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REVIEW ARTICLE

When Is It Better to Learn Together? Insights from Research on Collaborative Learning

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Abstract Although collaboration is often considered a beneficial learning strategy, research examining the claim suggests a much more complex picture. Critically, the question is not whether collaboration is beneficial to learning, but instead how and when collaboration improves outcomes. In this paper, we first discuss the mechanisms hypothesized to support and hinder group learning. We then review insights and illustrative findings from research in cognitive, social, and educational psychology. We conclude by proposing areas for future research to expand theories of collaboration while identifying important features for educators to consider when deciding when and how to include collaboration in instructional activities.

Keywords Collaboration · Learning · Mechanisms · Instruction

A common belief held among both educators and the public at large is that learning in collaboration with others is better than learning alone. The belief is manifested in instructional activities across grade levels, from K-12 to higher education, and across subject matter areas, from language arts to mathematics, although it is particularly prevalent in science and engineering. These instructional activities can take many forms including collaborative problem solving, jigsaw activities that require individual group members to complete distinct tasks, cooperative learning activities, constructive controversy, and think-pair-share activities, to name a few (see Johnson et al. 2000, 2007; Slavin 1980, 1995 for reviews). This belief has been influencing educational and instructional practices across cultures (e.g., Kollias et al. 2005) for decades (Johnson and Johnson 2009) and in some cases, for millennia (e.g., Roman empire era Quintilian's views of teaching rhetoric, Bloodgood 2002).

The purpose of the current paper is not to provide an extensive review of the multiple literatures related to collaborative learning (e.g., cognitive, social, educational, and computer-

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supported), as there are already several meta-analyses examining critical topics related to each of these areas (Johnson and Johnson 1989; Johnson et al. 2000; Lou et al. 2001; Springer et al. 1999). Instead, we aim to bring together complementary insights from research in cognitive, social, and educational psychology on the factors and processes that affect collaborative success and failure that have not been brought together in past work. Our central thesis is that collaborative learning is an important educational practice that can be effective when particular cognitive and social processes are supported. We begin by operationalizing the claim that learning in collaboration is better than learning alone and outlining the constraints of our review. We describe the mechanisms hypothesized to inhibit or support collaborative success in the context of recent theories of collaboration. We then review representative findings from two rich research traditions that have differed in how they assess collaborative outcomes by comparing the group to the average individual or to nominal groups (i.e., the group's predicted potential). We hope that by bringing these two traditions together, we can highlight both the progress in understanding collaborative learning as well as the opportunities for the cross-fertilization of ideas and methods. We also aim to provide educators an overview of what factors to consider when designing or implementing collaborative instruction.

Operationalizing the Claim

We define collaboration broadly to mean active engagement and interaction among group members to achieve a common goal. This definition shares several core features with previous formulations (e.g., interaction and common goals; Dillenbourg et al. 1996; Kirschner et al. 2009a) but also captures significant variation across definitions and types of collaborative activities present in the literatures (e.g., similar or different expertise across group members). We focus our review on dyads and small groups (typically less than 6), which is also consistent with past work on the topic. We constrain our empirical review to research that assesses some aspect of learning and do not include the expansive literature that examines dyad and group effects on performance on a single task at one time point. We define research on learning broadly as study designs that provide an initial encoding phase (performed either individually or collaboratively), followed by some type of an assessment (performed either individually or collaboratively). This definition captures much research in education on collaborative learning as well as research in cognitive psychology on the effects of collaboration on encoding and recall. We do not include research that has examined effects of dyad or group performance compared to individual performance on a single task such as puzzle problem solving (e.g., Laughlin et al. 2006), brainstorming (e.g., Paulus and Yang 2000), and scientific discovery (e.g., Okada and Simon 1997), among others (see Kerr and Tindale 2004 for a review). We include a broad range of learning activities, such as memorizing and recalling information, solving problems, and critiquing a paper across a variety of content domains (e.g., mathematics, science, and psychology). We structure our review around two features of the studies: the unit of analysis being compared across conditions, and whether the study takes place in the laboratory or classroom.

To address the question of what is being compared across conditions, we draw on a useful distinction in the psychology literature for two levels of analysis (Hill 1982; Lorge et al. 1958; Steiner 1966). The first level is a comparison of the group to the average individual. For this measure, the group is considered the unit of analysis and the question is whether the group performs some learning or test activity (accuracy, efficiency, depth of understanding, etc.)

better than an individual engaging in the same activity. The second level of analysis is at the level of the individual to see whether an individual learning in collaboration with others is performing better or worse than his or her predicted potential based on working alone. For this analysis, one compares group performance to a *nominal group*. Nominal group performance can be determined in a variety of different ways, including summing the performance of multiple individual performers to create a post hoc comparison group (e.g., Weldon and Bellinger 1997) or using algorithms that make estimates of nominal group performance based on individual performance (Kelley and Wright 2010; Wright 2007). For example, in a collaborative memory paradigm in which the goal is to remember items from a list, the nominal group score would be created for the individual condition by summing together individuals' non-redundant memory recall to make a post hoc group. One would then compare the average nominal group performance to actual group performance to determine whether recalling in a group is better than recalling alone.

If an individual performs worse in the group than he or she would have alone, it is called *collaborative inhibition*. In contrast, if the individual exceeds what he or she could do working alone, it is called *collaborative facilitation*. We include these comparisons as they provide a stringent evaluation of learning at the level of the individual within a group. These types of analyses have been conducted extensively in social and cognitive psychology laboratory studies (for a review see Hill 1982; Rajaram and Pereira-Pasarin 2010).

We also look at whether basic results have been replicated in both laboratory and classroom settings. Each context has different advantages and disadvantages for determining the strength of the findings. The laboratory provides a space in which there is typically more control over conditions, allowing for more specific comparisons examining the underlying mechanisms for particular outcomes. Further, laboratory studies can use more sensitive assessments that cannot typically be given in a classroom context (e.g., reaction times and repeated tests). However, activities and assessments explored in the laboratory may not have natural classroom analogs and may seem artificial or contrived in comparison to important features of typical classroom instruction (i.e., affordances of the task and motivation to engage), thereby reducing external validity. In contrast, evidence from classroom studies can provide ecological validity and support for generalization of the claims to real-world contexts, where there are often many other co-varying factors at play that are not typically under the control of the researcher or teachers (e.g., curriculum, content, and types of assessment).

One of the goals of research in collaborative learning has been to understand when and why groups fail and when and why they succeed. This goal suggests a gulf between the general claim that collaborative learning is better than individual learning, and the research that aims to identify and test the hypothesized mechanisms driving collaborative failure and success. Even the most enthusiastic proponents of collaborative education methods agree that there are critical processes and factors that must be supported in order for collaborative learning to be effective (Johnson and Johnson 2009; Slavin 2014).

Mechanisms of Group Failure and Success

A number of different mechanisms have been theorized to cause failure and poor performance in groups (Table 1, part a for an overview). One category of mechanisms concerns the cognitive costs of coordinating and collaborating with others. If the memory coordination

Table 1 Mechanisms hypothesized to drive collaborative failure or success

Outcome	Type	Mechanism
A. Failure	*Cognitive*	Memory coordination costs (e.g., Kirschner et al., 2009a; Nokes-Malach, et al., 2012)
		Retrieval strategy disruption (e.g., Basden et al., 1997)
		Production blocking (e.g., Diehl & Stroebe, 1987)
	Social	Social loafing (e.g., Karau & Williams, 1993)
		Fear of evaluation (e.g., Mullen, 1987)
B. Success	*Cognitive*	Cross-cueing (e.g., Congleton & Rajaram, 2011)
		Complementary knowledge (e.g., Johansson, et al., 2005)
		Increasing working memory resources (e.g., Kirschner et al., 2009a)
		Error-correction (e.g., Ross et al., 2004)
		Reexposure (e.g., Rajaram & Pereira-Pasarin, 2010)
		Relearning through retrieval (e.g., Roediger & Karpicke, 2006)
	Social	Observational learning (e.g., Craig, Chi, & VanLehn, 2009)
		Increased engagement (e.g., Johnson & Johnson, 1985)
		Joint management of attention (e.g., Barron, 2003)
		Construction of common ground (e.g., Nokes-Malach, et al., 2012; Roschelle & Teasley, 1995)
		Negotiating multiple perspectives (e.g., Kuhn & Crowell, 2011)

costs outweigh the potential benefits of collaboration, there can be group failures and process loss (Dillenbourg 1999; Kirschner et al. 2009a; Nokes-Malach et al. 2012; Steiner 1972).

Three recent models of collaboration that aim to explain this type of process loss include Nokes-Malach et al.'s (2012) zone of proximal facilitation (ZPF) model, Kirschner et al. (2009a) cognitive load model, and Rajaram and Pereira-Pasarin's (2010) collaborative memory model. The ZPF model (Nokes-Malach et al. 2012) hypothesizes that collaborative success or failure depends critically on the relations between task complexity, individual member competence for the task, and the group competence for the task. If group members can solve the task individually, then they will show little benefit from collaborating and may even show worse performance due to the cognitive costs of coordinating different strategies or approaches to the problem. The ZPF model also predicts failure when the task complexity is beyond the scope of the predicted group-level competence. A similar proposal by Kirschner et al. (2009a) focuses on a cognitive load analysis of the learning or problem-solving activity and predicts poor performance or no advantage for simple tasks because individuals could perform those tasks well alone and therefore have an additional cost but no benefit from group coordination. Alternatively, the model predicts that collaborators will experience an advantage on complex tasks with a high cognitive load, as individuals can benefit from distributing that load across group members.

A third model by Rajaram and Pereira-Pasarin (2010) hypothesizes that individuals encode information with their own idiosyncratic cognitive organization, and those organizations can later interfere with each other at retrieval. The model specifies collaborative memory processes including retrieval strategy disruption and production blocking as two mechanisms within a larger framework. *Retrieval strategy disruption* (Basden et al. 1997; Finlay et al. 2000) is the idea that one may lose his or her train of thought in a group because of paying attention to other group members, or that each individual's memory retrieval strategies interfere with others' strategies when interspersed (e.g., remembering by semantic category vs remembering by similar sounding words). *Production blocking* (Diehl and Stroebe 1987) is the idea that group members must wait for their turns while another person is talking, which may result in missed retrieval opportunities.

A second category of mechanisms associated with group failure concerns more social aspects of the collaborative process. One proposed mechanism for poor performance in groups is called *social loafing* (also called *diffusion of responsibility*; Karau and Williams 1993; Latane et al. 1979), where some group members do not engage optimally in the task because they believe someone else in the group will pick up the slack. A second social mechanism involves *fear of evaluation* from group members (Collaros and Anderson 1969; Mullen 1983, 1987). Individuals in the group might not share their solutions or be as forthcoming with criticisms because they are afraid of negative evaluation from other group members. These mechanisms have been primarily investigated in performance domains (i.e., no assessment of learning), although they are often referenced as possible explanatory mechanisms for research on collaborative learning. An educational theory of cooperative learning proposed by Johnson and Johnson (2009) hypothesizes that these outcomes may occur when there is an inadequate sense of individual accountability. Their social interdependence theory of cooperative learning focuses on individuals promoting the achievement of joint goals with others in their group (Johnson and Johnson 1989, 2009).

Despite the number of mechanisms shown to disrupt collaborative learning, there is also much empirical evidence of mechanisms through which collaboration can support learning (see Table 1 part b for an overview). One cognitive mechanism hypothesized to underlie group success is that group members can use their collective knowledge about a problem-solving task or domain to *cue each other's prior knowledge* when trying to think of ideas, strategies, and solutions (Congleton and Rajaram 2011; Harris et al. 2011; Meudell et al. 1995). This mechanism depends on collaborators having some shared (i.e., common) knowledge to increase the likelihood of retrieving the most relevant knowledge for the problem or task (Meade et al. 2009; Nokes-Malach, Meade, & Morrow 2012). A second cognitive mechanism dealing with collective knowledge occurs when partners have *complementary knowledge* or expertise so that different members of the group may contribute different components of the solution (Johansson et al. 2005). For example, one individual in the group with unique knowledge could explain to the others a strategy or solution, and this explanation could benefit both those who receive it as well as the one who generates it (Webb et al. 1995). This is also the idea behind the Jigsaw classroom (Aronson et al. 1978).

The two collective knowledge benefits of shared knowledge and complementary knowledge relate to a third mechanism of *increasing working memory resources* (Kirschner et al. 2009a). Although coordination costs consume memory resources, collaboration can also increase memory and problem-solving resources through each individual's contribution to the recall of the relevant problem features and possible strategies. This view is consistent with both the cognitive load model (Kirschner et al. 2009a) and the ZPF model (Nokes-Malach et al. 2012). Consequently, the group has more cognitive resources to spend thinking through possible solutions and correcting errors. *Error-correction*, in which individual members can check the logic and rationale of each other's solutions, has been hypothesized as a major source of benefit to groups (Ross et al. 2004).

Rajaram and Pereira-Pasarin's (2010) collaborative memory framework also includes the error-correction mechanism as well as two others not previously discussed: reexposure effects and relearning through retrieval. *Reexposure* is the idea that individual members of a group are given new opportunities to learn the material that the other group members recall and therefore improve their own learning of that material (e.g., Barber et al. 2012). The *relearning through retrieval* mechanism is not unique to collaborative learning but builds on the larger memory literature that shows attempting to retrieve information can improve individuals' memory of the information (Roediger and Karpicke 2006). Because many collaborative learning scenarios include recalling in groups, this mechanism has a high likelihood of being enacted. Prior research has shown that repeated retrieval has a larger impact on subsequent memory than repeated study (e.g., Karpicke and Blunt 2011).

Several of these cognitive mechanisms are also consistent with Chi's Interactive-Constructive-Active-Passive (ICAP) framework that connects instructional activities with greater cognitive engagement to more positive learning outcomes (Chi 2009; Chi and Wiley 2014). At the top of the engagement activities hierarchy are interactive behaviors defined as "*dialogues that meet two criteria: (a) utterances must be primarily constructive, and (b) a sufficient degree of turn taking must occur*" (Chi and Wiley 2014 p. 223). Chi defines constructive behaviors as learners generating outputs that go beyond the information given in the learning activity (e.g., asking questions and generating inferences). This model captures many of the aforementioned mechanisms of joint inferring, explaining, and error-correction activities associated with collaborative success. Importantly, this framework also connects these mechanisms to a theory of instruction that describes learning activities to support these processes.

Other more social processes hypothesized to support collaborative success include observational learning and increases in motivation and engagement (Barron 2003; Bossert 1988–1989; Engle 2012; Schwartz 1999). *Observational* or *vicarious learning* has been broadly defined as when one acquires information from watching another (Bandura 1986; Craig et al. 2009; Gholson and Craig 2006). We hypothesize that observational learning may be driven in part by several of the aforementioned cognitive mechanisms such as exposure to new ideas (i.e., complementary knowledge), explanations, and error-correction. In addition to these, modeling typically plays a role in putting what is learned from observation into practice (Bandura 1986). Collaborative learning has also been hypothesized to increase individual motivation and engagement. For example, students in cooperative groups help each other, encouraging engagement in the learning activity (Johnson and Johnson 1985). Several investigations of collaborative engagement have shown that processes related to the *joint management of attention* and the construction of *common ground* are critical for collaborative success (Barron 2003; Meade et al. 2009). The construction of common ground is the act of determining what knowledge is shared across collaborators (Beers et al. 2005; Roschelle and Teasley 1995). Further, research has shown that the process of *negotiating multiple perspectives* can lead to learning and the acquisition of more abstract representations than group members would acquire alone (Kuhn and Crowell 2011; Voiklis and Corter 2012).

In sum, there are many mechanisms that can support or diminish collaborative learning. Since collaborators are often subject to many of these mechanisms at once, how do they play out? Does the evidence suggest that success-supporting mechanisms win out and collaboration is generally better for learning, or do the failure-inducing mechanisms seem to dominate? How do results change across different types of tasks, learning environments, and comparison groups? To answer these questions, we now briefly review representative evidence of group benefits over the average individual, collaborative inhibition (i.e., individuals performing worse that their predicted potential), and collaborative facilitation (i.e., individuals performing better than their predicted potential). For each issue, we will provide a brief overview of the findings and also report the particular mechanisms that have been investigated in relation to each.

Evidence from the Laboratory

We first turn to the literature on collaborative learning in the laboratory (see Hill 1982; Rajaram and Pereira-Pasarin 2010 for reviews). Much research has shown that dyads and groups generally perform better than the average individual. This has been shown for memory tasks (e.g., memorizing and recalling *word lists* (Andersson and Rönnberg 1995), experiment 1; *stories* (Andersson and Rönnberg 1995), experiment 1; *problem scenarios* (Meade et al. 2009); *pictures* (Weldon and Bellinger 1997); and *videos* (Andersson and Rönnberg 1995), experiment 2), category learning (e.g., Voiklis and Corter 2012), and video game learning (e.g., Arthur et al. 1997). The primary mechanisms hypothesized to account for these advantages include pooled knowledge (Andersson and Rönnberg 1995; Weldon and Bellinger 1997), selective attention and perspective-taking (Voiklis and Corter 2012), and observational learning (Arthur et al. 1997). In terms of the generalizability of the findings, group benefits have been found for a range of tasks (e.g., memory, categorization, and problem solving), but those tasks have typically used laboratory stimuli that are novel to participants. Also, the vast majority of these studies have been conducted with adults, so it is not clear to what degree they would generalize to younger, school-aged populations.

There is also much laboratory evidence of collaborative inhibition. Collaborative inhibition has been found for participants engaging in memory recall (e.g., Andersson and Rönnberg 1995; Weldon and Bellinger 1997) and problem solving (e.g., Nokes-Malach et al. 2012). The two primary mechanisms hypothesized to account for these results are cognitive load (Steiner 1972) and retrieval disruption (Basden et al. 1997). The vast majority of the collaborative inhibition effects have been found on memory tasks (cf. Nokes-Malach et al. 2012), so it is not yet clear to what degree these findings extend to problem solving, decision making, and other learning tasks. Factors that have been shown to mitigate collaborative inhibition on memory tasks include features of the task structure (e.g., inhibition effects disappear when study and tests are repeated; Basden et al. 2000), stimulus organization (e.g., inhibition effects disappear when recalling stimuli from small categories but are present for large categories; Basden et al. 1997), type of memory assessment (e.g., inhibition effects disappear for cued recall and recognition but not free recall; Finlay et al. 2000), encoding with others (inhibition effects disappear with shared encoding; Harris et al. 2013), and increases in shared expertise (Meade et al. 2009; see Rajaram and Pereira-Pasarin 2010 for a review of these factors).

Finally, there are a few examples of collaborative facilitation in which the group performs better than nominal groups, although there are far fewer examples of this outcome than the prior two. These include studies on memory recall (Meade et al. 2009; Ross et al. 2004; Thorley and Dewhurst 2009) and problem solving (Nokes-Malach et al. 2012). Some of the same mechanisms that have been hypothesized to support group performance over the average individual also apply here including cross-cueing, explanation, and error-correction (Meade et al. 2009; Ross et al. 2004; Thorley and Dewhurst 2009). In addition, Meade et al. (2009) and Nokes-Malach et al. (2012) proposed that expertise could promote collaborative facilitation. In these studies, we examined the effect of aviation expertise in non-pilots', novices', and experts' recall and solving of various problem flight scenarios. Collaborative inhibition effects were found for non-pilots and novices, whereas collaborative facilitation effects were found for experts on memory and complex problem-solving tasks. Experts were hypothesized to perform better than nominal groups because they were more likely to build common ground, cross-cue, and elaborate each other's contributions compared to non-pilots and novices when recalling the flight scenarios. In regards to problem solving, experts' prior knowledge and skills afforded them opportunities to engage in constructive and interactive processes that supported solutions to the complex problems.

Evidence from the Classroom

Evidence is more mixed from classroom studies comparing groups to the average individual. Some studies have shown positive results with groups outperforming the average of individuals on model-building tasks (Azmitia 1988), hypothesis generation (Teasley 1995), and complex problem-solving tasks in biology (Kirschner et al. 2009b, 2011). A meta-analysis reported in Johnson et al. (2007) of classroom studies (n=168) has shown an overall positive effect of what the authors call cooperative instruction compared to individualistic instruction with an overall effect size of d=.53 on various measures of student achievement. However, other work has shown no differences for students working in dyads or groups compared to students working alone (e.g., Crooks et al. 1998; Kirschner et al. 2011), or groups performing worse than the average individual (Tudge 1989; Leidner and Fuller 1997). For example, elementary students working in dyads performed worse than the average individual on balance beam conservation problems (Tudge 1989), and students working together in an information management course performed worse than those working alone (Leidner and Fuller 1997). In sum, the majority of these studies suggest evidence similar to the laboratory studies by showing that groups can perform better than the average individual. However, there is also more variation in the classroom with some studies not showing an advantage, and a few others showing a disadvantage for collaboration.

Much less work has tested group performance against nominal groups or predicted potential in classroom studies. However, a few studies do provide some interesting results. In one study comparing students working in dyads to students working alone on a writing error-correction activity (i.e., finding writing errors in prose), we found a collaborative inhibition effect with dyads performing worse than nominal groups when correcting for superficial writing errors (e.g., stylistic errors; Gadgil and Nokes-Malach 2012). However, for structural writing errors, students in the dyads performed similarly to nominal groups and showed no collaborative inhibition effect. We hypothesized that the collaborative inhibition effect was mitigated because students brought shared prior knowledge to the task that they could build on during the activity and that the task itself was one of error-correction, which is a process known to benefit from group interaction.

Summary

There is much evidence for group-level benefits from collaboration over the average individual. The mechanisms that underlie these effects include pooled knowledge, explanation, cross-cueing, error-correction, reduced memory load, and observational learning. However, there is also much evidence from the laboratory, and a few studies from the classroom, that show individuals in a group can sometimes perform worse than if they work alone. The mechanisms associated with these outcomes are increased memory load (e.g., coordination costs) and retrieval disruption. These findings suggest a caution for instructors, as there are particular types of tasks and group contexts in which individuals fail to perform well, even as the group succeeds. Finally, there is some exciting evidence for collaborative facilitation in which the individuals within groups go beyond their predicted potential. Features that support this outcome are the creation of common ground between group members, tasks that benefit from multiple perspectives, and shared task-relevant information.

Implications and Future Work

We hope that this brief overview provides a sense of the empirical support for the claim and the hypothesized mechanisms associated with it. Educators may use this information in a variety of ways. We encourage teachers and instructors to analyze the affordances and constraints of an instructional activity and the types of knowledge their students bring to bear on that activity with regard to the mechanisms that either inhibit or support collaborative success. If an instructional task includes features that may trigger mechanisms associated with collaborative inhibition, this provides an opportunity to revise the activity, either by eliminating or mitigating these factors or by considering the ways it might be better used as an individual activity. We also hope that researchers find this analysis useful in pointing to where we need more work, such as classroom studies testing the same mechanisms found in the laboratory, examining the learning implications of group recall in the classroom, and further examining nominal group comparison. Also, we hope that this review inspires new work to develop a model of collaborative success and failure that bridges the gap between learning theory and instruction. For example, what types of assessments and tools would be helpful to teachers to determine students' knowledge and task features when considering how to structure classroom activities? The models of ZPF, cognitive load, collaborative memory, interdependence, and Chi's ICAP framework provide an important starting point. The challenge will be to integrate across these models and instructional theories in order to generate testable principles of collaborative learning.

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References

Andersson, J., & Rönnberg, J. (1995). Recall suffers from collaboration: joint recall effects of friendship and task complexity. *Applied Cognitive Psychology, 9*(3), 199–211.

Aronson, E., Blaney, N., Stephan, C., Sikes, J., & Snapp, M. (1978). *The jigsaw classroom*. Beverly Hills: Sage.

Arthur, W., Jr., Day, E. A., Bennett, W., Jr., McNelly, T. L., & Jordan, J. A. (1997). Dyadic versus individual training protocols: loss and reacquisition of a complex skill. *Journal of Applied Psychology, 82*(5), 783–791.

Azmitia, M. (1988). Peer interaction and problem solving: when are two heads better than one? *Child Development, 59*(1), 87–96.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs: Prentice Hall.

Barber, S. J., Rajaram, S., & Fox, E. B. (2012). Learning and remembering with others: the key role of retrieval in shaping group recall and collective memory. *Social Cognition, 30*(1), 121–122.

Barron, B. (2003). When smart groups fail. *The Journal of the Learning Sciences, 12*(3), 307–359.

Basden, B. H., Basden, D. R., Bryner, S., & Thomas, R. L. (1997). A comparison of group and individual remembering: does collaboration disrupt retrieval strategies? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*(5), 1176–1191.

Basden, B. H., Basden, D. R., & Henry, S. (2000). Costs and benefits of collaborative remembering. *Applied Cognitive Psychology, 14*, 497–507.

Beers, P. J., Boshuizen, H. P. A., Kirschner, P. A., & Gijselaers, W. H. (2005). Computer support for knowledge construction in collaborative learning environments. *Computers in Human Behavior, 21*, 623–643.

Bloodgood, J. W. (2002). Quintilian: a classic educator speaks to the writing process. *Reading, Research and Instruction, 42*(1), 30–43.

Bossert, S. T. (1988/1989). Cooperative activities in the classroom. *Review of Research in Education, 15*, 225–250.

Chi, M. T. H. (2009). Active-constructive-interactive: a conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1*(1), 73–105.

Chi, M. T. H., & Wiley, R. (2014). The ICAP framework: linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243.

Collaros, P. A., & Anderson, L. R. (1969). Effect of perceived expertness upon creativity of members of brainstorming groups. *Journal of Applied Psychology, 53*(2), 159–163.

Congleton, A. R., & Rajaram, S. (2011). The influence of learning methods on collaboration: prior repeated retrieval enhances retrieval organization, abolishes collaborative inhibition, and promotes post-collaborative memory. *Journal of Experimental Psychology: General, 140*(4), 535–551.

Craig, S. D., Chi, M. T. H., & VanLehn, K. (2009). Improving classroom learning by collaboratively observing human tutoring videos while problem solving. *Journal of Educational Psychology, 101*(4), 779–789.

Crooks, S. M., Klein, J. D., Savenye, W., & Leader, L. (1998). Effects of cooperative and individual learning during learner-controlled computer-based instruction. *The Journal of Experimental Education, 66*(3), 223–244.

Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: toward the solution of a riddle. *Journal of Personality and Social Psychology, 53*, 497–509.

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (pp. 1–19). Oxford: Elsevier.

Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). The evolution of research on collaborative learning. In E. Spada & P. Reiman (Eds.), *Learning in humans and machine: Towards an interdisciplinary learning science* (pp. 189–211). Oxford: Elsevier.

Engle, R. A. (2012). The productive disciplinary engagement framework: Origins, key concepts, and developments. In D. Y. Dai (Ed.), *Design research on learning and thinking in educational settings* (pp. 161–200). New York: Routledge.

Finlay, F., Hitch, G. J., & Meudell, P. R. (2000). Mutual inhibition in collaborative recall: evidence for a retrieval-based account. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*(6), 1556–1567.

Gadgil, S., & Nokes-Malach, T. J. (2012). Collaborative facilitation through error-detection: a classroom experiment. *Applied Cognitive Psychology, 26*(3), 410–420.

Gholson, B., & Craig, S. D. (2006). Promoting constructive activities that support vicarious learning during computer-based instruction. *Educational Psychology Review, 18*, 119–139.

Harris, C. B., Keil, P. G., Sutton, J., Barnier, A. J., & McIlwain, D. J. F. (2011). We remember, we forget: collaborative remembering in older couples. *Discourse Processes, 48*, 267–303.

Harris, C. B., Barnier, A. J., & Sutton, J. (2013). Shared encoding and the costs and benefits of collaborative recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(1), 183–195.

Hill, G. W. (1982). Group versus individual performance: are n + 1 heads better than one. *Psychological Bulletin, 91*(3), 517–539.

Johansson, N. O., Andersson, J., & Rönnberg, J. (2005). Compensating strategies in collaborative remembering in very old couples. *Scandinavian Journal of Psychology, 46*, 349–359.

Johnson, D., & Johnson, R. (1985). The internal dynamics of cooperative learning groups. In R. Slavin, S. Sharan, S. Kagan, R. Hertz-Lazarowitz, C. Webb, & R. Schmuck (Eds.), *Learning to cooperate, cooperating to learn* (pp. 103–124). New York: Plenum Press.

Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Edina: Interaction Book Company.
Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: social interdependence theory and cooperative learning. *Educational Researcher, 38*(5), 365–379.
Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2000). Cooperative learning methods: a meta-analysis. Retrieved April 14, 2015 from www.tablelearning.com/uploads/File/EXHIBIT-B.pdf.
Johnson, D. W., Johnson, R. T., & Smith, K. (2007). The state of cooperative learning in postsecondary and professional settings. *Educational Psychology Review, 19*(1), 15–29.
Karau, S. J., & Williams, K. D. (1993). Social loafing: a meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology, 65*(4), 681–706.
Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331*, 772–775.
Kelley, M. R., & Wright, D. B. (2010). Obtaining representative nominal groups. *Behavior Research Methods, 42*(1), 36–41.
Kerr, N. L., & Tindale, R. S. (2004). Group performance and decision making. *Annual Review of Psychology, 55*(1), 623–655.
Kirschner, F., Paas, F., & Kirschner, P. A. (2009a). A cognitive load approach to collaborative learning: united brains for complex tasks. *Educational Psychology Review, 21*(1), 31–42.
Kirschner, F., Paas, F., & Kirschner, P. A. (2009b). Individual and group based learning from complex cognitive tasks: effects on retention and transfer efficiency. *Computers in Human Behavior, 25*(2), 306–314.
Kirschner, F., Paas, F., & Kirschner, P. A. (2011). Task complexity as a driver for collaborative learning efficiency: the collective working-memory effect. *Applied Cognitive Psychology, 25*(4), 615–624.
Kollias, V., Mamalougos, N., Vamvakoussi, X., Lakkala, M., & Vosniadou, S. (2005). Teachers' attitudes to and beliefs about web-based collaborative learning environments in the context of an international implementation. *Computers in Education, 45*(3), 295–315.
Kuhn, D., & Crowell, A. (2011). Dialogic argumentation as a vehicle for developing young adolescents? Thinking. *Psychological Science, 22*, 545–552.
Latane, B., Williams, K., & Harkins, S. (1979). Many hands make light work: the causes and consequences of social loafing. *Journal of Personality and Social Psychology, 37*, 822–832.
Laughlin, P. R., Hatch, E. C., Silver, J. S., & Boh, L. (2006). Groups perform better than the best individuals on letters-to-numbers problems: effects of group size. *Journal of Personality and Social Psychology, 90*(4), 644–651.
Leidner, D. E., & Fuller, M. (1997). Improving student learning of conceptual information: GSS supported collaborative learning vs. individual constructive learning. *Decision Support Systems, 20*(2), 149–163.
Lorge, I., Fox, D., Davitz, J., & Brenner, M. (1958). A survey of studies contrasting the quality of group performance and individual performance. *Psychological Bulletin, 55*, 337–372.
Lou, Y., Abrami, P. C., & d'Apollonia, S. (2001). Small group and individual learning with technology: a meta-analysis. *Review of Educational Research, 71*(3), 449–521.
Meade, M. L., Nokes, T. J., & Morrow, D. G. (2009). Expertise promotes facilitation on a collaborative memory task. *Memory, 17*(1), 39–48.
Meudell, P. R., Hitch, G. J., & Boyle, M. M. (1995). Collaboration in recall: do pairs of people cross-cue each other to produce new memories? *The Quarterly Journal of Experimental Psychology, 48*, 141–152.
Mullen, B. (1983). Operationalizing the effect of the group on the individual: a self-attention perspective. *Journal of Experimental Social Psychology, 19*(4), 295–322.
Mullen, B. (1987). Self-attention theory. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behaviour* (pp. 125–146). New York: Springer-Verlag.
Nokes-Malach, T. J., Meade, M. L., & Morrow, D. G. (2012). The effect of expertise on collaborative problem solving. *Thinking and Reasoning, 18*(1), 32–58.
Okada, T., & Simon, H. A. (1997). Collaborative discovery in a scientific domain. *Cognitive Science, 21*(2), 109–146.
Paulus, P. B., & Yang, H. C. (2000). Idea generation in groups: a basis for creativity in organizations. *Organizational Behavior and Human Decision Processes, 82*, 76–87.
Rajaram, S., & Pereira-Pasarin, L. P. (2010). Collaborative memory: cognitive research and theory. *Perspectives on Psychological Science, 5*(6), 649–663.
Roediger, H. L., & Karpicke, J. D. (2006). The power of testing memory: basic research and implications for educational practice. *Perspectives on Psychological Science, 1*, 181–210.
Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Mally (Ed.), *Computer supported collaborative learning* (pp. 69–97). Berlin Heidelberg: Springer-Verlag.
Ross, M., Spencer, S. J., Linardatos, L., Lam, K. C. H., & Perunovic, M. (2004). Going shopping and identifying landmarks: does collaboration improve older people's memory? *Applied Cognitive Psychology, 18*(6), 683–696.

Schwartz, D. L. (1999). The productive agency that drives collaborative learning. In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 197–218). Oxford: Elsevier.
Slavin, R. E. (1980). Cooperative learning. *Review of Educational Research, 50*(2), 315–342.
Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice* (2nd ed.). Boston: Allyn & Bacon.
Slavin, R. E. (2014). Making cooperative learning powerful. *Educational Leadership, 72*(2), 22–26.
Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: a meta-analysis. *Review of Educational Research, 69*(1), 21–51.
Steiner, I. D. (1966). Models for inferring the relationships between group size and potential group productivity. *Behavioral Science, 11*, 273–283.
Steiner, I. D. (1972). *Group processes and productivity*. New York: Academic Press.
Teasley, S. D. (1995). The role of talk in children's peer collaborations. *Developmental Psychology, 31*(2), 207–220.
Thorley, C., & Dewhurst, S. A. (2009). False and veridical collaborative recognition. *Memory, 17*, 17–25.
Tudge, J. (1989). When collaboration leads to regression: some negative consequences of socio-cognitive conflict. *European Journal of Social Psychology, 19*(2), 123–138.
Voiklis, J., & Corter, J. E. (2012). Conventional wisdom: negotiating conventions of reference enhances category learning. *Cognitive Science, 36*(4), 607–634.
Webb, N. M., Troper, J. D., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of Educational Psychology, 87*, 406–423.
Weldon, M. S., & Bellinger, K. D. (1997). Collective memory: collaborative and individual processes in remembering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*(5), 1160–1175.
Wright, D. B. (2007). Calculating nominal group statistics in collaboration studies. *Behavior Research Methods, 39*, 460–470.