Paper code : BOO 01079

Presenter : Hong-Kwen Boo

Challenges of integrating cooperative learning in primary science classrooms

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Paper presented at a joint conference of Australian Association for Research in Education (AARE) and Singapore Educational Research Association (ERA)

2-6 December 2001, Fremantle, Australia.

Abstract

The challenge of teaching science is to teach in a way that enables pupils to learn science concepts while acquiring process skills and positive scientific attitudes. One of the effective ways of accomplishing these objectives is through involving pupils in hands-on activities in the context of cooperative learning. The use of cooperative learning presents immense practical challenges to teachers. This paper is based on classroom observations of science teaching where teachers reported that they were using some form of cooperative learning. These classroom observations were part of a larger study which examined primary classroom practices in Singapore. Our classroom observations reveal that while group work is being carried out in Science lessons, few of the teachers have structured group learning according to the principles of cooperative learning. A challenge faced by teachers is the design of group tasks that will require higher-order thinking and promote real collaboration among group members.

Introduction

A challenge faced by science teachers is to teach in a way that enables pupils to learn science concepts while acquiring process skills and positive scientific attitudes. A variety of teaching strategies have been advocated for use in science classrooms and these fall on a continuum, ranging from teacher-centred ones (such as exposition or didactic teaching) to more learner-centred ones (such as inquiry through individual investigations or through small group investigations, field trips, practical work and project work) each tailored to suit specific learning objectives, lesson content, learner characteristics and learning environment.

In Singapore, small group inquiry through investigations or hands-on activities involving concrete objects has been advocated since the mid –1980s and is one of the variety of methods described in a sourcebook given to primary science teachers (Ministry of Education (MOE), 1987). Since mid-1980s, workshops and courses organized jointly by MOE and the National Institute of Education (NIE) had been mounted to train teachers in conducting such small group and activity-centred lessons. Among the reasons given for use of small group work are that they encourage active pupil participation (in contrast to the passive learning that occurs in traditional classrooms where the teacher uses a transmission or didactic method of teaching); they increase opportunities for pupil talk and simultaneous interaction and processing of information, and for pupils to learn to exercise teamwork, cooperation and sharing of ideas, and for more productive thinking.

In the early 1990s, a more specific form of small group work, i.e., cooperative learning was introduced and included in primary science curriculum packages developed by the Curriculum Development Institute of Singapore (CDIS) (1993). It became one of the many methods highlighted in the second edition of primary science sourcebook (MOE, 1997). As part of the implementation plans of the new science curriculum packages, MOE and the NIE were involved in training teachers in the use of cooperative learning as part of their repertoire of teaching methods which they should be familiar with.

Cooperative Learning: Meaning and Benefits

Cooperative learning is "a relationship in a group of students that requires positive interdependence (a sense of sink or swim together), individual accountability (each of us has to contribute and learn), interpersonal skills (communication, trust, leadership, decision making and conflict resolution), face-to-face promotive interaction, and processing (reflecting on how well the team is functioning and how to function even better)" (Johnson and Johnson, 2001). For practical purposes, cooperative learning can be viewed as a learning method where pupils

work together in small groups to learn and are

responsible for their teammates'

learning as well as their own.

In a cooperative learning environment, pupils work in groups of two to six to achieve a common goal. These groups are structured heterogeneously, usually in terms of academic ability, sex and race. There are numerous cooperative learning strategies available to teachers, each with its different set of instructional procedures. These include Line-up, Numbered Heads Together, Listen-Think-Pair-Share, Sequential Roundtable and Jigsaw (CDIS, 1993a p. iii-viii).

Cooperative learning is seen as "a powerful tool to motivate learning" and has a positive effect on the classroom climate. Its uses as stated in the sourcebook (MOE, 1997, p.7) include "to encourage greater achievement, to foster positive attitudes and higher self-esteem, to develop collaborative skills" and "to promote greater social support".

These beliefs about the benefits of cooperative learning has been substantiated by research on cooperative learning, much of which has been conducted in North America and Israel. The research findings suggest that the use of cooperative learning in classrooms bring about positive effects on cognitive and affective learning. Several research reviews and meta-analyses (Johnson, Maruyama, Johnson, Nelson & Skon, 1981; Johnson, Johnson & Maruyama, 1983; Sharan, 1980; Slavin, 1980) concur on the positive impact of cooperative learning on academic achievement. Cooperative learning studies have also reported positive effects on a range of affective outcomes, including inter-group relations (Slavin, 1985), self-esteem (Sharan, 1980) and classroom climate (De Vries et al., 1974).

Challenges of integrating cooperative learning in science classrooms

What are the challenges involved in integrating cooperative learning in science classrooms? The findings reported here are based on data collected in the second phase of a three-part study of classroom practices in Singapore. The first phase is a questionnaire survey of how primary school teachers' in Singapore organize their classrooms in various subject areas (Chew, Ng, D'Rozario & Lee, 1997). For the second phase, the research team observed 50 lessons in four content curriculum areas – English, Mathematics, Social Studies and Science, and preliminary analysis of lessons across the four content areas have been made (Ng, Chew, Lee, Ambrose-Yeoh, Boo & D'Rozario, 1999).

Classroom Observations and Data Collection

Classroom observations of teachers using group work were conducted over two months in October – November 1998 in six primary schools and six teachers in each school were selected by the school principal or head of department. A second round of classroom observations was conducted in March – April 1999 in the same schools, with different teachers. The teachers had varying years of teaching experience. Fifty lessons in four content curriculum areas -

English, Mathematics, Social Studies and Science - at the lower (P1-P3) and upper (P4 - P6) primary levels were observed by the research team. Each lesson lasted one hour. Lesson planning was done by the teachers, without any discussion with the researchers. The researchers were careful not to influence how the teachers used group work as the purpose was to record how they were using the approach.

Each lesson was generally observed by one researcher. During the lesson, the researcher tried to be unobtrusive and was seated at the back of the room, note-taking with paper and pencil. Each lesson was recorded in detail, using a proforma form as a guide. The observation notes were narrative descriptions of the lesson, as the researcher concentrated at this stage on compiling neutral accounts of what took place. A short interview with the teacher followed the lesson, where the researcher asked the teacher questions about how they typically used group work, and clarified some points in the lesson. The researcher then returned to her office and independently added her reflections to the observation notes. The researcher's reflections focused on six aspects: whole-class teaching, group work, social skills, teacher-pupil communication, surprises in the lesson and post-group work.

The process of data analysis involved one research team member undertaking the task of reading all the observation notes. Observer notes were reduced to a matrix form which enabled cross analysis of group work practices. The conceptual frame used to analyse the group work practices was the key principles of cooperative learning. Apart from the inclusion of the key elements, evidence was sought of adaptations the teachers had made in practice which could reflect their understanding of the cooperative learning approach and their beliefs about learning.

The Teachers and Class Settings

Four of the twelve science teachers observed had less than 5 years of teaching experience, one had eight years, the rest had 20 and more years of experience. Half of the teachers had some form of cooperative learning training during their teacher preparation course, in-service courses or had attended cooperative learning workshops. The teachers who had no training in cooperative learning had all heard about the approach, usually from their colleagues.

This paper is based on an analysis of the twelve science lessons which were observed and examines the challenges involved in integrating cooperative learning in the context of teaching primary science in Singapore. To provide some insights into what went on in the classes, four cases are presented below.

Case 1: Primary 4 class studying the topic "plants around us"

This is the case where some form of cooperative learning appeared to be taking place.

Small group tasks

There were two small group tasks. The first task involved think-pair-share cooperative structure where pupils were first asked individually to think about how they would classify a set of three different leaves into two groups and then paired with a neighbour to discuss the task.

The second task involved classifying 7 sets of different leaves into 2 groups. Pupils were seated in groups of five. Each was assigned a role i.e. material handler, recorder, time- keeper, encourager and volume controller.

Seven different envelopes (labeled A to G) each containing 5 different leaves were passed round each of the groups in turn. Each pupil was to take a leaf from the envelope. First, the group members were to decide on a classification scheme for the five leaves in their envelope and then in a round-robin structure, each member was to put his/her leaf in the correct group of the classification scheme. After that, each group reported back to the class how they classified the leaves in the envelopes A to G.

Notes made by researcher-cum-observer

The tasks set by the teacher were divergent enough and hence appropriate for cooperative learning. The two cooperative learning structures used, think-pair-share and round-robin, were also generally appropriate as the first task was a simple lead-in activity that could be done individually, and the answers checked with a partner. The second task

was more complex, as it required the groups to think of a classification scheme. The round-robin activity should have given every pupil a chance to play a part. However, in one or two groups the round-robin structure did not work out well because there were one or two pupils who dominated the problem solving which revealed that some pupils had not understood the aims and benefits of teamwork.

It was a reasonably good lesson on cooperative learning; and the pupils appeared to be enthusiastic about the tasks. However, due to lack of effective time management, the teacher appeared to be running short of time and was in a hurry to wrap up the lesson. The result was there was inadequate probing of pupils' answers presented during oral presentation by small groups

Case 2: Primary 5 class studying the topic "communities"

Small group task

Pupils in groups of six were given an envelope containing 10 cards on which names of various animals have been written. The groups' task was to decide which community (leaf litter, seashore, pond, field, etc) each animal belongs to.

Notes made by researcher-cum-observer

No particular cooperative structure was used, neither was the language of cooperative learning used by the teacher. There was not much pupil discussion/interaction on the given task and the pupils were squeezed around a worktable that was too small for a group of six. Answers appeared to be decided by one or two dominant pupils in each group (or by pupils whom their group members thought were good in science).

Researchers' view on how the lesson could be re-structured to promote cooperative learning

While the task was suitable for group work, the teacher did not structure the activity such as to ensure effective group work. A "Teammates Consult" structure could have been used. This would require members in the group to share and discuss which community each animal belongs to, and finally write down their individual answers. Teachers who wish to use group work should also plan the physical arrangements of the class, so that the size of groups and the arrangement of pupil seating will support interaction.

Case 3: Primary 5 class studying the topic of "water & changes of state"

Small group task

Pupils sitting in base groups of 4 to 6 were asked to first to predict individually and mentally (i.e. without writing down) the temperature of crushed ice and of a mixture of crushed ice and salt. Then the groups were asked to complete a task (mentioned on page 42 of their Primary Science Workbook 5A(CDIS, 1993b) on measuring temperature, firstly of crushed ice, and secondly, of a mixture of crushed ice and salt.

Notes made by researcher-cum-observer

Pupils were seated in small groups; but there was no cooperative group work The teacher did not encourage pupils to share or to learn from each other. For example, the teacher did not encourage pupils who could read the thermometer to teach their peers who could not. There was no role division, other than that of the group leader who appeared to be doing all the work. Except for the reminder to lower the volume of their voices there appeared to be no emphasis on social or collaborative skills. No obvious attempt was made to involve pupils in thinking through the task to grasp the concepts behind what they were engaged in. The pupils appeared to be rather busy observing and trying to read the thermometer, when in actual fact there were not much talk between pupils or between pupils and the teacher, about the key science concepts involved, which is about the interaction between ice and the salt resulting in a lower melting point of ice.

Researchers' view on how the lesson could be re-structured to promote cooperative learning

Instead of asking pupils to mentally predict the temperatures of ice and the mixture of ice and salt, the teacher should have asked them to write down their predictions. This would have enabled them to move towards sharing/discussing their reasons for their predictions with a partner or within a small group.

It was surprising that the teacher covered so little ground in terms of content in the double- period lesson. The teacher took the trouble to obtain crushed ice and used the Science Room where the pupils could be seated in groups. Yet an important experiment which involved putting a small test tube containing about one teaspoon (or $0.5cm^3$) of water into the container of crushed ice and salt and observing the subsequent freezing of the water was not carried out. This experiment is really the main part of the activity; moreover it follows on naturally from the first part and does not require more than 10minutes. It would have been an interesting task for the groups to offer an explanation for the freezing of the water and to infer the working principle of the "mini-freezer".

Case 4: Primary 6 class studying the topic "energy"

Small group tasks

There were two group tasks assigned. The first task concerned the drawing of a concept map based on a list of seven concept words selected by the teacher. The second group task involved finding out the paper aeroplane (among the paper aeroplanes made by group members; each member made his/her own paper aeroplane following instructions given by the teacher) which flew the greatest distance. After that, the "champion" within the group competed with the "champion" of other groups.

Notes made by researcher-cum-observer on first small group task - concept mapping

For the task on concept mapping it was observed while pupils appeared to sit in heterogeneous base groups of 4, 5 and 6, no specific cooperative learning structure was used. In most of the groups, the work was done by one or two dominant pupils. Then the same dominant pupils from each group went out to the front of the class to present their maps. There were no interaction between presenters and their peers or the teacher during the oral presentation.

Researchers' view on how the first part of the lesson (concept mapping) could be re-structured to promote cooperative learning

For the concept mapping task, instead of organizing pupils into groups of 4 or 5 while the concept map was drawn by one or two dominant pupils, it would have been better to get pupils to work in pairs. The choice of cooperative learning structure should give consideration to the nature of the task, and be aimed at maximizing learning. Thus by using pairs check or a think-pair-square structure, more pupil participation and pupil-pupil interaction would have been fostered.

Notes made by researcher-cum-observer on second small group task – paper aeroplane challenge

In the case of the second task, it was noted that again no specific cooperative learning structure was used, and there was not much discussion within the groups concerning concepts and environmental conditions affecting the flight distance. The teacher did not assign specific and clear roles for carrying out the experiment. Consequently, while the group leaders were given the task of holding down the measuring tapes they had brought with masking tapes (and they took a long time doing this task), their group members were flying their aeroplanes playfully and aimlessly.

Researchers' view on how the second part of the lesson (paper aeroplane challenge) could be re-structured to promote cooperative learning

For the second part of the lesson involving finding out which of the paper aeroplanes made by pupils could fly the farthest, a "pairs compare" followed by "line ups" cooperative learning structure could have been used. In pairs, the

distance travelled by the paper aeroplanes could have been compared and the one which flew farther identified, thus eliminating the need for the use of measuring tape. Then the winning aeroplane of each pair of pupils could then be competed with the winning plane of another pair and so forth, and the winner among them decided. Likewise in the inter-group competition, the same two structures could have been used.

Overview of science lessons observed

Although all the lessons involved some amount of group work, the key features of cooperative learning – positive interdependence, individual accountability, interpersonal skills and face-to-face interaction and processing - were not significantly integrated in eleven of the twelve lessons observed. Cases 2, 3 and 4 typify these eleven lessons in that pupils were thought to be involved in cooperative learning when they are not. Case 1 represents a situation closest to our idea of a lesson based on cooperative learning. However, across the twelve lessons observed some noteworthy points were gleaned. These are:

1. Teachers were generally enthusiastic about group work, but some appeared to equate pupils sitting in groups with cooperative learning.

2. The arrangement of desks in the classrooms appeared to allow easy transition to seating in small groups.

3. Pupils were trained to get into groups quickly, and with minimum noise.

4. Pupils appeared to enjoy group activities.

5. Class management was generally good.

6. Teachers were generally successful in using some of the cues important in controlling cooperative work such as the "Quiet" signal.

7. Tasks given were generally suitable for cooperative work, in spite of the fact that in practice, pupils were not working cooperatively.

8. Teachers did move around in an attempt to monitor groups; although in practice, one would question the effectiveness of the monitoring since teachers were generally unaware that there was no cooperative work being done.

Challenges of integrating cooperative learning which surfaced from the study

Teachers' lack of adequate training in conducting lessons based on cooperative learning

The main challenge which surfaced appeared to be the teachers' lack of clarity concerning the aims, principles and theoretical foundation of the cooperative learning approach. This resulted in teachers implementing the method in a manner that lacks rigour and discipline, with some even believing that merely assigning students work in small groups or pairs brings about cooperative learning. This is perhaps a reflection that hitherto whatever training the teachers had in terms of integrating cooperative learning into science lessons has not been adequate. This inadequacy has resulted in most, if not all, of the other challenges discussed below.

Principles of cooperative learning were largely not in place

Teachers generally did not attempt to encourage each group member to be responsible for participating and learning, i.e., there is lack of individual accountability. While pupils were given a common task and were sitting in small groups, the other basic principles of cooperative learning i.e. positive interdependence, interpersonal skills, face-to-face interaction and processing, were also largely not in place. Hence what was observed was work done by pupils sitting in small groups, but not really cooperative work. Other than the leader, the other members in the small groups were

generally not assigned specific roles. Also many pupils saw the task completion process as a competition between groups rather than cooperation within groups; and the speed of completion of task was seen as the essence of the work rather than the process of discussing and ensuring that every member understood the work and had a part in the task. Many pupils also tended to defer to the views of their more able peers (or those who were perceived as more able in science), resulting in a lack of debate or discussion or other interaction among group members. Thus, much of the small group work was dominated by one or two dominant pupils. Weaker or slower pupils tended to be side- lined or had their ideas over-ruled. The result was unequal participation among group members, and a general lack of solidarity among group members.

Pupils not trained in collaborative skills

Pupils were, by and large, not trained in collaborative and oral skills. More specifically, they were not trained to articulate or to elaborate or defend their own ideas or to seek clarification on others' ideas. They were not trained to listen and respect ideas or viewpoints of pupils from the same group or from other groups. Nor were they trained to wait for or tutor a weaker peer. There was not much pupil-pupil interaction within a small group, other than talk concerning procedural matters. Nor was there not much pupil-pupil interaction across groups. Group sizes were generally too big comprising 5-8 members, instead of 3-4. This renders it difficult to have air one's views on any matter.

Some of the small group tasks were not appropriate for cooperative learning

Some of the tasks were not suitable for cooperative work because they are convergent and not divergent tasks. An example is a primary five class working on the topic "water and changes of states". The given task merely involved taking the reading of the thermometer when it was placed, firstly in a container of crushed ice and then, in a mixture of crushed ice and salt. The task could hardly be considered challenging for a primary five (P5) class and did not allow for divergent views. The task could have been modified by extension of the thought processes – by requiring students to propose explanations for the observed drop in temperature of the ice upon mixing salt with it.

Where small group tasks were appropriate, output of work was not capitalized

Teachers generally did not capitalize on the output of group work. Pupils' attention were not drawn to the diversity of acceptable answers. There were no evidence that output of group work was assessed and rewards given based on evidence of individuals working as a group in the process of completing the tasks.

Suggestions on integrating cooperative learning in science lessons

Working cooperatively requires adequate and systematic training of teachers as well as of pupils. The limited one or two sessions on the use of cooperative learning in the context of science lessons covered in pre-service teacher education programmes such as the post-graduate diploma in primary education programme are clearly inadequate in terms of equipping teachers in the integration of cooperative learning in their science lessons. While most of the teachers would at the same time be exposed to equipping sessions aimed at helping them integrate cooperative learning into English, Mathematics or Social Studies lessons (being generalist teachers who generally teach all non-Mother tongue subjects in the primary school curriculum i.e., English, Mathematics, Science and Social Studies) perhaps the transfer of learning from one subject to another did not occur to a significant extent.

A further challenge facing teachers is the need to formulate or design interesting and meaningful group tasks that require higher-order or divergent thinking and promote real collaboration among group members. Such a challenge could perhaps be addressed by teachers working together in cooperative groups within schools as well as across schools.

In the same way that teacher training in the use of cooperative learning needs to be more extensive and rigorous, training of pupils are just as vital. Pupils need to be systematically trained in the use of various collaborative skills and various cooperative roles – such training would require investment of time and effort. Cooperative groups also need to

be carefully chosen after the teacher has built up knowledge of pupils' personalities, interests, skills and abilities, as well as how they interact with each other. The teacher needs to be a good facilitator by showing pupils that s/he is aware of what is going on in each group. The teacher needs to be well-prepared for each activity; to have materials ready and explain procedures clearly. The teacher needs to summarize the ideas of groups presented and to assist pupils in constructing a coherent understanding of phenomenon investigated.

The teacher also needs to learn to give rewards based on positive group behavior and participation.

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