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Understanding Tutor Learning: Knowledge-Building and Knowledge-Telling in Peer Tutors' Explanations and Questions

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Prior research has established that peer tutors can benefit academically from their tutoring experiences. However, although tutor learning has been observed across diverse settings, the magnitude of these gains is often underwhelming. In this review, the authors consider how analyses of tutors' actual behaviors may help to account for variation in learning outcomes and how typical tutoring behaviors may create or undermine opportunities for learning. The authors examine two tutoring activities that are commonly hypothesized to support tutor learning: explaining and questioning. These activities are hypothesized to support peer tutors' learning via reflective knowledge-building*, which includes self-monitoring of comprehension, integration of new and prior knowledge, and elaboration and construction of knowledge. The review supports these hypotheses but also finds that peer tutors tend to exhibit a pervasive* knowledge-telling bias*. Peer tutors, even when trained, focus more on delivering knowledge rather than developing it. As a result, the true potential for tutor learning may rarely be achieved. The review concludes by offering recommendations for how future research can utilize tutoring process data to understand how tutors learn and perhaps develop new training methods.*

KEYWORDS: peer tutoring, tutor learning, knowledge-building, explaining, questioning, metacognition

One of the most intriguing aspects of peer tutoring, in which students tutor other students, is its potential to support learning for both the tutees and the tutors. The belief that tutors benefit academically, along with lower costs and the large pool of potential tutors, has provided a long-standing justification for peer tutoring programs (Allen & Feldman, 1976; Gartner, Kohler, & Riessman, 1971). For example, the 17th-century philosopher Comenius argued that "the process of teaching . . . gives a deeper insight into the subject taught" (as quoted in Wagner, 1982, p. 31). Similar ideas were echoed two centuries later by the Swiss educator, Johann Pestalozzi, who wrote that his students "were delighted when they knew something they could teach to others . . . and they learned twice as well by making the younger ones repeat their words" (as quoted in Wagner, 1982, p. 118). More recently, researchers have demonstrated empirical evidence of learning gains for tutors compared to nontutors (P. Cohen, Kulik, & Kulik, 1982), which we refer to as the *tutor learning effect*.

Previous reviews have described the scope of the effect and contributed to our knowledge of effective program design. In this review, we critically examine research on the actual tutoring process to better understand how tutor learning occurs. We focus on how tutors' explaining and questioning activities during the tutoring sessions may incorporate either *reflective knowledge-building* (e.g., monitoring of comprehension and knowledge) or *knowledge-telling* (e.g., summarization with little monitoring or elaboration), which should lead to stronger or weaker learning, respectively. Explaining and questioning are chosen because they are ubiquitous and fundamental aspects of the tutoring process (Graesser, Person, & Magliano, 1995) and have been specifically studied as sources of tutor learning (King, Staffieri, & Adelgais, 1998).

Our review is presented in three major sections. We first briefly highlight evidence of tutor learning across a variety of formats, students, and domains. We then discuss hypotheses regarding how tutors learn from explaining and questioning and evaluate these ideas by considering studies that directly analyzed tutors' behaviors. In the final section, we consider methodological issues in the literature and recommend directions for new research. Throughout this review, we adopt a primarily cognitive perspective. We are interested in how peer tutors acquire and transform their subject matter knowledge, and so we focus on the processes that directly support such changes. Of course, peer tutoring also occurs within a larger community of educational and social expectations. Peer tutors' perceptions of their tutoring role, and their motivational attitudes and beliefs, may influence how peer tutors approach their task and, thus, their tutoring actions (Foot, Shute, Morgan, & Barron, 1990). To address these issues in depth is beyond the scope of this article, but aspects of these factors will be addressed in our final section.

Evidence of Tutor Learning

We define peer tutoring as the recruitment of one student to provide one-on-one instruction for another student, accompanied by explicit assignment of participants to "tutor" and "tutee" roles. Typically, the tutor is more expert or advanced than the tutee, but in some variations of tutoring this knowledge gap is minimal. At the most fundamental level, it is the instructional task and the asymmetrical tutor and tutee roles that distinguish peer tutoring from other forms of peer learning. For example, in peer collaboration, students might work together in small groups to solve math problems (Webb, Troper, & Fall, 1995). Although group members may differ in ability and are encouraged to help each other, none are explicitly assigned to tutor their peers. In contrast, math tutors are expected to use their math knowledge to teach key concepts and guide tutees toward correct solutions and understanding.

Topping and Ehly (2001) have defined several features that can vary across programs, such as training method, participant age, duration, and curriculum. Different combinations of features give rise to a wide range of tutoring programs. Remarkably, the opportunity to tutor a peer seems able to enhance learning for diverse students working in a variety of such settings (Allen, 1983; Britz, Dixon, & McLaughlin, 1989; P. Cohen et al., 1982; Cook, Scruggs, Mastropieri, & Casto, 1986; Goodlad &

Hirst, 1989; Greenwood, Carta, & Hall, 1988; Mastropieri, Spencer, Scruggs, & Talbott, 2000; Mathes & Fuchs, 1994; McMaster, Fuchs, & Fuchs, 2006; Robinson, Schofield, & Steers-Wentzell, 2005; Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003; Topping, 2005). However, despite such broad applicability, meta-analyses tend to report effect sizes that are underwhelming in magnitude.

To further illustrate these points, we briefly consider tutor learning across three key program features: format, demographics, and domain. Relevant mean effect sizes are summarized in Table 1. The most common comparisons used in individual studies were between students who learned by tutoring versus studying a text (Annis, 1983) or participating in regular classroom activities (Sharpley, Irvine, & Sharpley, 1983). In fewer cases, tutoring was compared to an alternative treatment such as reciprocal teaching (Klingner & Vaughn, 1996). Effect sizes reported in the meta-analyses were calculated by taking the difference in means between tutoring and nontutoring groups and dividing by the standard deviation or pooled standard deviation. The resulting value describes group differences in standard deviation units, and positive values indicate an advantage for tutors. As a rule of thumb, effect sizes around .20 are considered small, effects around .50 are medium, and effects of .80 or higher are large (J. Cohen, 1992).

Different populations were considered across the five meta-analyses. P. Cohen et al. (1992) considered only studies using general education students, whereas Cook et al. (1986), Mastropieri et al. (2000), and Mathes and Fuchs (1994) considered special education students. Mathes and Fuchs further focused on reading programs. Rohrbeck et al. (2003) analyzed studies occurring in elementary school settings.

Tutor Learning Has Been Observed Across Different Tutoring Formats

Tutoring formats can vary based on the age and knowledge gap between participants and the nature of their roles. In cross-age tutoring, older and more advanced students instruct younger novices. These roles typically remain "fixed" because tutees cannot legitimately teach the more expert tutors, although role reversals can be used as a game to support tutee engagement (Juel, 1996). Tutor learning has been observed in cross-age programs with large and small age gaps, such as college students tutoring first-graders (Juel, 1996) or fifth- and sixth-graders tutoring second- and third-graders (Allen & Feldman, 1973; Sharpley et al., 1983). Tutor learning has also been found with moderate gaps, such as high school (Cloward, 1967; Rekrut, 1992) or middle school tutors (Jacobson et al., 2001) with elementary school tutees.

In same-age tutoring, tutors and tutees are of a similar age or grade. Participants are more likely to be actual peers than in cross-age settings because they attend the same classes or interact outside of tutoring. Another issue is the relative ability of the tutors and tutees. Cross-age tutors' advanced age and grade creates a clear gap between tutors and tutees. In same-age tutoring, tutors and tutees may possess overlapping or complimentary expertise, enabling them to learn from each other. As a result, same-age tutoring is often "reciprocal," and students take turns tutoring each other. Tutor learning has been demonstrated with both role arrangements.

Several studies using undergraduates have observed tutor learning in same-age, fixed-role settings (Annis, 1983; Coleman, Brown, & Rivkin, 1997). Reciprocal

TABLE 1 Summary of reported effect sizes across format, population, and domain variables

	Variables and Effect Sizes				
Category	*P. Cohen, Kulik,, and Kulik (1982)*	*Cook, Scruggs, Mastropieri, and Casto (1986)*	*Mastropieri, Spencer, Scruggs, and Talbott (2000)*	*Mathes and Fuch (1994)*	*Rohrbeck,Ginsburg-Block, Fantuzzo and Miller (2003)*
Format	Cross-age (.38); Same-age (.28)		Fixed-role (.36); Reciprocal (.63)	Cross-age (.38); Same-age (.32); Fixed-role (.42); Reciprocal (.34)	Cross-age(.80) Same-age (.47)
Duration	<1 month (.56); 1-5 months (.38); >5 months (.10)				<19 hours (.38); >19 hours (.32)
Structure	Unstructured (.32); Structured (.34); No training (.32); Training (.34)				Unstructured (.33); Structured (.30); Less autonomy (.30); More autonomy (.94)
Grade	Grades 1-6 (.35); Grades 7-9 (.28)				Grades 1-6 (.33)
Population	General education (.33)	Special education (.59)	Special education (.36)	Special education (.42)	<50% Minority (.51); >50% Minority (.23)
Domain	Math (.62); Reading (.21)	Math (.67); Reading (.30)			Math (.27); Reading (.26); Science (.62); Social studies (.49)

Note. Effect size values are given in parentheses.

tutoring has been studied more frequently and has shown favorable results across many interventions (Fantuzzo, Riggio, Connelly, & Dimeff, 1989; Fuchs et al., 1997; Greenwood, Delquadri, & Hall, 1989; King et al., 1998; Mastropieri, Scruggs, Spencer, & Fontana, 2003; McMaster et al., 2006; Rohrbeck et al., 2003; Topping, 2005). One caveat is that reciprocal tutoring may incorporate elements of peer collaboration. Both participants teach and learn from each other, and this role and task symmetry makes it difficult to determine whether gains are due to tutoring or being tutored.

Meta-analyses (Table 1) show positive effects across formats, although the effects seem low in magnitude overall. Comparisons also hint that all formats do not support tutor learning equally. For example, peer tutors may learn more in cross-age than same-age tutoring. Additional evidence surprisingly shows higher effect sizes in shorter programs, which might imply that tutor learning benefits occur early in the process, and nontutor controls catch up over time. Few differences were observed between programs with or without training and structure. However, effects were larger in programs that gave students more autonomy (e.g., self-selected goals). We also know that training tutors to use strategies based on constructivist theories of learning (e.g., Fuchs et al., 1997; King et al., 1998) leads to impressive gains compared to less trained tutors. Thus, whereas the *amount* of training or structure does not strongly influence tutor learning, the *kind* of training or structure is critical (see also Fantuzzo, King, & Heller, 1992; Topping, 2005).

Finally, there is interesting evidence that students can benefit by teaching computer-simulated peers that "learn" based on inputs from the student (Schwartz, Blair, Biswas, Leelawong, & Davis, 2007). For example, in one system (Biswas, Leelawong, Schwartz, Vye, & TAG-V, 2005), students tutor a computer program named Betty about river ecology. If students provide inaccurate or insufficient information, Betty cannot correctly answer the quiz questions. By working to teach Betty a correct model and repair her mistakes, students developed a more integrated knowledge of the material than those who used the same system without a tutoring format (Biswas et al., 2005). Although this is not peer tutoring, it is impressive that adding a peer-tutoring-like format to an intelligent tutoring system increased students' learning gains.

Tutor Learning Has Been Observed With Students of Diverse Backgrounds

Research on tutor learning has found benefits for tutors from all age groups, including college (Annis, 1983; Topping, 1996), high school (Cloward, 1967; Morgan & Toy, 1970), middle school (Jacobson et al., 2001; King et al., 1998), and elementary school (Fuchs et al., 1997; Sharpley et al., 1983). Effect sizes have not been reported for all grades, but effects sizes for elementary and middle school tutors were small but positive (Table 1).

Some researchers have studied tutor learning in populations that often experience academic challenges. Researchers have shown positive outcomes for tutors from underprivileged backgrounds and/or living in urban areas (Greenwood et al., 1989; Jacobson et al., 2001; Rohrbeck et al., 2003). Robinson et al. (2005) noted that African American tutors sometimes learned more from math peer tutoring than White students. Rohrbeck et al. (2003) similarly found that programs with greater than 50% minority enrollment showed a larger mean effect size than programs with low enrollment. Studies focusing on special education tutors with learning disabilities or behavior disorders have also noted positive outcomes (Cook et al., 1986; Fuchs, Fuchs, & Kazdan, 1999; Klingner & Vaughn, 1996; Mastropieri et al., 2000; Mathes & Fuchs, 1994; Scruggs & Osguthorpe, 1986). In sum, the benefits of peer tutoring appear to be highly inclusive, with the potential to support learning for a diverse sample of students.

Tutor Learning Has Been Observed Across Different Subject Matter Domains

Tutor learning has been observed in reading (Juel, 1996; Klingner & Vaughn, 1996; Mathes & Fuchs, 1994; Rekrut, 1992), math (Fuchs et al., 1997; Robinson et al., 2005; Sharpley et al., 1983), science (Coleman et al., 1997; Fantuzzo et al., 1989; King et al., 1998; Topping, Peter, Stephen, & Whale, 2004), social studies (Annis, 1983; Mastropieri et al., 2003), and other domains. As with comparisons of tutoring format, tutor learning effect sizes seem to differ across subject matter domains. Tutors seem able to learn no matter what subject matter they are teaching, but math and science programs may exhibit stronger gains than reading programs.

Understanding the Tutor Learning Effect

Prior research has established that tutor learning is a real phenomenon with broad application across different tutoring formats, diverse student populations, and a variety of domains. However, a rough average estimate based on available effect sizes reveals that the magnitude of the tutor learning effect, approximately .35, is rather modest. Although there is ample evidence that tutors can learn in a variety of settings, such outcomes are not guaranteed (P. Cohen et al., 1982; Mathes & Fuchs, 1994; Renkl, 1995; Rohrbeck et al., 2003).

Program design and implementation can account for some of the successes or failures of tutor learning. Potential gains might be limited for cross-age tutors who teach material far below their level (Sprinthall & Scott, 1989) or if program duration is too short for tutors to improve their skills or knowledge (Topping & Bryce, 2004). Similarly, a lack of autonomy (Rohrbeck et al., 2003), proper training (King et al., 1998), or suitable rewards (Fantuzzo et al., 1992) might inhibit learning. Treatment fidelity and assessment are also crucial. Well-designed interventions may fail if participants ignore their assigned tasks (Dufrene, Noell, Gilbertson, & Duhon, 2005), and standardized tests may be less sensitive to learning gains than assessments designed around program content (Cook et al., 1986; Rohbeck et al., 2003). In sum, careful evaluations of the implementation and outcomes of peer tutoring can reveal important conditions under which tutor learning is more or less likely to be observed.

An alternative method for understanding tutor learning is the direct examination of peer tutors' instructional and learning activities. This typically requires recording and transcription of the tutoring sessions, followed by systematic coding of target behaviors and interactions. This can be time-consuming, but process-based approaches can complement outcome-based approaches in important ways. Process data enables detailed manipulation checks, allowing researchers to determine whether tutors followed instructions or if they modified their training in unproductive or innovative ways. Process data can also lead to insights about tutors' learning-related behaviors. For example, tutors might use unexpected but effective strategies, which educators could develop into new methods. Tutors may also show behaviors that appear beneficial but are actually counterproductive. For instance, tutors might ask many questions, but the questions are shallow or fail to target key concepts. Thus, when studies do not show significant learning gains, data on tutor and tutee behaviors might help researchers diagnose and respond to the problems that hampered learning.

Such analyses can also be extended to the behaviors of control groups. Some students naturally use self-explaining strategies when reading a text, and students in the same classroom could collaborate to solve problems and explain difficult concepts. Thus, the “failure” of tutors to surpass nontutors may sometimes reflect the use of good strategies by controls, rather than the use of bad strategies by tutors. It is also possible that tutors and controls could attain similar learning outcomes using different strategies. Analyses of both tutors’ and nontutors’ learning behaviors could help to further understand how peer tutoring differs from other learning settings and how it creates or inhibits learning opportunities for tutors.

Process data also enables more powerful and flexible hypothesis-testing. Whereas outcome data can test whether program manipulations facilitated learning, process data can shed light on the underlying causes of these effects. Researchers can explore how training methods affected target behaviors and whether target behaviors were truly predictive of achievement. That is, researchers can determine if learning gains were accompanied by specific strategies and if the occurrence of those strategies were correlated with learning measures. Data can also be reanalyzed to focus on different tutoring behaviors (i.e., feedback, questions, hints, etc.) or to consider the same activities from different perspectives (e.g., individual inferences versus reasoning dialogues). Analyses may reveal unexpected patterns that lead to new hypotheses. For example, one might find that training in one set of strategies suppresses other nontargeted behaviors, or discover differences in how target strategies are used by female and male tutors.

Despite this potential of process data, research on tutoring has focused on outcomes and implementation (Fogarty & Wang, 1982; Foot et al., 1990). When the peer tutoring process has been studied, researchers have typically assessed only how *tutee* outcomes were affected by tutor behaviors (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Graesser et al., 1995). To fully understand how tutors learn, researchers must evaluate tutor learning outcomes in conjunction with analyses of their learning behaviors and processes. By combining approaches, we can develop a richer knowledge of how and why tutors (and tutees) learn. In the remainder of this review, we will consider research on the processes of tutor learning in the context of explaining and questioning activities.

Processes of Tutor Learning

Analyses of expert or experienced tutors have demonstrated the complex nature of the tutoring task. Effective tutoring can involve a variety of tactics, such as explaining, questioning, assessment, and feedback (Lepper, Drake, & O’Donnell-Johnson, 1997; McArthur, Stasz, & Zmuidzinas, 1990; Merrill, Reiser, Merrill, & Landes, 1995; Shah, Evens, Michael, & Rovick, 2002; VanLehn, Siler, Murray, Yamauchi, & Baggett, 2003). These tactics require tutors to use and apply their subject matter knowledge and transform this knowledge in creative ways to teach their tutee. As a result, the very factors that make tutoring cognitively demanding may also contribute to tutor learning (Allen & Feldman, 1976; Bargh & Schul, 1980; J. Cohen, 1986; Foot et al., 1990; Gartner et al., 1971; King, 1998; Renkl, 1995; Topping, 2005).

Tutoring a peer has been hypothesized to help tutors *metacognitively reflect* upon their own expertise and comprehension, and *constructively build* upon their prior knowledge by generating inferences, integrating ideas across topics and domains, and repairing errors. This *reflective knowledge-building* process is argued to result in a better understanding. For example, Gartner et al. (1971) proposed,

> In the cognitive area . . . the child having taught another may himself learn as a result of a number of processes. He reviews the material; he has to organize, prepare, illustrate the material to present it to his student; he may try to reshape or reformulate it so as to enable his pupil to learn it and thus himself sees it in news ways; he may need to seek out the basic character of the subject, its structure, in order to teach it better, and may thereby himself understand it better. (p. 62)

However, peer tutors might adopt an alternative approach, called *knowledge-telling*, defined as peer tutors "lecturing" or "stating what they already know" by summarizing facts with little elaboration or self-monitoring. There is little reason to expect tutors to experience significant advancement if they focus on delivering their knowledge without ever questioning its quality or trying to improve upon it. This distinction provides a straightforward framework for analyzing peer tutors' behaviors in terms of their potential for learning.

In the following sections, we summarize our review methods and then consider two hypothesized tutor learning activities: explaining and questioning. We first explore how these activities could support tutors' reflective knowledge-building and improved understanding, then evaluate the plausibility and validity of these hypotheses based on tutoring process data.

Review Methods

Target studies for this review included published research reporting quantitative observations of tutor behaviors, ideally accompanied by objective measures of tutor learning.

To identify relevant cases we searched the PsycInfo and ERIC databases using terminology drawn from the established literature: *peer tutoring*, *cross-age tutoring*, *same-age tutoring*, *reciprocal tutoring*, *peer-assisted learning*, *learning-by-tutoring*, *tutoring strategies*, *tutor training*, *explaining*, *questioning*, *scaffolding*, and so on. Our search included commonsense variants of these terms (e.g., *peer tutoring* versus *student tutoring*) and theory-guided combinations (e.g., *peer tutoring* and *explaining*).

We reviewed the titles and abstracts of thousands of references to locate peer tutoring studies. We used the abstracts of this subset to determine if the publication examined tutor learning and/or the tutoring process. We attempted to obtain all studies that presented both outcome and process data for peer tutors in an academic subject matter (e.g., math, reading, etc.). We also obtained process-only studies that might usefully supplement our primary sources. We excluded studies in which students taught each other games or how to build an object (Cooper, Ayers-Lopez, & Marquis, 1982; Ludeke & Hartup, 1983; Verba, 1998; Wood, Wood, Ainsworth, &

O'Malley, 1995) and those that did not examine behaviors related to explaining or questioning (Jason, Ferone, & Soucy, 1979; Niedermeyer, 1970).

Overall, our search yielded six references combining tutor learning data and process data (entries 1-6 in Table 2). Only these studies can be used to assess whether target tutor behaviors are linked to patterns of learning outcomes. Our search also yielded 12 supplementary references focusing on the tutoring process (entries 7-18). These studies cannot be used to directly examine how tutors learn, but they can provide useful insights about the nature of peer tutors' typical behaviors. Together, this sample of articles can be informative about what behaviors may support or hinder tutor learning, how commonly they occur or do not occur during tutoring. Table 2 summarizes the tutoring setting and format for data collection, participant age and ability, the domain, and the types of data collected. Several studies were embedded in reciprocal tutoring programs, but the actual process data was collected in fixed-role sessions (Bentz & Fuchs, 1996; Fuchs et al., 1996, 1997; Fuchs, Fuchs, Bentz, Phillips, & Hamlett, 1994).

The overall lack of research is a weakness in the literature, and closer examination of the distribution of studies across formats, grades, and domains reveals specific gaps. Most studies were conducted in same-age rather than cross-age settings, and there were more elementary school studies than other grades. In addition, many programs focused on reciprocal tutoring, and there was a strong bias toward math. We were not able to locate process studies in elementary school science, middle school reading/writing, or math tutoring in higher education. Similarly, a number of settings, such as elementary school cross-age tutoring, higher education reading tutoring, science tutoring in high school, and so on, have been addressed by only one publication.

An obvious consequence of this pattern is that our knowledge of how tutors learn is incomplete and skewed toward a subset of possible environments. This is important because previous reviews suggest that context can impact tutor learning gains (P. Cohen et al., 1982; Rohrbeck et al., 2003), and these effects likely stem from how the tutoring setting shapes the tutoring process. Unfortunately, there is not enough data to assess how such design factors affect tutors' learning behaviors. To further complicate matters, there is also little consistency in how peer tutors' behaviors are analyzed. Researchers often employ distinct coding schemes that are not easily compared in a detailed manner. We will revisit these issues in later sections.

The Explaining Hypothesis

Explanations are statements that convey information with the goal of making some idea clear and comprehensible and are one of the primary ways in which tutors teach their tutees. Tutors use verbal explanations to communicate key ideas, principles, and relationships and to correct tutee mistakes and misconceptions. These explanations may involve a variety of elements such as summarizing main ideas, examples, analogies, and so on, and can be used to share known information (e.g., a formula for calculating *t* tests) or make sense of new information (e.g., interpreting the results of a scientific study). Tutor explanations may also be embedded in scaffolding interactions, in which tutors and tutees interact over successive turns to gradually develop tutees' knowledge and explanations. Not surprisingly, the richness of explaining has led many to hypothesize that it contributes

TABLE 2 Summary of studies incorporating peer tutoring process data

Reference	*Format and Setting*	*Participants*	*Outcome Measures and Process Categories*
1. Fuchs et al. (1997)	Same-age, fixed-role; mathematics; classroom-based	ES Grades 2, 3, 4; AA tutors, LD tutees	Comprehensive Mathematics Test; explanations, questions, feedback , demonstrations
2. Fuchs, Fuchs, Kazdan, and Allen (1999)	Same-age, reciprocal; reading; classroom-based	ES Grades 3, 4, 5; HA, AA, or LD tutors in cross-ability pairs	Stanford Diagnostic Reading Test; error correction, help-giving strategies, questions
3. Ginsburg-Block and Fantuzzo (1997)	Same-age, reciprocal; mathematics; classroom-based	ES Grades 4, 5; AA tutors, LD tutees	Stanford Diagnostic Math Test; curriculum test; help and support behaviors, engagement, insults
4. Ismail and Alexander (2005)	Same-age, reciprocal; physics; classroom-based	HS students	Teacher/researcher-designed written tests; questions, responses/explanations
5. King et al. (1998)	Same-age, reciprocal; human physiology; classroom-based	MS Grade 7	Teacher/researcher-designed written tests; explanations, questions, feedback
6. Roscoe and Chi (2004)	Same-age, fixed-role; human physiology; laboratory	Undergraduates	Researcher-designed written tests; explanations, questions, responses, self-monitoring
7. Bentz and Fuchs (1996)	Same-age, fixed-role; mathematics; classroom-based	ES Grades 2, 3, 4; AA tutors, LD tutees	Prompts, helping, explanations, questions, feedback
8. Chi, Siler, Jeong, Yamauchi, and Hausmann (2001)	Cross-age, fixed role; human physiology; supplemental	Nursing/biology majors; middle school tutees	Explanations, questions, feedback, self-monitoring, scaffolding
9. Crahay. Hindryckx, and Lebe (2003)	Same-age, fixed role; mathematics; supplemental	ES Grades 5, 6; HA tutors, LA tutees	Explanations, questions, feedback, demonstrations, patterns of interaction
10. Duran and Monereo (2005)	Same-age, fixed-role vs. same-age, reciprocal; writing; supplemental	HS Grade 10; HA tutors, LA tutees vs. same-ability pairs	Writing activities, questions, feedback, scaffolding, patterns of interaction

11. Fogarty and Wang (1982)	Cross-age, fixed-role; math, computers; supplemental	MS students; elementary school tutees	Explanations, questions, feedback, scaffolding
12. Fuchs, Fuchs, Bentz, Phillips, and Hamlett (1994)	Same-age, fixed-role; mathematics; classroom-based	ES Grades 3, 4, 5; AA tutors, LA tutees	Explanations, questions, feedback, demonstration
13. Fuchs et al. (1996)	Same-age, fixed-role; mathematics; classroom-based	ES Grades 2, 3, 4; HA and AA tutors, LD tutees	Explanations
14. Graesser and Person (1994)	Cross-age, fixed role; algebra; research methods; supplemental	Graduate methods tutors, undergraduate tutees; HS algebra tutors, MS tutees	Questions
15. Graesser, Person, and Magliano (1995)	Cross-age, fixed role; algebra; research methods; supplemental	Graduate methods tutors, undergraduate tutees; HS algebra tutors, MS tutees	Explanations, questions, feedback, scaffolding
16. Juel (1996)	Cross-age, fixed-role; reading; supplemental	College undergraduates; Grade 1 tutees	Scaffolding and modeling
17. MacDonald (1994)	Same-age, fixed-role; various topics; supplemental	College undergraduates	Explanations, questions, feedback, sequences of interactions
18. Topping, Campbell, Douglas, and Smith (2003)	Cross-age, fixed-role; mathematics; classroom-based	– ES (ages 7 and 11); age 11 tutors, age 7 tutees	Mathematical words, procedural talk, strategic talk, feedback

Note. “Classroom-based” tutoring was primarily integrated with classroom activities. “Supplemental” tutoring typically occurred outside of a classroom (e.g., after-school tutoring or pull-out tutoring) to help tutees with assignments or areas of difficulty. “Laboratory” tutoring occurred as part of a laboratory experiment unaffiliated with a particular classroom or curriculum. HA = high achiever; AA = average achiever; LA = low achiever; LD = learning disability; AR = at-risk; ES = elementary school; MS = middle school; HS = high school.

to tutor learning (Bargh & Schul, 1980; J. Cohen, 1986; Coleman et al., 1997; Gartner et al., 1971; King, 1998; Topping & Ehly, 2001).

When explaining, tutors must transform their prior knowledge into instructive messages that are relevant, coherent, complete, and accurate (Coleman et al., 1997; King, 1994; Leinhardt, 2001; Webb, 1989). However, although peer tutors may be more advanced than their tutees, they are not likely to have expert domain knowledge. True expertise takes time and much practice to develop (Chi, 2006), and so tutors' knowledge is probably novice-like in a number of ways. They may still possess knowledge gaps and misconceptions, and their knowledge of the material and procedures may be largely implicit, fragmented, and poorly organized. This may be true even though the tutor has shown good grades and test performance (Chi, 2000).

The tension between the demands of effective explaining and peer tutors' less than perfect knowledge may push tutors to engage in reflective knowledge-building. For example, to generate relevant explanations that address key topics in a meaningful way, tutors may have to think carefully about conceptual relationships and prioritize information. Generating coherent explanations that are internally consistent and follow a natural progression of ideas may require tutors to reorganize their own disjointed mental models by forming or rearranging connections among concepts. Thus, explaining may help tutors improve the organization and accessibility of their knowledge (Bargh & Schul, 1980; King et al., 1998; Webb, 1989).

Similarly, striving to producing complete explanations that integrate key concepts and principles could push peer tutors to reassess the depth and breadth of their own prior knowledge. Generating accurate explanations may cause tutors to evaluate their own comprehension and ability to explain the material. Tutors may also have to assess whether their explanations make sense and are logical. Thus, explaining may help peer tutors to metacognitively recognize and confront their own knowledge gaps and misconceptions. To the extent that peer tutors attempt to repair these problems through elaboration and inferences, their understanding should be enhanced (Coleman et al., 1997; King et al., 1998; Roscoe & Chi, 2004).

In some ways, this pattern of generating, reflecting upon, and revising explanations may be analogous to self-explaining, in which learners make sense of new information by using prior knowledge and inferences to explain it to themselves (Chi, 2000). These self-explanations occur when learners realize they do not understand or cannot solve a problem, perhaps because they are missing information or a have a flawed mental model (Chi, 2000; Chi & VanLehn, 1991). Such "impasses" may occur frequently for peer tutors who are trying to explain ideas they have learned only recently or imperfectly. In these cases, tutors may have to work out a correct explanation for themselves before (or while) conveying this knowledge to the tutee.

Research on self-explaining has established the efficacy of this strategy (see Chi, 2000; McNamara, 2004; Roy & Chi, 2005, for reviews). Analyses of self-explaining while studying worked-out examples have shown that successful learners check their comprehension, generate inferences linking underlying principles and operations for each step, explain relationships between steps, and anticipate future steps (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Renkl, 1997). Less successful learners monitor their comprehension rarely, focus on repetition and paraphrasing, and do not integrate and apply domain principles. Researchers have also studied self-explaining in learning from multiple representations (e.g., text and diagrams). Multiple representations can facilitate learning by providing extra information and supporting complementary reasoning processes, but learning in this setting requires integration of information across representations (Ainsworth, 1999; Schnotz & Bannert, 2003). Self-explaining may facilitate this by supporting inferences that combine information within and across representations in a coherent mental model, and may make implicit links between representations explicit (Butcher, 2006; Roy & Chi, 2005).

Peer tutors' explanations may often be embedded in examples and multiple representations. For example, chemistry tutors might walk their tutee through examples of combustion reactions to discuss how the reagents interact and energy is released. In discussing the examples, the tutor may use formulas to calculate energy, the periodic table, and drawings of molecular bonds to represent the reaction processes in different forms. To maximize the usefulness of these tools, peer tutors may need to deconstruct the examples and explain underlying principles and relationships between steps. The tutors must also explain how information across the different representations is related and complementary and explain their uses and constraints.

An important limitation on these processes may be peer tutors' effort and ability in monitoring their own understanding (King, 1998). A long history of research shows that this activity can be challenging (Brown, Bransford, Ferrara, & Campione, 1983; Glenburg, Wilkinson, & Epstein, 1982; Hacker, 1998; Maki, Shields, Wheeler, & Zacchilli, 2005). Learners have trouble recognizing comprehension failures, assessing what they know or do not know, predicting test performance, and so on. If peer tutors are unable or unwilling to evaluate the quality of their own explanations, then reflective knowledge-building may be forestalled.

In sum, explaining plausibly provides rich opportunities for tutors to engage in reflective knowledge-building processes that support learning. As tutors work to produce quality explanations, they may recognize flaws in their own expertise, leading them to reorganize their knowledge and generate inferences to repair errors. In addition, common contexts for explaining, such as working through examples and manipulating different representations, may further support productive sense-making behaviors. However, tutors' lack of metacognitive awareness may constrain their learning.

Evidence Regarding Explaining in Peer Tutoring

Do peer tutors' explanations predict learning? To what extent do tutors actually engage in reflective knowledge-building versus knowledge-telling? We address these questions by reviewing studies that analyzed both tutor learning and behavior and several studies that explored tutors' explanations without learning data. For clarity, we group studies roughly by grade level and domain (see also Table 2).

Elementary school tutors. The majority of process data on peer tutoring have been collected in elementary school math settings. Much of this work has been done by Fuchs and colleagues, who have assessed a variety of tutoring strategies. In this research, reciprocal peer tutors are taught to give corrective feedback when tutees make mistakes and to gradually reduce help over time to encourage tutee participation. The learning outcomes of tutors using this feedback strategy are then compared to untrained tutors, or tutors trained in novel strategies hypothesized to make tutoring more effective. Process data are collected in separate generalization sessions in which representative students from each condition tutor a peer while being recorded. Tutoring roles in these sessions are usually fixed instead of reciprocal.

Only one study in this paradigm presented both outcome and process data related to explanations. Fuchs et al. (1997) trained second- through fourth-grade peer tutors (same-age, learning-disabled tutees) to give “conceptual explanations” that incorporated examples, discussed the meaning of concepts and strategies, and contained questions about problem-solving steps. Scores on the Comprehensive Mathematics Test showed that math gains were significantly higher for tutors trained to give conceptual explanations than tutors only trained to give corrective feedback. Generalization sessions further showed that explanation tutors offered significantly more knowledge-building “conceptual explanations,” whereas feedback tutors produced knowledge-telling “lectures” that described concepts without probing for tutee understanding or participation. However, some variability was observed. Less trained peer tutors did generate some conceptual explanations, at about equal proportion to their lecture-like explanations.

Several process-only studies provide additional information about elementary school math peer tutors’ typical explaining behaviors. Bentz and Fuchs (1996) taught tutors to use help-giving strategies. Tutors were average-ability second- through fourth-graders who taught same-age, learning-disabled peers. Generalization sessions showed that tutors trained in help-giving strategies offered more help than tutors trained only to give corrective feedback. In terms explaining, there was also a nonsignificant trend for feedback tutors to simply solve problems for tutees, point out errors, or give procedural help on how to solve the problems. In contrast, help-giving tutors were more likely to give knowledge-building conceptual explanations about the meaning or necessity of certain operations. However, some conceptual explaining was observed in both conditions.

Fuchs et al. (1994) examined the behaviors exhibited by peer tutors trained to give corrective feedback versus untrained tutors. The tutors were average-ability third- through fifth-graders working with lower ability, same-age peers. Generalization sessions indicated that untrained tutors gave didactic, knowledge-telling explanations in which they showed tutees how to solve the problem instead of letting tutees do the work. Untrained tutors did produce a few knowledge-building explanations. In contrast, trained tutors were much more likely to use explanations and questions to stimulate knowledge-building discussions and tutee participation. Tutees who worked with a trained tutor also solved more problems correctly during the session.

The influence of the peer tutors’ prior ability was evaluated by Fuchs et al. (1996), which analyzed the explanations of trained second- through fourth-grade tutors who scored “high” versus “average” on a standardized math Computation and Applications Test. Tutees were learning-disabled same-age peers. Analysis of tutors’ explanations revealed that both high and average ability tutors relied on “nonelaborated” (i.e., no help or just the answer) and “procedural” (i.e., restated the problem or used manipulatives) knowledge-telling explanations. However, high-ability tutors also generated some knowledge-building explanations that “bridged procedural and conceptual” information (i.e., used real-life examples, rephrased problems to emphasize missing features, checked answers for sensibility) or were “primarily conceptual” (i.e., explained underlying concept).

In sum, the results reported by Fuchs et al. (1997) show that reciprocal peer tutors who generated knowledge-building explanations scored higher on posttests than tutors who generated knowledge-telling explanations. However, evidence from that study and several process-only studies suggests that these behaviors did not often occur naturally. Many tutors focused on knowledge-telling unless they received explanation strategy training, although some untrained and less trained tutors were able to engage in knowledge-building spontaneously.

Researchers using alternative methods have obtained comparable results. Crahay, Hindryckx, and Lebe (2003) examined whether same-age, fixed-role peer tutors (fifth- and sixth-graders) with minimal training utilized "retroactive" versus "proactive" tactics. Retroactive tactics were those in which tutors encouraged tutee participation and built upon tutees' statements, errors, and questions. This knowledge-building category included assessing tutee understanding and debating, explaining, and synthesizing ideas. Proactive tactics were those in which the tutor demonstrated steps or guided tutee actions in a procedural, knowledge-telling manner, with little tutee problem solving or discussion of principles. Proactive tactics accounted for 69% of tutors' actions. Tutors told their tutees what to do and how to do it and "rarely explained the rationale of the approaches and computations they prescribed" (p. 208). Retroactive tactics accounted for only 16% of tutors' behaviors. Argument, explanation, and synthesis statements made up 8% of tutors' behaviors. Thus, in this process study of untrained tutors, we again see a strong predominance of knowledge-telling with a few spontaneous instances of knowledge-building.

Ginsburg-Block and Fantuzzo (1997) compared learning outcomes for students trained to complete math drills in reciprocal dyads versus individually. Reciprocal, same-age tutors scored significantly higher than nontutors on a researcher-constructed Curriculum-Based Computation Test. To understand how tutoring experience influenced students' behaviors, students from both conditions were asked to participate in a recorded tutoring session. Peer tutors' explanations were analyzed together with several "help" behaviors, including "task presentation, verbal or nonverbal feedback, providing answers, [and] guided questioning" (p. 137). Frequencies of help behaviors did not differ across conditions; nor were they significantly correlated with posttest scores. One reason for this pattern may be that the coding category combined elements of knowledge-building (e.g., explaining) and knowledge-telling (e.g., giving answers). Separate coding of activities may have revealed more distinct relationships with learning.

One process-only study examined math cross-age tutoring (Topping, Campbell, Douglas, & Smith, 2003), in which 11-year-olds tutored 7-year-olds. Explanations were not directly coded, but researchers analyzed whether dialogue was "procedural" (i.e., discussing steps to take or turn-taking) versus "strategic" (i.e., verbalizing one's thoughts, or discussing the reasons and strategies underlying moves). The cross-age tutors initially generated more procedural dialogue, which significantly decreased as a result of the program intervention. Strategic dialogue also significantly increased.

Middle and high school tutors. With elementary school tutors, we observed that peer tutors relied on knowledge-telling explanations, which was somewhat offset by tutor training. Although one might hope that older students with more educational experience would be more sophisticated tutors, this does not appear to be the case. The following studies show that middle- and high-school-age tutors were just as prone to knowledge-telling as younger tutors. This research also further highlights how training in reflective knowledge-building strategies improves, but does not eliminate, this trend.

One process-only study examined the behaviors of volunteer middle school math and computer literacy cross-age tutors who taught elementary school tutees (Fogarty & Wang, 1982). The authors found that the "instructional process that occurred . . . was not characterized by a sophisticated or variable repertoire of instructional behaviors" (Fogarty & Wang, 1982, p. 460). The most common behavior (29.6%) was simply giving confirmation for correct responses, or noting incorrect responses, without explaining. Tutors also frequently gave procedural explanations consisting of directions for solving problems (27.7%). Explanations that incorporated knowledge-building were less common; tutors did not often elaborate with examples or links to related concepts (7.6%) or provide conceptual explanations (5.7%).

King et al. (1998) examined tutoring behaviors and learning with middle school same-age, reciprocal tutors studying human physiology. Three groups were trained to take turns giving explanations that made conceptual connections and discussed underlying causes and mechanisms. Two of these groups were further taught to generate questions to scaffold each others' learning. This included "review" questions to discuss basic concepts and prior knowledge and "thinking" questions requiring inferences and integration. Sequenced-inquiry tutors were taught to ask these questions in a specific sequence (i.e., review, probing and hinting questions, and thinking questions). Inquiry-only tutors were not taught this sequence. Learning was assessed through teacher- and researcher-constructed exams testing tutors' ability to integrate and generate ideas. Immediate and delayed posttests showed that the sequenced-inquiry tutors generally scored higher than inquiry-only tutors, who in turn outperformed unprompted tutors.

The reciprocal tutors' behaviors were consistent with test scores. All tutors initially generated knowledge-telling statements that restated facts from the materials. Even after training, knowledge-telling statements were still more common than knowledge-building statements, but significant group differences were found. Sequenced-inquiry tutors generated more explanations that integrated, applied, and generated knowledge, whereas unprompted tutors produced more knowledge-telling statements. Inquiry-only tutors fell in the middle. Unfortunately, many tutors reverted back to knowledge-telling in transfer sessions when prompt cards were removed.

Only one study focused exclusively on tutor learning with high school tutors (Ismail & Alexander, 2005), using methods adapted from King et al. (1998) for use in a physics classroom. Scores on teacher and researcher designed exams indicated that all three groups were equivalent before the intervention. However, posttests showed that sequenced-inquiry tutors showed better understanding of the material than inquiry-only and unprompted tutors, who were equivalent to each other. After 4 weeks, tests found that sequenced-inquiry and inquiry-only tutors were equivalent in their recall of the material, and both remembered more than unprompted tutors.

Process data was collected in sessions before and after training, and with or without prompt cards. The reciprocal tutors' explanations were coded as low-level (i.e., knowledge-telling of facts and definitions) or high-level (i.e., knowledge-building with connections between ideas and explaining underlying causes and principles). All tutors initially produced few knowledge-building explanations, and unprompted and inquiry-only tutors tended to produce the most knowledge-telling explanations. After training, sequenced-inquiry tutors generated significantly more knowledge-building explanations and less knowledge-telling explanations, whereas other tutors continued to engage in more knowledge-telling than knowledge-building. This was often true regardless of whether prompt cards were used. After 1 month, the groups no longer differed significantly, but the overall quality of explaining was still improved for all tutors.

Higher education tutors. The same behavioral patterns observed with primary and secondary grade tutors are also seen with college tutors. For example, Graesser and Person (1994) and Graesser et al. (1995) examined a variety of tactics used by student cross-age tutors. Their data were drawn from graduate student research methods tutors (undergraduate tutees; 54 one-hour sessions) and high school algebra tutors (middle school tutees; 22 one-hour sessions). Tutors had no formal tutor training in these domains but were able to successfully tutor their pupils in the study. Both samples were similar in their patterns of behaviors, and were collapsed into one data set. Tutor learning was not assessed in these studies.

To account for the efficacy of the inexperienced cross-age tutors, Graesser et al. (1995) examined whether their tutors naturally used pedagogical moves similar to expert tutors, such as facilitating active student learning, using real-world examples, or Socratic questioning. Evidence for these tactics was sparse. The student tutors were highly directive, setting the agenda for the sessions and topics of discussion, and tutors rarely employed sophisticated tutoring techniques in a deliberate manner. The tutors covered a fairly consistent set of topics, examples, and questions with each tutee. Moreover, these examples were not challenging cases requiring deep reasoning, but concrete examples to demonstrate ideas or formulas. Tutors tended to borrow these examples directly from textbooks or exams.

Within the confines of the tutors' semiscripted lessons, however, scaffolding dialogues occurred in which explanations were further developed. Graesser et al. (1995) noted a five-step dialogue frame: tutor asks a question, tutee answers the question, tutor gives feedback, tutor and tutee elaborate upon the tutee's answer, and tutor evaluates the revised answer. The fourth step is potentially rich in terms of knowledge-building, because the tutors may deviate from their script to revise or generate new explanations. Many of the tactics observed in this phase were fairly shallow (e.g., prompting the tutee for key words, interrupting tutees to insert correct answers, or summarizing main ideas), but the discussions often stretched over multiple turns, with tutors and tutees gradually developing better explanations in small steps. In addition, tutors offered thoughtful explanations in response to tutee errors about 25% of the time. Thus, although the cross-age tutors rarely utilized expert-like tutoring strategies, the interactive scaffolding process may have naturally offered tutors the chance to gradually refine their explanations.

A similar portrait of tutoring was reported by Chi et al. (2001), in which nursing/biology majors taught middle school students about the circulatory system.

These cross-age tutors were knowledgeable of the domain but had little tutoring experience. Tutors were instructed to tutor in whatever manner they preferred to prepare their tutees to answer recall and comprehension questions. Assessment tests showed that tutees improved significantly in their ability to articulate core domain knowledge and draw an accurate model of the circulatory system.

During the sessions, more than half of the tutors' coded behaviors consisted of didactic explanations. Regression analyses showed that these contributed mainly to shallow tutee learning. The main tutor activity linked to deep tutee learning was scaffolding, in which the tutor supported tutees' constructive activities by giving hints, decomposing and modeling skills, asking questions, and giving examples. As noted above, these kinds of scaffolding moves might provide knowledge-building opportunities for tutors. However, tutors' questions and scaffolding combined accounted for only 15% of their statements. Tutors made overt self-monitoring statements only 2% of the time.

The influence of tutor-tutee interactions on tutors' explanations was further explored by Roscoe and Chi (2004), which combined process and outcome data. Tutors were undergraduates with low knowledge about the topic of the human eye and received no training. The peer tutors first learned about the eye by studying a text, and then either taught this material to another student (instructional dialogue) or generated a videotaped explanation that could be later used by a peer to learn the material (instructional monologue). Thus, in the dialogue condition, tutees could influence tutors' explanations via questions and comments. Posttest comparisons revealed that dialogue tutors were better able to define key terms and correctly answer integration and application questions. Thus, interactions with a tutee seemed to support stronger tutor learning.

Analyses of peer tutors' explanations showed that all tutors mainly generated knowledge-telling explanations in which they paraphrased and summarized text facts. These explanations were not significantly correlated with posttest scores. However, dialogue tutors engaged in significantly more reflective knowledge-building than monologue tutors. When reviewing concepts, dialogue tutors built upon prior knowledge by generating new inferences and elaborations. They also sometimes made sense of confusing concepts by thinking aloud in a manner akin to self-explaining. These elaborated reviewing and sense-making activities were highly metacognitive (i.e., contained overt self-monitoring statements) and significantly and positively correlated with measures of fact recall and comprehension. This was the only study that examined tutors' overt metacognitive behaviors in conjunction with learning outcomes.

One study researched the explanations of cross-age reading tutors (Juel, 1996). Low-achieving student-athletes participated in a course in which they worked on improving their reading skills while also tutoring at-risk elementary school children. Tutoring activities during the sessions included reading books with the children, writing short stories and journals, and practicing word and letter sounds. A number of standardized measures were used to assess the tutee performance (e.g., Iowa reading comprehension and listening comprehension subtests and Wide Range Achievement Test). These measures showed that about half of the tutees made gains in reading comprehension, decoding, word recognition, and spelling, but half gained much less. These subgroups were labeled as "successful" and "less successful" tutoring dyads, respectively.

The author hypothesized that successful tutoring dyads would show more frequent scaffolding by the tutors. Their results indicated that the successful tutors indeed gave significantly more scaffolded instruction during discussions of tutees' reflective journals, letter-sound instruction, story writing, and reading comprehension. The amount of scaffolding was positively correlated with tutee reading and listening comprehension scores. Less successful tutors spent less time scaffolding, suggesting that they tutored in a knowledge-telling fashion.

Finally, a study by MacDonald (1994) examined the behaviors of four college tutors who each taught a different subject (chemistry, economics, writing, and critical thinking) to another undergraduate. Analyses focused on five peer tutoring behaviors: initiation of dialogue, replies to an initiation, evaluation of responses, addition of information, and markers (i.e., continuers). Of primary interest is the "addition" category, which described an utterance that "clarifies, illustrates, extends, or elaborates the current topic" (p. 4). For tutors, this category accounted for only 30% of their behaviors. However, analyses did not clearly distinguish between types of explanations that could be categorized as knowledge-telling or knowledge-building.

Discussion. Few studies have quantitatively evaluated both tutor learning outcomes and explaining behaviors, but this research shows that tutors' explanations, when they incorporate elements of reflective knowledge-building, do support more effective tutor learning. Tutors trained to give explanations that include new examples, discuss underlying principles and applications, connect ideas, or otherwise elaborate upon the source materials scored higher than less trained tutors on measures of comprehension, transfer, and delayed recall (Fuchs et al., 1997; Ismail & Alexander, 2005; King et al., 1998). Similarly, Roscoe and Chi (2004) found that some untrained tutors spontaneously monitored their own comprehension and generated knowledge-building explanations when interacting with a peer, which were positively correlated with factual recall and comprehension. Only one study did not replicate these patterns (Ginsburg-Block & Fantuzzo, 1997). However, this is likely due to the combination of distinct behaviors (e.g., explaining and questioning) into a single category.

Despite the benefits of knowledge-building, peer tutors appeared to rely most heavily on knowledge-telling explanations. Tutors tended to give explanations that simply revealed answers, summarized facts, or described procedures with little elaboration or construction of knowledge. This *knowledge-telling bias* was demonstrated by tutors across age, domains, and formats (Bentz & Fuchs, 1996; Chi et al., 2001; Crahay et al., 2003; Fogarty & Wang, 1982; Fuchs et al., 1994, 1996; Graesser et al., 1995; Roscoe & Chi, 2004). Knowledge-telling explanations were linked to significantly lower test scores than knowledge-building explanations (Fuchs et al., 1997; Ismail & Alexander, 2005; King et al., 1998; Roscoe & Chi, 2004).

Another interesting finding was the variability shown in tutors' explaining activities (Bentz & Fuchs, 1996; Fuchs et al., 1994, 1997; King et al., 1998; Ismail & Alexander, 2005). Even with training in knowledge-building strategies, knowledge-telling often occurred more frequently than knowledge-building. Thus, although training positively influenced tutors' behaviors and learning, it was not the only determinant of tutors' activities. Some tutors continued to adopt a knowledge-telling bias even after extensive training, and King et al. (1998) found that the knowledge-telling bias returned when training cues were removed. However, this variability is also seen in the other direction. Some untrained tutors occasionally engaged in spontaneous knowledge-building (Crahay et al., 2003; Fogarty & Wang, 1982; Graesser et al., 1995; Roscoe & Chi, 2004), naturally revising and improving their explanations and knowledge.

Knowledge-telling may have some benefits. Tutors' factual recall might improve by rehearsing the material, and knowledge-telling could be a necessary precursor to knowledge-building. Tutors may need to define basic concepts before delving into deeper topics, and tutors' initial knowledge-telling explanations may provide the catalyst for subsequent self-monitoring and repair. Tutors' explanations can also expose tutees to information they might otherwise lack (VanLehn et al., 2007), and Chi et al. (2001) found that tutors' explanations aided shallow tutee learning. Thus, although an obvious goal is to increase the overall amount of reflective knowledge-building, the total elimination of knowledge-telling is probably not desirable. It is not clear at this time what an optimal ratio of knowledge-telling to knowledge-building would be.

In sum, tutors benefit by generating reflective knowledge-building explanations, but the pervasive knowledge-telling bias limits the potential for tutor learning. Although programs have made strides in overcoming this bias, there is room for improvement. An important challenge for future research is to better understand those tutors who naturally engage in reflective knowledge-building. What factors prompt tutors to adopt productive learning behaviors? One important element, tutors' self-monitoring, has been largely neglected in the literature. However, we have seen evidence that asking and answering questions might support tutor learning and reflective knowledge-building (King et al., 1998; Roscoe & Chi, 2004). In the next sections, we consider the impact questioning activities may have on tutor learning.

The Questioning Hypothesis

Questioning, which refers to both asking and answering questions, is another ubiquitous tutoring activity. Tutors ask questions to introduce topics and to guide and assess tutee thinking. Similarly, tutors must respond to tutee requests for information or clarification and to tutees' expressed confusion. Although these two activities are distinct, both involve making inquiries of the material that may lead to learning. Researchers have hypothesized that asking (Fantuzzo et al., 1989; King et al., 1998) and answering questions (Bargh & Schul, 1980; J. Cohen, 1986; Foot et al., 1990; King et al., 1998; Roscoe & Chi, 2004) should support tutor learning.

We first consider the value of the questions tutors ask to support tutee learning. Tutors can make use of a variety of question types, such as review questions to introduce topics and activate prior knowledge and comprehension questions to assess tutee understanding. Tutors also use questions to provide subtle hints, such as asking, "What about the numerator?" instead of simply telling the tutee that the answer is incomplete. Tutors may stimulate deeper reasoning by asking questions about underlying principles or hypothetical situations (e.g., "What would happen if the denominator was zero?").

Peer tutors' questions are different from the information-seeking questions that are the usual focus of student questioning research (van der Meij, 1998). Student questioning generally follows a pattern in which the student recognizes a contradiction, a lack of information, or otherwise experiences a metacognitive sense of "perplexity" (Graesser & McMahen, 1993; van der Meij, 1994). The student then puts this problem into words, articulating a question to elicit an answer. This formulation process can require organizing and integrating concepts as well as higher order reasoning. Questions may also be self-directed, in which the student draws upon his or her own knowledge to answer the question (Gavelek & Raphael, 1985; Wong, 1985). After receiving or generating an answer, the asker must evaluate the quality of the response and integrate the new information into their existing knowledge.

Research on student questioning, especially self-questioning, has shown positive outcomes for this process, most often when the answers require some reflective knowledge-building (Dillon, 1998; Gavelek & Raphael, 1985; King, 1994; Rosenshine, Meister, & Chapman, 1996; Wong, 1985). Most student questions focus on basic facts and are often posed as yes-or-no verification questions; the student simply requests the confirmation of an assertion she or he already believes is correct. However, questioning is most beneficial when students ask deeper questions that require integration of new and prior knowledge, reorganization of mental models, generation of inferences, and metacognitive self-monitoring. For example, King (1992) has developed a technique in which students use question stems to formulate reasoning questions for themselves or a partner, such as, "What is a new example of . . . ?" or "What do you think causes . . . ?" (p. 113). King found that generating and answering questions based on these stems, either alone or with a collaborative partner, result in higher exam scores.

Tutors do not ask true information-seeking questions (Graesser et al., 1995) because they already know the answers. However, peer tutors may benefit from constructing questions to help tutees think deeply about the material. For example, tutors may devise questions that contrast concepts ("How are these two kinds of problems different from each other?"), apply concepts ("Could you use Newton's Third Law to solve this problem?"), unpack causal relationships ("What would happen if this force were zero?"), and so on. To generate integration and reasoning questions, tutors may have to also reflect upon the fundamental ideas, relationships, and principles needed to produce a correct answer. Thus, question-asking may help tutors further reinforce and organize their own understanding (Fantuzzo et al., 1989; King et al., 1998).

It is also important to remember that peer tutors' domain knowledge is likely to contain gaps and misconceptions because they have only recently or imperfectly learned the material. In some cases, tutors may believe they know the answer to a question and discover that they are wrong. This may often happen when tutors try to ask deeper questions that go beyond the source materials. In this case, the tutor has inadvertently posed an information-seeking question. To the extent that tutors attempt to identify or construct a correct answer to such questions, similar to self-questioning (Wong, 1985), they may experience learning benefits.

It is not clear how often peer tutors pose deep questions, or questions they cannot answer, and so it is uncertain how much tutor question-asking contributes to tutor learning. A potentially more powerful learning and knowledge-building opportunity may arise from responding to tutee questions. Tutors may initially rely on favorite scripted or well-understood explanations and examples, but persistent tutee confusion may force tutors to generate a revised or novel explanation to help their pupil understand. Similarly, tutee questions might indicate areas where tutors' knowledge is flawed. Tutees might become confused because the tutors' explanation is contradictory or incomplete. Thus, tutees' questions may provide a metacognitive cue, or source of cognitive conflict, leading peer tutors to revise their own understanding and knowledge deficits to provide better explanations for their tutees. (Bargh & Schul, 1980; J. Cohen, 1986; Doise, 1990; Foot et al., 1990; King et al., 1998; Roscoe & Chi, 2004).

Answering tutee questions in this manner may be analogous to responding to questions in other settings, such as adjunct questions embedded in text. Research on adjunct questions has examined a number of factors such as the location, amount, and type of embedded questions (Hamaker, 1986). In terms of question type, such research has found that questions prompting for elaboration, inferences, and logical reasoning lead to significantly stronger learning outcomes than shallower factual questions (Andre, 1979; Hamaker, 1986) For example, a recent study by Peverly and Wood (2001) found that inference and main-idea questions inserted into text improved reading comprehension for high school students with reading disabilities.

Other work has examined embedded questions as scaffolding prompts in computer-based learning environments (Azevedo & Hadwin, 2005; Craig, Sullins, Witherspoon, & Gholson, 2006; Davis, 2003). Davis (2003) has used prompts such as "Pieces of evidence we didn't understand very well included . . ." or "In thinking about how these ideas all fit together, we're confused about . . ." to stimulate collaborative partners' knowledge-building and science learning. Their results show that this computer prompting improved students' comprehension of the material. Prompted students also monitored themselves more effectively, generated more principle-based explanations, and integrated new and prior knowledge.

As with questions embedded in text or computer materials, the nature and quality of tutees' questions may impact tutors' explanations. Shallow questions about basic facts ("How many valves does the heart have?") may not elicit reflective or constructive responses from tutors. Peer tutors most likely have a firm grasp of the material at this low level, and so these questions offer little challenge or need for knowledge-building. In contrast, questions that tap deeper reasoning and application ("What would happen if we didn't have valves?") may provide more opportunities for reflective knowledge-building. These questions are probably more likely to touch upon disorganized, fragmented, or misconceived areas of the tutors' subject matter knowledge (King, 1998; Roscoe & Chi, 2004).

Another issue is the obstacle of getting tutees to ask questions at all. Research on question-asking in classrooms has shown that students often ask few questions and even fewer questions that request meaningful answers (Good, Slavings, Harel, & Emerson, 1987). This reluctance to ask questions may stem from students' difficulty with identifying and expressing their confusions clearly, or from fear of social embarrassment by admitting ignorance (Graesser & McMahen, 1993; Graesser & Person, 1994; van der Meij, 1994). These same factors may also affect tutees in the tutoring sessions, limiting the number or quality of questions asked.

In sum, two related questioning activities in peer tutoring, asking and answering questions, could support tutors' engagement in reflective knowledge-building and knowledge-learning. Formulating questions may help tutors reinforce important concepts and relationships. Questions asked by tutees may further prompt tutors to generate or revise their explanations and knowledge. One implication is that responding to tutee questions, especially deeper questions, may help tutors overcome the knowledge-telling bias. However, the overall frequency or quality of questions may be an important obstacle.

Evidence Regarding Questioning in Peer Tutoring

Do tutor or tutee questions predict tutor learning? To what extent do peer tutors or tutees ask questions that support reflective knowledge-building or knowledge-telling? We address these questions in the same manner as explaining, with studies grouped roughly by grade level and learning domain (see also Table 2). Due to the sparseness of research, the following sections consider both tutor and tutee questioning together. Many studies addressed questioning at a very coarse grain size and did not distinguish between different kinds of questions asked or how tutors responded to tutee questions.

Elementary school tutors. In addition to examining tutors' explanations, Fuchs and colleagues have also considered questions asked by reciprocal peer tutors. Fuchs et al. (1997) found that tutors trained to give knowledge-building explanations attained higher test scores and asked more "procedural" questions than less trained tutors. These were questions that focused on problem-solving steps and encouraged tutees to participate. It is not clear whether these were shallow or deep questions. In addition, comprehension-gauging questions were sometimes embedded in tutors' conceptual explanations. Process-only studies by Fuchs et al. (1994) and Bentz and Fuchs (1996) similarly observed that trained tutors asked more questions than less trained or untrained tutors. These studies suggest that training can increase the rate of tutor and tutee questioning, but the effects on different kinds of questions are not clear.

A broader array of questions were examined by Crahay et al. (2003). Several questions were fairly shallow in nature: asking tutees to read/write problem information, perform a computation, or give an answer. These accounted for about 12% of the same-age math tutors' behaviors. In a few cases, tutors prompted tutees to formulate an approach or strategy for solving the problem (6.3%). Such questions could be productive if tutors reflected upon the underlying purpose and fitness of different problem-solving strategies. Tutors also occasionally (3.6%) prompted tutees to express their understanding or confusion, which might be helpful if the tutors simultaneously thought carefully about likely misconceptions or sources of confusion. Overall, questions with potential for deep reasoning were not common in untrained tutoring. The tutees also rarely initiated discussions, expressed misunderstanding, or asked questions of the tutor.

Interesting data on age effects have been obtained in reading tutoring. Fuchs et al. (1999) examined outcomes for second- through fourth-grade reciprocal-reading tutors (high-ability tutors paired with low-ability students) trained to use help-giving strategies. All tutors were taught to summarize main ideas and make predictions about the text. Tutors in the help-giving condition were also taught to use questions to help tutees attend to key characters and events and choose important ideas for summarizing. Scores on the comprehension subtest of the Stanford Diagnostic Reading Test showed that help-giving tutors in the fourth grade scored higher than their less trained counterparts. However, for second- and third-graders, the less trained tutors outperformed help-giving tutors.

Process data examined only the percentage of tutee errors corrected by tutors using the helping strategies. Individual question types or strategies were not coded. For second- and third-graders, use of the strategies was low overall: 0% for less trained tutors and 39% for trained tutors. For the fourth-graders, strategy use was higher: 39% for less trained tutors and 97% for trained tutors. Thus, it seemed that younger reciprocal tutors were less able to implement the questioning strategies, and may actually have found it counterproductive to take on this additional task. Older tutors were able to implement and benefit from the strategies more effectively.

Middle and high school tutors. Middle school and high school tutors also tended to ask few questions or questions that tap deeper understanding. Fogarty and Wang (1982) found that about 21% of their cross-age tutors' behaviors consisted of asking questions, and about 14% of tutees' behaviors consisted of questions. No data was presented on what kinds of questions were asked or how tutors responded to tutee questions.

King et al. (1998) and Ismail and Alexander (2005) directly tested impact of questioning on tutoring and tutor learning. In both studies, same-age, reciprocal tutors were taught to give knowledge-building explanations. In addition, some tutors were further trained to ask review questions to activate prior knowledge and thinking questions to stimulate critical thinking. Written measures of comprehension and recall showed that questioning significantly improved tutors' learning outcomes, especially when tutors (i.e., sequenced-inquiry tutors) were trained to ask questions in a specific sequence: review questions followed by thinking questions. The quality of the reciprocal tutors' explanations also improved, and in both studies the sequenced-inquiry tutors produced more knowledge-building explanations than the other reciprocal tutors.

Analyses of the reciprocal tutors' questioning behaviors showed a related pattern. King et al. (1998) found that all tutors asked very few questions before training. After training, sequenced-inquiry tutors asked significantly more comprehension, thinking, hinting, and probing questions than inquiry-only and unprompted tutors. In light of tutors' explaining and learning patterns, these results suggest that asking and answering deep questions helped to stimulate more knowledge-building explanations. No analyses were presented to directly show how participants responded to each kind of question.

Ismail and Alexander (2005) similarly demonstrated low levels of questioning at pretest, although reciprocal tutors asked some review questions about basic facts. After training, the frequency of thinking questions increased for all tutors, but sequenced-inquiry tutors asked thinking questions significantly more often than inquiry-only and unprompted tutors. Again, these results suggest that deeper thinking questions elicited knowledge-building explanations that contributed to learning. Indeed, Ismail and Alexander (2005) reported a positive correlation ($r = .52$) between the frequency of thinking questions and high-level explanations.

In one of the few studies to address writing tutoring, Duran and Monereo (2005) compared same-age, fixed-role, and reciprocal tutoring with high school tutors. Tutors worked together to write a narrative short story and a review of a book, film, or music album. Analyses of tutors' behaviors focused on the distribution of "collaborative" versus "tutorial" behaviors. Collaborative behaviors included asking questions and building on partners' statements via "splicing." Tutorial behaviors included hints and guiding tutees through problem-solving steps and incorrect answers. Similar to Graesser et al. (1995), Duran and Monereo (2005) found that 82% of the tutoring activities occurred during this cooperative dialogue step. Forty-seven percent of coded messages were splicing statements, 24% were guiding statements, and 10% were hints, but only 4% of tutors' actions were questions. Some differences were found across fixed-role and reciprocal tutoring: Fixed-role tutors engaged in more guided instruction (31%) than reciprocal tutors (18%) and engaged in less splicing (41%) than reciprocal tutors (52%). These results suggest that reciprocal tutoring may have supported more collaborative interactions. However, as with studies in math and science tutoring, question-asking was infrequent overall.

The authors (Duran & Monereo, 2005) also presented a limited sequential analysis of tutoring behaviors. In terms of questions, tutee questions (which accounted for only 12% of their activities) tended to elicit hints and guiding statements from the tutor, which in turn initiated cycles of additional hints, splicing, and guidance from tutors and more tutee questions. Thus, as Graesser et al. (1995) noted, the collaborative step of tutorial dialogues may involve shallow tutor moves but might still help tutors engage the material more deeply as they scaffold tutee learning. Duran and Monereo's (2005) analysis further suggests that tutee questions are an important component of getting these productive discussions started. It is not clear whether different types of questions were more or less effective in this process.

Higher education tutors. Several studies conducted with older tutors corroborate the trends with lower grades. The most comprehensive coding of questions asked during tutoring was reported by Graesser and Person (1994). Approximately 16 question types were identified, divided into short-answer, long-answer, and deep-reasoning categories. Shallow questions included verification ("That equals 9, right?"), completion ("What was the subject population in that study?"), quantification ("How many levels does that variable have?"), and other questions about basic facts. Long-answer questions involved conceptual information and some reasoning, such as definition ("What is an independent variable?") and example questions ("What is an example of a descriptive statistic?"). Deep-reasoning questions included questions requiring reasoning about cause-and-effect relationships, the purpose of solution steps, and contradictions. Examples include consequence ("What would happen if we doubled the slope?") and procedure questions ("How would you counterbalance those conditions?").

Graesser and Person (1994) examined question-asking for graduate school research methods tutors (undergraduate tutees) and high school algebra tutors (middle school tutees). They found that their cross-age tutors asked about 100 questions per hour, and the most frequent were verification (45%), completion (10%), quantification (9%), and procedure (9%) questions. Thus, yes-or-no questions asking for confirmation of an assertion were the most common kind of tutor question. Overall, deep-reasoning questions accounted for only one fifth of tutors' questions. The tutees asked only 25 questions per hour and also tended to ask verification (22%) questions most often, followed by procedural (21%), completion (11%), and quantification (11%) questions. One third of tutees questions were deep-reasoning questions. However, because tutees asked only 25 questions per hour, only 8 deep questions were asked in a typical session.

Cross-age tutors in Chi et al. (2001) asked an average of 63 questions during a typical 2-hour session. Relative to all tutor behaviors, 6% of tutors' statements were questions about the subject matter and 4% were questions intended to assess tutee comprehension. Tutees asked about 7.8 questions per hour, accounting for only 7% of their behaviors.

A few studies have tried to examine how peer tutors respond to tutee questions. MacDonald (1994) considered sequences of several behaviors. For our purposes, "initiations" roughly correspond to questions, and we can treat MacDonald's "replies" as shallow, text-based responses to questions and "additions" as more explanatory answers. Analyses showed that less than 25% of tutors' statements and 20% of tutees' statements were questions. Tutee questions received shallow replies about 55% of the time and tutor additions in less 2% of cases. However, when tutees offered explanations, tutors followed with explanations (27%) more often than shallow replies (<2%), and tutor explanations elicited tutee explanations. Thus, once an explanatory discussion began, it tended to continue.

Only one study has directly examined how tutee questions influenced peer tutors' reflective knowledge-building activities (Roscoe & Chi, 2004). Peer tutoring dialogues were coded to identify tutee questions and their subsequent tutor responses. Each content-relevant question asked by tutees was coded as "deep" or "shallow" depending on whether it contained or required a meaningful inference. Tutors' responses were similarly coded as deep or shallow, and as "metacognitive" or "nonmetacognitive" depending on whether they contained overt self-monitoring statements (e.g., "I'm not sure what that means"). Across all sessions, tutees asked a total of 152 shallow versus 88 deep questions. Only 14% of shallow questions received deep responses, whereas 41% of deep questions received deep responses. Similarly, 21% of shallow questions elicited self-monitoring, but 48% of deep questions prompted tutors to overtly evaluate their own thinking. Thus, the nature of tutees' questions had a meaningful impact on peer tutors' reflective knowledge-building.

Discussion. A few process-outcome studies offer evidence that questioning activities can support tutor learning and reflective knowledge-building. Reciprocal tutors trained to ask and answer integration, application, and reasoning questions outperformed less trained tutors on measures of comprehension and recall (Ismail & Alexander, 2005; King et al., 1998). These tutors also generated more knowledge-building explanations, which suggests that the questions may have elicited these higher level explanations. Similarly, tutors trained to use question strategies to support reading comprehension outperformed less trained tutors, but this was true only for fourth-graders, and not younger second- and third-grade tutors (Fuchs et al., 1999). However, because all these studies involved reciprocal tutoring roles, one cannot determine whether learning was most supported by asking or answering questions when being the tutor or tutee.

Process-only studies examining sequences of tutor-tutee behavior provide suggestive evidence that responding to questions could be helpful for tutors. Duran and Monereo (2005) showed that tutee questions could help to initiate collaborative dialogues in which tutors and tutees worked together to improve answers and explanations (see also Graesser et al., 1995; MacDonald, 1994). Question quality was an important factor. Roscoe and Chi (2004) found that shallow tutee questions elicited shallow tutor responses, but deeper questions helped to support tutors' reflective knowledge-building explanations. Thus, in some circumstances, tutee questions can help to overcome the knowledge-telling bias. No studies have focused on the specific or unique benefits of tutor question-asking.

Another important observation is that tutor and tutee questions seem to constitute a relatively small proportion of their respective behaviors. Various studies show a rate of questions ranging from a low 4% to about 20% for both tutors and their tutees (Chi et al., 2001; Crahay et al., 2003; Duran & Monereo, 2005; Fogarty & Wang, 1982; MacDonald, 1994). In addition, the questions that are asked are mainly shallow rather than deep. Tutors tended to ask questions about basic facts, definitions, or computations more frequently than questions requiring deeper reasoning and reflection (Crahay et al., 2003; Graesser et al., 1995; King et al., 1998). Similar patterns were shown for tutee questions (Graesser et al., 1995; Roscoe & Chi, 2004).

In sum, questioning has strong potential for tutor learning, but tutor and tutee questions tend to prompt for knowledge-telling rather than knowledge-building. As a consequence, most questions in peer tutoring may only serve to reinforce rather than overcome the knowledge-telling bias. A few studies have shown that training in elaborated questioning strategies can sometimes improve the number and quality of questions during the tutoring sessions (Fuchs et al., 1994, 1997, 1999; Ismail & Alexander, 2005; King et al., 1998). However, more fine-grained research on how different kinds of questions support learning, and how tutors ask or respond to such questions, will be needed to further explore these findings.

Summary and Directions for Future Research

The belief that students benefit academically by tutoring has provided a long-standing justification for the use of peer tutoring programs. In support of this assumption, research has shown that there is a replicable tutor learning effect associated with tutoring in various formats, student populations, and domains. However, we also find that the magnitude of these gains are somewhat low. Based on prior reviews (P. Cohen et al., 1982; Cook et al., 1986; Mathes & Fuchs, 1994; Rohrbeck et al., 2003), we roughly estimate an effect size for tutor learning of about .35.

Efforts to improve tutor learning have traditionally focused on program design, leading to the development of a number of successful interventions. Less research has examined tutors' actual behaviors. As a result, the literature says more about *what* interventions work than *why*. For this reason, studies such as those by Fuchs et al. (1997), King et al., (1998), Ismail and Alexander (2005), and Roscoe and Chi (2004) are critical. This research combines quantitative measures of learning with process analyses, allowing us to determine with greater clarity how tutors learn.

Our review of the literature showed straightforward conclusions about tutor learning in regards to explaining and questioning. Peer tutors benefit from explaining when they integrate concepts and principles and generate new ideas through inferences and reasoning. Tutors also need to monitor their own understanding and repair confusions when they arise. Deeper reasoning questions asked by tutees and tutors can help to support this reflective knowledge-building. Unfortunately, peer tutors primarily summarize information with little elaboration or reflection, and students' questions tend to ask about basic facts. Even when trained, some peer tutors seem to focus on *delivering* rather than *developing* their knowledge, often resulting in disappointing tutor learning gains.

We also see interesting variability in peer tutors' knowledge-telling and knowledge-building behaviors. Tutors who receive extensive training in particular strategies nonetheless find ways to modify or undermine these techniques in unexpected ways. Similarly, untrained tutors typically show a knowledge-telling bias but can sometimes engage in impressive reflective knowledge-building activity spontaneously. Such variability may partly explain the wide range of learning outcomes seen within and across tutoring programs. Peer tutors can approach their tutoring tasks in dramatically different ways, and these choices create or inhibit a variety of learning opportunities. For educators, researchers, and parents, these findings underscore how process data can lead to important realizations about the limits and potential of tutor learning, providing stronger foundations for the development of effective future tutoring programs.

Recommendations for Future Research

Available research shows that tutors can benefit from explicit training in knowledge-building strategies. For example, tutors can be taught about the qualities of good explanations and questions and appropriate timing of these instructional activities. The works of Fuchs and King describe such training methods in detail and demonstrate their effectiveness. In keeping with the theme of our review, our concluding sections focus on how tutor learning and process research might be improved and how these data might uncover reasons why peer tutors engage in knowledge-building or show a knowledge-telling bias. In turn, these data might inform new training methods that support the occurrence of knowledge-building. We first offer general recommendations for future research, and then briefly discuss several specific areas for further study and development.

Expanding and improving the research. Evidence from meta-analyses suggests that tutor learning is not uniform across program design variables such as format and domain, but the underlying reasons for these differences are not well understood. In light of Topping's (2005) taxonomy of peer learning design features, it is clear that there is a huge variety of possible tutoring environments. The current literature is unprepared to say how complex interactions between these features affect the process of tutor learning. We thus encourage researchers to conduct process-outcome evaluations as a standard component of peer tutoring research.

A key direction for this research may be studies that analyze and compare behaviors and learning across different program variables, such as tutoring format and structure. For example, Duran and Monereo (2005) found that reciprocal tutoring supported more collaborative interactions than fixed-role tutoring. Reciprocal tutors were more likely to build off of each others' statements, whereas fixed-role tutors took a more directive role, providing hints and guidance to scaffold their partner's learning. Fogarty and Wang (1982) found that middle school cross-age tutors of older elementary school children were more responsive and interactive in their tutoring style than tutors who worked with younger children. More research of this kind may show us how opportunities for tutor learning differ across programs and could help educators decide what forms of tutoring would be best to implement in their circumstances.

A related recommendation is to also collect process data on the behaviors of students in nontutoring control groups. Peer tutors' behaviors may be more or less productive, and this is equally true of students studying alone (Renkl, 1997), working in cooperative groups (Webb et al., 1995), and so on. When tutor learning is measured against nontutoring control conditions, process data from both groups could be helpful in several ways. First, these data may be needed to argue that tutors learn for the reasons they are hypothesized to learn. That is, when tutors outperform controls, we would hope to find that their learning strategies are in some way superior to those of controls (e.g., higher proportion of knowledge-building statements). These data may be even more critical when tutors and controls perform at the same level. Analyses could help to diagnose whether tutors failed to learn due a strong knowledge-telling bias, or if controls learned particularly well because they spontaneously self-explained. A very interesting finding would be if both groups learned equally well but utilized different knowledge-building strategies. The more we can discover about learning opportunities and constraints unique to peer tutoring, the better able we will be to design tutoring environments that specifically support tutor learning.

Finally, in addition to an expanded base of process-outcome research, it will also be crucial to simultaneously strengthen coding methods. We observed several problems related to the level of analysis and inclusiveness of many coding schemes. For example, some studies used broad categories that may have combined distinct behaviors (Ginsburg-Block & Fantuzzo, 1997). As we have seen, explaining and questioning (or other tutoring behaviors) may support learning in distinct ways. Collapsing these behaviors into a single category might obscure their specific or unique contributions to learning. In other studies, key behaviors were coded separately, but different forms of those activities were not teased apart (Duran & Monereo, 2005; Fogarty & Wang, 1982; Fuchs et al., 1994, 1997). Our review demonstrated that explanations and questions can take on distinct reflective knowledge-building and knowledge-telling qualities, with a major influence on learning. Future work may thus need to employ more fine-grained analyses of target behaviors. Graesser and Person (1994) is a good example of how questions can be coded in a meaningfully detailed manner. Similarly, Fuchs et al. (1996) divided explanations into two forms of knowledge-telling (i.e., nonelaborated and procedural) and knowledge-building (i.e., procedural-conceptual and conceptual).

These recommendations are challenging to implement but may be facilitated by building upon coding techniques used in prior studies (Crahay et al., 2003; Duran & Monereo, 2005; Fuchs et al., 1997; Graesser & Person, 1994; King et al., 1998). Replications or extensions of previous methods would help us to compare findings across studies. Researchers are also urged to develop new coding schemes that capture reflective knowledge-building and knowledge-telling aspects of more tutoring activities. It should be noted that many tutoring programs collect learning data for large numbers of students across multiple classrooms, but process data can be drawn from a smaller set of "representative students" from each location. Studies by Fuchs and colleagues are good examples of sample size management and feasibility.

Another possibility for expanding research might be to use teachable agents (Schwartz et al., 2007) to test hypotheses about specific tutor behaviors. We have noted that tutors' and tutees' behaviors can be highly variable. The use of computer-simulated tutees might allow us to exert more control over the tutee side of the interaction. For example, simulated tutees could be programmed to ask only shallow questions or only deep questions, to make few mistakes or frequent mistakes, to have high prior knowledge or low prior knowledge, and so on. Thus, we could assess more carefully to how tutors respond to particular kinds of tutee interaction. One current limitation on this approach is that most teachable agent programs do not support spoken dialogue, which is the canonical medium for human tutoring. However, research on spoken dialogue in tutoring systems is developing rapidly (Litman et al., 2006).

Contexts for explaining and questioning. One way to apply finer-grained analyses to the study of tutor learning is to look more carefully at specific instructional activities, such as using multiple representations or correcting tutee errors. Instead of treating all explanations as one kind, it may be beneficial to tease apart patterns of knowledge-building and knowledge-telling associated with different activities. For instance, we earlier described links between explaining and learning from worked-out examples. With examples, students learn by explaining underlying principles, solutions steps, and operations, which parallels the ways that tutors might use examples in their explanations. However, Graesser et al. (1995) observed that tutors borrowed examples directly from textbooks and reused the same examples across students. Examples involving deeper reasoning and real-world applications were not often selected.

Another interesting context is scaffolding, which we earlier defined as successive tutor-tutee interactions that gradually develop the tutees' knowledge over multiple turns. Although knowledge-telling explanations and questions are predominant, low-level activities might give rise to knowledge-building after several exchanges (Chi et al., 2001; Duran & Monereo, 2005; Graesser et al., 1995; VanLehn et al., 2007). Although little research examined how tutors or tutees responded to each others' questions, a few analyses have shown that tutors' scaffolding moves can stimulate deeper thinking from tutees (Chi et al., 2001), and deeper tutee questions can elicit more elaborated responses from tutors (King et al., 1998; Roscoe & Chi, 2004).

Analyses of tutors' explanations, questions, and learning in specific contexts could have immediate implications for tutor training. By identifying how peer tutors utilize or squander learning opportunities inherent to each context, we can develop tutor training methods that specifically target desirable behaviors and limit less productive behaviors. For example, peer tutors may often avoid deeper examples and may not explain how key example steps are driven by underlying principles and operations. Thus, tutors' reflective knowledge-building and learning may be improved if tutors are trained in concrete strategies for selecting, decomposing, and reasoning with examples with their tutees.

Underlying cognitive skills. Considering the intellectual demands of tutoring, cognitive and developmental variables will likely influence tutors' learning. Fuchs et al. (1994) found that tutors with higher prior achievement offered more sophisticated explanations than students of average prior achievement. This finding suggests that a certain level of background knowledge, or particular cognitive skills, may be needed to fully engage in reflective knowledge-building. However, more research is needed to identify what teachable skills have the most influence on tutors' instructional behaviors and learning. With this knowledge, we could design training methods that simultaneously introduce peer tutors to desired tutoring strategies and support the development of the underlying skills needed to use those strategies effectively.

One concrete example may be metacognitive monitoring skill, the ability to reflect upon and regulate one's own learning progress (Hacker, 1998; King, 1998). To repair or revise their explanations, peer tutors must first be able to detect any mistakes or contradictions that arise. For example, tutors may have trouble answering questions, causing them to reconsider the quality of their own knowledge. Only one study has examined tutors' overt self-monitoring statements embedded in their explanations and responses to questions (Roscoe & Chi, 2004). Their results suggested that self-monitoring contributed to knowledge-building and tutor learning and also demonstrated the feasibility of analyzing tutors' overt metacognitive actions.

However, many students find error detection and comprehension monitoring very challenging (Glenburg et al., 1982; Hacker, 1998; Maki et al., 2005), overestimating how well they know or remember information. Students also have difficulty choosing appropriate strategies for overcoming comprehension failures. It seems very likely that peer tutors will also have such problems. Future research could build upon the results of Roscoe and Chi (2004) by testing additional aspects of self-monitoring, such as the valence (i.e., "I know this" versus "I don't know this") and accuracy of tutors' self-evaluations. One could also examine how tutors respond to these evaluations, to determine whether knowledge-telling or knowledge-building are more likely to occur after particular kinds of self-judgments.

Peer tutors may benefit from learning specific strategies for monitoring their own understanding and choosing self-regulation strategies for addressing errors and misconceptions. Research has shown that self-monitoring strategies are learnable with instruction and practice and benefit learners in nontutoring settings (Bielaczyc, Pirolli, & Brown, 1995; Ghatala, 1986; Palincsar & Brown, 1984). Thus, incorporating such methods into peer tutoring training may be a potentially strong method for supporting the "reflective" component of reflective knowledge-building and, thus, significantly enhancing tutor learning.

As a final consideration, it must be noted that any training based on cognitive skills and strategies will need to take age into consideration. Not surprisingly, several studies have shown that the tutors' age plays a role in their behaviors (Fuchs et al., 1999; Ismail & Alexander, 2005; King et al., 1998; Ludeke & Hartup, 1983; Wood et al., 1995). A difference of just one or two grade levels had an impact on tutors' ability to implement helping strategies in Fuchs et al. (1999). Similarly, high school tutors in Ismail and Alexander (2005) were better able to use reciprocal questioning strategies unaided than were middle school tutors in King et al. (1998). It may be necessary for researchers to directly compare how peer tutors from different age groups implement similar strategies. These data could help us identify aspects of peer tutoring that are more challenging to younger tutors, and then modify strategies to ensure age-appropriateness.

Motivational beliefs. In addition to cognitive and developmental issues, tutors' motivational beliefs may also influence their tutoring activities. Self-regulated learning theory proposes that learners' academic engagement is guided by their self-perceptions and attitudes, and positive correlations have been observed between self-reported strategy use, effort, interest, and self-efficacy (Pintrich, 2003). It makes intuitive sense that tutors' feelings of capability and curiosity may affect how they tutor. High-efficacy tutors (i.e., those who feel they can understand and teach the material) may feel capable of generating deeper elaborations and repairing their own errors and thus more readily do so when opportunities arise. Low-efficacy tutors may skip over difficult topics to avoid failure and embarrassment. Similarly, high-interest tutors (i.e., those who enjoy tutoring or the domain) may find it rewarding to think deeply about the material and share these ideas with tutees. Low-interest tutors may focus on knowledge-telling because they perceive little enjoyment in talking about difficult or boring concepts.

Motivational variables are more typically studied as outcomes rather than predictors. Researchers have hypothesized that tutoring improves tutors' self-efficacy and interest (Benware & Deci, 1984; J. Cohen, 1986; Fantuzzo et al., 1989, 1992; Gartner et al., 1971) but have found mixed results. Benware and Deci (1984) reported that studying with a teaching expectancy increased enjoyment of the material relative to studying for a test, but Renkl (1995) found a decrease in interest and along with an increase in anxiety. Similarly, Fantuzzo et al. (1992, 1989) observed that reciprocal tutors increased in self-efficacy while decreasing in anxiety, but Rittschof and Griffin (2001) were unable to replicate that finding. P. Cohen et al.'s (1982) meta-analysis noted only a moderate positive effect of tutoring on tutors' attitude toward the material (*ES* = .42) and a small effect on self-concept (*ES* = .12).

Few studies have examined the impact of motivation on tutors' behavior. Medway and Baron (1977) found that tutors who felt more capable of helping tutees solve problems (i.e., higher efficacy) exerted more effort toward tutoring. Gabarino (1975) observed that offering tutors a reward based on tutees' performance undermined tutors' interest in tutoring, leading them to be more critical of their tutees, feel less positive about tutoring, and be less effective instructors. Tutors who were not offered a reward reported more enjoyment, were more supportive and patient, and their tutees learned more. Thus, tutors' attitudes and self-perceptions seemed to affect their tutoring behaviors. These results are paralleled by research on "teaching efficacy" (Tschannen-Moran & Hoy, 2001) showing that classroom teachers' sense of efficacy in teaching is associated with more persistence and openness to innovation in the classroom.

The examination of tutors' motivation as a predictor of behavior and learning may help to disentangle prior mixed results regarding motivational outcomes of tutoring. These analyses might also reveal a need for "motivation training" of peer tutors in addition to strategy training. For example, it is likely that novice peer tutors will feel anxiety about their ability to explain challenging concepts, or being responsible for another student's learning. Such worries might be offset by incorporating "efficacy-building" exercises into the training phase of the program. Peer tutors could be given opportunities to practice tutoring on a low-stakes topic, such as how to play a game or about a favorite hobby. Early tutoring successes may increase tutors' perceptions of their own capabilities and give them the confidence to generate their own ideas during tutoring and tackle deeper topics. Thus, just as it is critical to support positive motivational and emotional engagement for tutees (Lepper et al., 1997), and indeed all learners (e.g., Meyer & Turner, 2006), we may also need to attend to tutors' own affective experiences.

Perceptions of tutoring. Peer tutors' perceptions of the tutoring role may also influence their choice of tutoring behaviors (Allen, 1983; Foot et al., 1990; Robinson et al., 2005). Peer tutors are cast in the role of "instructor" and are expected to know the subject matter and guide tutees toward a more accurate understanding. Some tutors might interpret this to mean they should convey the material without embellishment, leading them to develop a knowledge-telling bias. Others may believe that elaboration and self-improvement are vital to promote tutee learning, leading them to engage in reflective knowledge-building. In a review of children's perceptions of teaching (Foot et al., 1990), students focused more on social support (e.g., friendliness, humor, and praise) than instructional factors (e.g., explain clearly and provide variety) and did not include learning-by-teaching as a part of the tutoring role. Thus, some tutors may not perceive the potential or need for tutor learning.

To our knowledge, no study has sought to elicit peer tutors' beliefs about tutoring and link these perceptions to their tutoring behaviors or learning outcomes, but some related work has been done. Bierman and Furman (1981) manipulated the recruitment rationale given to tutors. Some tutors believed they were recruited based on expertise, whereas others thought they were selected based on appearance, at random, or were given no reason. Tutors given a concrete reason (i.e., expertise or appearance) showed a more positive self-concept and attitude than the other conditions. In collaborative learning, Webb, Nemer, and Ing (2006) have shown that peers emulated their teachers' instructional style. Teachers presented calculations and answers rather than elaborated explanations and did not encourage students to verbalize their thoughts and ask questions. When peers collaborated, help-givers similarly focused on giving unelaborated answers, doing the work for their partners, and rarely checking partners' understanding.

Research on peer tutors' role perceptions could help us to discover whether students have beliefs about tutoring that inhibit reflective knowledge-building. Such perceptions might be challenged during tutor training. Peer tutors may need to be encouraged to generate their own examples and analogies, because they believe that they should not digress from the textbook. Another idea may be to explicitly teach tutors that they are able to learn from tutoring. Many students might feel that "good tutors already know everything" and that "only bad tutors make mistakes." By teaching peer tutors that learning from tutoring is possible and desirable, they may be more willing to confront and repair their own knowledge gaps and misconceptions. Peer tutors might even be informed that tutor learning is a required component of good tutoring and that they should actively work to improve their own understanding. Tutors could then model good learning strategies for their tutees, in addition to teaching them the necessary concepts.

Conclusion

Tutor learning is a meaningful phenomenon that further validates peer tutoring as a worthwhile educational intervention. Commonplace tutoring activities, such as explaining and questioning, provide many opportunities for tutors to engage in reflective knowledge-building. Unfortunately, tutors do not always take advantage of these opportunities. By analyzing peer tutors' actual behaviors and their connection to learning outcomes, we may further extend the impact and effectiveness of peer tutoring programs. Future research should also examine how the tutoring and learning process is shaped by program features and student characteristics.

This knowledge can then be used to develop tutor training strategies that target such factors. Research of this nature may lead to immediate and exciting applications for educators and students.

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