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The influence of achievement goals on the constructive activity of low achievers during collaborative problem solving

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Background. Previous research on small-group learning has found that level of constructive activity (solving or explaining how to solve problems using ideas stated or implied in the explanation provided by a partner) was a better predictor of post-test achievement than either a student's prior achievement or the quality of help received (Webb, Troper, & Fall, 1995).

Aims. The purpose of this study was to extend this research by examining the influence of additional factors, in particular, achievement goals and comprehension monitoring, on low achieving students' constructive activity after receiving help from a high achieving peer.

Sample. Thirty-two low achieving upper elementary students from an urban school district in the mid-west of the United States were paired with high achieving partners.

Methods. Videotape data from a previously reported study on peer collaboration were transcribed and reanalyzed. In that study, dyads were randomly assigned instructions designed to induce either a learning or performance goal and were videotaped as they worked together to solve a set of mathematical word problems. The following day, students were individually post-tested on problems similar to the ones worked on in pairs.

Results. Consistent with previous research, low achieving students' level of constructive activity predicted post-test performance. In addition, constructive activity was found to mediate the relationship between achievement goals and learning. However, achievement goals were not related to low achievers constructive use of help. Instead, achievement goals were related to low achievers' relative accuracy in comprehension monitoring, which in turn was related to level of constructive activity.

Conclusions. The meaning of these results for understanding the processes by which low achievers learn from peer help and implications for classroom practice are discussed.

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It is common practice for teachers to have high achieving and low achieving students work together in hopes of boosting low achievers' performance. Indeed, many forms of peer learning strongly encourage teachers to group students heterogeneously, both to enhance social as well as academic outcomes. However, previous research on peer learning suggests that not all members of a group or pair equally benefit from the opportunity to work with their peers (e.g. Cohen & Lotan, 1995; Depaulo *et al.*, 1989). For example, research on unstructured small group learning has consistently shown that those group members who give help (explanations) tend to experience positive individual learning outcomes (e.g. Webb, 1989, 1991). However, the relation between receiving explanations and learning is inconsistent and weak, indicating that those students who are the recipients of this help do not necessarily learn much from the experience (Hooper, 1992; Ross & Cousins, 1995; Webb & Farivar, 1999). In addition, reviews of this line of research indicate that prior achievement level is usually positively correlated with giving help, suggesting that it is primarily the higher achieving group members who give explanations and therefore cognitively benefit the most from small group work, and it is the lower achieving group members who tend to receive explanations and presumably benefit less (Webb, 1991). Taken together, these findings suggest that understanding how to support low achievers learning from peer help, so that they may take full advantage of the opportunities provided by working with high achieving partners, is necessary in order to improve the learning outcomes for *all* students. Below, we selectively review several factors that research suggests influence low achievers success in learning from high achieving partners. We then focus on one factor, student's achievement goal, which has received limited attention in the research literature but appears to both be theoretically and practically important for understanding how to support low achievers' learning from a high achieving peer. Finally, we describe the focus of this study, in which we experimentally manipulate achievement goals and explore how they relate to factors that influence learning from peer help.

Factors that influence learning from peer help

Although a variety of factors may help explain why low achieving students do not always benefit from peer learning situations, two important variables that have received attention in the research literature are the quality of the help that is received by the learner, and the extent to which the learner cognitively processes this help after receiving it. Below, we briefly review studies that examine these two factors in the context of peer learning situations.

Quality of help received

Some researchers have speculated that differences in the quality of explanations given may be responsible for why some students benefit from receiving explanations and others do not (Fuchs *et al.*, 1996; Webb & Kenderski, 1984). These researchers note that the few studies that have reported positive correlations between receiving explanations and learning have been conducted with older and high ability students, whereas those studies that have not reported supportive findings have involved younger and average achieving children. If one assumes that high achieving, older students are more likely to produce better explanations than younger, average achieving students, then this account of the inconsistent pattern of results of previous research makes sense. In support of this hypothesis, Fuchs *et al.* (1996) designed a study in which they compared the quality of mathematical explanations given by high achieving and average achieving second, third and fourth grade students who were paired with the same low achieving (learning disabled) partner on two different occasions. Videotapes of the tutoring sessions for both the high achieving tutor and the average achieving tutor were collected and analysed to compare the quality of the explanations given. Results indicated that high achieving students were rated as providing higher quality explanations, incorporated a greater variety of explanatory strategies and offered more conceptually oriented strategies than average achieving students when paired with a low achieving (learning disabled) student. Unfortunately, no independent assessment of the low achieving partners' learning from the tutoring sessions were collected, so that the relationship between receiving explanations and learning was not directly addressed.

Quality of constructive activity

Although there seems to be good reason to believe that the quality of explanations received would be an important precondition for learning from a peer to occur, it may not be the only limiting condition. For example, Webb and Farivar (1999) suggest that one reason why receiving help and subsequent individual learning are often not found to be correlated may be because previous research has typically failed to examine what students who receive explanations do with this help. Webb and Farivar suggest that in addition to receiving an elaborated explanation the learner must engage in constructive activity after receiving the explanation in order for learning to occur. Constructive activity, which is typically contrasted with passive learning, is a general term used to refer to a range of behavioural as well as internal cognitive activities a learner engages in that involves cognitive reorganization and active involvement. In this sense, constructive activity can be a verbal and public activity or a non-verbal (or at least silent) and private activity. Such activities as self-explanation, elaboration, summarization, answering and asking questions, explaining to another, drawing diagrams or concept maps are all forms of constructive activity that have repeatedly been shown to relate to individual learning (Chi, 1996, 2000). As it relates to learning from peer explanations during group problem solving, Webb, Troper, and Fall (1995) provided empirical support for the hypothesis that students' constructive use of the help they receive plays a crucial role in learning from peers. In that study, Webb *et al.* (1995) observed and tape-recorded small heterogeneous groups of students while they worked together on sets of problems during maths class. Students were given unit achievement post-tests to assess individual learning. Level of constructive activity (from most active to least active) was inferred from the verbal and non-verbal behaviour of students after they received help from a partner 'according to how independent a student's work was as opposed to work solely intended to reproduce another student's correct answer'. Regression analyses revealed that differences in the level of constructive activity on the part of the recipient of help was the best predictor of learning in unstructured small groups. Interestingly, the level of help received was not found to be a significant predictor of individual learning for these same students. However, level of help received was found to be a strong predictor of level of constructive activity, suggesting that the quality of explanations received plays a necessary yet indirect role in learning from peer help in small groups.

Despite the contribution of this study to our understanding of the process of how peers learn from each other during unstructured group problem solving, several issues remain relatively unexplored and in need of further clarification. One question that was not directly addressed in the Webb *et al.* (1995) study was the extent to which low achieving students constructively use help effectively to learn. One goal of this study was to focus specifically on the quality and relative effectiveness with which low achieving students engage in constructive activity after receiving help from a peer.

In addition, we still know very little about the conditions and factors that may contribute to the constructive use of help in peer learning situations. A second goal of this study was to systematically examine the influence of achievement goals and comprehension monitoring on the level of constructive activity low achieving students engage in during collaborative problem solving.

Achievement goals and constructive activity

A vast body of research has characterized the effects that two distinct achievement goals, referred to as *learning* and *performance goals*, have on students' achievement-related behaviours (e.g. Dweck, 1986). Students who exhibit a learning goal are characterized as oriented towards trying to understand their work, improving their level of competence, and using self-reference standards rather than social comparison with others to judge the quality of their work. In contrast, for students who adopt a performance goal, the central purpose of the learning situation is to demonstrate ability or to avoid demonstrating a lack of ability. Because students oriented to performance goals are concerned with either appearing competent or avoiding looking incompetent to others (peers and teachers), they may in certain circumstances engage in behaviours that are at odds with successful learning.

Much of the research on achievement goals has focused on linking achievement goals to individual cognitive and affective outcomes. This line of research has repeatedly shown that students who adopt learning goals exhibit high levels of intrinsic motivation (e.g. Butler, 1992), prefer challenging work and persist in the face of difficulties (e.g. Elliot & Dweck, 1988), report more active cognitive engagement (e.g. Meece, Blumenfeld, & Hoyle, 1988), engage in adaptive help-seeking (e.g. Newman, 1998) and tend to utilize higher quality learning strategies (e.g. Nolen, 1988). In contrast, previous studies examining the effects of performance goals on individual cognitive and affective outcomes have produced mixed results. Some studies have linked performance goals to use of superficial strategies and effort withdrawal. Other studies have found null results on similar measures, while still others studies have linked performance goals to enhanced effort, performance and intrinsic motivation (Senko & Harackiewicz, 2002). These inconsistent results may be due in part to how performance goals have been defined (Elliot, 1999). For example, some researchers have described performance goals in terms of performance approach (an orientation to demonstrate ability) and performance avoid (an orientation to avoid demonstrating lack of ability) components and developed separate measures of these goal constructs. Recent research that has distinguished between performance approach and avoidance goals has consistently linked performance avoid goals to maladaptive patterns of learning and behaviour. In contrast, research that has examined performance approach goals has yielded inconsistent findings, reporting positive, negative or no effects depending on type of outcome, context, and characteristics of the learner (see Midgley, Kaplan, & Middleton, 2001, for a selective review of this body of research). In summary, research on the effects of achievement goals suggests that learning goals are consistently related to the kind of motivational and cognitive processes that are likely to be utilized when engaged in constructive activity during learning opportunities. Performance goals, on the other hand, are likely to be negatively related to constructive activity, to the extent that they are associated with effort withdrawal and avoidance of situations or actions in which students are likely to display incompetence on the way to overcoming a challenge.

Achievement goals and learning from peers

Although the link between students' achievement goals and students' constructive activity during group work seems theoretically plausible, virtually no research has explored this directly. Moreover, very little research on achievement goals has been conducted within the context of peer learning situations. One exception is recent work by Gabriele and Montecinos (2001). In this experimental study, Gabriele and Montecinos induced students to adopt either learning or performance goals and then examined the effects of these achievement goals on how low achieving students verbally interacted with higher achieving peers during collaborative problem solving. Gabriele and Montecinos reasoned that when low achieving students pursue learning goals, their attention is more likely to be focused on aspects of the task critical to learning, and they will pursue verbal forms of constructive activity like asking questions, contributing ideas and or soliciting feedback that are aimed at enhancing their competence. Gabriele and Montecinos argued that, in contrast, low achieving students who adopt performance goals should be much more passive in their interaction with higher achieving partners for fear of looking/feeling incompetent. These hypothesized differences in verbal participation should translate into differences in learning.

Results from this study only partially supported the hypotheses advanced by Gabriele and Montecinos (2001). Low achieving students given learning goal instructions were found to learn more from their high achieving partners than low achievers given performance goal instructions, even though there were no differences found in the performance of dyads. However, despite differences in individual learning outcomes, no statistically significant differences were found in the frequency or the level of verbal participation of either the low- or the high achieving partners in the two goal conditions.

One interpretation of this pattern of findings then is that achievement goals do not enhance learning gains by affecting verbal and public forms of constructive activity that low achievers engage in when they interact with a partner. However, it may be that quality of talk during peer learning does not completely capture the active cognitive processing that occurs non-verbally. Relating this back to Webb *et al.*'s (1995) work, it may be that other non-verbal forms of constructive activity, such as reworking a solution on paper in response to a disagreement or feedback from a peer and so on, contribute to learning and are influenced by achievement goals. In the present study, videotape data from the Gabriele and Montecinos (2001) study was transcribed, recoded and reanalyzed so that the influence of achievement goals on the level of constructive activity (both verbal and non-verbal forms) of low achievers during collaborative problem-solving with a high achieving partner could be directly examined. Based on previous research in the achievement goal literature, we would expect students who adopt learning goals to engage in higher levels of constructive activity than students who adopt performance goals.

Achievement goals, meta-cognitive skills and constructive activity

In addition to achievement goals, we were also interested in the role of a meta-cognitive variable, comprehension monitoring, and examined its relationship to achievement goals and the quality of constructive activity low achievers engaged in during collaborative problem solving. Meta-cognition is generally recognized as a key variable in both effective problem solving and self-regulation, and often distinguishes between unsuccessful and successful learners (National Research Council, 1999). Chi (2000) in a recent reanalysis of her classic work on the self-explanation effect (as mentioned earlier, a form of constructive activity linked to learning outcomes) lends some support for the existence of an important relationship between meta-cognitive processes and constructive activity. She suggests that the self-explaining process may be driven by the goal of revising one's own faulty mental model. According to this view, comprehension monitoring, or detecting comprehension failures, precedes and leads to the initiation of self-explanation, which results in self-repair of the mental model. Chi reports that in her previous work using a think aloud methodology, detection of misunderstandings (monitoring of comprehension failures) were followed by self-explanations 73% of the time they occurred. Based on this and other data analyses, Chi argues that 'the source of individual differences in self-explaining might be the frequency with which students monitor their understanding' (p. 219). Based on this and other previous research findings on meta-cognitive monitoring (e.g. Nietfeld, Cao, & Osborne, 2005; Stone, 2000), we expected low achievers' accuracy in monitoring their comprehension would be related to the quality of constructive activity they engaged in during collaborative problem solving.

With respect to the effects of achievement goals on comprehension monitoring, research in the achievement goal literature suggests a link between the adoption of learning goals and use of meta-cognitive strategies (Middleton & Midgley, 1997). However, this research has typically relied on self-reported use of meta-cognitive and cognitive strategies through surveys and has been correlational in nature. To our knowledge, no research has experimentally induced students to adopt either a learning or a performance goal and examined its effects on students' meta-cognitive processes. In the present study, we used a technique often used in memory and text processing research that infers comprehension monitoring by looking at the match between student confidence ratings of their performance and their actual performance to measure their monitoring accuracy or calibration. We speculated that the act of adopting a learning goal may prompt the use of meta-cognitive processes, because students who adopt learning goals are interested in improving their understanding and therefore are more likely to seek out and rely on both self-generated and other-provided feedback on their learning progress. In contrast, we speculate that students adopting performance goals (in particular, performance-avoid goals) may be less likely to instantiate comprehension monitoring processes because they are either more concerned with impression-management concerns (i.e. not appearing incompetent to others) or are using criteria other than comprehension to judge the success of their cognitive effort.

The cueing of meta-cognitive processes in turn may promote requests for and constructive use of help during group work. As a student attempts to rework a problem after receiving an explanation (i.e. engage in constructive activity), he or she may monitor his or her understanding and notice 'comprehension failures', which, in turn, signal to the student that more cognitive effort and/or help is required, leading to further help-seeking and subsequent constructive use of this help after receiving it. The process and products of constructive activity are monitored as well, presumably leading to more accurate estimates of how much the individual has learned as well as to increased learning.

The current study
To summarize, the purpose of this study was twofold: (1) to examine whether the findings of Webb *et al.* (1995) on the importance of constructive activity in determining learning from peers extend to low achieving upper elementary students engaged in collaborative problem solving with a high achieving peer, and (2) to further explore factors that influence low achieving students engagement in constructive activity. More specifically, we examined the extent to which achievement goals, accuracy of comprehension monitoring and the quality of help received predict the quality of constructive activity low achievers engage in after receiving help.

With respect to our first goal, we expected our results to be consistent with Webb *et al.*'s findings: we predicted that low achievers who engaged in higher levels of constructive activity would learn more than low achievers who engaged in lower levels of constructive activity and that the quality of help received by the low achieving partner would influence their level of constructive activity, with higher quality explanations provided by high achieving partners encouraging low achievers to more actively process this information. Finally, we expected level of constructive activity to mediate the relationship between achievement goals and low achievers' learning from a peer. That is, we expected the relationship between achievement goals and learning reported in our previous study to be statistically diminished after controlling for constructive activity, suggesting that constructive activity mediates the effects of achievement goals on learning and adding further support to the central role of the learners' constructive use of help in explaining the benefits of working with a more knowledgeable partner.

With respect to our second goal, we expected achievement goals and comprehension monitoring to influence low achieving students' level of constructive activity, although our predictions about the exact mechanisms were less straightforward. We expected low achieving students who over estimated their comprehension (e.g. poor comprehension monitoring accuracy) to engage in lower levels of constructive activity than low achieving students who more accurately monitored their understanding. With respect to the effects of achievement goals on constructive activity, we expected achievement goals to either directly or indirectly influence level of constructive activity through the cueing of comprehension monitoring processes.

Method

Participants
Participants in this study were fourth and fifth grade students (ranging in age from 9 to 11 years of age) from three urban public elementary schools in the mid-western region of the United States. Each school served a diverse ethnic and socio-economic community. Eligibility for free or reduced lunch was reported as over 35% in two schools and 12% in the remaining school. Participating schools reported their minority enrolment as comprising 18.3, 20.6 and 29.7% of the school student body, respectively. The ethnic breakdown for participating students in this study was 75% White, 16% African American and 9% Latino.

Thirty-two heterogeneous dyads were created by pairing low achieving fourth and fifth grade students with a same-sex, same grade level high achieving partner. The Iowa Test of Basic Skills (ITBS) mathematics achievement scores from the previous spring were obtained from each school and were used to classify students as high or low in mathematics achievement status. Students whose ITBS mathematics achievement scores fell below the 35th national percentile rank were classified as 'low achievement status'; students with mathematics achievement scores above the 75th national percentile rank were classified as 'high achievement status'. Students who scored within the 35th and 75th national percentiles were not included in the study.

In addition, to ensure that low achieving students participating in the study had not reached ceiling on the mathematics problems to be used during the dyadic session, we pre-tested all students in the participating fourth and fifth grade classrooms with a group administered paper-and-pencil test. Included in the pre-test was a subset of three mathematical word problems that were identical to the target problems to be used during the dyadic session. Only low achievement status students who were unable to solve any of these problems and high achievement status students who correctly solved at least two of these problems were selected for participation in the study.

Once pairings were made and consultation with the classroom teachers had confirmed that pairs would work well together, dyads were randomly assigned to either the learning or the performance goal condition. A total of 30 boys (15 pairs) and 34 girls (17 pairs) participated in the study with a roughly equal distribution of boys and girls across the two experimental conditions. The mean (with standard deviations in parentheses) national percentile rank of the ITBS mathematics achievement score for the low achievement status partner in the learning and performance goal conditions were 29.7 (12.6) and 27.8 (10.1), respectively. The mean national percentile rank of the, mathematics achievement score for the high achievement status partner in the learning and performance goal conditions was 90.6 (7.0) and 90.2 (9.7), respectively.

Materials

Achievement goal instructions

Prior to working on the maths problems, instructions designed to induce students to adopt either a *learning* or *performance* goal were read to each pair of students. The goal instructions were adapted from procedures used by Newman and Schwager (1995), Elliot and Dweck (1988) and Schunk (1996). The achievement goal instructions were inserted into the overall set of instructions that included general instructions on working together and how to submit answers when a problem was completed. Students receiving the learning goal instructions were told that we were 'interested in how working together to solve multi-step mathematics word problems helps you learn new things in mathematics' and that ' understanding how to solve multi-step maths problems will help you become more skilful at solving other problems because it tends to sharpen the mind and make you think. The harder you try the more you will learn'. In contrast, students receiving the performance goal instructions were told that we were 'interested in how much kids your age know about multi-step mathematics word problems' and how 'working together helps you correctly solve these problems'. We also emphasized in our instructions that we were interested in 'how the two of you do compared with other kids at your grade level' and that children 'are either good at solving these problems compared with other kids their age or they are not'.

Maths problems

The problems used in this study were three multi-step arithmetic story problems. These problems were chosen because previous research has indicated that students at this grade level have difficulty accurately representing these types of problems despite having relatively little trouble executing the required computations (Lewis, 1989; Resnick, 1988;

Silver, Mukhopadhyay, & Gabriele 1992). Thus, we anticipated pairs would be likely to request and generate elaborated explanations regarding how to represent and solve these problems. In addition, the well-structured nature of these problems made it relatively easy to precisely construct equivalent versions of the problems. Two versions of the word problems were constructed. One version was used as part of the pre-test to screen students for those who met the study's selection criteria. These same problems were also used during the dyadic session. The second version of the word problems was used for individual post-testing. The two versions of the word problems were isomorphic with respect to mathematical structure (i.e. same type and order of mathematical operations) but differed with respect to the cover story and numbers mentioned in the story. Pilot work with these problems indicated that the two versions were of roughly equivalent difficulty and provided appropriate challenge for fourth and fifth graders alike.

Procedure

During the experimental sessions, pairs of students were taken out of their classroom by one of two researchers to a room on the school premises and were videotaped while they worked together to solve the multi-step maths problems. Members of each pair were given three stapled pieces of 8 × 11.5 inch 'scratch paper' and different colour pens to facilitate identification of partners' written work and verbal contributions from the videotape. Prior to working on the maths problems, the experimental instructions designed to induce students to adopt either a learning or a performance goal were read to each pair of students. In addition to these goal instructions, students were told that for each problem they worked on together, they needed to submit a single answer with which they both agreed. They were told that they could work together on each problem in whatever way they felt worked best for them. They were encouraged to share their ideas and were told that if there were any disagreements or ideas they did not understand, they should 'talk it out' so that the answer they submitted made sense to both of them. Dyads worked on each problem and submitted to the researcher an answer which they 'mutually agreed' upon before working on the next problem. No feedback from the researcher on accuracy of solutions was given to reduce the likelihood that learning gains would be attributable to feedback.

After dyads had completed working on the problems, they were given a set of questions to assess their individual confidence in how well they understood the solutions used for solving problems they had worked on together as well as some affective reactions to the dyadic session in general (e.g. how much did they like working with a partner, etc.). Instructions on how to rate items were provided orally by the researcher as well as in written form. After instructions were explained and participants worked on 2 practice items, the researcher read each item aloud and students completed their ratings of the items independently.

After completing these items, students were told not to discuss the maths problems or procedure with their classmates, were returned to their respective classrooms and the experimental procedure was repeated with the next pair of students. The entire experimental session lasted approximately 30 minutes for each pair of students.

The following day, all students who had worked in pairs the previous day were assembled and taken to an empty classroom where they completed a paper-and-pencil individual post-test, which included problems similar to the three maths problems worked on collaboratively.

Dependent variables

Individual problem solving

To assess learning, we analysed the individual post-test performance of low achieving partners on the three mathematical word problems. As mentioned above, differences in performance of low achievers on these problems at post-test would reflect gains in performance (learning) because all low achieving students selected for participation in the study were unable to solve similar problems at pre-test.

Each written solution to a problem was scored on a 3-point scale with 0 points assigned for an incorrect solution, 1 point for a 'structurally correct' solution (a solution that would have resulted in a correct answer if all the computation had been accurately performed) and 2 points for a correct solution that was both computationally and structurally accurate. Solution scores for each of the three problems were coded and summed creating an overall problem-solving score that ranged from 0 to 6.

Help received and constructive activity

To code the quality of the help received and the constructive use of this help by low achievers, videotapes of the collaborative problem-solving sessions were first transcribed and then, in conjunction with the videotapes, transcripts were used to identify instances of helping behaviour and constructive activity. To pinpoint our search for instances where help and constructive use of help were most likely to facilitate individual learning, we limited our search to only those problems where correct solutions were generated by the pair and submitted as final answers. Next, we located in the transcript where the answer to a problem was first introduced by the high achieving partner during solution. We then examined the dialogue that occurred both prior to and subsequent to this point in the transcript. All help that the high achieving partner provided prior to proposing an answer was coded as a single instance of helping behaviour (e.g. help received during solution); all help that occurred after an answer had been proposed was coded as a separate instance of helping behaviour (e.g. help received after solution). Thus, for each problem a pair correctly solved, it was possible to identify two instances of help received. For some low achievers, help was received only during solution; for some, it occurred only after an initial answer was proposed; and for a few, it occurred both during and after the initial answer was proposed.

For each of these instances of help received, we coded the level of help using a coding scheme adapted from Webb *et al.* (1995). In this coding scheme, the level of elaboration of help received by the low achiever was distinguished among four levels: (4) partner provides elaborated explanation with labelled numbers; (3) partner provides a solution procedure with unlabeled numbers; (2) partner provides a sequence of unconnected numbers and or operations; (1) partner provides little or no help, other than sharing answer. Inter-rater agreement was established on a 33% sample of the total number of identified instances of help received (18 of 53). The percentage of agreement in using the coding categories between two coders was 89%. Examples of level of help received appear in Table 1.

Once all instances of help received were coded for a particular pair, we created an average level of help received score for each pair across all successful problem-solving episodes. In those cases where two instances of help received had been identified for a single problem-solving episode, we first averaged these scores before averaging this score with the level of help received scores from the other problems worked on collaboratively.

Table 1. Description and examples of coding scheme used to classify levels of help received by the low achieving partner

Level of help received	Example
Level 4: High achieving partner provides elaborated explanation with labelled numbers	(Hi): OK. So, Ann has 15 pencils (*both Hi and Lo start writing the numbers down*) And Ann has 8 fewer pencils than Jessica, so that means that Jessica has 8 more pencils than Ann. So we add 15 and 8 . . . 23. So Jessica has 23 pencils. And Nancy has 4 times as many pencils as Jessica. So we multiply 23 by 4. OK, 3 times 4 . . . (*Lo and Hi start computing on paper*) (Lo): 92 (Hi): Yep. 92 pencils. OK
Level 3: High achieving partner provides a solution procedure with unlabelled numbers	(Hi): OK. 15 plus 8 is 23. 23 times 4, that's 12. . . I think I've got the answer. 92 (Lo): 92? Wait, let me see (*Lo looks over at Hi's sheet and writes down numbers*) (Hi): 3 times 4 is 12 and then we have to add the one . . . 2 times 4 is 8 . . . plus 1 is 9 (*Hi looks over at Lo's sheet, while Lo is computing*) (Hi): So I think the answer is . . . (Lo): 92
Level 2: High achieving partner provides a sequence of unconnected numbers and or operations	(Hi): If Anne has 15 and she has 8 fewer than Jessica . . .you would add 8 to 15 . . . (*Lo is writing down and computing*) . . . What's 8 plus 5? (Lo): 13 (Hi): Yeah . . . 3 . . . and you put one . . . two . . .OK . . .now you times that by 4 . . . 12 . . . 2 . . .1 . . .4 times 2 . . . (Lo): Is 8 (Hi): Plus 1 . . . 9 . . . so 92. (*Lo writes down the answer*)
Level 1: High achieving partner provides little or no help, other than sharing answer	(*Lo reads problem aloud, Hi starts computing while Lo rereads problem*) (Lo): What did you get? (Hi): 92 (Lo): Hmm . . . OK. (*Hi writes the final answer down*)

To code constructive use of help, we used the videotapes and transcripts to examine the low achievers' verbal and non-verbal behaviour just after receiving help from their high achieving partner. Only one instance of constructive use of help was coded for each correct solution. Again, we adapted Webb *et al.*'s (1995) coding scheme and distinguished among four levels, from most constructive to least constructive: (4) reworks all or significant parts of the problem independently, rephrases explanation or acknowledges understanding explanation after asking specific questions to clarify the explanation given; (3) does independent computational work that is directed or set-up by high achieving partner, either orally or on paper; (2) acknowledges help received, agrees to answer and/or writes down numbers as dictated by high achieving partner but does no further work on problem; (1) says nothing and does not appear to be working on the problem individually. Inter-rater agreement was established on a 33% sample of the total number of identified instances of constructive use of help (16 of 49). The percentage of agreement in using the coding categories between two coders was 86%. Examples of level of constructive activity appear in Table 2. Once all instances of constructive activity were coded, we used the same procedure described above to create an average level of constructive activity score.

Overconfidence in learning
To assess comprehension monitoring, students were asked to rate, on a 5-point Likert scale, how well they understood how to solve the maths problems after working with their partner. The scale ranged from *very well* (5) to *not very well* (1). These confidence ratings were then used to measure students' overconfidence in their learning. Following a procedure described by Schommer, Crouse, and Rhodes (1992), we used confidence ratings to generate predicted maths learning scores by regressing learning scores on confidence ratings. Actual maths learning scores were subtracted from predicted maths learning scores to yield a measure of comprehension monitoring accuracy. For this measure of overconfidence in learning, positive scores indicate that the student has overestimated their learning and negative scores indicate that the student has underestimated their learning. In this study, we analysed only the overconfidence scores of low achieving partners.

Results

Opportunities to learn during collaborative problem solving
Before reporting our main analyses, we conducted preliminary analyses on the relative distribution of opportunities to learn during collaboration. Examination of the 96 solutions produced in total by all dyads in the study (32 dyads $\times$ 3 problems attempted each) revealed that only 49 (51%) of these dyadic solutions resulted in correct answers. As shown in Table 3, the distribution of correct solutions submitted by dyads in the learning and performance goal conditions was roughly equivalent, with dyads in the learning goal condition submitting a total of 26 correct solutions and dyads in the performance goal condition submitting a total of 23 correct solutions. Three dyads failed to produce any correct solutions and were eliminated from further analyses. All subsequent analyses were conducted on the remaining 29 dyads in the learning goal ($N = 15$) and performance goal ($N = 14$) conditions.

For each of the 49 correct solutions submitted by pairs of students, the quality of help received was coded. A total of 53 episodes of help received were coded. The vast majority of dyads (25 of 29) were coded as having one instance of help received for each correct solution submitted. Statistical analyses failed to reveal any significant differences between low achievers in the learning goal and performance goal conditions in the frequencies of different levels of help received from the high achieving partners.

Taken together, these analyses mirror the findings of our earlier study and suggest that the gains in maths learning outcomes that were associated with learning goals (as reported in that study) are not likely to be attributable to differences in frequencies of opportunities to learn from help.

Table 2. Description and examples of coding scheme used to classify levels of constructive activity by the low achieving partner

Level of constructive activity	Example
Level 4: Low achieving partner reworks all or significant parts of the problem independently, rephrases explanation or acknowledges understanding explanation after asking specific questions to clarify the explanation given	(Hi): OK, so Anne has 15 pencils, and Jessica has 8 fewer than Anne . . . she has 8 fewer, then that means 15 plus 8. So that's 23, 23 pencils (Lo): Anne has . . . (Hi): She has 8 fewer than Jessica, so that would be 23. Right? (Lo): Anne has 15 pencils. She has 8 fewer than Jessica, so Jessica has. . . (Hi): So you take Anne's 15 pencils and add 8 (Lo): Or take away? 15 take away 8? (Hi): No, she has fewer than Jessica, so that means Jessica would have more than her (Lo): I know, but she's Anne. She's Anne, not Jessica (Hi): No, Anne has 8 fewer than Jessica (Lo): She has . . . (Hi): Yeah, but they mean Anne (Lo): Ah, OK. So, it's 23 (Hi): Yes, and then Nancy has . . . (Lo): . . .has 4 times as many pencils as Jessica (Hi): So it would be 23 times 4 (Lo): (computes on worksheet) 23 . . . 92 (Hi): That's what I got, too (Lo): So Nancy has 92 pencils. (*Lo writes down the answer*)
Level 3: Low achieving partner does independent computation directed by high achieving partner	(Hi): OK. 15 plus 8 is 23. 23 times 4, that's 12. . . I think I've got the answer. 92 (Lo): 92? Wait, let me see (*Lo looks over at Hi's sheet and writes down numbers*) (Hi): 3 times 4 is 12 and then we have to add the one . . . 2 times 4 is 8 . . . plus 1 is 9. (*Hi looks over at Lo's sheet, while Lo is computing*) (Hi): So I think the answer is . . . (Lo): 92
Level 2: Low achieving partner acknowledges help received, agrees to answer and/or writes down numbers as dictated by high achieving partner but does no further computational work on problem	(Hi): OK, I took 15 plus 8 because it says that Ann has 15 pencils and she has 8 fewer than Jessica. Nancy has 4 times as many as Jessica. How many pencils does Nancy have? So, if Ann has 8 fewer than Jessica does, take 15 plus 8 and that equals 23 and then I took 23 times 4 that is 92, because it's 4 times as many pencils as Jessica. What did you do? (Lo): I have 4 and 8 and then 12 (Hi): Why? (Lo): Because Nancy has 4 and then Nancy has 12 and Annie has 7

Table 2. (*Continued*)

Level of constructive activity	Example
	(Hi): No, because it says that Ann has 15 pencils but she has 8 fewer than Jessica. So Jessica has more than 15 pencils. So Nancy can't have 4 pencils because she has more than Jessica has. (*Lo starts writing numbers on her own sheet*) What are you doing? (*Hi looking over at Lo's sheet*) (Lo): 15 plus 23 (Hi): No, you take 15 plus 8 and then times 4 because the first problem you only use 15 and 8. And those are out. And then you use 23 and 4 and then those are out. So, what do you think? (Lo): (*looking at Hi's sheet*) OK, I get it. Let's write it down
Level 1: Low achieving partner says nothing and doesn't appear to be working on the problem	(*Lo reads problem aloud, Hi starts computing while Lo rereads problem*) (Lo): What did you get? (Hi): 92 (Lo): Hmm . . . OK. (*Hi writes the final answer down*)

Correlational analyses

Correlations among the main variables of the study are displayed in Table 4. As expected, low achievers' level of constructive activity and their individual post-test problem-solving scores were significantly positively correlated ($r = .46$, $p < .05$), indicating that the more actively engaged the low achieving partner was in constructively using help, the more they learned. As previously reported, achievement goal condition was found to be statistically significantly negatively correlated with individual post-test problem-solving scores[1] ($r = -.39$, $p < .05$), indicating that low achievers in the learning goal condition (dummy coded as 1) scored higher on the individual post-test scores than low achievers in the performance goal condition (dummy coded as 2). No other variable was statistically related to individual post-test problem-solving scores.

Our predictions that low achievers' level of constructive activity would be related to: (a) the level of help received from a high achieving peer, and (b) achievement goal condition were not supported. As shown in Table 4, although both the correlation coefficients are in the expected direction, neither was found to be statistically significant. However, as expected, we did find statistically significant correlations between the variable overconfidence in learning and the variable constructive activity ($r = -.45, p < .05$). This result suggests that the more a low achiever did not know that they did not know (high overconfidence score), the less likely they were to engage in high levels of constructive activity, presumably because they thought they understood how to solve the problem after receiving help and did not perceive a need to engage in further cognitive effort.

[1] *For the purpose of clarification, we also included in this table the correlation between achievement goal condition and individual problem solving score, which is statistically equivalent to the analysis reported in our previous study (Gabriele & Montecinos, 2001).*

Table 3. Distribution of correct solutions submitted by dyads during collaborative problem-solving session by goal condition

	Number of correct dyadic solutions submitted by each dyad			
Condition	None	1 correct solution	2 correct solutions	3 correct solutions
Learning goal ($N = 16$)	1	7	5	3
Performance goal ($N = 16$)	2	8	3	3

Note. Numbers reflect frequency of dyads.

Table 4. Correlations between main variables in the study ($N = 29$)

Variable	1	2	3	4
Individual problem solving	–			
Level of help received	−.02	–		
Level of individual constructive activity	.46*	.26	–	
Overconfidence in learning	–	.04	−.45*	–
Goal condition	−.39*	−.13	−.29	.47*

*$p < .05$ two-tailed test of significance.

Finally, as expected, achievement goal was found to be positively correlated with overconfidence in learning ($r = .47$, $p < .05$), indicating that low achievers in the learning goal condition (dummy coded as 1) were less inclined to exhibit high overconfidence scores than low achievers in the performance goal condition (dummy coded as 2). This suggests that learning goals may have encouraged low achievers to monitor their comprehension more closely, leading to a more accurate assessment of what they did and did not understand. Performance goals, on the other hand, may not have encouraged low achievers to monitor their comprehension, making it more likely that they were less accurate and overconfident in their assessment of their degree of learning.

Next, we further explored these relationships using a series of multiple regression analyses in which we isolate each variable and examine its effect on a selected dependent variable while controlling for the remaining variables of interest.

Factors related to the learning outcomes of the low achieving partner

On the whole, the findings presented thus far are consistent with previous studies and indicate that there is a significant association between low achievers' learning, their constructive use of help, and achievement goals. Also consistent with prior research (e.g. Webb *et al.*, 1995), the quality of help received by the low achieving partner was not found to be directly related to learning. Next, we conducted more stringent tests of association between these constructs and their relative contribution to learning.

To examine this, we conducted a series of multiple regression analyses. The dependent variable was individual problem-solving score. The independent variables were level of help received, level of constructive activity, and achievement goal condition. Each variable was entered last to examine whether it contributed to learning when controlling for the two other variables. The procedure was forced entry multiple regression.

As shown in Table 5, the first step involved entering the control variables level of help received and goal condition as the first block for that analysis. In the second step, after level of help received and goal condition were controlled, with level of constructive activity added, the *R* was .56, showing that level of constructive activity accounted for an additional 15% of the variance in low achievers' post-test performance which was significant, $F(1, 25) = 5.63$, $p = .03$. Similar analyses, in which goal condition or level of help received was entered in the second step after the other variables were controlled, failed to account for additional variance in low achievers' post-test performance. This suggests that the earlier reported relationship between achievement goals and low achievers' post-test performance may be mediated by level of constructive activity.

Table 5. Multiple regression predicting low achiever's problem-solving score from help received, constructive activity, and goal condition ($N = 29$)

Variable	R	R^2	ΔR^2	ΔF	ΔSig
Controls[a]	.39	.16	.16	2.41	.11
Level of constructive activity	.56	.31	.15	5.63	.03
Controls[b]	.49	.24	.24	4.04	.03
Goal condition	.56	.31	.07	2.69	.11
Controls[c]	.53	.28	.28	5.18	.02
Level of help received	.56	.31	.03	0.95	.34

[a] Level of help received; Goal condition.
[b] Level of help received; Level of constructive activity.
[c] Level of constructive activity; Goal condition.

Factors related to the constructive activity of the low achieving partner

Next, factors that influence low achievers' constructive activity after receiving help were examined using a similar hierarchical multiple regression approach. As shown in Table 6, after level of help received and goal condition were controlled and overconfidence in learning added in the second step, the *R* was .53, showing that overconfidence in learning accounted for an additional 14% of the variance in low achievers' level of constructive activity which was significant, $F(1, 25) = 5.11, p = .03$. Similar analyses in which goal condition or level of help received was entered in the second step after the other variables were controlled failed to account for additional variance in low achievers' level of constructive activity.

Factors related to the comprehension monitoring of the low achieving partner

Finally, we explored factors that influenced low achievers' overconfidence in learning scores. As shown in Table 7, after level of help received and goal condition were controlled, level of constructive activity accounted for an additional 13% of the variance in low achievers' overconfidence in learning scores which was significant, $F(1, 25) = 5.11, p = .03$. When level of help received and level of constructive activity were controlled, goal condition also accounted for additional 13% which was significant, $F(1, 25) = 5.19$, $p = .03$. Level of help received failed to account for additional variance in low achievers' over confidence in learning scores after the other variables were controlled.

Table 6. Multiple regression predicting level of constructive activity from help received, overconfidence in learning and goal condition ($N = 29$)

Variable	R	R^2	ΔR^2	ΔF	ΔSig
Controls[a]	.37	.14	.14	2.06	.15
Overconfidence in learning	.53	.28	.14	5.11	.03
Controls[b]	.53	.28	.28	4.04	.02
Goal condition	.53	.28	.00	0.08	.78
Controls[c]	.46	.21	.21	3.51	.04
Level of help received	.53	.28	.07	2.47	.13

[a] Level of help received; Goal condition.
[b] Level of help received; Overconfidence in learning.
[c] Overconfidence in learning; Goal condition.

Table 7. Multiple regression predicting overconfidence in learning from help received, constructive activity and goal condition ($N = 29$)

Variable	R	R^2	ΔR^2	ΔF	ΔSig
Controls[a]	.48	.23	.23	3.94	.03
Level of constructive activity	.60	.36	.13	5.11	.03
Controls[b]	.48	.23	.23	3.89	.03
Goal condition	.60	.36	.13	5.19	.03
Controls[c]	.57	.33	.33	6.35	.01
Level of help received	.60	.36	.03	1.32	.26

[a] Level of help received; Goal condition.
[b] Level of help received; Level of constructive activity.
[c] Level of constructive activity; Goal condition.

Discussion

The results of this study are largely consistent with the work of Webb *et al.* (1995) in documenting the critical role of constructive activity in learning from a peer during collaborative problem solving. As with the findings reported by Webb *et al.*, the learning of the low achieving partner was best predicted by their own level of constructive activity after receiving help from their high achieving partner. The quality of help received from the high achieving partner was not found to be directly associated with the learning of the low achieving partner. These results support Webb *et al.*'s assertion that the inconsistent and weak relationship between help received and learning often reported in the peer learning literature may be due in part to the extent to which recipients of explanations actively use help to build a deeper understanding of the strategies used to solve problems or study the materials at hand.

In contrast to Webb *et al.*'s (1995) findings, we did not find a statistically significant relationship between the quality of explanations provided by the high achieving partner and the level of constructive activity of the low achieving partner. There are numerous differences between this study and Webb *et al.*'s study that may explain why we did not replicate this finding. As noted above, this experimental study involved upper elementary (fourth and fifth grade) students and focused exclusively on pairs of high and low achievers working together. In addition, only the constructive activity and learning of the low achieving partner were included in our analyses. In contrast, Webb *et al.*'s study was conducted with middle school (seventh grade) students working in heterogeneous (including high, average and low achieving students) small groups of four to five students. Webb *et al.*'s analyses did not single out one achievement level, but rather included the constructive activity and learning of any student who was the recipient of help. It may be that for younger, low achieving students, simply receiving a high quality explanation is not sufficient for a student to spontaneously engage in constructive use of that explanation. Alternatively, the failure to achieve statistical significance may have been an artifact of this study's relatively small sample size. Future research with larger samples and older, low achieving students might examine these possibilities empirically.

Instead, we found evidence that low achieving partners' comprehension monitoring, as indexed by their relative overconfidence in how much they had learned from working with their high achieving partners, was correlated with their own level of constructive activity and accounted for an additional unique portion of the variance after quality of help and achievement goals were statistically controlled. This finding is consistent with what the literature on meta-cognition and problem solving suggests: more active learning and effective problem solving often involves the use of meta-cognitive knowledge and skills (e.g. Cardelle-Elawar, 1992; Chi, 2000; Chi, Bassock, Lewis, Reimann, & Glaser, 1989). However, these findings should be viewed tentatively given that we inferred the use of comprehension monitoring processes from an indirect measure based on self-reported confidence ratings. Future research should attempt to examine these processes in more detail by including direct observational measures of meta-cognitive regulation or through more in-depth self-report techniques (e.g. stimulated recall, clinical interview, etc.).

Finally, we found that achievement goals were related to comprehension monitoring – low achievers given performance goal instructions were more likely to overestimate their understanding than low achievers given learning goal instructions. This is an intriguing result because it suggests that low achieving students who adopt a goal to understand and improve their competence (i.e. a learning goal) may not only increase the effort they are willing to expend (and presumably employ more sophisticated learning strategies), but also may engage in more self-monitoring and evaluation of current understanding during learning from a peer. Indeed, the complex relationship between achievement goals and self-evaluation has been explored in other research examining influences on children's mathematics learning (Schunk, 1996). For example, in a study with fourth grade students, Schunk (1996) found that frequent prompts to self-evaluate progress can override predicted differential effects of learning and performance goals on learning outcomes. When students were prompted to self-evaluate their progress less frequently, significant differences in maths learning outcomes were found between students who adopted learning versus performance goals. One interpretation of these findings is that learning goals seem to encourage students to engage spontaneously in self-evaluative and comprehension monitoring processes, whereas performance goals tend to either discourage or at least fail to cue these processes. This pattern of findings seems consistent with our results and helps to provide a more detailed picture of how achievement goals influence engagement in constructive mental activity.

Taken together, the findings of this study suggest that interventions that focus on helping low achievers actively use peer explanations by encouraging them to adopt learning goals and or evaluate their comprehension more closely show promise and provide additional support for the idea that classrooms that foster the development of learning goals will improve the quality of learning that takes place in heterogeneous small groups or pairs. Approaches to establishing learning goal orientations at the classroom and school level have typically focused on making substantial structural changes in the tasks, grading practices, recognition policies and grouping patterns traditionally used by teachers (e.g. Ames, 1992; Maehr & Midgley, 1991). Although these approaches, when fully implemented, have been shown to be successful in altering achievement goal orientations in classrooms, we think additional approaches involving less sweeping structural changes may offer viable options to teachers and schools, and should be studied further. For example, we find it noteworthy that the approach taken to establishing learning goals used in this study, through a relatively simple set of verbal suggestions, was potent enough to influence the learning of low achieving students. Other researchers have had similar success in manipulating students to adopt learning goals with brief verbal statements even when they are disposed to hold personal performance goals or implicit theories of intelligence (i.e. entity theories) that are not normally associated with learning goals (e.g. Newman, 1998; Thompson & Musket, 2005). Similar and more extensive approaches, where teachers seek to build learning goal orientations through everyday verbal interactions with students, may offer an alternative way of influencing students' achievement motivated behaviour (see Anderman, Patrick, Hruda, & Linnenbrink, 2002; Marshall, 1987; Patrick, Anderman, Ryan, Edelin, & Midgley, 2001, for some examples of this type of approach).

In either case, we believe that a focus on cultivating learning goal orientations in students may prove to be an important factor in maximizing the effectiveness and flexibility of group work in the classroom. The advantages of interventions that focus on influencing students' achievement goals relative to other approaches to increasing the effectiveness of group work (e.g. role assignments, incentives, social skill training, etc.) should be investigated. It may be that establishing norms in the classroom that represent a learning goal orientation will provide teachers with additional flexibility and lead to wider successful implementation of group work in the classroom.

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