Developing Primary Students’ Group Metacognitive Processes in a Computer Supported Collaborative Learning Environment.

Chris Chalmers
Centre for Mathematics, Science and Technology Education
Queensland University of Technology
Australia
ca.chalmers@student.qut.edu.au

Rod Nason
Centre for Mathematics, Science and Technology Education
Queensland University of Technology
Australia
r.nason@qut.edu.au

Abstract
This study investigated the development of group metacognition by three small groups of middle-grade primary school students engaged in the collaborative construction of computer-based mathematical models. The three groups of students were part of a cohort of 30 Grade 4-5 students engaged in the construction of mathematical models within the context of a computer-supported collaborative learning (CSCL) environment. These three groups were chosen for the group metacognition study because they were seriously malfunctioning, little co-operation was evident between them and most of their time was spent on non-productive conflict. During the six week period of the study, the three groups were provided with sets of metacognitive scaffolds and strategies to facilitate group metacognition. The design of the metacognitive scaffolds and strategies was informed by a conceptual framework that was derived from the literature in the fields of metacognition, cooperative learning, cooperative group metacognition, and computer-supported collaborative learning. The study found that providing the students with metacognitive scaffolds and strategies resulted in positive changes in the students’ cooperative work and increased levels of knowledge-building activity. The students formed a ‘collective cognitive responsibility’ for their group work and developed an understanding of how to contribute effectively to the knowledge-building progress of the group.

Introduction
This study was part of a larger research project (Nason, Woodruff, & Lesh, 2001-2003) in which the focus was on creating and maintaining a mathematical knowledge-building community of practice within a cohort of two grade 4/5 composite classes from an inner-city school in eastern Australia. Groups of students within this study were engaged in the task of creating an alternative model that could be used for ranking nations’ performance at Olympic Games which de-emphasised the mind-set of “gold or nothing.”

In order to create their model, each group of students was required to search for relevant information from a web based database and using this information (e.g., population, gross domestic product, literacy rates etc.) develop an Excel® spreadsheet model which ranked 20 different countries’ performance at the Sydney Olympic games in a “fairer way” than by ranking in terms of gold medals won. Following the development of their initial model, each group of students was required to post their model into Knowledge Forum® (Scardamalia & Bereiter, 1998), a computer-supported collaborative learning environment that enables users to share their model with other groups in the community and also to view and make constructive comments about other groups’ models. Thus, following the posting of their own model, each group of students looked at the models the other groups had posted on Knowledge Forum® and provided constructive feedback (such as comments, questions, propositions) to the other groups about their models. They also simultaneously engaged in the
process of iteratively revising and improving their model based on the feedback they received from the other groups of students.

While several studies have suggested that groups are more productive than individuals (Archer-Kath & Johnson, 1994; Johnson & Johnson, 1999), not all groups are co-operative (Johnson & Johnson, 1999). It was apparent to all involved in the larger research project that the majority of students in the two grade 4/5 composite classes needed to improve their group work skills, as they were not working co-operatively. Three groups in particular were dysfunctional and were having a deleterious effect on the overall functioning of the learning community. Therefore, the major aim of this study was to investigate how the introduction of group metacognitive strategies to these three groups of students would affect their group work at computers. This study also aimed to discover the nature of group metacognitive knowledge by describing how group behaviours changed due to the metacognitive experience.

**Conceptual framework for the study**

The conceptual framework for this study was derived from research literature from the fields of metacognition, group work, and computer-supported collaborative learning (CSCL).

A review of the research literature from the field of metacognition revealed that group metacognition can be scaffolded in these three ways: 1) knowledge about learning processes and strategies being explicitly taught (Hartman, 2001; Schraw, 2001; Wilson & Johnson, 2000; Xiaodong, 2001); 2) metacognitive strategies such as planning, monitoring and evaluating being promoted by introducing self reflection of learning through the use of tools such as a diary (Blakey & Spence, 1990; Wilson & Johnson, 2000) and checklists (Tombari & Borich, 1999); and 3) the creation of a supportive social environment in which students can practice and evaluate their use of metacognitive strategies (Gourgey, 2001; Xiaodong, 2001).

Research conducted regarding group work indicates that: 1) Working together in a problem-solving group means that an effort must be made in order to help all group members understand the task (Johnson, Johnson, & Johnson-Holubec, 1993); 2) Students need to encourage one another’s learning and feel responsible for helping each other for the sake of the group product (Cohen, 1994); 3) A complex task ensures that students use task skills and teamwork skills in order to work together to solve the problem (Dishon & O’Leary, 1984); 4) Effective group work requires metacognitive thought (Johnson & Johnson, 1993); and 5) To ensure that small group processing takes place, time needs to be allocated for members to participate in group processing and structure needs to be provided in order for group members to process how they worked together (Johnson, Johnson, & Johnson-Holubec).

Research from the field of CSCL indicates that: 1) The type of CSCL task determines how students co-operatively work around the computer (Bennet & Dunne, 1992); 2) Students need to metacognitively consider their group work as a component of group problem-solving around the computer (Antaki & Lewis, 1986); 3) When students are engaged in knowledge-building activity within a CSCL environment, they need to take responsibility for metacognitive functions (Bereiter & Scardamalia, 1989; Scardamalia, in press); and 4) How students communicate and behave around the computer also influences group learning (Crook, 1999; Light & Littleton, 1999).

Key ideas derived from the review of the research literature from these three fields were synthesised into the conceptual framework presented in Figure 1. The key elements of the framework are co-operative learning and metacognition; both are important elements in co-operative problem-solving within CSCL environments. The framework highlights how group problem-solving tasks require groups to think metacognitively about effective co-operative group behaviours, as well as the group problem-solving task. The conceptual framework
shows effective group metacognition requires three important factors. First, social skills and group roles need to be scaffolded in order to assist groups’ co-operative processes. Second, the metacognitive strategies of planning, monitoring, and evaluating are important in fostering metacognition. Finally, a supportive environment needs to be fostered in which students are motivated and receive positive feedback. These three factors form the conceptual basis for the interventions employed in this study.

Figure 1: Conceptual Framework

The Study

Because the major focus of this study was on the co-operation aspects of group problem-solving rather than the problem-solving per se, a qualitative case study design that incorporates many aspects of a teaching experiment approach was used in this study. The purpose of a case study was to “investigate a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 1994, p. 13). Therefore, a case study approach was most appropriate for this investigation. Aspects of a teaching experiment approach were incorporated into the study in order to study the influence of group metacognition instruction on the co-operative groups (Cohen, Manion, & Morrison, 2000).

The participants selected for this study were three groups of students: Group 1 consisted of two grade 4 boys and one grade 5 boy (Greg, Bobby, Peter); Group 2 consisted of three students, two grade 5 boys and one grade 5 girl (Sam, Mike & Alice); and Group 3 comprised of three grade 4 girls (Marsha, Jan, Cindy). These three groups were chosen because they were experiencing great difficulties working collaboratively as a group.

Five sources of data were utilised in this study: 1) Participant observations, 2) Focus group interviews, 3) Diaries, 4) Group processing checklists, and 5) Semi-structured interviews. Participant observations were conducted during each of the sessions. The three groups were observed and videotaped to capture the discourse within their group. Salient portions from the videotapes which showed evidence of students’ use of either task or maintenance aspects of cooperative group work were noted for further discussion. Focus group interviews were conducted after each session. During these interviews, each group was asked about how they thought their group had functioned, their reactions towards group work, as well as their perceptions of the group processes that had occurred during the session. They also were
asked a series of questions based on Hoyles and Healy (1994) that focussed on group metacognition of the task and maintenance aspects of group work. Group Diaries were given to each group in order to document issues the group encountered in the process of working together. The scaffolds within the group diaries focused on group skills such as encouraging others, checking for agreement, disagreeing in nice ways etc. These scaffolds were based on Hare and O’Neill (2000) and Walker (1985). Group processing checklists were completed by each group during the computer session. This checklist directed the participants’ attention towards “How is our group doing” and “How did each member help the group today”. The design of the checklists was based on Johnson and Johnson (1993). Each group’s responses to the checklist were discussed during the focus group interviews. Semi-structured individual interviews were conducted at the conclusion of the four week observation period. The questions in which students were asked about their perceptions of co-operative group work were similar to the questions used in a study by Whicker, Nunnery and Bol (1997).

The research study proceeded in two phases:

1. Direct instruction of group learning skills
2. Development of group metacognition skills.

Direct instruction of group learning skills
In order for the groups to incorporate effective co-operative behaviours, three fifteen minute lessons were presented over a period of three weeks. These lessons were conducted prior to each session in the computer laboratory. The lessons introduced specific skills needed for effective co-operative groups. These skills were derived from the review of the research literature. The group diary was introduced to the three groups during the third lesson in order to scaffold group metacognition.

In Lesson 1, the students were made aware of the group roles of Keyboarder, Checker, and Encourager (Cohen, 1994). The group roles were placed on cards and attached to the whiteboard in order to publicly clarify the roles and help students understand what each role entailed (Cohen, 1994; Johnson & Johnson, 1993). In Lesson 2, the students were asked to reflect on why co-operative groups are needed and students were shown a poster with the task and maintenance aspects of group work. The columns in the poster were later renamed as the ‘What’ and ‘How’ of group work. By Lesson 3, the students were required to take increased responsibility for planning, monitoring, and evaluating their own group learning. Student groups recorded one ‘What’ and one ‘How’ behaviour in their group diary which they used for self monitoring and evaluating their group work.

Development of group metacognition skills
During the next four sessions that were conducted over a period of four weeks, the groups began to use their group diaries to plan, monitor, and evaluate their application of introduced group skills. All groups completed a group-processing checklist during the computer sessions. Initially, the checklists were used to monitor the effectiveness of instruction and students were given an opportunity to provide feedback on their understanding of topics raised. Eventually each group of students created their own list of group skills appropriate for their group to be effective. This is a procedure recommended by Benjamin, Bessant, and Watts (1997) and Cathcart, Samovar, and Henman (1996).

Results and Discussion
Analysis of data from the videotapes of groups co-operatively working as well as extracts from group diaries and interviews indicated that a number of new group behaviours were adopted by each of three groups in order for their group to work effectively.

As the study proceeded, positive group behaviours such as encouraging others, being nice to other group members, and listening and being supportive of other group members were seen
to develop. These changes to their group behaviours were clearly reflected in the group metacognitive diaries. For example, Group 3 when asked what their group had done best in the second last session wrote, “Encourage others.” In earlier sessions, few examples of encouragement were observed with this group. These changes in group behaviour were also reflected in the students’ responses to interview questions. When asked what he had learnt, Mike replied, “I’ve learned a lot about computer group work and how to agree and disagree nicely.” Comments similar to Mike’s were noted in the interviews of most of the other students.

In addition to new group behaviours being adopted, changes to group roles that positively impacted on how the groups worked also occurred as the study progressed. Group members increasingly shared group leadership roles and developed a sense of group responsibility similar in many ways to what Scardamalia (in press) describes as a collective cognitive responsibility. Bales (1970) indicated that there were two basic types of group leaders: task leaders and socio-emotional leaders. Distinct task leaders and socio-emotional leaders emerged in two of the three groups.

The task leaders showed behaviours associated with completing the group task such as contributing ideas to the group, sharing information, and opinions. For example, during the sessions Alice (the task leader in Group 2) contributed the highest number of communication acts (see Figure 2) and displayed task leader behaviours such as taking charge and giving directions. Other group members also perceived Alice in this role. Mike sardonically referred to Alice as, “Captain of the fleet.”

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Sociogram of Week 1" /></td>
<td><img src="image2.png" alt="Sociogram of Week 2" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Sociogram of Week 3" /></td>
<td><img src="image4.png" alt="Sociogram of Week 4" /></td>
</tr>
</tbody>
</table>

Figure 2: Sociograms from Group 2 (Mike, Sam and Alice)

The socio-emotional leaders exhibited behaviours such as encouraging participation and other friendly behaviours. The socio-emotional leader in Group 2 was Mike. Alice emphasised the importance of the socio-emotional role engaged by Mike as being beneficial to the group when she commented:
Mike has humour and Sam has brains so they make a good mix…
Brains are brains they don’t go, need to also have a bit of humour to make it all stick together.

The analysis of the data also revealed that the quality of co-operative group work depended, to a large extent on the nature of the learning task (c.f., Bennet & Dunne, 1992; Cohen, 1986; Jonassen, 2000). The two major behaviours noted during the course of the study were giving information and giving suggestions. When problem tasks were simple, students exhibited group behaviours that focused mainly on giving information. For example, when Group 2 were engaged in the task of collecting data from a database, Mike dictated the following information about Canada from the computer screen to Alice who was making notes, “Climate, temperate with sharp regional contrasts.” When completing more complex tasks, such as constructing If-Then conditional formulae for the Excel spreadsheets models, groups tended to give more suggestions to each other, as they discussed how to proceed and negotiate the requirements of the task. For example, after they had entered data and formulae into their first spreadsheet model and they were deciding how they could make better sense of the data on the model, Alice directed Mike by giving the following suggestion, “Let’s sort them (the data) first.” This finding is consistent with various studies that suggest the problems themselves have an effect on the co-operative process, as problems with unclear goals or multiple solutions need a high level of co-operation and discussion (Cohen, 1986; Gillies, 2000; Jonassen & Carr, 1984).

All groups appeared to benefit from using the group diaries. Groups assumed increasing responsibility for planning and regulating their group learning through the use of the diaries, building on past group understanding and collaboratively refining ideas on effective groups (c.f., Hyde & Hyde, 1991). This increased responsibility facilitated the joint construction of understanding with respect to negotiating group behaviour. This negotiated group behaviour is exemplified by the group generated criteria, as group members took the responsibility for creating lists of behaviour relevant to their group. Students used the group generated criteria to monitor and evaluate their groups’ performance during the following session. During the final focus group interview conducted after the last session in the computer laboratory, all of the students indicated that they felt that their groups had evolved into functioning entities. The students considered a major factor of their improved group work was the use of the group diaries. For example, Alice writing for Group 2 wrote,

The group diary helped enormously. I think we get on well (much better than we did) working in this program & with them (e.g., Mike) & (Sam) was fun.

Group 1 wrote, “If we don’t do diary, we can forget to quarperate (sic) or what to do.” This finding is consistent with the literature, which indicates that students who monitor their own learning process, through the use of diaries or learning journals, are more proficient group learners (Gourgey, 2001).

Analysis of the interview data and the group cohesiveness scale questionnaires tended to corroborate the analysis of the observation data and group diaries. While the questionnaire elicited mainly positive reactions, students were also provided with an opportunity to express their own thoughts on the group. Overall students were positive about their membership of the groups and indicated that they considered participation in the group useful for sharing ideas. Students also indicated they would not change anything about their group and would like to be in the same group next year. Considering the high levels of discord and malfunctioning that had occurred in the groups prior to the intervention, this was most surprising (and gratifying).
Summary and Conclusions
The results from this study indicate that providing the three groups with knowledge of group skills and metacognitive scaffolds resulted in more efficient group work. The students built an understanding that their co-operative process could be improved through the use of relevant metacognitive group strategies including planning, monitoring, and evaluating. By planning which group skills would be focused on, students were able to identify group skills that needed to be improved. Students were also able to monitor and evaluate their group’s success, discarding inappropriate group skills. As the study progressed, the groups assumed increasing responsibility for planning and regulating their group learning through the use of the diaries, building on past group understanding and collaboratively refining ideas on effective groups (c.f., Hyde & Hyde, 1991). By having choices on what skills to incorporate, and by recognising certain group behaviours as promoting more effective group work, students continued to use them. Previously exhibited non-functional behaviours such as disruption, aggression, or withdrawal from the group, were mainly replaced with positive functional group behaviours, as members were encouraged to participate and group members constantly clarified the group goal. Individual group member’s perception of their contribution to the group also improved. The groups reflected this increased cohesiveness in improved knowledge building. These findings are consistent with those of previous co-operative learning and metacognitive research, which have shown that students benefit from the explicit instruction of both co-operative group skills and metacognition strategies (Flavell, 1976; Johnson & Johnson, 1993; Tombari & Borich, 1999; Xiaodong, 2001).

Johnson and Johnson, (1999) state that while whole groups are responsible for achieving group goals, each individual member needs to take on a certain role in order to do their share of the work. This was evident with the three groups as group members negotiated the different group roles; certain members tended to adopt roles distinct from other group members. Bereiter and Scardamalia (1989) state that students need to be engaged in knowledge construction, taking responsibility for metacognitive functions. By collaboratively building knowledge on effective group work, students in this study developed an understanding of how to contribute to the group. Students showed an awareness of other group members’ needs and the groups developed ‘collective cognitive responsibility’ in order to complete the group task (Scardamalia, in press).

Because of the improved functioning of these three groups, by the end of this study each group was able to make significant contributions to the knowledge-building activity of the whole community engaged in the process of constructing mathematical models for ranking different countries’ performances at Olympic Games within the context of a CSCL environment. For example, by the end of the study, each group had posted to the CSCL environment at least one viable model. They also had forwarded many constructive feedback notes that assisted other groups in the process of improving their models. Therefore, by the end of the study, the three groups had become legitimate participants in the CSCL-mediated learning community contributing to the advancement of knowledge by the whole community.

References


