perspective would lead to qualitative differences in the role of the teacher. For instance, in relation to the nature of the teacher's intervention, the teacher might support the interactive nature of the children's discourse by making interventions that enable the children to continue with their dialogue. Alternatively the teacher might encourage the children to work cooperatively by asking them to explain their thinking or to listen to one another's explanations. Wood & Yackel (1990, p.248) argue that "the teacher mutually establishes with the children the expectations and obligations necessary to conduct collaborative dialogue as they engage in mathematical activity". The way that the teacher models instructions of small-group activities is the key to the occurrence of benefits such as peer assistance. Forman & Cazden point out that the teacher's model must be learnable by the children. The children learn what to say and do in the questioner role from the teacher model.

Appropriate tasks for group work

Bennett and Dunne (1992) note that very little has been written about the kinds of tasks that are most appropriate for cooperative group work. They argue that learning outcomes are an issue of task design. However instruction cannot be seen just as a collection of 'good activities' and tasks need to be located in a coherent structure. Much of the literature on cooperative group work discusses interventions set up outside the normal classroom programme. There is some question as to how useful such studies are in changing regular classroom mathematics programmes designed by teachers if the activities are to be part of a coherent structure.

Discussion

For this paper I will draw my example from an elementary classroom. It was one of those randomly chosen as part of a study into ways of increasing the value of peer group learning in terms of the mathematical processes learning outcomes in the NZ curriculum. 113 mathematics lessons, each of approximately an hour in length, were observed, audio-taped, and video-taped. The lessons were evenly spread across 8 classrooms of 5 and 6 year old children. Standard ethnographic practices were used with a focus on a small group of children in each classroom.

The example chosen for this paper is of a game - one of the commonest, independent learning tasks currently used as part of NZ elementary mathematics programmes. The purpose of such games is for children to learn different mathematical concepts, and to develop autonomy as learners. Typically there is a great deal of interaction between students as they work together to play the game.

	(The teacher introduces the game, Workers and Their Tools, to a group on the mat.)
Teacher:	*This is a new game. There's four, no eight big cards. What do you think you'd do with that?*
	(Four children have big cards in front of them.)
Teacher:	*Does it look like the chart we did today?*
	Has this one got arrows on it? It's got (the teacher pauses) little squares and (the teacher pauses) lines (the children join in the answers) so what do you think belongs in the little squares?
	The little things that the person in the square might use.
Teacher:	*Kerry, you have another turn. Erin, you have another turn.*
Teacher:	*What do you think a builder needs?*
	(Tom suggests some things.)
Teacher:	*Would you like to help Linda?*
Teacher:	*Now fill in the whole thing. (The teacher holds one up.)*
Teacher:	*What do you think that one is Kerry?*
	Okay what would happen if you wanted one of these and someone else wanted the same card and you both thought it belonged to your picture? How could you work out if it belonged to your picture? You might have a discussion about who should have it.
Teacher:	*In Lisa's picture the gardener might use a ladder but in Gina's picture the painter might use a ladder.*
	(The teacher and the children go through the little cards deciding which of them a painter might use.)
Teacher:	*If we gave the ladder to the painter is there something here that the builder might use? Think hard.*
	(She holds up the sander.) So where do you think the sander should go?

In her introduction of the activity the teacher relates it to the children's previous learning and thereby locates the task in a coherent structure. In this case, the game relates to the work on relationships. The game involves matching smaller cards showing pictures of tools with larger cards of workers who might use them. Each player has a board with spaces for two larger cards and four smaller cards which the player chooses on the basis of the relationship to the larger card. In this game there are more possibilities than spaces on a board for each of the workers. There are many different ways that the cards can be related to any of the workers and different outcomes are possible in different sessions. The teacher suggests to the children that they might need to have a discussion about who should have a card.

The task is designed in such a way that the children are encouraged to think about the mathematical ideas embodied in the task; in this case stating the relationship between the elements of two sets - the workers and their tools. During the introduction the teacher structures the play so the players' thought processes of decision-making are highlighted and the procedures of play are only mentioned in passing. The teacher does this through modelling reflective discussion by asking the children about possible moves in the game and possible actions they could take if there was disagreement or that as a group they could not decide between the possibilities.

(The children now have the opportunity to play the game themselves with the teacher choosing four children, Tom, George, Megan and Gina, to play the game. As they play the game they discuss the possible ways of relating the elements of the two sets, the workers and their tools.

Gina:	*Do you know I could use the ladder as well.*
	(She has the gardener card.)
Tom:	*But you don't use it most [compared to the painter].*
Gina:	*I'm just having a little look to find out.*
George:	*I can see your one.*
	(They are looking at the small cards that they could choose from.)
A few minutes on...	
George:	*I can see one which Gina needs.*
	I can see one Megan needs.
Gina:	*Who uses toilet paper? (She holds the small card up.)*
	No that's nurse stuff. Maybe it's a bandage or something.
	(The whole group are looking at the toilet paper card.)
Gina:	*Oh it's hard.*
Tom:	*If you like I'll find one for you.*
	(Tom hands Megan one to put on her board.)
Tom:	*Now it's my turn. I can see another one as well. George's turn.*

Gina:	*If I don't think one's right I can put one back and get another one again. That and that and that. They all use it. (She points to a number of cards.) I've got one place left and two things. What do you think I should do? (to the group)*
Tom:	*Megan's got one. Who uses scissors?*
Gina:	*The hairdresser uses scissors more. I might just have to do that.*
Tom:	*What do you think I should get? Now what else would a doctor use?*
Gina:	*I'll start another [board].*
Children:	*Ding - (together) wheelbarrows.*
Gina:	*Cos gardeners use wheelbarrows.*
Tom:	*It's not your turn, it's George's.*
Tom:	*I'm trying to help you as well. (Tom puts one on Megan's board.) That goes with that.*
George:	*That's right.*
Gina:	*That goes with that. Just let me have a look cos I might be able to find something. Would he [the cleaner] use a drier? No [in answer to her own question].*
Gina:	*That hairdrier would go zip. I know we'll get onto that and see what is the last pair.*
George:	*The last thing that is left out will be it.*
Gina:	*Now I'll start. There. (She places the wheelbarrow.)*
Tom:	*Now Megan. I can see one. (It is Megan's turn.)*
George:	*So can I.*
Tom:	*(whispered) A spade, a spade, a spade.*
Play continues for another few minutes...	
Tom:	*There, (placing a small card) and there's only one more left for me.*
Gina:	*Megan, after this turn she still won't be finished will she?*
Tom:	*The only one which is left is the spade and the rake. (Gina has the gardener's card.)*
George:	*Is it my go?*
Tom:	*No, Megan's. Megan does.*
George:	*I was thinking.*
Tom:	*That was the only thing left. It must go there. (The spade is left and Megan puts it in her remaining space with the cleaner.)*
Gina:	*No - that just puts holes in things. My dad's got one. Gosh as soon as we were finished the bell rings. (The children in the end have matched the spade to the cleaner.)*

The children's supportive attitude towards each other is evident in the above transcript. For instance, George notes that he can see cards that Gina and Megan need. Tom offers to find a card for Gina when she comments that it is hard. Although Gina pointed out the problems of the cleaner having the spade, the children did not seem to take this up. Maybe they thought that as this was the only one left it must go there, or perhaps it was that at that point the bell rang to signal the start of lunchtime.

The teacher later said that she felt that it was important to explain this game because otherwise the children were likely to just play "memory" with it. She was pleased that they had had a discussion about who should get a particular card.

As discussed at the start of this paper, the features identified as key factors of effective small group instruction would appear to be present in the preceding example. This task generated discussion, encouraged children to think about the mathematical idea embodied in the task, and provided an opportunity for all children to participate by giving rise to multiple sub-tasks. The children appeared to want to help each other. The way in which the teacher introduced the children to the task by mutually establishing the nature of the interactions seemed important. The teacher had a clear expectation of the children engaging in collaborative dialogue.

Any exploration of the possibilities for small-group instruction to meet the outcomes of the curriculum must include an examination which considers the design of the task, appropriate teacher behaviour, and effective patterns of children's interactions which promote cooperative group work.

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