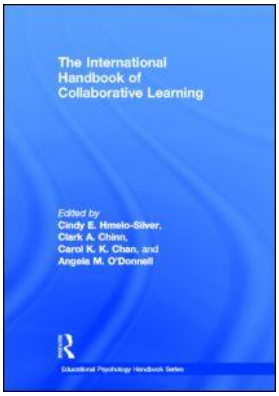

The International Handbook of Collaborative Learning

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Information Processing Approaches to Collaborative Learning

Publication details
https://www.routledgehandbooks.com/doi/10.4324/9780203837290.ch1
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Published online on: 04 Feb 2013

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Theoretical Approaches

1

INFORMATION PROCESSING APPROACHES TO COLLABORATIVE LEARNING

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The potential of small-group collaboration to promote student learning is recognized by educators, researchers, and policy-makers alike. Confirmatory research evidence began appearing decades ago (e.g., meta-analyses by Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Slavin, 1983a,b). Since then much research has focused on clarifying the mechanisms by which working with peers produces positive learning outcomes. This chapter addresses the question from an information-processing perspective; that is, how students can learn by actively processing information while collaborating with others. In particular, this chapter focuses on the relationship between the dialogue among students and processes tied to cognitive change. The first part of this chapter describes the overt communication processes and internal cognitive processes that may be associated with positive learning outcomes. The second section describes debilitating processes that might prevent learning. The final section describes approaches that have been used to promote beneficial processes and inhibit detrimental processes.

MECHANISMS THAT MAY PROMOTE LEARNING

A number of overt communication processes during collaboration may trigger internal cognitive processes that are associated with learning. During group collaboration, students may present their ideas, and thereby convey information to others (e.g., when solving a problem, completing a task, or summarizing material); they may explain to their group mates to help the latter understand the material or learn how to complete the task; or they may justify their ideas in response to challenges, questions, disagreements, or perceived conflicts or discrepancies. Both the speakers and the listeners involved in these overt communication processes can learn by engaging in a number of internal cognitive processes. First, students may activate and strengthen their understanding of material they have already learned. Second, they may fill in gaps in their understanding, thus repairing mental models that may be correct globally but are fragmented or

incomplete with gaps of missing knowledge (Chi, 2000). Third, they may correct misconceptions in what Chi (2000) terms flawed mental models, which may include local mistakes or global inaccuracies. In all of these internal processes, learners actively construct their own learning by generating new relationships among pieces of information they already know, by linking new information to information they have previously learned, and by changing their thinking in light of new information they encounter (cf. Wittrock, 1990).

Both preparing to present ideas and presenting the ideas may promote learning on the speaker's part. In the process of *formulating* an explanation or idea to be presented, students must transform what they know into communication that is relevant, coherent, complete, and accurate so that others can understand it. During this preparation, students may rehearse information they already know; identify the salient features of the problem or task; prioritize, reorganize, and clarify information to make it more coherent; see new relationships and build new connections between pieces of information or concepts; generate multiple ways of representing information and make explicit the links among different representations; monitor their own understanding and develop a metacognitive awareness of their own misconceptions or gaps in understanding—and seek new information to correct those misconceptions or fill in gaps in their understanding; and strengthen connections between new information and previously learned information, all of which may help these students to develop new perspectives and deeper understanding (Bargh & Schul, 1980). *Presenting* ideas may elicit many of the same processes, especially when the presentation exposes contradictions or incompleteness of ideas that are recognized by the explainer or are pointed out by others.

To communicate most effectively, those presenting material or explaining to others must take into account the level of understanding and extent of knowledge of their listeners. Having to tailor explanations to listeners' comprehension may push speakers to construct more elaborate conceptualizations than they would otherwise do (Chi, 2000). First, *anticipating* the listener's level of comprehension may promote such activity on the part of the explainer (Benware & Deci, 1984). Second, *responding* to evidence of listeners' comprehension (e.g., as conveyed through listeners' questions) may force explainers to generate revised or novel explanations (Roscoe & Chi, 2007).

Listeners may engage in processes analogous to those carried out by presenters. When comparing their own knowledge with what is being presented, listeners may recognize and fill in gaps in their own knowledge, recognize and correct misconceptions, see contradictions that cause them to seek new information (e.g., by asking questions), and generate new connections between their own ideas, or between their own and others' ideas. They may generate self-explanations that help them internalize principles, construct specific inference rules for solving the problem, and repair imperfect mental models (Chi, 2000; Chi & Bassock, 1989; Chi, Bassock, Lewis, Reimann, & Glaser, 1989). To promote learning, then, listening must be active. The benefits will accrue when learners *apply* the information received to try to solve the problem or carry out the task themselves (Vedder, 1985).

Presenting and listening to information shared during the context of peer collaboration may be especially effective compared to other contexts such as explaining to or listening to adults (e.g., teachers), because peers share a similar language and can translate difficult vocabulary and expressions into language that fellow students can understand (Noddings, 1985). Moreover, learning material at the same time as other students

may help them tune into each other's misconceptions, so they may give more relevant explanations than adults can (Vedder, 1985). And learners can control the pace of group discussion to better understand information and explanations offered.

The information-processing perspective on learning in collaborative groups is not independent of other theoretical perspectives discussed in this volume. First, for example, in sociocognitive conflict theory based on a Piagetian perspective (Piaget, 1932), conflict arises when there is a perceived contradiction between the learner's existing understanding and what the learner experiences in the course of interacting with others. Learners may respond to this perceived contradiction and disturbance to their mental equilibrium by taking into account their own perspectives while considering others' incompatible viewpoints, reexamining and questioning their own ideas and beliefs, seeking additional information to reconcile the conflicting viewpoints, and trying out new ideas (De Lisi & Golbeck, 1999; Forman & Cazden, 1985). They may carry out these processes as a result of hearing contradictory information or opinions, or through confronting others' ideas and justifying their own positions.

Second, in sociocultural theory based on a Vygotskian perspective (Vygotsky, 1978), through a process sometimes called scaffolding or guided participation, a more skilled person enables a less competent person to carry out a task that the latter could not perform without assistance. By actively listening to the more competent person, explaining what he has heard, and applying the new information to the task at hand, the less-proficient student can practice, develop, and internalize skills so that they become part of his individual repertoire.

Third, in a perspective that may be termed *coconstruction of knowledge*, students contribute different pieces of information or build upon others' explanations to jointly create a complete idea or solution (Hatano, 1993). By acknowledging, clarifying, correcting, adding to, building upon, and connecting each other's ideas and suggestions, students may collaboratively build and internalize knowledge and problem-solving strategies that no group member has at the start (Hogan, Nastasi, & Pressley, 2000).

Empirical Evidence

Indirect evidence about the mechanisms in collaborative settings that may promote learning comes from correlational research linking explanations and learning outcomes. The strong relationship between explaining and achievement in collaborative groups has been well documented (Webb & Palincsar, 1996; more recently by Howe et al., 2007; Veenman, Denessen, van den Akker, & van der Rijt, 2005). Moreover, giving complex explanations (e.g., reasons elaborated with further evidence) has been shown to be more strongly related with learning outcomes than giving less complex explanations (e.g., simple reasons; Chinn, O'Donnell, & Jinks, 2000). Tutoring studies also corroborate the importance for tutor learning of giving elaborated explanations, such as conceptual explanations (e.g., discussing how an answer does or does not make sense; Fuchs et al., 1997), and explanations that integrate concepts and draw upon prior knowledge to generate new inferences (e.g., generating novel examples and analogies; Roscoe & Chi, 2008).

In contrast to the positive relationship between giving explanations and learning outcomes, research on the relationship between receiving explanations and achievement is inconsistent (Webb & Palincsar, 1996). In support of Vedder's (1985) hypothesis that in order for receiving explanations to be effective, students must have and use the

opportunity for practice by attempting to apply the explanation received to the problem at hand, engaging in constructive activity after receiving an explanation (e.g., reworking the problem, paraphrasing the solution strategy) has been found to be positively related to achievement, whereas receiving or hearing an explanation without carrying out constructive activity is not (Webb & Mastergeorge, 2003; Webb, Troper, & Fall, 1995).

More direct evidence about mechanisms that promote learning comes from analyzing collaborative dialogues for indications that students are engaging in the cognitive processes described above. For example, Roscoe and Chi's (2008) coding of explaining episodes in which students explained to other students about the basic structure, location, and function of the human eye revealed instances of students drawing upon their prior knowledge and making additional new connections with prior knowledge, generating novel examples and analogies, generating new inferences that went beyond the text material they were studying, rethinking their ideas, and repairing perceived errors and misconceptions. Explainers' metacognitive statements were especially useful for signaling when students were making new connections and building their understanding (e.g., "This is something that I didn't really get before"; Roscoe & Chi, 2007, p. 336). Other analyses of group discussions show how the group's challenge of an explainer's incomplete or incorrect ideas may cause the explainer to reexamine her prior knowledge, to formulate and test predictions based on her incorrect mental model, and to use information provided by her peers in response to her predictions to revise her ideas (e.g., a student revising her overly general concept of camouflage as an animal defense mechanism to a more accurate understanding that an animal will change its color to match only those in its natural background; Brown, Campione, Webber, & McGilly, 1992, pp. 177–178).

DEBILITATING PROCESSES

Despite the potential benefits of collaborative work, researchers have documented a number of debilitating processes that inhibit positive outcomes. Students may fail to share elaborated explanations, may not seek help when they need it, may disengage from interaction or suppress other students' participation, may engage in too much conflict or avoid it altogether, may not coordinate their communication, and may engage in negative social-emotional behavior that impedes group functioning.

Failure to Provide Elaborated Explanations

The tendency of students to present ideas with little elaboration is well documented (e.g., Galton, Hargreaves, Comber, Wall, & Pell, 1999; Meloth & Deering, 1999). For example, when tutoring their peers, students tend to restate, paraphrase, or summarize text information with little elaboration (a "knowledge-telling bias"; Roscoe & Chi, 2008), unless they are trained to give elaborations (e.g., King, Staffieri, & Adelgais, 1998). Untrained tutors may provide elaborated explanations (e.g., creating analogies, drawing inferences, making new connections) only when their tutees ask deep questions about content not provided explicitly in the text (Roscoe & Chi, 2008). In some cases, the lack of elaboration may be due to students modeling their communications on teacher discourse that consists of giving unlabeled calculations, procedures, and answers to mathematics problems instead of labeled explanations or explanations of mathematical concepts (Webb, Nemer, & Ing, 2006).

Failure to Seek and Obtain Effective Help

Some listeners may be students who are having difficulty with the material and need help. They may not be able to correct their misconceptions or fill in gaps in their understanding if they fail to seek help when they need it and fail to obtain effective help when they do seek it. Students may fail to seek help for many reasons (Nelson-Le Gall, 1992). Students may lack the metacognitive skills necessary to monitor their own comprehension and so may not realize that they don't understand the material or can't perform the task without assistance, or they may watch their teammates solve a problem or accomplish a task and assume that they can do it too.

Even if students are aware that they need help, they may decide not to seek it for fear of being judged incompetent and undesirable as a work mate, they may not want to feel indebted to those giving the help, they not want to be seen as dependent upon others, or they may not believe they are self-efficacious—that they can do well in school and can control learning through their own efforts (Newman, 1998; Schunk, 1989). A reluctance to seek help may be associated with a performance-goal or relative-ability-goal orientation, in which students are focused on looking good compared to others, performing better than others, being publicly recognized for their superior performance, and having others judge their competence positively (Ryan, Pintrich, & Midgley, 2001). These students are especially concerned about how others view them and will avoid help seeking because they feel it signals a lack of competence. (Students with a mastery-goal orientation, in contrast, are focused on learning, improving their progress, and mastering the task, and, because they are less focused on external evaluation, help seeking does not threaten their self-perceptions about their abilities.) Similarly, students who are concerned with their social status (especially if they don't feel socially competent) may avoid help seeking because it exposes them to evaluation and scrutiny by others and threatens their self-worth (Ryan et al., 2001).

Students may believe that help-seeking is undesirable as a result of classroom norms that call for students to remain quiet and work alone, or classroom norms that value performance over learning, or sex-typed norms that view help-seeking as more appropriate for females than males. Or they may have received antagonistic or unsatisfactory responses to previous help-seeking attempts. Students may also believe that no one in the group has the competence or resources to help, or that they themselves lack the competence to benefit from help provided.

When students do seek help, they may select helpers who are nice or kind, or who have high status, rather than those who have task-relevant skills (Nelson-Le Gall, 1992). Or students may not have effective strategies for eliciting help. In particular, the kinds of questions students ask often have important consequences for the kinds of responses they receive. Requests for elaborated help that are explicit, precise, and direct, and targeted to a specific aspect of the problem or task are more likely to elicit explanations than unfocused questions or general statements of confusion (Webb & Palincsar, 1996). Asking precise questions makes it easier for other group members to identify the student's misconceptions or nature of their confusion and to formulate appropriate and precise responses. Detailed requests for explanations may also signal to the group that the help-seeker is motivated to learn how to solve the problem, already has at least some understanding of the problem that enabled him to pinpoint a specific area of uncertainty, and will profit from the explanations provided, making it more likely that the group will put forth the effort to provide elaborated help (Webb, Nemer, & Ing, 2006).

Asking precise questions may have still another benefit for the help-seeker. The act of articulating a specific question (e.g., putting words to a confusion) may help the questioner to organize and integrate his thinking in new ways that lead to improved understanding (Roscoe & Chi, 2007).

In contrast to specific questions, general questions ("How do you do this?") or general declarations of confusion ("I don't get it") leave potential help-givers with little clue about what the help-seeker does not understand. Such help-seeking behavior may also signal to the group that the help-seeker lacks ability or motivation to work or learn, especially when students seek help before expending any discernible effort on the task. Help-givers may be unwilling to work hard to generate explanations if they perceive that the help-seeker lacks the competence to be able to understand or use them, or is depending on others to do the work for him.

Even if groups are willing to help, they may not have the skills to provide effective explanations. Help-givers may be confused or have misconceptions themselves, may not be able to translate their thinking into appropriate or understandable language, may not be willing or able to use examples and language familiar to the help-seeker, may not provide enough detail or detail relevant to the help-seeker's particular difficulty, may not be able to identify the help-seeker's problem, or may have difficulty integrating what they know with the help-seeker's misconceptions (Ellis & Rogoff, 1982).

Because help-givers tend not to test whether their explanations are effective for the help-seeker, for example, by asking the help-seeker to recapitulate the explanation, practice the problem, or apply it to other problems (Fuchs et al., 1997; Ross & Cousins, 1995), help-seekers must take responsibility themselves for ascertaining whether the help they receive is beneficial for improving their understanding. Help-seekers can make it more likely that they will obtain effective help and gain understanding if they persist in asking questions, for example, by repeating their questions, paraphrasing them, prefacing their question with a description of the parts of the problem they do not understand; insist on being given explanations (instead of calculations or answers); reject group members' attempts to dictate the solution; resist group members' invitations or commands to copy their papers; and apply help they receive to determine whether it allows them to solve the problem on their own without assistance (Webb & Mastergeorge, 2003).

Failure to seek help is not only detrimental for those who need help but may also be a missed opportunity for other students to benefit from being questioned. Responding to peers' questions may force students to clarify confusing explanations, or to resolve contradictions or incompleteness in their explanations, leading to improved understanding (Roscoe & Chi, 2007). Moreover, deep questions (those that require reasoning and application of knowledge) may stimulate knowledge-building on the part of explainers in ways that shallow questions about basic facts do not; for example, "How does that [the structure of the blind spot] affect your vision?" vs. "The blind spot is where all the nerves are located?" (Roscoe & Chi, 2008, p. 341).

Suppressed Participation

Students wishing to participate actively in group collaboration don't always have opportunities to do so. Personality characteristics may explain some effects such as extroverted, outgoing, and energetic members doing most of the talking and dominating group work. Status characteristics may also determine relative influence in the group (Cohen & Lotan, 1995). High-status students, especially those with high academic

standing or peer status characteristics (perceived attractiveness or popularity), tend to be more active and influential than low-status individuals; while low-status individuals tend to be less assertive and more anxious, talk less, give fewer suggestions and less information, and ask fewer questions than high-status individuals. Interviews of low-achieving students working in groups with high-achieving students have revealed their frustration with having their ideas ignored, being left behind by the speed with which others solved problems or completed tasks, and being left out of decision-making processes (King, 1993). Social characteristics, such as gender or race, may also operate as status characteristics in heterogeneous small groups, with boys and White students being more active than girls and students of color. Even artificially created status differences, such as classifying students' competence on the basis of fictitious test scores (Dembo & McAuliffe, 1987) can create imbalances in individual participation and influence, with students designated as "high status" dominating group interactions and being perceived as more capable than "low status" students.

Whereas some students may be shut out of interactions, other students may choose not to participate. Students may engage in social loafing, or diffusion of responsibility, which arises when one or more group members sit back and let others do the work, possibly because they believe that their efforts can't or won't be identified or are dispensable. This free rider effect may turn into a sucker effect when the group members who complete all of the work discover that they had been taken for a free ride and start to contribute less to the group work in order to avoid being a sucker (Salomon & Globerson, 1989).

Students who choose not to be involved or who are excluded from group interaction will not experience the benefits of active participation described in the previous sections. And the students who do participate will not benefit from the knowledge and perspectives of the passive students, and may even lead the group off track by pursuing the wrong task or suggesting incorrect solutions that are not challenged.

Too Little or Too Much Cognitive Conflict

Although students can learn by resolving discrepancies in ideas, too little or too much conflict can be detrimental (Bearison, Magzamen, & Filardo, 1986). Infrequent conflict may reflect suppression of disagreements, or pseudoconsensus or pseudoagreement, in which students minimize disagreements or pretend they don't exist. Because disagreements may be seen as threatening group members' self-image, students may avoid disagreement to maintain positive social relationships (Chiu & Khoo, 2003). In these cases, incorrect ideas may persist and go unchallenged. Too much conflict, on the other hand, may prevent group members from seeking new information to resolve their disagreements. If they spend all of their time arguing they may never develop new insights, especially if their aim is to win the argument regardless if they are right or wrong.

Lack of Coordination

Opportunities to benefit from information being shared in the collaborative group may be lost when group members do not coordinate their communication. Lack of coordination of group members' efforts and participation can impede both group functioning and individual learning (Barron, 2000). Low levels of attention to, and uptake of, group members' suggestions may inhibit group progress on a task, even when those suggestions are correct and potentially productive. In uncoordinated conversations, students advocate and repeat their own positions and ideas, ignore others' suggestions, reject

others' proposals without elaboration or justification, and interrupt others or talk over them. When students do not pay attention to what others say, they cannot learn from their suggestions. Barron (2000) documented a number of ways in which students may fail to attend to others' suggestions. Students may engage in "skip connecting" in which they do not acknowledge or reference what another speaker has just said, but instead reassert what they had said previously. They may also reject a suggestion or idea out of hand, without any rationale for why it was incorrect or inappropriate. Or they may refuse to yield the floor to other speakers by continuing to talk without making eye contact with others.

In highly coordinated groups, in contrast, members acknowledge each other's ideas, repeat others' suggestions, and elaborate on others' proposals. Speakers' turns are tightly connected, with group members paying close attention and responding to what other members do and say, giving space for others' contributions, and monitoring how the unfolding contributions relate to the problem-solving goal. Proposals are directly linked to the prior conversation, are acknowledged and discussed, are not ignored, and are not rejected without reasons being given (Barron, 2000). Repeating others' ideas, asking questions about them, and elaborating on them are important components of active listening. These communication behaviors may help listeners test their own understanding of the ideas being proposed, help them identify what they find confusing or unconvincing, may help them evaluate the ideas for accuracy and completeness, and may provide a foundation to help them link the new information to what they already know and generate new inferences or connections they had not previously seen.

Negative Socioemotional Processes

Negative socioemotional processes, such as rudeness, hostility, and unresponsiveness, can also impede group members' participation. Rudeness (especially rude criticisms of others' ideas, such as "You're wrong," compared to the more polite criticism: "If 6 is multiplied by 2, we don't get 10") may cause students to withhold correct information and disagree with correct suggestions posed by others, with negative effects on the quality of groups' solutions to problems (Chiu & Khoo, 2003, p. 507) and correspondingly, with reduced opportunities for group members to learn. Such processes can also suppress help-seeking, especially when students are insulted when they seek help, receive sarcastic responses, or have their requests rejected or ignored. Students who carry out negative behavior may themselves have their requests for help rejected (Webb & Mastergeorge, 2003).

APPROACHES TO PROMOTING BENEFICIAL PROCESSES AND INHIBITING DETRIMENTAL PROCESSES

Simply asking students to collaborate will not ensure that they will engage in productive dialogue. Therefore, researchers have designed and tested a number of approaches for maximizing the chances that beneficial processes will occur while preventing detrimental processes, as well as investigating factors that may influence the quality of group dialogue. This section addresses how students may be prepared for collaborative work, how group work itself can be structured to require certain student behavior, how teachers may intervene with collaborative groups, and how teacher discourse in the classroom more generally may influence student–student dialogue.

Preparation for Collaborative Work

A number of activities may take place before students begin their collaboration. Teachers can build students' communication skills, arrange group membership to encourage productive communication, and design group tasks that support high-quality dialogue.

Instructing Students in Communication, Explaining, or Reasoning Skills. Instruction in communication, explaining, or group reasoning skills is a primary component of many small-group learning programs, and produces positive effects on the depth of collaborative group discussions and, often, group performance and student achievement. For example, preparation in communications skills is a central feature of the Social Pedagogic Research into Group work (SPRinG) program designed to help teachers create inclusive and supportive classrooms (Baines, Blatchford, et al., 2008; see also Baines, Blatchford, & Chowne, 2007; Blatchford, Baines, Rubie-Davies, Bassett, & Chowne, 2006). Students receive instruction in taking turns speaking; engaging in active listening; asking and answering questions; making and asking for suggestions; expressing and requesting ideas and opinions; brainstorming suggestions, ideas, and opinions; giving and asking for help; giving and asking for explanations; explaining and evaluating ideas; arguing and counterarguing; using persuasive talk; and summarizing conversations.

Many other programs also train students in similar constellations of communication skills. Some teach students to actively listen to each other, to provide constructive feedback for each other's suggestions and ideas, to encourage all group members to contribute to the group task, to try to understand other group members' perspectives, and to monitor and evaluate the progress of the group (e.g., Gillies, 2003, 2004). Others focus on joint group activity such as jointly analyzing problems, comparing possible explanations, and making joint decisions), and help students learn how to share all relevant suggestions and information, provide reasons to justify assertions, opinions, and suggestions, ask for reasons, listen to others attentively, discuss alternatives before making decisions, and accept and respond to constructive challenges (Mercer, Dawes, Wegerif, & Sams, 2004; Rojas-Drummond & Mercer, 2003). Some training programs include specific activities designed to improve students' explanation-giving and help-seeking skills (e.g., giving explanations rather than answers, asking clear and precise questions; Veenman et al., 2005).

Still other programs focus on teaching principles of argumentation as a way of developing students' reasoning skills. Students may receive instruction on the definition, purpose, and uses of arguments, as well as the parts of arguments, the position, the reasons supporting the position, the supporting facts, the objections that might be raised, and the responses to the objections (Reznitskaya, Anderson, & Kuo, 2007). Or they may be taught how to carry out argumentation processes such as providing reasons and evidence for and against positions, challenging others with counterarguments, and weighing reasons and evidence (Chinn, Anderson, & Waggoner, 2001).

Assigning Students to Groups. Also under the teacher's control is how to compose groups. Most often compared empirically are group compositions in terms of the gender and ability mix of groups (Webb & Palincsar, 1996), but results are not sufficiently clear-cut to produce recommendations for teachers about optimal groupings. Moreover, as some studies have demonstrated, whether a particular group composition is optimal for its members depends on the group processes that ensue, and similar groupings

may produce different processes and, consequently, different outcomes for students. For example, in an investigation of why high-ability students performed better in homogeneous than in heterogeneous ability groups (as had been reported by Webb, Nemer, Chizhik, & Sugrue, 1998), Webb, Nemer, and Zuniga (2002) found that high-ability students in some heterogeneous groups performed very well whereas high-ability students in other heterogeneous groups did not. Outcomes for high-ability students corresponded to the quality of their groups' functioning, rather than to the composition of the group, such as the level of help that high-ability students received, the level of contributions they made, and whether their group engaged in negative socioemotional behavior. Such results suggest that manipulating group composition cannot by itself guarantee optimal participation; teachers may more productively focus on ways to maximize group functioning for all students such as preparing students for collaborative work (as described above), and structuring group interaction (as described below).

Constructing the Group-Work Task. To encourage the participation of all group members, Cohen (1994b) recommended that teachers give groups complex tasks or open-ended problems without clear-cut answers or that require procedures that cannot be completed very well by a single individual and that utilize the combined expertise of everyone in the group. Such tasks encourage groups to recognize the multiple skills and perspectives needed in order to complete the task, and to value the different contributions that each student makes. Tasks or problems that can be completed by one student with the requisite skills, on the other hand, are more likely to limit the participation of students without those skills.

In a series of studies that supported Cohen's views, Chizhik and colleagues (Chizhik, 2001; Chizhik, Alexander, Chizhik, & Goodman, 2003) compared group collaboration and learning on open-ended or ill-structured tasks (e.g., designing a swimming pool and estimating its volume) versus single-answer or well-structured tasks (e.g., calculating the volume of a swimming pool with given dimensions). These studies showed smaller differences in participation rates between high-status and low-status group members (whether artificially assigned status scores or social characteristics such as ethnic background) with ill-structured than with well-structured tasks.

Other research, however, raises questions about the correspondence between task type and patterns of participation within groups. Esmonde (2009) showed that groups might interpret the same task in different ways, with some groups approaching the task as if following a procedure in which one student was expert and could direct other group members, and other groups approaching the same task as a problem to solve in which all students collaborated. One task, for example, was a group quiz (e.g., a mathematics quiz asking groups to determine the number of cakes a dessert shop should bake to maximize profits, subject to certain constraints). Esmonde described the interaction in some groups as asymmetrical in which some students who positioned themselves as "experts" taught "novices" and the novices deferred to the experts. In other groups, the interaction was more symmetrical, with no students positioned as experts or novices, and all students asking for and providing help and jointly collaborating. Esmonde's results suggest that groups' beliefs about group members' relative expertise and groups' perceptions about whether the task can be completed by a small number of experts are important predictors of group participation patterns beyond how a teacher conceives the task initially.

Structuring Collaborative Work: Requiring Students to Carry Out Specific Activities or Adopt Specific Roles

Some collaborative learning approaches structure group interaction in specific ways to improve the quality and depth of discussion. Features of these methods include requiring groups to carry out certain strategies or activities, assigning students to play certain roles, or both. Research finds that these approaches have positive effects on the nature of group collaboration, on group task performance, and, often, on student achievement.

Explanation Prompts. Some peer-learning approaches give students specific prompts in order to encourage them to engage in high-level discourse about the task. Students are given written prompts to help them to construct explanations, to find patterns in experiment results, to justify answers and beliefs, to relate prior learning to the task at hand, and to use as well as distinguish between "scientific" and "everyday" definitions and explanations (Coleman, 1998; Palincsar, Anderson, & David, 1993). Coleman (1998, pp. 406–412) gave the following examples of explanation prompts: "Explain why you believe that your answer is correct or wrong. Can you compare how you used to think about this with how you think about it now? How does your explanation compare with the scientific definitions that we learned in class? Is this explanation a scientific definition or an everyday definition?"

In Mevarech and Kramarski's (1997) metacognitive questioning method, groups answer questions to enhance their mathematical reasoning. Comprehension questions ("What is the problem/task all about?") help students reflect on problems before solving them; strategic questions ("Why is this strategy/tactic/principle most appropriate for solving the problem/task?") prompt students to propose and explain problem-solving strategies; and connection questions ("How is this problem/task different from/similar to what you have already solved? Explain why") prompt students to find similarities and differences between current and past problems they have solved or tasks they have completed (Mevarech & Kramarski, 2003, p. 469).

Reciprocal Questioning. In reciprocal questioning, students are trained to ask each other high-level questions about the material to help them monitor their own and each other's comprehension as well as to encourage students to describe and elaborate on their thinking (Fantuzzo, Riggio, Connelly, & Dimeff, 1989). For example, students may be given "how" and "why" question stems to guide their discussions of text, such as, "Why is … important? How are … and … similar?" (King, 1992, p. 113). Or students may be given questions to help them coconstruct and explain strategies for solving problems, such as "What is the problem?"; "What do we know about the problem so far?"; "What information is given to us?"; and "What is our plan?" (King, 1999, p. 101). Similarly, Fuchs, Fuchs, Kazdan, and Allen's (1999) students were trained to ask each other questions that begin with who, what, when, where, why, or how.

Structured Controversy. In order to promote the benefits that can arise when students try to resolve conflicting ideas, Johnson and Johnson (1995) built controversy into the group's task by subdividing groups into teams and requiring the teams to master material on different sides of an issue (e.g., should there be more or fewer regulations governing hazardous waste disposal), to present their views to the other team, to switch roles and repeat the process, and then to synthesize the two positions. Compared with

groups required to seek concurrence by working cooperatively and compromising, groups required to discuss opposing ideas often carried out more high-level discussion of the material and less description of the facts and information; they also showed higher achievement.

Cognitive Role Specialization. Students can be required to adopt specific roles so that they will carry out particular cognitive activities. Students may be assigned such roles as recaller (also called learning leader or summarizer) and listener (also called active listener, learning listener, or listener/facilitator; Hythecker, Dansereau, & Rocklin, 1988; Yager, Johnson, & Johnson, 1985), which can be incorporated into scripts for groups to follow (O'Donnell, 1999). The recaller summarizes the material and the listener is responsible for detecting errors, identifying omissions, and seeking clarification. Students then work together to elaborate on the material; they change roles for the next part of the task. In a variation of this scripted cooperation approach, Lambiotte et al. (1987) suggested that instead of the summarizer and listener studying the same material, students should study and teach each other different material. Lambiotte et al. hypothesized that listeners in this situation will be more likely to ask questions of clarification (because they have not already studied the material), and summarizers will be forced to organize the material more effectively and clearly, and to remember it better to present it to others (because they cannot assume that others have knowledge about the material). Finally, students in both roles will worry less about how others will evaluate their questions and summaries, and can focus better on the task.

Students can also be trained to engage in reciprocal peer tutoring, in which students playing the tutor role model strategies such as summarizing text as well as how to give explanations, corrections, and feedback about other students' work. To promote high-level discourse during paired discussions, teachers can train tutors to give highly elaborated conceptual rather than algorithmic explanations to their partners (e.g., using real-life examples, discussing why an answer does or does not make sense; Fuchs et al., 1997). Reflecting the importance of the activity of the help-receiver, some peer tutoring models guide the tutor in helping the *tutee* to give high-level explanations (King, 1999). The tutor asks questions designed to encourage the tutee to provide explanations of the material, asks further questions to push the tutee to elaborate upon or justify her or his explanations as well as to correct incomplete or incorrect explanations, and asks questions to push tutees to make connections among ideas and to link new material to their prior knowledge.

It should be noted that "teacher" and "learner" role specialization was a feature of some of the earliest cooperative learning methods. In the *Jigsaw* (Aronson, Blaney, Stephan, Sikes, & Snapp, 1978) classroom, students are assigned responsibility for mastering a portion of the material (and discussing that material with other students assigned the same topic) and then for teaching their topic to the other members of their groups. In *Group Investigation* (Sharan & Hertz-Lazarowitz, 1980), in which students carry out research on their piece of a group project and then come together as a team to integrate their findings and plan their class presentations, students are involved in teaching their own project pieces to the group and in learning from their peers about the remaining portions of the project.

Reciprocal Teaching. In reciprocal teaching, students carry out certain strategies designed to improve their comprehension of the text, including generating questions

about the text they have read, clarifying what they don't understand, summarizing the text, and generating predictions (Brown & Palincsar, 1989; Palincsar & Brown, 1984; Palincsar & Herrenkohl, 1999). The teacher has an explicit role during group work to help students become proficient in these strategies. Teachers initially take the leadership in small groups, explaining the strategies and modeling their use in making sense of the text. Then teachers ask students to demonstrate the strategies, but give them considerable support. For example, in order to help a student generate questions to ask her group mates, the teacher might probe what information the student gleaned from the text and help the student phrase a specific question using that information. The teacher gradually assumes the less active role of coach, giving students feedback and encouraging them. Students then carry out the text-comprehension strategies in their small groups.

Group Processing. Some social psychologists maintain that groups will function most effectively if they discuss their group's interaction and how they might improve it, sometimes called "group processing." Such discussions may help groups identify, understand, and solve general communication problems (e.g., lack of student participation, disruptive or bullying behavior) and may reinforce student collaboration (Johnson, Johnson, & Holubec, 1988). Gillies (2007) suggested sample checklists and activities that teachers and students can use in order to evaluate group processes. Ross (1995) added another group processing component. In addition to having groups complete and discuss a self-appraisal instrument, Ross provided groups with feedback about their group functioning in the form of five-page excerpts of the transcripts of their conversations, and transcript scores that rated their levels of requesting help, of giving help, and of being on task. Ross observed that groups gave more help (in terms of procedures, explanations, acknowledgments, and evaluations of each other's work) after they received this feedback than before.

Activities of the Teacher during Collaborative Work

Altering Expectations and Status Relationships. Students don't always participate actively in groups. While personality characteristics may explain why some students participate more actively than others (extroverted, outgoing, and energetic members may talk the most), researchers have also found that status characteristics can produce inequities in participation by determining relative activity and influence in the group (Cohen & Lotan, 1995; Mulryan, 1992, 1995). High-status students, especially those with high academic standing or peer status characteristics (perceived attractiveness or popularity), tend to be more active and influential than low-status individuals; while low-status individuals tend to be less assertive and more anxious, to talk less, and to give fewer suggestions and less information than high-status individuals (e.g., Bianchini, 1997, 1999; Esmonde, 2009). Individuals' characteristics, such as gender or race, may also operate as status characteristics in heterogeneous small groups, with boys and White students often being more active than girls and Black students (for some specific examples of the dominance of boys over girls and high-achievers over low-achievers, see Baxter, Woodward, & Olson, 2001; King, 1993; Mulryan, 1992, 1995). Even artificially created status differences (such as classifying students' competence on the basis of fictitious test scores) can alter group members' participation and influence. Dembo and McAuliffe (1987) found that, regardless of actual competence and ability to give help,

students designated as "high status" dominated group interaction, were more influential, and were perceived to be more capable than "low-status" students.

To prevent low-status students from being marginalized in group interaction, Cohen and colleagues (e.g., 1995) developed two status interventions based on broadening the notions of status and student competence. In the multiple ability treatment, the teacher raises students' awareness of the multiple skills necessary to accomplish a task. The teacher discusses with students the multiple abilities needed to solve complex problems (e.g., visual thinking, intuitive thinking, and reasoning) and stresses the fact that no single student possesses all of the needed abilities but that all students have some of them. In the second treatment, teachers assign competence to low-status students by observing groups at work to spot instances of low-status students exhibiting intellectual abilities relevant to the task, publicly identifying the contributions, and commenting on the importance and value of them. Cohen and Lotan noted that, as high-status persons, teachers' evaluations have a strong influence on students' beliefs about their own and others' competence. To carry out these interventions, a teacher must have a deep and comprehensive understanding of the multiple competencies relevant to the task and must be a very astute observer to look for abilities that may not be noticed by students in the group. For example, Cohen and Lotan described how teachers might observe the work of quiet students to pick out accurate, informative, or creative work that they are doing, bring it to the group's attention, and encourage the group to listen to the quiet students describe and explain their work.

These approaches have shown success in reducing the relationship between status (based on, for example, language background, ethnicity, race, socioeconomic status, or academic ability) and behavior in small groups (Cohen & Lotan, 1997). The more frequently teachers talk about the multiple abilities needed for a task (and the fact that no one has all of the abilities), as well as comment on the value of low-status students' contributions, the more low-status students participate, and the smaller the gap between high-status and low-status students' participation rates.

Other Teacher Interventions with Small Groups. Many prominent cooperative learning researchers and theorists advise teachers to monitor small-group progress and to intervene when groups seem to be functioning ineffectively (e.g., Johnson & Johnson, 2008). Conditions calling for teacher intervention may include: when no group member can answer the question, when students exhibit problems communicating with each other, when students dominate group work without allowing true dialogue, and when students fail to provide reasons for their opinions and ideas (Ding, Li, Piccolo, & Kulm, 2007; Tolmie et al., 2005).

Cohen (1994a) proposed several guidelines for how teachers should intervene, including asking open-ended questions to redirect groups' discussions and telling students they all need to be able to explain what the task is about. Cohen cautioned teachers to carefully listen to group discussions so that they can form hypotheses about the groups' difficulties before deciding on what questions to ask or suggestions to make. She argued that students are more likely to initiate ideas and to take responsibility for their discussions if teachers provide little direct supervision (such as guiding students through tasks, or answering individual student's questions before the group has attempted to work collectively to solve a problem). Any help that teachers do provide should be based on careful observations of group progress and not meant to supplant group efforts. It is

important that guidance provided, such as pointing out key aspects of the task, checking for students' understanding of what the problem is asking, and filling in missing parts of students' knowledge, does not constitute the teacher doing the task for the group or directing them in how to carry out the task, but rather is intended to help groups to negotiate the task (Cohen, 1994a).

Research on the impact of teacher interventions on collaborative activity and student learning largely supports her recommendations. The first theme supported by research concerns the benefits of teachers listening to students' interaction and then providing indirect guidance to help them elaborate their thinking. One set of studies showed that pushing students to explain their thinking and probing their ideas while minimizing direct instruction about how to complete the task or solve the problem promoted student explanation and achievement. Hogan, Nastasi, and Pressley (2000) found that asking a variety of questions meant to elicit the details of students' thinking about how to create a mental model of the nature of matter (e.g., asking students to describe their initial thinking, to elaborate on specific points they made in their initial explanation, and to clarify the language they used) was beneficial for the complexity of scientific reasoning that groups attained (e.g., how well students' ideas were supported and explained; the logical coherence of their thinking), especially when groups were not prone to engage in high-level reasoning when the teacher was not present. When teachers did make statements, they were repetitions or restatements of *students'* ideas, and were intended to clarify students' suggestions or to emphasize certain aspects of students' proposals rather than to tell students how to carry out the task. Similarly, Webb, Franke, De, et al. (2009) found positive effects from intense probing of students' ideas. The teacher intervention that nearly always produced more student explaining, and often resulted in groups giving correct and complete explanations about how to solve the problem, was teachers probing student thinking so that students gave further details about their problem-solving strategies beyond their initial explanations. Moreover, probing students' explanations was most likely to result in additional student explaining (especially correct and complete explanations) when teachers used the details of students' strategies given in initial explanations to drive their probing questions, when teachers persisted in asking questions in order to push students to clarify the ambiguous aspects of their explanations, and when teachers did not interject their own thinking (or their own assumptions about what students were thinking) into their probing questions.

Gillies (2004) reported similar results in a study in which some teachers were trained to engage in the kinds of probing interventions described above. These teachers were instructed to ask students probing and clarifying questions ("Can you tell me a little more about what you're intending to do here?"), acknowledge and validate students' ideas ("I can see you've worked really hard to find out how these items are related. I wonder what you could do now to identify a key category they can all fit into?"), identify discrepancies in students' work and clarify the options they may take ("I wonder how you can include … when you've already mentioned …?"), and offer suggestions in a tentative fashion ("I wonder if you've considered doing it this way?"; Gillies, 2004, p. 260). Compared to teachers who did not receive training in these specific communication skills but were instructed only to set and discuss ground rules for cooperative group discussions (e.g., sharing information, giving reasons, challenging others, considering alternatives before making decisions), the specially trained teachers asked more questions, especially to ascertain students' ideas and strategies, and carried out more

mediated-learning behaviors (e.g., challenging students to provide reasons, highlighting inconsistencies in student thinking, prompting students to focus on particular issues, asking tentative questions to suggest alternative perspectives; see Gillies, 2006). Their students provided more detailed explanations, more often expanded on other students' suggestions, asked each other more questions, and exhibited greater learning than did the students of the teachers who did not receive the specific training.

The second theme supported by recent research is the detrimental effect of providing direct instruction to collaborative groups, especially when teachers provide suggestions before evaluating students' progress on the problem or task. In Chiu's (2004) study, the explicitness of teachers' help (on a 4-point scale that included no help, focusing student attention on certain concepts or aspects of the problem, explaining a concept or a part of the problem, and giving the solution procedure) was negatively related to students being on task immediately after the teacher's intervention and to groups' performance on that problem. As Chiu explained, one explanation for this result was that teachers who gave explicit help and issued many directives tended not to evaluate the group's ideas before intervening. As an example, a teacher did not inquire about the group's work and so missed the group's misinterpretation of a problem, told the group the steps to carry out to solve the problem (but did not stay with the group to ensure that the students could solve the problem correctly), and the group failed to make further progress after the teacher left. As this episode shows, when teachers do not have, and do not seek, information about the group's ideas, their options for how to provide help are limited. Another unintended consequence of providing explicit content-related help may be decreased student engagement. In Dekker and Elshout-Mohr's (2004) study, the teacher providing detailed instruction often communicated with just one student (typically the student who asked the teacher for help) and other students tended to drop out of further conversations.

There is some evidence that providing direct instruction might be effective *if* teachers tie their help to student thinking. Meloth and Deering (1999) described several instances of explicit teacher guidance that did not reduce productive discussion, including giving brief, direct explanations of key concepts, briefly explaining what students were supposed to learn, and providing examples of how groups could locate or apply information. After these teacher interventions, students provided further elaboration of their thinking and made new suggestions. In these cases, teachers had asked questions to determine the groups' need for information or guidance, including soliciting details of students' ideas, and so the teacher guidance was closely tied to the group discussions. This same study suggested that teacher direct instruction that is not closely tied to student thinking may not have a deleterious effect under one condition; namely, when groups are proceeding well and are confident in their approach to the task or problem. When teachers interrupted such group collaborations to make suggestions without having heard the groups' discussions, these groups simply disregarded the teachers' suggestions and returned to their conversations.

Teachers' Discourse with the Whole Class

The nature of teacher discourse with students in the context of whole-class instruction and the norms teachers negotiate with the class about expected interpersonal exchanges may also influence group collaboration, especially the extent to which students explain their thinking and try to learn from others.

It is well known that teacher discourse, especially their questioning practices, plays an important role in limiting or enhancing students' opportunities for participation during whole-class discussion (Cazden, 2001). Recitation-style discourse (Nystrand & Gamoran, 1991) in which teachers ask students questions and evaluate their responses in a rapid-fire sequence of questions and answers with little or no wait time (Black, Harrison, Lee, Marshall, & Wiliam, 2002; Turner et al., 2002) places limits on student discourse, especially when teacher queries consist of short-answer, low-level questions that require students to recall facts, rules, and procedures (Ai, 2002; Galton et al., 1999; Graesser & Person, 1994). In contrast, high-level teacher questions that require students to draw inferences and synthesize ideas (Hiebert & Wearne, 1993; Wood, 1998), encourage students to provide justifications for their work (Boaler, 1997), and create opportunities for argumentation that promote student explaining, listening, and evaluation of each other's ideas and arguments (Forman, Larreamendy-Joerns, Stein, & Brown, 1998).

Emerging research suggests that these patterns of teacher discourse in the whole class, especially the extent to which teachers press students to explain their thinking, are also important for the depth of students' discussion in collaborative groups. That is, the patterns of behavior that students exhibit during whole-class discussions carry over to their small-group collaborations. In mathematics classrooms in which teachers press students to explain beyond their initial descriptions or explanations of their problem-solving strategies, students are likely to use mathematical arguments to explain why and how their solutions work, to justify their choice of problem-solving strategy, as well as to arrive at a mutual understanding about solutions (Kazemi & Stipek, 2001; Webb, Frank, Ing, et al., 2008*)*. Such pushing of students to explain their thinking may include asking students to justify every step in their procedure, asking specific questions about why students chose particular approaches or how they obtained their intermediate results, asking for clarification of steps in procedures even when solutions are correct, and to demonstrate procedures in different ways or using different representations (e.g., verbal descriptions, diagrams, fractions). In literature classrooms in which teachers push students to help interpret the story and ask them questions in order to encourage them to elaborate on their ideas and to generalize from the text, students in small groups engage in deep reasoning. They generalize from the text instead of describing facts or giving literal interpretations, elaborate on their ideas, and frequently ask each other to explain their reasoning (Smagorinsky & Fly, 1993).

When teachers assume responsibility for doing most of the work during whole-class instruction, students may show little initiative to explain their thinking during collaborative group work. In mathematics classrooms, when teachers set up the steps in the mathematics problems and ask students only to provide the results of specific calculations that the teachers themselves pose, students in their group work may correspondingly provide low-level information such as answers, calculations, and procedural descriptions instead of explanations, and not inquire about their peers' thinking (Webb, Nemer, & Ing, 2006). In literature classrooms, when teachers assume responsibility for interpreting the text and do not often ask students to contribute, small-group discussions may largely consist of students giving brief interpretations of the text without elaborating on their suggestions (Smagorinsky & Fly, 1993).

Teacher discourse during whole-class instruction (especially whether they ask students to explain their thinking) sends signals about the desirability of explaining and challenging others to explain and justify their thinking versus passively accepting

others' transmitted knowledge. Teachers can also carry out specific activities with the whole class to mutually construct classroom norms for student engagement. Yackel and colleagues (Yackel, Cobb, & Wood, 1991; Yackel, Cobb, Wood, Wheatley, & Merkel, 1990) described strategies that teachers may use to develop norms around student explanations. Teachers can invent scenarios or use specific situations that arise spontaneously during group work (e.g., one student completing the activities without his partners' being able to understand his solutions or being able to construct their own solutions) as springboards for whole-class discussions about students' responsibilities during group work, such as their obligations to create and explain their own meaningful problem-solving approaches, and to probe and challenge other students' thinking and solutions. Negotiating norms for active student participation can also head off debilitating processes such as social loafing or diffusion (Salomon & Globerson, 1989). Emphasizing students' responsibilities to explain, defend, and evaluate their own and others' thinking (Turner et al., 2002) may also encourage them to ask for help from their peers when they need it, and to engage in more effective help-seeking.

CONCLUSION

Research on collaborative dialogue and student learning has revealed important links between group processes and students' learning outcomes. In many cases, these results have been used in the design of specific collaborative learning approaches, with encouraging results for student learning. Much remains to be learned, however, about how collaborating with peers produces changes in student thinking and understanding. Carrying out detailed analyses of the interaction among students, especially at a sufficiently fine-grained level to detect changes in student thinking, promises to increase our understanding of how students learn in collaborative settings as well as the conditions that either promote or inhibit student learning in collaborative groups.

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