The Influence of the Tutee in Learning by Peer Tutoring

Rod D. Roscoe (roscoe@pitt.edu) **Michelene T. H. Chi (chi@pitt.edu)**

Learning Research and Development Center, 3939 O'Hara Street
Department of Psychology, University of Pittsburgh
Pittsburgh, PA 15260 USA

Abstract

Previous research has demonstrated that students can learn by tutoring other students. Tutors are thought to learn because they generate instructional explanations and monitor their own understanding while teaching. We analyzed verbal data from tutorial sessions to explore how the *tutees* influence this process. We found that tutors were primarily responsible for introducing topics, but the tutees stimulated more thorough discussions of topics. We also found that tutee questions influenced tutor explanations and metacognition. Tutor responses to "deep" questions were more likely to contain inferences and self-monitoring than responses to "shallow" questions. In sum, tutees had a significant and positive influence on the tutors' learning activities and opportunities.

Introduction

Peer tutoring and cross-age tutoring are popular and cost-efficient educational interventions in which students provide instruction for other students. One reason for the widespread use of these interventions is their effectiveness – with training, students seem quite capable of successfully teaching each other and younger pupils (e.g. Cohen, Kulik, & Kulik, 1982; Greenwood, Carta, & Hall, 1988). Another reason for the popularity of peer and cross-age tutoring programs is the robust finding that the tutors also benefit academically from the teaching experience (e.g. Allen & Feldman, 1973; Annis, 1983; Cloward, 1967; Cohen et al., 1982; Greenwood et al., 1998; Morgan & Toy, 1970; Rekrut, 1992). Based on such findings, some researchers have advocated reciprocal tutoring programs in which the participating students take turns being the tutor and tutee. In general, these programs are educationally effective (e.g. Fantuzzo, King, & Heller, 1992; Fantuzzo et al., 1989; Fuchs et al., 1997; King, Staffieri, & Adelgais, 1998; Palincsar & Brown, 1984).

Why do students learn by tutoring? Some evidence suggests that tutors learn by generating instructional explanations, which facilitates integration and organization of knowledge. For example, Coleman, Brown, & Rivkin (1997) found that when students were told to teach a peer by explaining, they learned better than students told to teach by summarizing and better than students who did not teach. Similarly, Fuchs et al. (1997) showed that training students to give each other conceptually-rich explanations during reciprocal tutoring was more effective than classroom instruction and reciprocal tutoring without such explanations. Additional evidence indicates that tutoring may also encourage students to engage in metacognitive self-monitoring, which helps learners to detect and repair missing knowledge and misconceptions. For example, King et al. (1998) trained reciprocal tutors to give quality explanations and to ask each other questions that stimulated critical thinking and self-monitoring. They found that these explaining and metacognitive activities resulted in better learning than explaining activities alone. Explaining and self-monitoring have also been shown to improve learning in solo studying (e.g. Chi, 2000; Chi, deLeeuw, Chiu, & LaVancher, 1994) and collaborative learning (e.g. Coleman, 1998; Webb, Troper, & Fall, 1995), which further highlights the efficacy of these activities.

In this paper, we explore the hypothesis that tutees influence the learning activities of the tutors in important ways. In other words, tutors might be able to learn by explaining and self-monitoring, but tutees may affect how and whether these activities occur. One way that tutees may guide the tutorial session is by choosing which topics are discussed and in how much detail, thus creating or limiting opportunities to think about the underlying ideas. Another powerful way in which tutees may influence the learning activities of the tutor is through the kinds of questions they ask. As described above, King (e.g. King, 1994; King et al., 1998) has shown that when students construct and ask each other questions based on high-level question stems (i.e. questions prompting for comparisons, justifications, causes-and-effects, evaluations, etc.), they produce better explanations and learn more effectively. Coleman (1998) has demonstrated very similar findings in collaborative learning settings with students using high-level explanation prompts. Research on naturalistic tutoring has shown that tutees do occasionally ask "deep" questions in tutoring sessions, although the majority of questions are "shallow" (Graesser & Person, 1994). These deep questions, although they may be rare, should stimulate deeper responses.

In order to address these hypotheses about the influence of the tutee on tutor learning, we analyzed tutor learning in a non-reciprocal and naturalistic (i.e. little or no training) tutoring context. This design allowed us to be more sensitive to the benefits and processes of tutoring. In reciprocal tutoring, by definition, students learn from both teaching and being taught, and thus it is almost impossible to assess the specific contribution of tutoring activities to learning in these settings. Similarly, it is possible that when tutoring programs are highly structured (i.e. training on when and how to explain, ask and answer questions, etc.), important aspects of spontaneous tutoring behaviors that positively or negatively impact learning may be obscured.

Method

Background

In a larger study, we compared learning by self-explaining to learning by explaining-to-others. Overall, we found that self-explaining was superior to explaining-to-others on measures of both deep and shallow learning. Self-explaining also seemed to more naturally foster productive learning activities. However, the focus of the current analyses is on the learning outcomes and activities associated with providing instruction for other students.

Conditions

The data we analyze here was obtained from two tutoring conditions. In one condition, a student who had read and studied a text about the human eye and retina (the tutor) taught this information to another undergraduate (the tutee) in a face-to-face setting. In a second condition, a student who had read and studied the human visual system test (the tutor) produced a videotaped explanatory lesson that could be later used by a different student to learn the material (an "anticipated" tutee). The face-to-face tutoring condition can be conceptualized as an "instructional dialogue" whereas the videotape condition can be thought of as an "instructional monologue." The participants received no formal training for the tutoring task. The tutors were simply instructed to explain the text information by "going beyond what the text says." Students in the instructional dialogue condition were encouraged to try to answer the tutees' questions.

Participants

Twenty-four college undergraduate students participated in the instructional dialogue (n = 7 tutor/tutee pairs) and instructional monologue conditions (n = 10 tutors) of the original study. In order to ensure that all participants had low prior knowledge about the learning domain (the human eye and retina), students who had taken certain biology, physiology, and neuroscience courses were not eligible to participate. Participants were paid for their time.

Materials

Human Visual System Text All tutors initially read and studied a short text describing the structure and functions of the human eye and retina. The text was divided into topic-based sections, with each topic presented on a separate page. These topics included both familiar, everyday concepts (e.g. the pupil) and unfamiliar, technical ideas (e.g. refractive properties of the vitreous humor), thereby providing ample opportunities to make connections with prior knowledge and explore new ideas. However, the text itself provided few examples or analogies. The text was accompanied by a labeled cross-section diagram of the whole eye and a schematic diagram of the retina. Prior research has shown that the availability of diagrams can support and stimulate effective explaining (Ainsworth & Loizou, 2003).

Learning Assessments Learning outcomes were assessed using two written measures. For the Definition Test, students provided definitions of key terms. For the Question Test, students responded to short-answer questions testing recall, integration, and application of information. The Definition Test can be viewed as a measure of the students' shallow learning, and the Question Test can be considered a measure of deeper learning. Both measures were scored by tabulating the number of correct and relevant ideas produced.

Procedure

The study was divided into two sessions in order to facilitate recruitment and scheduling of participants. In the first session, the tutors read and studied the text for 30 minutes and then completed both learning assessments (tutor pre-test). It should be noted that the tutors studied the text without foreknowledge of their future teaching task. The purpose of this design was to bypass complications due to preparation-to-teach effects (Bargh & Schul, 1980; Renkl, 1995). The tutees also completed both learning assessments in this phase, but did not have the opportunity to read about the visual system (tutee pre-test). In the second session, the tutors either taught an actual tutee or produced a videotaped lesson (30 minutes duration). Afterwards, the tutors and tutees completed the learning assessments again (post-test).

Coding of Tutor Activities

The tutorial sessions of the dialogue and monologue conditions were transcribed and segmented according to changes in the topic of discussion. These segments formed the boundaries of episodes, which were categorized by the type of learning activity that occurred. Several different activities were observed and are briefly described below.

Summary In "basic" summaries, the tutor paraphrased the current contents of the text without elaborating on the text ideas. In "elaborated" summaries, the tutor paraphrased the text, but also provided additional information or inferences not contained in the text. Neither type of summary was significantly correlated with learning outcomes.

Review In "basic" reviews, the tutor reviewed previously discussed information without elaboration. In "elaborated" reviews, the tutor reviewed previously covered material, but also provided new information and inferences. Elaborated reviews were highly metacognitive (i.e. students monitored themselves for understanding and accuracy) and positively correlated with learning outcomes.

Sense-Making In sense-making episodes, the tutor generated inferences and integrated text concepts in order to address a perceived misconception or one's own curiosity. Sense-making episodes were highly metacognitive (i.e. students monitored themselves for understanding and accuracy) and positively correlated with learning outcomes.

Analyses and Results

Tutor and Tutee Learning

Our results indicated that the two tutoring conditions were not equally effective for learning (Table 1). Tutors in the instructional dialogue condition performed better than tutors in the instructional monologue condition on post-test measures of shallow learning (Definition Test) and deeper learning (Question Test), although only the Definition Test difference was statistically significant after controlling for pre-test differences, $F(1,14) = 9.22$, $p = .009$.

In order to establish that the dialogue tutors were effective instructors, we compared the tutors' final scores to their tutee's final scores. For both tests, the tutees performed almost as well as their tutors, suggesting that the tutors were mostly successful in teaching their pupils (Table 1). Neither difference was significant. Although the tutees learned somewhat less than the tutors, it is still quite impressive given that the tutees were exposed to the material only once (the tutoring session) and never read the text.

Table 1: Mean Definition Test and Question Test scores.

Measure	Monologue Tutors	Dialogue Tutors	Dialogue Tutees
Definition Test	21.3	33.0	27.5
Question Test	20.2	28.0	25.4

Spontaneous and Elicited Tutor Activities

These learning outcome differences were paralleled by the extent to which the tutors engaged in episodes of integrative and metacognitive activity (Table 2). Overall, the dialogue tutors produced more elaborated review and sense-making episodes than monologue tutors, $F(1,14) = 5.47$, $p = .035$ and $F(1,15) = 16.22$, $p = .001$, respectively. No other differences were significant.

Table 2: Overall mean frequency of episodes.

Episode Category	Monologue Tutors	Dialogue Tutors
Summary		
Basic	10.5	13.0
Elaborated	4.4	5.4
Review		
Basic	3.1	6.3
Elaborated	0.2	1.7
Sense-making	0.4	3.7

In order to examine this finding more closely, we further distinguished between activities that the tutors self-initiated and activities that were elicited by the tutee. An episode was coded as "tutee-initiated" if the tutee selected the topic or asked a question leading the tutor to engage in some activity. All other episodes were categorized as "tutor-initiated". All of the monologue tutors' activities were counted as tutor-initiated because no tutee was present.

The pattern of episode frequencies (Table 3) suggests that tutors in both conditions preferred to summarize the text, while tutees in the dialogue condition elicited most of the reviewing activities. Direct comparisons of the mean frequencies of tutor and tutee-initiated activities confirmed this impression. Dialogue tutors initiated significantly more basic and elaborated summaries than dialogue tutees; $F(1,12) = 8.2$, $p < .05$ and $F(1,12) = 8.3$, $p < .05$, respectively. However, the tutees initiated significantly more basic and elaborated reviews; $F(1,12) = 7.5$, $p < .05$ and $F(1,12) = 5.3$, $p < .05$, respectively.

Table 3: Mean frequency of tutor-initiated and tutee-initiated episodes.

Episode Category	Monologue Tutor-Initiated	Dialogue Tutor-Initiated	Dialogue Tutee-Initiated
Summary			
Basic	10.5	9.7	3.3
Elaborated	4.4	4.7	0.7
Review			
Basic	3.1	1.3	5.3
Elaborated	0.2	0.2	1.5
Sense-Making	0.4	2.3	1.4

The critical difference between the monologue tutors' activities and the tutor-initiated activities of the dialogue tutors was in the occurrence of sense-making episodes; $F(1,15) = 4.5$, $p < .05$. No other difference was significant. Tutors engaged in sense-making when they realized that they had a flawed or incomplete understanding of some concept and needed to revise their own knowledge. Thus, in addition to eliciting productive reviewing of the material, the tutees seem to also directly and indirectly facilitate the tutors' recognition and repair of their own misconceptions. Perhaps the tutee's misunderstandings and questions served as a signal to the tutor that the tutor's explanations were incorrect or unclear, and this realization spurred the tutor to engage in sense-making in order to understand the material better and to be a more effective teacher.

In sum, these results provide evidence that tutors in non-reciprocal tutoring settings, and with minimal training, can learn from generating instructional explanations and self-monitoring. However, when tutors provided instruction to an actual tutee, they learned and explained more effectively. Thus, it appeared the tutees did in fact contribute to the tutors' learning activities in meaningful ways. In the next sections, we explore two hypothesized mechanisms for this influence, topic selection and tutee questions.

Topic Coverage

One way that tutees may guide the tutorial session is by choosing which topics are covered and how much time is spent on those topics. Topics that receive more thorough consideration should be better learned. To examine the coverage of topics in the tutoring sessions, each episode was coded by whether it contained a novel topic (i.e. topic was

introduced in that episode) or whether it contained a continuation of a previous topic. A continuation episode could contain a review or elaboration of the topic, and thus represents a deeper or more thorough discussion (Table 4).

Overall, we observed a clear pattern in which the tutors were primarily responsible for introducing new topics in the tutoring session (76% of novel episodes were tutor-initiated), whereas tutees stimulated much of the subsequent discussion of topics (61% of continuation episodes were tutee-initiated). This pattern was statistically significant; $\chi^2(1,N=349 \text{ episodes}) = 50.0$, $p < .001$, and indicates that tutees directly influenced opportunities for tutors to delve more deeply into the text information by selecting topics for review or elaboration.

Table 4: Introduction and continuation of topics of discussion by tutors and tutees.

Topic Selector	Novel Topic	Continued Topic
Tutor	134 (76%)	67 (39%)
Tutee	42 (24%)	106 (61%)
Totals	176	173

Tutee Questions and Tutor Responses

Another important mechanism by which tutees might influence the learning activities of the tutor is through asking questions. By asking deeper questions, tutees may stimulate a more enriched discussion and higher quality tutor explanations, which should facilitate learning.

Because the episodes used in previous analyses could contain multiple tutee questions, we re-segmented the dialogue tutoring protocol data using "question-response exchanges" as the unit of analysis. A "question" was defined as an interrogative statement in which the tutee requested information (or verification of information). For the purposes of this paper, we excluded questions that were not directly relevant to the content (i.e. questions about task procedures or off-topic issues were not counted). A "response" was defined as any information or feedback (or lack thereof) provided by the tutor in answer to the question.

Tutee questions were then labeled as either "shallow" or "deep." A deep question was one that either required the tutor to generate an inference or contained a tutee-generated inference that the tutor had to evaluate. A shallow question was one that did not contain or require any information beyond the text contents. Tutor responses to these questions were similarly coded as "shallow" or "deep," depending on whether they contained inferences or novel elaborations of the text. Tutor responses were further classified as being "metacognitive" or "non-metacognitive," based on whether they contained self-monitoring statements (a statement such as "I don't know that" or "This is easy to remember").

Out of a total of 240 content-relevant questions asked across the seven dialogue tutoring pairs, 37% (88 questions) were classified as deep and 63% (152 questions) were shallow. Our results indicated that shallow questions were much more likely to receive a shallow response, but deep questions were equally likely to elicit a deep or shallow response (Table 5). In other words, deep questions were more likely to receive a deep response (41%) than were shallow questions (14%). It was fairly rare for a question to be ignored (receive no response). The overall pattern was significant; $\chi^2(2,N=240 \text{ questions}) = 26.1$, $p<.001$.

Table 5: Tutee questions and subsequent shallow or deep tutor responses.

Question Depth	No Response	Shallow Response	Deep Response	Totals
Shallow	15 (10%)	116 (76%)	21 (14%)	152
Deep	12 (14%)	40 (46%)	36 (41%)	88

Analyses of self-monitoring in tutor responses to tutee questions showed a similar pattern (Table 6). Shallow tutee questions tended to elicit non-metacognitive responses. However, the tutees' deep questions elicited metacognitive responses from the tutors about half the time. This pattern was significant; $\chi^2(1,N=240 \text{ questions}) = 20.8$, $p<.001$.

Table 6: Tutee questions and subsequent metacognitive or non-metacognitive tutor responses.

Question Depth	Metacognitive Response	Non-Metacognitive Response	Totals
Shallow	32 (21%)	120 (79%)	152
Deep	42 (48%)	45 (52%)	88

In order to confirm that tutor responses to deep questions were both deep and metacognitive (rather than one or the other), we cross-tabulated tutors' shallow versus deep and metacognitive versus non-metacognitive responses (Table 7). This analysis generally confirmed that deep, inferential responses were more likely to contain self-monitoring statements. Shallow responses were more likely to be non-metacognitive. This pattern was significant; $\chi^2(1,N=212 \text{ responses}) = 43.3$, $p<.001$.

Table 7: Tutors' deep and metacognitive responses

Response Type	Metacognitive Response	Non-Metacognitive Response	Totals
Shallow	29 (19%)	127 (81%)	156
Deep	37 (66%)	19 (34%)	56

In summary, the nature of the tutees' questions had an substantial impact on the subsequent integrative and metacognitive activities of the tutors. When tutees asked shallow questions, the tutors responses were frequently shallow and non-metacognitive. However, when tutees asked deep questions that contained or required an inference, the tutors were more likely to respond with a deep and metacognitive response.

Examples of Question-Response Exchanges

The following excerpts demonstrate how these processes occurred in a tutorial session. In the first example, a tutor and tutee are discussing the blind spot in the retina. The tutor summarizes background information and the tutee follows up with a deep question that leads the tutor to generate a novel analogy. The text provided only a structural description of the blind spot with no analogies.

Tutor: This is the blind spot [points to diagram]. You can't see anything there because that's where the optic nerve leaves the eye. So there aren't receptors right there. (paraphrase)
Tutee: Okay, wait. The blind spot is where all the nerves are located? (shallow question)
Tutor: Yeah. Like, that's where all of the optic nerves come together. They go all around and that's where they all pull together and go back to the eye. Or back to the brain. So right there, there aren't any receptors. (shallow, text-based response)
Tutee: So how does that affect your vision? (deep question)
Tutor: If something comes in and your lens refracts it to that point then you don't see it. (new inference)
Tutee: Oh, okay.
Tutor: So, it's just like when you're driving and there's that little spot in the mirror where you just won't see the person behind you. It's like that, except for the eyes. (deep response; novel analogy)

In the second example, a tutor and tutee are talking about the relationship between the iris and the pupil. The tutee's deep question causes the tutor to engage in sense-making activity, drawing on her prior knowledge in order to visualize and better understand these eye components. The text only discussed how the iris/pupil regulates the amount of light that can enter the eye, but did not describe how the iris reacts to light.

Tutor: The iris is the colored part of your eye. And it can expand or contract radially or circularly (paraphrase).
Tutee: What's radially? Like outward? (shallow question)
Tutor: Um. It explains that on the next page [skims text]. Yeah. That's outward. And when the radial muscles contract, the pupil gets larger. (shallow, text-based response)
Tutee: Okay. So, pretty much… contract is to make it smaller. So wouldn't the iris get smaller? (deep question)
Tutor: *Oh*. That makes so much sense now. Yeah. Like when your iris gets smaller, your pupil gets bigger. Like when someone's coming out of dark room or they get surprised. Your pupil gets really big and your iris gets really small. (new inference; draws on prior knowledge to visualize)
Tutee: Mm hmm.

Missed Opportunities for the Tutors

It is important to note that the mapping between tutee question quality and tutor response quality was far from perfect. About half of the tutees' deep questions failed to elicit a deep, metacognitive response from the tutor.

There are several potential explanations for this problem. One explanation is that the tutee's deep question contained an obvious inference and the tutor did not feel it was necessary to elaborate. Another explanation is that the tutor evaded the question because he or she did not have the requisite knowledge to answer it. A third reason might be that the tutor did not recognize the depth of the tutee's question. Chi, Siler, & Jeong (in press), have shown that even adult, non-peer, tutors often fail to diagnose a tutee's understanding. In all cases, the tutors miss out on an chance to build on their existing knowledge, fill knowledge gaps, or remediate errors – to learn, in other words.

The following excerpt provides an example of one of these missed opportunities. In this example, a tutor and tutee are discussing light refraction and the role of the cornea and lens in that process. The tutee asks two deep questions about the function of the cornea. Unfortunately, the tutor cuts this potentially productive exchange short rather than attempting to repair his knowledge gap.

Tutor: I'm going to talk about refraction, which is bending of the light. Most of it is done with the cornea [points to diagram]. But there's additional light bending done through the pupil. Or through the lens, I mean. And this is changed by altering the thickness of the lens. (paraphrase)
Tutee: The cornea doesn't change at all? (deep question)
Tutor: The cornea just stays the same. (new inference)
Tutee: Okay. Then how is it responsible for 70% of the focusing power? (deep question)
Tutor: I don't know. It doesn't say. (expresses ignorance and misses opportunity to repair this knowledge gap)

Conclusion

Previous research has established that students benefit academically from teaching other students. These learning outcomes have most often been attributed to the tutors' generation of instructional explanations and metacognitive self-monitoring while teaching. However, these mechanisms have been relatively understudied outside of reciprocal tutoring settings, which confound the benefits and processes of tutoring and being tutored. The analyses presented in this paper provide some converging evidence from a non-reciprocal tutoring setting that students learn by teaching due to explaining and self-monitoring activities. In addition, these behaviors were unstructured, indicating that tutors can learn even without a great deal of support and training (although well-structured interventions probably support more efficient and consistent learning behaviors).

Our findings show that the tutees played a very important role in shaping the learning activities and learning opportunities of the tutors. Although tutors paraphrased the text and introduced many of the topics discussed in the tutoring sessions, tutees stimulated much of the reviewing activity in which topics were covered more thoroughly. Tutees also directly and indirectly facilitated sense-making activities in which the tutors became aware of their own misconceptions and then attempted to repair them. These

elaborated reviewing and sense-making activities were likely guided by the kinds of questions that the tutees asked. Shallow questions tended to receive shallow and non-metacognitive responses from the tutors. However, deep questions asked by the tutees provided an important (if not always consistent) impetus for integrating ideas, generating inferences, and self-monitoring. More research is needed to understand how and why "missed opportunities" occur.

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