Thinking Together and Alone

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Collaborative intellectual engagement is held in high regard in contemporary educational thought as a pedagogical practice of broad value to K–12 students. To what extent is this enthusiasm warranted? Is the practice uniformly productive, or does variability exist in the contexts in which collaboration is effective, the mechanisms involved, and the objectives achieved? In addition to examining these questions, this article suggests further questions that might be addressed with the objective of establishing a more comprehensive base of evidence to substantiate the practice of collaborative learning. Finally, the article reconsiders why collaborative cognition should be a critical concern.

Keywords: argumentation; cognitive processes/development; collaboration; cooperative learning; discourse; discourse analysis; experimental design; inquiry; mixed-methods; pedagogy; reasoning thinking

Two middle school science teachers are covering the topic of extinction of the dinosaurs. One does so quickly; he tells students the cause is not certain, mentions a couple of possibilities, and moves on. The teacher next door adopts a newer approach, one requiring her to devote more time to the topic. She makes available some background information and organizes students in small groups to debate among themselves which of two competing theories is more likely to be correct and why. The activity seems appealing, and students engage energetically. But what do students in the second class stand to gain from this larger investment of instructional time?

The question is worth asking on both theoretical and practical grounds. Across the K–12 curriculum, peer collaboration has come to be highly regarded as enlightened educational practice. Students benefit by engaging intellectually with one another, it's widely believed. If so, we need to know what these benefits are.

The views fall into two camps. The more recent is the characterization of collaboration as a "21st century skill" (Dede, 2010; Trilling & Fadel, 2009) essential to students in their adult lives and therefore a critical one for them to gain proficiency in. Young people who have not mastered it will find themselves at a serious disadvantage in the professional workplace as well as outside it. Like most skills, it is only mastered with sustained practice that ought to begin early and continue throughout the school years.

The longer standing view is captured in the title of a 25-year-old article, "The Development of Individual Competencies Through Social Interaction" (Doise, 1990). Less a desired end in its own right, peer collaboration is regarded as a means to achieve another objective—intellectual advancement on the part of the individual who participates in it. The favor in which this view of collaboration as a tool for individual intellectual gain continues to be held might lead one to think there is more evidence in support of its effectiveness than in fact exists. Moreover, what evidence does exist is not consistent: As elaborated here, cognitive collaboration with peers does not always yield identifiable benefits, and whether it does or not appears to depend on who is learning what and under what conditions.

Few in number are rigorous experimental studies that compare groups and individuals engaging in a comparable intellectual task and demonstrate greater cognitive gain on the part of those who participated in the group condition—exactly the evidence that educators would presumably want to justify the collaborative method. Some students, in fact, appear not to benefit at all from collaboration. Sampson and Clark (2009), for example, found that one-third of students' individual explanations following group work on a science problem were inferior to the solution that their small group had produced. Collaboration may even lead to a decline in thinking quality, it has been noted, due to overconfidence that group interaction can produce (Koriat, 2012; Minson & Mueller, 2012).

More common are studies of collaboration by investigators seeking to uncover its benefits but in the absence of a comparison condition in which individuals work alone. Without this comparison, quality of performance on the part of the group may be attributable simply to the performance of its most able member, what has been called a "truth wins" account (Schwartz,

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Educational Researcher, Vol. 44 No. 1, pp. 46–53
DOI: 10.3102/0013189X15569530

1995). This most competent member achieves a correct solution and dominates but does not necessarily transmit this competence to others in the group. Given initial variability in competence among group members, any group is likely to contain a member more competent than the median competence level of individuals working alone, hence accounting for overall superior performance of groups compared to individuals.

Group performance superior to that of individuals working alone may also be attributable simply to division of labor within the group (Kirschner, Paas, & Kirschner, 2009). In the case in which individual gains are later identified, the most likely mechanism is transmission of knowledge or skill: The more knowledgeable group member(s) share knowledge with less knowledgeable ones, as a result of which the latter show gains in subsequent individual assessments.

It is important to make the distinction between a transmission of knowledge process and what Littleton (2011) defines as genuine collaboration—mutual engagement in a coordinated effort in which group performance and/or subsequent individual performance exceeds that which any member brought to the group. In some cases, evidence of benefit at the group level may even be missing (Kapur, 2008, 2012; Sampson & Clark, 2009). As Kapur's (2008, 2012) studies of "productive failure" have elegantly shown, the group may fail in a problem-solving effort while cognitive benefits to participating individuals are subsequently identified.

The criterion for judging a collaborative activity as productive might thus be regarded as identification of subsequent gain on the part of at least some of the participating individuals. We adopt that criterion here and furthermore narrowly define such gain as pertaining to cognitive competence. Other gains could accrue that are more social-emotional or dispositional in nature, and we do not undertake to examine here.

When Does It Work?

Even within the restricted category of cognitive competence outcomes, there is evidence to indicate that collaboration produces these desired outcomes in some contexts and not others. It was this puzzle that led to my own interest in the topic. I have for some time been involved in investigation of two broad families of intellectual skills, inquiry and argument (Kuhn, 2005). In both cases, we have observed students working collaboratively and compared them to students working individually and eventually were left with the puzzling conclusion that collaboration appeared to be unimportant in the case of one family of skills and very important in the case of the other. In pondering this curiosity, I began to contemplate the differences, as well as similarities, between the two as well as to compare our findings to those of researchers studying tasks different from ours.

People can be asked to work together on many different kinds of cognitive tasks. It's been found that rote kinds of learning are less likely to show a collaborative benefit (Pai, Sears, & Maeda, 2014; Phelps & Damon, 1989) than more conceptual learning. But that still leaves the field wide open, as there exist a great many kinds of conceptual problems. Few if any advocates of collaborative learning are interested in it as a tool for mastery of rote knowledge, especially as much is already known about methods for optimizing such mastery.

The majority of the cognitive tasks that have been studied under collaborative conditions have been what are called well-structured tasks. This means they have clear and definite correct answers, ones uncontestably superior to alternatives. The problems I have examined in my research, in contrast, for the most part have been ill-structured problems. That is, they lack a single, correct answer, although analytic frameworks can be imposed on them allowing some answers to be categorized as superior to others. Studies of collaboration on ill-structured problems perhaps have been less common than those involving well-structured problems since investigation of group processes carries with it its own set of formidable challenges and researchers haven't wished to add the burden of having to evaluate the merit of different kinds of responses to the problem.

Task conditions, as well as the task itself, stand to influence outcomes. A meta-analysis by Pai et al. (2014) found outcome differences as a function of degree of structure imposed on the collaboration. Asterhan and Schwarz (2007) found that instruction to argue produced more lasting conceptual change than instruction simply to collaborate. Other studies, however, have shown superior performance under instructions to reach agreement rather than to persuade (Garcia-Mila, Gilabert, Erduran, & Felton, 2013). Other conditions that may affect outcomes of collaboration are participant characteristics, such as ability or age (Muldner, Lam, & Chi, 2014; Sears & Reagin, 2013), as well as the relation between participants' ability levels. Lower-performing participants are more likely to progress when interacting with higher-performing ones, both in ongoing (problem-by-problem) microgenetic observation (Kuhn & Pease, 2009) and subsequent assessment of individuals' cumulative gain (Azmitia, 1988; Wiedmann, Leach, Rummel, & Wiley, 2012).

To fully identify the conditions under which collaboration is likely to be fruitful, it is essential to understand the underlying mechanisms. To do so requires examining the group interaction itself, and, likely due to its labor-intensive nature, only a minority of studies have undertaken in-depth analyses (Howe, 2010). Moreover, only some of these have included a comparison condition of individuals working alone and/or assessment of effects of the group experience on subsequent individual competence. On the positive side, however, studies that do exist lead to some consistent conclusions (Barron, 2003; Dimant & Bearison, 1991; Howe, 2010; Moshman & Geil, 1998; Schwartz, 1995; Schwarz & Linchevski, 2007; Schwarz, Neuman, & Biezunger, 2000). In studies of small groups interacting under equivalent conditions, only some of the observed groups showed individual gains and/or group performance exceeding that of individuals' initial competence; other groups did not. More productive collaborations have been identified as those in which participants directly engage one another's thinking. They listen and respond to what their peers say. In less successful collaborations, participants are more likely to work in parallel and ignore or dismiss the other person's contributions. Schwarz et al. (2000) identified presence of conflicting positions as a productive factor, notably when both were incorrect (see also Ames & Murray, 1982, and Bearison, Magzamen, & Filardo, 1986, for earlier versions of the conflict hypothesis). Schwartz (1995) emphasized the need that his tasks required to develop a shared representation of the

problem referents, a representation that then supported constructing a problem solution.

The Collaboration or the Problem?

One defining feature common to collaborative learning activities is that participants are assigned a problem. The other is that they are asked to work together to achieve a solution. Participants may or may not have conflicting initial positions or strategies. It may be sufficient for them to draw on existing knowledge to debate their respective positions and seek a resolution. Or they may need to seek additional knowledge that will contribute to the problem solution, in which case the task draws on skills of inquiry as well as argumentation.

The increasingly popular practice known as problem-based learning (PBL) best fits the latter category. PBL originated in the context of medical education but subsequently became of broader interest (for review, see Gijbels, Dochy, Van den Bossche, & Segers, 2005; Hmelo-Silver, 2004). Its defining features are that students in small groups engage deeply with a problem with knowledge insufficient to solve it, requiring that they extend existing knowledge and understanding and apply them to generate a solution. The rationale for the method is that students engage actively (Chi, 2009) and because knowledge acquisition is purposeful and the knowledge contextualized, students activate prior knowledge, creating associations that make new knowledge more meaningful and retrieval pathways that make it more accessible (Hmelo-Silver, Duncan, & Chinn, 2007; Wirkala & Kuhn, 2011). PBL has achieved an identity as a promising educational practice, with meta-analyses reporting superior learning and transfer compared to traditional instruction methods (Allen, Donham, & Bernhardt, 2011). Our own highly controlled experimental comparisons showed PBL to yield superior acquisition and application of new conceptual knowledge compared to direct instruction among both adults (Capon & Kuhn, 2004; Pease & Kuhn, 2011) and children (Wirkala & Kuhn, 2011).

A confound, however, has characterized comparisons of PBL to more traditional instruction. The example of the dinosaur extinction topic introduced earlier well illustrates the confound. Relative to the more traditional treatment in one classroom, students exposed to the more progressive approach in the other classroom experience two things the first class does not. One is contemplating solutions to a puzzling problem. The other is intellectual exchange with peers.

Collaborative interaction in solving the problem has been regarded as an integral part of the PBL method. My students and I wondered, however, whether it is the problem or the collaboration that makes PBL an effective learning tool, and we obtained a clear answer. In studies involving college students (Pease & Kuhn, 2011) and middle schoolers (Wirkala & Kuhn, 2011), we presented challenging, ill-structured problems to individual students and to small groups over several hours of instruction; we also acquainted them with a set of concepts that could be useful in solving the problem. Each participant addressed one problem in the group context and one problem working alone, in counterbalanced order.

Results were consistent across age groups. In individual assessments a number of weeks later, performance on the problem a student encountered in the individual condition and performance on the problem the same student encountered in the group condition reflected equivalent mastery of concepts. Also equivalent across problem conditions was successful application of concepts in the context of a new problem administered at a different time in a new context not connected to the original ones. Also, students in both group and individual conditions showed superior mastery and subsequent application compared to students taught the same concepts in whole-class lecture-discussion instruction of the same duration. Thus, learning new concepts in the context of a problem requiring their application, rather than social collaboration, appears to be the effective component of PBL.

In the studies just noted, students needed to apply newly acquired declarative conceptual knowledge (physics concepts in the case of the college students and social science concepts in the case of the younger students). Jewett and Kuhn (2015) found that the pattern of results observed extends to procedural knowledge—specifically, the control of variables strategy and multivariable causal inference (Kuhn, Pease, & Wirkala, 2009), both central to scientific thinking. Over three problem-solving sessions, underachieving urban middle school students investigated a database bearing on a realistic social issue, the causes of variation in teen crime rates across localities. Some students worked in groups of three, some worked individually, and students in a third group each observed the work of one of the individual problem solvers. Results were again clear-cut. Group and individual problem solvers showed equivalent mastery on a subsequent individual transfer task and outperformed the observers. Thus, again, the benefit appears to come from the goal-directed experience of working on the problem rather than from social collaboration. Moreover, passive participation does not yield the same benefit (for related findings, see Kapur, 2014).

Do Differing Perspectives Require Coordinating?

This would appear to be the answer to the question, then—it's the problem not the collaboration that's providing the benefit—and the end of the story, except that it's not. In the collaborative PBL settings just considered, group members share a common goal—to reach the best solution to a problem they have been asked to jointly solve. Their perspective is thus a unilateral one, directed toward a single shared goal. They may have different ideas to contribute, and they may react to one another's ideas, but it is not essential that they do so. This is so primarily because the need for a solution provides its own feedback, most powerfully in the negative form of goal failure, which can be experienced either by a sole individual or a group. If, for example, it remains indeterminate which of potential contributors to teen crime can be eliminated and which play a role, the only conclusion that can be drawn is that the problem has not been solved. As our findings show, individuals recognize this goal failure as well as groups, and both profit, with such failure heightening awareness of the need for a better problem solution and hence a better procedural approach.

In other work, we have studied collaboration under a different set of conditions in which participants' perspectives are of necessity bilateral (or multilateral) rather than unilateral.

Participants collaborate with one another in an extended intervention designed to develop argumentation skills (Crowell & Kuhn, 2014; Iordanou, 2010, 2013; Kuhn & Crowell, 2011; Kuhn, Goh, Iordanou, & Shaenfield, 2008; Kuhn, Zillmer, Crowell, & Zavala, 2013). The core activity entails two students who share a position on a social issue engaging over time in electronic dialogs with a series of pairs of classmates who hold the opposing view.

The objective is twofold, reflecting what have been defined as the dual goals of argumentative discourse (Walton, 1989). The pair must attend to and examine the opposing pair's position with the aim of weakening it. They must also work to develop and uphold their own position in the face of parallel efforts of the opposing pair to weaken it. These dual objectives can only be met successfully if participants recognize the two different perspectives that exist, reflect on and gain understanding of each of them, and strive to coordinate them in a manner that fulfills the objectives of the activity. In contrast to the unilateral perspective characteristic of problem-based collaborative activity, where the focus is on the external problem, the centrality to the task of the opposing perspectives makes interacting with and representing the contents of others' minds an essential aspect of the task. In a word, participants in argumentative discourse must engage with other minds in order to succeed.

In addition to being motivated to probe another mind, discourse participants experience others' scrutiny of their own positions—scrutiny that is valuable precisely because it is so notoriously difficult to carry out on one's own thinking. With continued engagement, research has shown, this meta-level reflection becomes more extended and interactive (Grau & Whitebread, 2013; Kuhn et al., 2013), as the effort is made to reconcile the opposing positions. Thus, participants' talk is not confined to the task content itself; they also engage in talk about their thinking. In our electronically mediated argumentation activity, this talk occurs both between the same-side partners and between the opposing-side pairs.

This socially mediated metacognitive talk about thinking may be a key factor in conferring any benefit the collaborative activity provides. Such an account, note, goes beyond the more long-standing account of the effective factor as simply the substantive discrepancy between two conflicting positions (for review, see Dillenbourg, Baker, Blaye, & O'Malley, 1996). In any case, however, if we subtract the social component of the activity, we should expect the benefit to diminish or disappear—in contrast to what we found in the case of the PBL studies described earlier, where it was seen to be engagement with the problem itself rather than collaboration that yielded the benefit.

We found some initial indication that this was the case, made possible by the design of the collaborative activity to include two distinct forms of collaboration—electronic discourse between the two opposing pairs and verbal discourse between the like-minded members of a pair as they decide how to respond to what the opposing pair has said. We undertook to distinguish their effects by observing a group in which we subtracted the face-to-face component. In this group, same-side partners were eliminated and each student individually interacted electronically with a succession of opposing individual peers (Shaenfield & Moore, 2009). The results were so decisive that we terminated the experiment early, just a few months into the school year. The electronic discourse of students in this group became less productive, qualitatively and quantitatively, when conducted without the collaboration of a same-side peer.

In current work, we are exploring this same-side interaction, having in earlier work examined changes over time in the electronic discourse between opposing pairs (Kuhn et al., 2013). What factors cause some same-side pairs to collaborate more productively than others in fulfilling their shared objective of effectively addressing their opponents? In other work, we have compared the individual and collaborative contexts more sharply by eliminating collaboration entirely among one group. We did this by comparing the thinking students displayed in discourse with opposing-side peers to the thinking they displayed in an individual essay (Kuhn & Moore, 2015).

Dialogs Versus Essays

There are of course many differences between conversing and writing. Conversation flows while writers very often stare at a blank page. Yet an opposing view of course continues to exist in the latter, noncollaborative context; it is just in more implicit form. A claim without an alternative does not warrant argument. We bother to argue for X only because not-X is at least a possibility. In the case of an individual's argumentative essay, however, the alternative is only implicit rather than embodied in another person. We thus wondered how individual argument, with its implicit alternative, and argumentative discourse, with the alternative explicitly present in the thinking of another individual, would differ. Does the explicitly social context of discourse change the quality of thinking that is exhibited?

To compare the two contexts, we asked middle school students either individually or in small groups (consisting of a pair who favored one side of a social issue conversing with a pair who favored the other) to argue for their positions and in the group case to try to reach agreement (Kuhn & Moore, 2015). The medium was written in both cases (via electronic communication in the dialogic case, making the two contexts more comparable). In addition, all participants had available a set of brief pieces of factual evidence relevant to the topic. They were told they were welcome to make use of this information in making their arguments if they wished but were not required to do so. The pieces of evidence were balanced, equal numbers favoring one side and the other. Furthermore, one group of these young adolescents had participated in our extended argumentation intervention described earlier and another group had not. As expected, the group who had participated in the intervention exhibited more advanced argumentative reasoning in both dialogs and essays than the group who had not. Yet, within each group the differences in performance across individual and dialogic contexts were consistent.

Unsurprisingly, both essay writers and dialog participants made more statements to support their own position than statements seeking to weaken the opposing position. Yet two major differences appeared in the comparison of dialog transcripts and individual essays. The essays almost exclusively comprised claims and evidence in support of the own-side position. The dialogs, in contrast, were more balanced, in both the more and less

skilled groups. For example, in the more skilled group, an average of one-third of evidence-based claims served the function of weakening the opposing position, versus only 4% in the individual essays of these same participants. (For consistent findings, ee also Iordanou & Constantinou, in press-a, in press-b; Khait, 2014.)

A second difference between dialogs and essays had to do with the kind of evidence drawn on. In the Kuhn and Moore (2015) study, because both shared (from the set made available to all participants) and personal (generated from the individual's own personal knowledge) evidence was available in both dialog and essay conditions, we could directly compare their respective use. The essay writers confined themselves almost exclusively to the shared evidence—an average of 82% of references to evidence were of this type. In the dialogs, in contrast, the results were the reverse. In dialogs, participants were much more likely to draw on evidence from their own prior personal knowledge—only 20% of evidence references came from the shared evidence set and 80% from participants' personal knowledge.

How should we interpret these differences? Dialogs demand attention to the other. Furthermore, dialogs appear to engage arguers more deeply and authentically, prompting them to bring what they already know to the exchange. In writing an individual essay, in contrast, the same dialog participants, we saw, kept largely to the information provided to them as the most efficient way to complete their task. This could not have been because they knew of nothing else to bring to bear, as their quite different dialog performance confirmed. Rather, they appeared not to recognize its relevance to the task they'd been assigned.

These differences are of more than theoretical significance. Essay writing is a staple of the school curriculum. Yet, it may be dialog that offers the most productive path to its development (Kuhn, Hemberger, & Khait, 2014). Essay writing arguably elicits a particular school-related genre—one in which students take the task to be one of integrating the material at hand into a sequence of statements that support a claim, avoiding inclusion of anything that might suggest otherwise. From this perspective, the comparative merit of the dialogic form is that it inserts the missing interlocutor that provides a more authentic point or purpose to the activity (Graff, 2003). It also stands to remedy the weakness most typical of novice arguers (Felton & Kuhn, 2001; Rapanta, Garcia-Mila, & Gilabert, 2013), as well as that of far too much contemporary personal and public discourse—ignoring or dismissing opposing perspectives and restricting one's interpersonal exchanges to the echo chamber of one's own favored ideas.

Where Do the Benefits Lie?

The differing demands of the dialogic and essay tasks, as well as the differing demands of argumentative tasks and the PBL tasks discussed earlier, can help to identify, conceptually as well as empirically, contexts in which we are most likely to see a benefit of intellectual collaboration. Physical embodiment of "the other" (even in the case of electronic discourse where the other is present only in the form of their contributions to the dialog appearing on a computer screen) serves the critical function of demanding this other be heard. What the other has to say cannot be as readily ignored as it can when the other's perspective is only implicit and at most abstractly represented or when it is not essential to the task goal as in the PBL context.

At the same time, as dialog demands the other's position be attended to, the other holds one's own position to the light. This scrutiny on the part of the other contributes to one's coming to recognize one's own position as contestable and thus needing to be justified in a framework of alternatives and evidence. As a result, peer discourse, as the research evidence shows, comes to incorporate joint "meta-talk" about standards of evidence and argument (Kuhn et al., 2013; Michaels, O'Connor, & Resnick, 2008; Resnick, 1991), which are essential to skilled discourse.

We have restricted our attention to the strictly cognitive benefits of peer collaboration. This focus is not meant to diminish the likelihood of noncognitive benefits of collaboration. Engaging with peers to address nontrivial problems may enhance not only social skills but children's curiosity, interest, and confidence. Still, as the PBL research discussed earlier illustrates, it is necessary to isolate specifically the role of the collaborative component in identifying the benefit of such activities. We have also restricted our attention to activities in which students engage with a single peer or a small group of peers rather than activities conducted in a whole-class format. In the latter case, interaction risks being confined largely to interactions between the teacher and successive students rather than between peers (Howe, 2010), yet this is not to say that some of the implications drawn here could not be applied at the whole-class level. Again, the collaborative component of the activity needs to be clearly distinguished and its role evaluated.

The take-home message offered here is not that argumentative discourse between holders of opposing positions is the only context in which we can anticipate cognitive benefits of K–12 students' collaboration. The claim is only that it is a promising one where we have a solid basis for expecting such benefits, for the reasons we have elaborated. Nor do we dismiss the likelihood that the design of highly structured scaffolds to support and enhance argumentative discourse (Amelsvoort, Andriessen, & Kanselaar, 2007; Andriessen, Baker, & Suthers, 2003; Pinkwart & McLaren, 2014) can be effective. Our approach has been to first focus observation on how the skills in question develop through dense engagement and practice in an environment that supports them. Knowing as much as possible about the patterns of such development is a critical resource in designing and evaluating interventions.

The distinction between adversarial argumentation, defined simply as argumentation involving opposing viewpoints, and what has been called "coalescent" (or what we referred to earlier as unilateral or shared-objective) argumentation (Gilbert, 1997) raises the possibility of a different view—namely, that it is the latter that stands to be more intellectually productive (Scardamalia & Bereiter, 2006). In coalescent argumentation, differing initial perspectives are not identified and participants work together to construct a common understanding.

Rather than regarding the two as alternative modes, however, one can be regarded as a subtype, or building block, of the other. That is, opposing ideas are an essential component of collaborative discourse that propel it forward. Without an argument-counterargument-rebuttal structure firmly in place as a foundation and tool, inexperienced arguers, we have observed,

seem uncertain as to whether a potential contribution to discourse that they make or may be contemplating making is simply an unanchored addition to the current talk about the topic ("Here's another thing that might be relevant") or has an identifiable function to perform that moves the discourse forward. The "here's another thing" form of discourse we have observed to be very common among inexperienced (and even some experienced) arguers. Coalescent argumentation runs the risk of being minimally productive to the extent that it is confined to accumulating contributions that fail to build on one another. Thus, our argumentation curriculum for young adolescents (Kuhn et al., 2014) focuses in its first year on encouraging students to address one another's ideas; later, as their argumentation becomes richer and they have more ideas to contribute, we suggest to them that in responding to their opponents they first address the opponents' contribution and then, if they have them, to introduce new ideas.

Collaboration as a Necessity, Not a Silver Bullet

Noting these developmental progressions is useful in highlighting the fact that intellectual collaboration does not come naturally. A sociocultural perspective regards all individual cognition as social in origin (Vygotsky, 1978; Wertsch, 1979). Nonetheless, it is not enough simply to put individuals in a context that allows for collaboration and expect them to engage in it effectively. Intellectual collaboration is a skill, learned through engagement and practice and much trial and error (Ladd et al., 2013). Without sufficient skill development, children may fail to benefit from it (Muldner et al., 2014).

Developmentally, the origins of collaboration lie in the phenomenon of joint attention that emerges when infants first recognize that they are sharing an object of attention with another (Brownell, 2011; Tomasello, & Carpenter, 2007). Increasing monitoring of this early joint attention leads gradually to a metacommunicative awareness (Barron, 2003) through which a child comes to recognize and appreciate the differing perspective of another. Even more gradually will children learn to coordinate perspectives in the interests of effective collaboration (Grueneisen, Wyman, & Tomasello, 2014; Hamann, Warneken, & Tomasello, 2012; Henderson & Woodward, 2011). Thus, collaboration has a developmental trajectory of its own (Tomasello & Hamann, 2012), one well worthy of close study by researchers and careful attention on the part of practitioners. In our review of research findings, we thus have been attentive to the possibility that results may vary across groups possessing different levels of collaborative skill.

A developmental progression raises the possibility of introducing educational interventions with the objective of accelerating progress and/or maximizing attainment. Are these warranted, or should we assume that all children will develop the needed skills in the course of their normal experience? There will always be some proportion of children who need intervention to enable them to interact productively with peers. Whether all children would benefit from such intervention is a question we do not as of yet have sufficient empirical evidence to answer, although the likelihood is that they would. Collaboration entails demanding, resource-consuming skills of coordination, as we have highlighted, as well as affective, interpersonal ones. Their development, at a minimum, requires extended practice.

What we can say, however, is that the implications extend beyond collaboration as a vehicle for intellectual development. This claim returns us to the distinction raised at the outset regarding objectives. When we engage students in the practice of intellectual collaboration, do we do so as a means to an end or as an end in itself? The evidence is still equivocal regarding the first alternative, as we have reviewed, with the conditions that yield productive outcomes in need of further specification. Collaboration is a long way from the silver bullet many educators might wish it to be.

With respect to the second alternative, however, there is little uncertainty. Effective collaboration increasingly is a requirement in a great many contexts of adult life. The intellectual demands encountered in adult life are not only many and varied but also subject to frequent and rapid change. A large proportion of these are encountered in contexts that are collaborative. Collaborative cognition thus needs our attention as a research topic first and foremost because it warrants a place as a core component of what educators are today calling 21st century readiness. Young people have not been well prepared for adult life today unless they are comfortable and well practiced in addressing collaboratively the kinds of problems and objectives that 21st century life poses. Without question we need to learn how best to prepare them for these roles.

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Manuscript received April 4, 2014
Revisions received August 12, 2014, and December 22, 2014
Accepted January 6, 2015