WHAT CAN LEARNING SCIENCE CONTRIBUTE TO OUR UNDERSTANDING OF THE EFFECTIVENESS OF PROBLEM-BASED LEARNING GROUPS?

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Recent education reforms informed by learning science support the effectiveness of collaborative learning strategies such as problem-based learning groups. However, the efficacy of these methods depends on the authenticity of the problem context and the quality of the dialog established. Communication within groups must be dialogic, and students must address problems using relevant concepts and deep principles. Although dialogic communication is rare and difficult to facilitate, if it is achieved, students will construct useful knowledge that can be applied beyond the classroom.

Keywords: problem-based learning; group work; learning theory

The increased use of problem-based learning groups as a method of instruction in management education is part of a broader wave of education reform stimulated by theory and research in learning science. Because it is a method of instruction, rather than a theory of learning, answers to questions about the effective use of problem-based learning should be informed by its broader theoretical foundation and the research that supports it. I present a brief overview of the theoretical rationale for problem-based learning and focus on the implications of two key assumptions of this model: (a) the authenticity of the presenting problem is the key to stimulating productive dialog in problem solving groups and (b) the quality of the dialog is directly

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linked to the quality of learning. My specific premise is that theory and research in learning science privilege dialogic communication as a catalyst for the construction of useful knowledge. There is evidence that powerful and useful knowledge can be constructed in problem-based learning groups if students engage in genuine dialog (i.e., if they actively confront each others' ideas using central concepts and deep principles from the course content). Research also indicates, however, that it is very difficult to create conditions in the classroom that promote this type of dialog. Research on classroom social practices indicates that students working in small groups tend to express their personal opinions without connecting them to important academic concepts and principles. They also avoid confronting each other's ideas. Overcoming these tendencies is the key to creating effective problem-based learning groups.

The Theoretical Foundation for Problem-Based Learning Groups

The emergence of the interdisciplinary field of learning science has transformed the dominant view of educators about how people learn (Bransford, Brown, & Cocking, 1999). This new perspective on learning is changing educational practice across the range of educational settings from elementary classrooms to corporate training programs. Although these reforms have been implemented more slowly in higher education, there is a growing interest in the implications of these theories for higher education (Halperin & Hakel, 2003; Krockover et al., 2002; National Center for Postsecondary Improvement, 2002; Shulman & Sherin, 2004).

Recent education reforms are associated with a range of philosophical and theoretical perspectives that fall under several different labels (e.g., constructivism, social constructionism, socioculturalism, anchored instruction, situated cognition, activity theory). Although there are important differences between these theoretical positions, they share a common belief that knowledge is constructed by learners rather than transmitted to learners. The fundamental change in perspective associated with these reforms has been a shift away from transmission methods such as lecturing toward experiential methods like problem-based collaborative learning in groups where knowledge is constructed in dialogic communication (Cobb, 1994; Hufferd-Ackles, Fuson, & Sherin, 2004). For the purposes of this article, I avoid dealing with the differences between these positions and concentrate on beliefs they share. To this end, I use the general terms learning science and constructivist and sociocultural positions to capture the middle ground between the positions debated in this field. More extensive justifications for adopting this combined position appear elsewhere (Cobb, 1994; Innes, 2004).
Constructivist and sociocultural theories make a distinction between *useful knowledge* and *inert knowledge* that can be traced back to their roots in the philosophy of John Dewey. This distinction is foundational because it addresses the fundamental aims of education (Dewey, 1938; Whitehead, 1929). *Useful knowledge*, defined as learning that can be applied to problem-solving beyond the classroom, is contrasted with *inert knowledge* that is memorized for tests or recitation within the school setting, but isolated from the repertoire of knowledge and problem-solving skills used in the "real world." Inert knowledge is useful only in the limited context of the school. Useful knowledge, on the other hand, is meant to be employed to solve problems that are important to the learner (Bransford et al., 1999). Knowledge is useful if it increases the adaptive capacity of the learner: if it helps learners behave more intelligently in the environments they will confront beyond the classroom (Dewey, 1938).

The reasons why inert knowledge remains in its sequestered space in the context of schooling are directly relevant to the educational value of dialogic instructional methods such as problem-based learning groups (Bransford, Franks, Vye, & Sherwood, 1989; Schank, 1999). Bakhtin (1981) drew a distinction between *authoritative discourse* (knowledge that authorities tell us to believe) and *persuasive discourse* (ideas we process in dialog and make our own by combining our ideas with the ideas of others). Bakhtin thought that ideas transmitted from authorities remained "in quotes"—away from the ideas we use to govern our everyday lives. For Bakhtin (1984), an idea remains inert until "it enters into a genuine dialog with the ideas of others" (p. 88).

**The Importance of Authenticity**

If we hope that students will connect their learning to problem solving beyond the classroom, they must wrestle with their ideas, incorporate them into their existing thinking, and see them as relevant to the real world. This is why authenticity is a primary criterion for evaluating any method of instruction employed in a course design informed by constructivist and sociocultural theories (Herrington & Oliver, 2000; Wong, Pugh, & the Dewey Ideas Group at Michigan State, 2001). Authenticity is directly relevant to the central focus of this article because it drives the conversations that take place in problem-solving groups and connects them to their application for future problem solving.

One of the dominant themes that characterizes new perspectives on learning is an emphasis on context. Knowledge and the thinking and the social processes that construct them are seen as contextualized or situated in a range of contexts (Brown & Duguid, 1996; Gee, 1996; Gergen, 2001; Greeno, 1997). This view, in turn, leads to a focus on authenticity. To produce useful knowledge, learning activities and environments must stimulate the students’
interests and have important similarities to the environments where the learning will be applied (Herrington & Oliver, 2000). Authenticity also requires connections to a set of basic concepts and deep principles that increase the students’ abstract understanding of the problem situation. If a connection to important ideas is missing, the experience cannot be labelled as *educative*.

The most common strategy for establishing an authentic context in the classroom is to present a group of students with a complex unstructured problem that is similar to the problems they will confront in nonschool environments. The presenting problem establishes an arena for group inquiry and collaborative problem solving. Authentic problems motivate students to inquire about and engage in dialog to find a solution. The instrumental nature of the problem situation keeps learners connected to the goal and the presenting problem (Lee & Smagorinsky, 2000; Schank, 1999). Meanings are constructed in a way that maintains the natural transactional relationship between the problem situation, actions, and ideas. If these elements are disconnected, the students will be unable to construct deep principles that can be used to solve future problems. Wong et al. (2001) captured the essence of what they called idea-based experiential education: “The goal is to teach the students to more fully perceive the world by teaching them how to see it through the lenses of powerful ideas” (p. 330).

When learning is embedded in authentic contexts, students can connect their own experience within the learning environment to their previous experience and their future experience working in organizations. Most important, they can use the narrative framework of the simulation to index the concepts and the deep principles embedded in the learning environment in a way that they can be applied to different settings (Schank, 1999). Authentic contexts serve to connect theory and experience by organizing elements of the problem space within a unifying activity structure. The activity structure is bounded by the problem space (i.e., from problem identification, through the process of inquiry, to the problem solution). An underlying assumption of these theories is that goal-directed behavior is a “natural” motivational and integrating force in human life. This places knowledge and the dialogs we use to construct it within goal-directed behavior motivated by an authentic problem (Schank, 1999).

**THE CRITICAL ROLE OF DIALOGIC COMMUNICATION**

The most important factor that determines the quality of learning in a group problem-solving situation is the quality of the dialog. Learning scientists have developed a number of instructional models derived from various forms of constructivist and sociocultural perspectives on learning (e.g., Bransford et al., 1989; Brown, 1997; Bruffee, 1993; Schank, 1999). All of these models and the teaching practices derived from them place dialogic communication as a key mechanism for constructing meaningful and useful learning.
Dialogic communication is defined as open, nonmanipulative, two-way interaction designed to reach mutual understanding and consensus where all parties assert and defend their views and listen actively to the views of others (Habermas, 1984; Keefer, Zeitz, & Resnick, 2000; Watson, Correia, Lee, & Schwen, 2004; Wertsch & Toma, 1995). One model for dialogic communication that is straightforward and relatively easy to communicate to students is Argyris’ (1993) general criterion for effective communication: Communication should be high in advocacy and inquiry (i.e., participants should support their own positions with evidence and listen carefully until they fully understand the positions of others).

The theories and research that support the use of groups in classrooms and teams in organizations place dialogic communication as a critical form of discourse that promotes the construction of useful knowledge. A key assumption of most of these theories (e.g., sociocultural and activity theories) is that knowledge moves from the social plane to the internal plane of ideas and mental representations (Lee & Smagorinsky, 2000; Sfard, 2001; Vygotsky, 1978). Meanings are constructed in learning communities where groups of people solve problems together (Bransford et al., 1999; Brown, 1997; Brown & Campione, 1994; Cobb, 1994).

In classrooms, dialogic communication is seen as a dynamic process that leads to a fundamentally different outcome than teaching using one-way transmission methods such as lecturing. Because two-way conversations in problem-solving groups are part of goal-directed collaborative problem solving, they actively engage students in a fundamentally different way. The reason that theorists think that dialog produces qualitatively different knowledge than listening to a lecture is that dialog “allows for the comparison of our own understanding of the subject matter with that of others” (Draskovis et al., 2004, p. 451). In genuine conversations, new ideas are tested, manipulated, confront old ideas, and get incorporated into existing knowledge systems.

A learning model that sees useful learning as taking place in cooperative inquiry into an authentic problem within a learning community is more difficult to accomplish than is immediately apparent. The learning process is now embedded in a complex set of social practices (e.g., dialogic communication) and activity structures (e.g., a management simulation involving problem-solving groups). Lave and Wenger (1991) characterized the environment as having “structuring resources” that shape the behavior and the cognition of learners. Sfard (2001) characterized “learning as participation rather than acquisition” (p. 14). Constructivist and sociocultural perspectives reframe the metaphor for teaching from transmission to the orchestration of instrumental discourse. We are faced with the challenge of designing a learning environment that promotes the type and quality of dialog that will help students construct useful knowledge. The key to the success of this model lies in the types of conversations that take place in problem-solving groups.
Theoretically and practically, methods such as the use of collaborative problem-solving groups promoted by education reformers are tied to a careful analysis of "how people learn" (Bransford et al., 1999). It is obvious to even the casual observer that all conversations are not equally educative. Most everyday conversations, in fact, do not produce useful learning, even if the participants are knowledgeable people (insert your own humorous remark about faculty meetings).

In general, the key prerequisite for an effective dialogue is that it takes place in an authentic context (Hoffman-Kipp, 2003). This presents a problem to educators that does not exist in organizations. Conversations in real organizations are about real problems (faculty meetings notwithstanding). Conversations in organizations take place within a community of practice where experts and novices are in an apprentice relationship (Lave & Wenger, 1991). In our classrooms, however, we have to create authentic problems for students to solve and design learning experiences in a way that students adopt the problem as their own. Authenticity is the fuel that drives important conversations. The power of the activity structure maintains the focus on solving the problem and sustains the interest of students. The knowledge that we want students to acquire is embedded in the structural form of the dialog and the other aspects of the social practices of the classroom (Wersch & Toma, 1995).

GUIDELINES FOR DIALOGIC COMMUNICATION

Constructivist and sociocultural theories see knowledge as appropriated through interactions in social contexts. Rather than forming ideas internally through contemplating the world and then expressing these ideas to others, theorists such as Vygotsky (1978) saw knowledge as developing on the social plane and then being internalized as thought. This shift in perspective stimulated educators to think more seriously about the nature of dialog between students and between teachers and students. Research in learning science supports the idea that the type of dialog that occurs in classrooms and small groups is a primary factor determining whether an experience will be educative or noneducative (Nystrand, 1997; Sfard, 2001; Wertsch & Toma, 1995). Nystrand (1997) summarized the conclusions drawn from this body of research: "the bottom line for instruction is that quality of student learning is closely linked to quality of classroom talk" (p. 29).

Although there are several models that characterize "ideal" classroom discourse, they all promote some form of open, nonmanipulative, two-way dialogue (Cazden, 2001; Hoffman-Kipp, 2003; Nystrand, 1997). In the tradition of Habermas (1984), these models distinguish between debate designed to "win" an argument and dialogic communication designed to achieve mutual understanding and build consensus (Banathy, 2003; Watson et al., 2004; Wertsch & Toma, 1995). Biesta (1994) defined productive discourse in terms
of *practical intersubjectivity* (i.e., we construct ideas through dialog within a purposeful social context). In group problem-solving activities, then, students should be working toward a common goal in an authentic context. The quality of the dialog also depends on the extent to which students are working toward a goal of mutual understanding. Biesta's characterization of effective learning as a "co-constructive process in a symmetrical relationship" (p. 301) is consistent with the body of research in learning science (Bransford et al., 1999; Brown, 1997).

There are number of structural qualities of dialogue and activity that affect the learner's ability to utilize knowledge in a context beyond the classroom. Van Boxtel and Roelofs (2001) developed a set of guidelines for productive disciplinary discourse:

1. The amount and type of discourse about the concepts that have been appropriated . . .
2. The amount and type of elaboration . . .
3. The amount and type of co-construction . . .
4. The use of available tools. (p. 56)

The first guideline indicates that conversations in problem-solving groups should address problems through the lens of concepts and deep principles drawn from the course content. The other characteristics of the conversation are educationally irrelevant unless they are connected to ideas. The discussion should go beyond concrete examples to explore the meaning of principles and their relationships to each other and the problem learners are trying to solve. It is important to remember that students do not enter our courses as clean slates. They already have "everyday theories" about how to solve the problems we present. Teaching is always about changing or confirming these personal theories rather than giving students new theories. Unless classroom learning experiences are authentic and relevant, students will leave their school learning in the classroom and revert to their original everyday theories when they leave the classroom.

Van Boxtel and Roelofs' (2001) second and third principles reference the nature of dialogic communication and the source of its reconstructive power: Students should challenge each others' ideas—especially by asking other students to defend their positions with evidence. The contributions made by one student should include connections, revisions, and elaborations to the contributions of previous students. In productive dialogs, students construct ideas together using each other's knowledge and skills and incorporate the learning resources we have provided for them in the course curriculum. Productive dialog connects with resources and provides the chemistry for constructing ideas. This picture of the dialogic classroom also assumes that interacting with knowledgeable students will help less knowledgeable students traverse what Vygotsky (1978) called the *zone of proximal development* (the difference between what they could manage on their own and what they could understand with the help of a more
competent colleagues). Dialogic communication bridges the boundaries between individuals to make the distributed expertise of the group available to group members.

Tochon (2000) defined didactics as “the study of how signs are made meaningful in specific disciplines” (p. 335). In organizational settings, people learn by participating in conversations that are integrated with the “doing” of problem solving and “doing business as usual.” A new employee learns “how we do things around here” by learning to “talk like” and “see like” people who are “in the know” (Foucault, 1980; Lave & Wenger, 1991). Meanings in the real world of organizations are pragmatics (meanings embedded in context). Traditional schooling tends to focus on semantics (decontextualized meanings; Tochon, 2000). For knowledge to become useful, these meanings must find new connections in the environments where they will be used to inform problem solving. Even if we are able to create environments in the classroom with important similarities to the environments in real-world organizations, student dialog must foster associations between the knowledge embedded in the learning context and the students’ previous experience to actively confront their everyday theories about the world. Without some form of active confrontation that challenges everyday theories, school knowledge stays in the school, and everyday theories govern everyday behavior.

Tochon (2000) saw effective dialog as the process and product of learning: “the pragmatic links produced with experiential knowledge (whether biographical or situated) constitute the axes of learning and thus explain the importance of oral exchange in learning” (p. 341). This sounds good; however, it only “makes sense” if educators are able to create the types of dialogs that can help students make complex connections between their own experience, the deep principles embedded in classroom learning experiences, and the contexts in which they will be applied.

DIALOGIC COMMUNICATION IS DIFFICULT TO ACHIEVE

A promising picture of how learning is enhanced through methods such as problem-based learning groups imagines that all of the elements in this complex learning environment interact in a system where synergy produces powerful and useful knowledge. An alternate scenario finds these complex elements “out of synch” or missing a critical piece of the puzzle that prevents the process from working effectively. By most accounts, the quality of discourse in student problem-solving groups is one of the key elements that can make or break the model forwarded by learning scientists.

If dialogic communication is important or even essential to this model’s success, it is especially troubling that evidence indicates that it is very difficult
to accomplish in the classroom. Students are habituated to the conventions of schooling and very resistant to efforts to change the way they communicate with each other and the teacher (Cobb et al., 1997).

Observational research in classrooms indicates that dialogic communication is rare and difficult to achieve (Blanton, 2002; Hoffman-Kipp, 2003; Sfard, 2001). Nystrand (1997) found that middle-school students were involved in dialogic communication for fewer than 1 minute per day and were involved in small-group work for fewer than 30 seconds per day. These data are typical of everyday school life and serve to demonstrate that our students come to us with very little preparation for working effectively in small groups.

MacLellan and Soden (2004) looked at the quality of dialog in university classrooms. In productive dialogs, we expect students to demonstrate their understanding of the standards of evidence in our disciplines by supporting their statements with research and theory. The 25 students MacLellan and Soden (2004) observed relied almost exclusively on personal experience to justify their claims—none justified their opinions with reflective responses. Kittleson and Southerland (2004) focused on “conceptual negotiations” in dialogs in engineering classes. They defined a conceptual negotiation as “a form of interaction in which more than one participant actively contributes to the evolving conceptual content of the conversation” (p. 271). They found that conceptual negotiations were extremely rare.

Project groups encounter another, more practical, impediment to spending time in the kinds of conversations that would enhance knowledge construction. Students have a strong tendency to follow what Mintrop (2004) called an “ideology of efficiency.” They tend to divide projects into individual tasks and go their separate ways to complete them. Mintrop found that this noninteractive approach to group work saved time but severely reduced or eliminated collaborative dialog.

HOW CAN PRODUCTIVE DIALOG BE FOSTERED?

Despite the fact that productive discourse is a rare occurrence in most classrooms, it is possible to achieve. Research evidence generally supports the assertion that well-designed learning experiences can generate productive dialog and produce useful knowledge. As indicated earlier, the authenticity of the activity is a central factor in driving productive dialog. Engle and Conant (2002) identified four ways of fostering productive classroom dialog: “(a) problematizing subject matter, (b) giving students authority to address such problems, (c) holding students accountable to others and to shared disciplinary norms, and (d) providing students with relevant resources” (p. 399). There is also evidence that students need specific communications training to improve the quality of their classroom dialog. (Blanton, 2002; Cohen et al., 2002).
DIALOGIC COMMUNICATION AND USEFUL LEARNING

If we are able to promote productive dialog in problem-solving groups, there is evidence that our efforts will help students acquire deep principles and disciplinary understanding. Mathematics students who participated in productive dialogs in learning communities had higher scores on tests designed to assess their ability to apply mathematics to real world problems (Boaler, 1999). Blanton (2002) found that participation in productive dialog increased mathematical understanding in an undergraduate geometry course. Chernobilsky, Dacosta, and Hmelo-Silver (2004) found that students involved in problem-solving groups showed increased ability to use the specialized language of the discipline to analyze problems and found a relationship between participation in productive dialog and learning. Capon and Kuhn (2004) did a well-controlled study that compared the outcomes of student learning using a traditional lecture method of instruction with a work-group, problem-solving method. In traditional recall tests at the end of the course, there were few significant differences. The students in one of the lecture groups, in fact, performed better. At 12 weeks following instruction, however, the performance of students who participated in the problem-solving groups was dramatically better on tasks that required application of in-depth understanding of course concepts to unstructured problems. In their discussion, Capon and Kuhn (2004) concluded that:

The benefit of problem-based learning . . . lies not in the superior acquisition or recall of new concepts but in the potential for greater understanding reflected in an integration of the new concept with existing knowledge, and with it, the possibility of restructuring and enhanced conceptual coherence. (p. 74)

There is substantial body of research on the implementation of problem-based learning, conducted primarily in medical schools, that is focused on the general question of whether problem-based approaches are more effective than traditional methods. In general these studies have found that problem-based learning achieves better results when students are asked to connect concepts and apply them to problem solving. They are not more effective if learning is evaluated by asking students for simple factual information. (See Gijbels, Dochy, Van den Bossche, & Segers, 2005, for a review and meta-analysis of this research.) In a study of 89 first-year medical students working in six problem-based learning groups, Draskovis et al. (2004) found that knowledge elaborations mediated the relationship between task-oriented interactions and knowledge acquisition. Elaborations had much more effect on the acquisition of metacognitive understanding and relational knowledge than on the acquisition of factual knowledge. There is also evidence that students involved in problem-solving groups are more motivated and involved in learning activities (Csikszentmihayi & Schneider, 2000; Peterson & Miller, 2004).
Summary and Conclusions

A growing body of theory and supportive research in learning science is generating guidelines for effective problem-based learning groups. The most concise summary of what we know about what governs the quality of learning in these types of experiences is that the quality of the conversations in problem-solving groups and the learning generated from them depend on the authenticity of the problems and activities that drive these conversations.

The best evidence indicates that dialogic communication is an essential characteristic for the effective implementation of this method. However, it is important to avoid letting a sharp focus on the specific characteristics of productive and constructive dialogs obscure the broader context in which these dialogs take place. Although the quality of the dialogs in small groups may be the key catalyst for knowledge construction, small groupwork is a piece of a much larger puzzle. Meaningful dialogs are fueled by the successful implementation of complex curriculum designs. The foundation of every well-designed learning experience is a clear articulation of the concepts and deep principles students are expected to construct.

The criteria for measuring the quality of dialog within problem-based learning groups must focus on the quality of the ideas employed to frame and address the problem. The rationale for employing problem-based learning groups does not rest on a claim that it is the most efficient way to get the right answer, but on the claim that participants will know why the solution they reached could be defended. It is a core assertion of proponents of collaborative learning that the potential outcome of these conversations is an enhanced understanding of deep principles. The specific mechanisms for the development of increasingly sophisticated ideas are embedded in the content and structure of the dialog. A background assumption of most theories is that constructive dialogs bring ideas into conflict. Most theories also see goal-directed behavior stimulated by an authentic problem as the primary source of energy and motivation for learning. The dialog has to create transactions between authentic problems and the deep principles that can be used to solve similar problems in the future. Ideas are the focus of education, even if experiential methods are used. This is why some types of interaction are constructive (e.g., asking and answering questions, elaborations of other students' ideas) and some are not (e.g., serial presentations of uncorroborated opinions unconnected to previous statements by other students). Meaningful dialogs involve group members in the coconstruction of knowledge.

To return to the question posed in the title of this article (What can learning science contribute to our understanding of the effectiveness of problem-base learning groups?), learning scientists would dissuade us from focusing on the method itself and ask ourselves a series of questions about why we
want to use this method at this time in the learning process. What do we hope students will be talking about in these groups? What deep principles related to the primary objectives of the course will be useful for solving problems that have important similarities to the ones we have presented to our students? How have we organized the learning experience to stimulate conversations about these deep principles? All of these questions map back to the initial step of the curriculum development process: defining the enduring understandings that will help students solve important problems in the future.

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