RELATING SOCIAL-INTERACTION ROLES AND METACOGNITIVE FUNCTIONING IN MATHEMATICS PROBLEM SOLVING

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This conference paper discusses possible relationships that may exist between social-interaction roles and children's metacognitive functioning. The paper reports on results of a study which compared the effectiveness of two approaches to group problem solving, specifically: (a) non-directed group activity involving limited teacher involvement only in the form of posing problems and engaging in follow-up discussions; and (b) role-directed group activity involving direct teacher intervention through the training of social-interaction roles (recorder-reporter, checker, and leader-judge) and the organising and rotating of these roles as well as posing problems and follow-up discussion. The role directed groups appeared to: (a) perform better in maintaining task commitment and producing quality solutions; and (b) develop superior metacognitive ability. The paper concludes by proposing relationships between social-interaction roles and metacognitive processes and discussing possible ways to study these relationships.

The literature on problem solving has long espoused the efficacy of groups (e.g. Johnson & Johnson, 1989; Noddings, 1985). There is evidence that cooperative learning experiences promote higher achievement in reasoning strategies, the generation of new ideas and transfer (e.g. Johnson & Johnson, 1991) and enhance problem-solving performance and develop problem-solving skills (e.g. Assessment of Performance Unit, 1985; Clement & Konold, 1989), particularly when members of the group have been assigned social-interaction roles (Dalton & Smith, 1986).

One of the major reasons for researchers advocating groups in problem solving situations is the effect of collaboration on metacognition. Metacognitive processes (e,g, planning, monitoring, regulating, evaluating) have emerged as important components of problem solving (e.g. Costa, 1984, Reeve & Brown, 1985). Research is showing that metacognition can be developed through group activities such as reciprocal teaching (Reeve & Brown, 1985). Johnson and Johnson (1991) contended that this development is due to the interactions amongst group members resulting in improved summarising, explaining and elaborating skills. They argued that "Material being learned to be taught to collaborators is learned using higher-level strategies more frequently than material being learned for one's own use." (page 299), a position which is supported by Male (1990) who argued that the effectiveness of groups is provided by positive interdependence between group members (through setting group goals, partitioning the task amongst group members, providing only one resource to be used by the group as a whole, assigning roles and/or providing rewards for group effort and cooperation). As stated by McTighe & Clemson (1991; 108), "... the articulation of strategies and reasoning within a group helps to render the invisible process of thinking visible for participants.". In addition, as Johnson & Johnson (1991; 105) warned, unless groups are appropriately structured, they "... can be characterised by self-induced helplessness, diffusion of responsibility and social loafing, ganging up against the task, reactance, dysfunctional divisions of labour, inappropriate dependence on authority, destructive conflict and other patterns of behaviour that debilitate group performance.".

The purpose of this paper is to explore relations between roles and metacognition. It reports on a study to compare the effectiveness of social-interaction roles on group problem solving and proposes a relationship between roles and metacognitive processes.

THE STUDY

The purposes of the study were to:

(1) determine if group work constitutes an effective instructional form for developing expertise in mathematics problem solving; and
(2) compare the effectiveness of two approaches to group problem solving, specifically: (a) non-directed group activity, involving teacher intervention only in posing problems and follow-up discussions, and (b) role-directed group activity, involving direct teacher intervention through the training of social-interaction roles and the organising and rotating of these roles, as well as posing problems and follow-up discussions; on children's problem-solving performance and higher-intellectual functioning in mathematics.

Subjects

The subjects for the study consisted of thirty-six children from two year five classes in a predominantly low socio-economic status government primary school.

Instruments

The data gathering instruments for the study were group interview and observation. The tasks for the two interviews, one before the problem solving activities (the pre-interview) and one after (the post-interview), consisted of a two-dimensional dissection puzzle and an open problem concerned with determining an appropriate course of action in a social situation. The observations were taken while the students solved three open (no specific goal) and three closed problems.

Procedure

The thirty-six children were divided into twelve groups of three and these groups were randomly assigned to two treatments: role-directed and non-directed. All groups were pre-interviewed and the interviews video-taped. All groups were given five one-hour problem-solving lessons on the three open and three closed problems. The non-directed groups could solve the problems in any manner they wished as long as it was a group activity. The role-directed groups were required to solve the problems with members acting out three social-interaction roles: (a) recorder-reporter, writing down key points, preparing written material and reporting back to the group; (b) checker, checking to see if everyone in the group understands and agrees with the group's responses, evaluating the quality of what the group is doing and encouraging members to stay within their roles; and (c) leader-judge judge, overseeing the activity of the group and making decisions when the group is unable to do so (these were based on those developed by Dalton & Smith, 1986). At the end of all the problem-solving sessions, each group was post-interviewed and the interviews videotaped.

Results

The interviews showed a noticeable improvement in the role-directed group's problem solving and higher-intellectual functioning compared to that of the non-directed groups. Overall, the role-directed groups displayed improvements in the following metacognitive processes: (1) planning, brainstorming for ideas (pre-planning phase) and formulating plans; (2) acting, cooperating within the group, persisting on the problem-solving task, displaying cohesion as a group and displaying independence; (3) monitoring, displaying active listening behaviours and detecting inadequacies in solution paths; (4) regulating, opportunistically modifying plans and strategies when deficiencies are shown to exist; and (5) evaluating, reflecting on performance and verbalising the path to their thinking. The observations showed even more extreme differences. To the last session, the role-directed groups remained strongly committed to task, sustaining collaboration and planning and monitoring their work together. Typically, the role-directed groups were able to cooperatively use one set of materials, talking together and discussing options while one member recorded the findings. In contrast, by the last session, collaboration and cooperation had broken down in the non-directed groups. Children were interfering with each other, complaining and arguing, refusing to share material and being angry and aggressive. There was also large differences between the achievement of the groups, with the role-directed groups giving reasoned and complex answers to the open problems, while the non-directed groups' solutions were trivial.

DISCUSSION AND PROPOSAL

The results of the study tended to support a complex relationship between groups and performance (similar to Johnson & Johnson, 1991), i.e. that the group formation for successful improvement in problem-solving skill includes a social dynamic that encourages children to focus on their own thinking. The role-directed groups' improved performance in problem solving came with improved performance in the metacognitive skills of planning, monitoring, evaluating and regulating (similar to McTighe & Clemson, 1991).

The findings of Male (1990) and Johnson & Johnson (1991) provide a framework for understanding the success of the role-directed groups in this study, i.e. the roles provided a framework for skills in leadership, conflict management and communication and for determining who will do what and when. The study supported the contention that the recorder-reporter and checker roles enhance monitoring and evaluating, while the leader-judge (decision maker) role enhances planning and regulating as well as monitoring and evaluating.

Dalton & Smith (1986) have indicated that there are a wide variety of social-interaction roles that may prove useful in group work. It is therefore useful to analyse the metacognitive characteristics of all Dalton & Smith's social-interaction roles, because, with their possible effect on metacognition documented, a procedure for selecting the appropriate role for the needs of a group is available. A possible analysis is below. It is interesting to note the dearth of roles that relate to planning. There may be a need to consider further roles or to change roles to provide a planning focus.

ROLE	FUNCTION	METACOGNITIVE CHARACTERISTICS
Checker	Checks to determine if there is agreement	Monitors and, to a lesser extent, evaluates
Leader -Judge	Makes executive decisions if no group consensus	Involved in all aspects of metacognitive activity
Encourager	Encourages each member to participate	Monitors, regulates and evaluates
Networker	Checks information with other groups, shares info.	Super-ordinate position similar to decis. maker
Observer	Observes what group does, relates back to the group	Monitors and evaluates
Organiser	Ensures resources are available	Monitors ('housekeeper' function)
Paraphraser	Restates ideas, feelings, actions, etc.	Monitors
Recorder -Keyboarder	Writes down group's ideas, keys in info. on computer	Monitors, evaluates, summarises and acts
Reporter	Verbalises the processes /products of the group	Reflects, provides a trail of thinking
Summariser	Reviews group ideas	Monitors and evaluates
Time-keeper	Times groups' activities	Monitors and regulates
Turn-teller	Ensures everyone has turn	Monitors, regulates and evaluates

IMPLICATIONS

The implication is that teachers may be well served by concentrating their efforts on the social dynamics (e.g. assigning social-interaction roles) of the group situation, rather than directing all their efforts into intervening in a cognitive sense (e.g. providing strategic hints). Teachers will need to introduce, explain, demonstrate and clarify

the roles, particularly in the acquisition stage. As students become more confident and competent in the the use of the roles, the teacher may be able to cede control. It will be important that teachers develop methods for diagnosing students' performances in group situations so that roles can be assigned which match the needs of the students. In addition to the social-interaction roles, teachers should employ a range of techniques such as providing rationales and developing micro-skills (e.g. questioning). A range of problems from open to closed would also appear to be warranted.

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