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Exploring the Relationships between Perceptions of Tutoring and Tutoring Behaviours: A Focus on Graduate Students Serving as Peer Tutors to College-Level Chemistry Students

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It has been established that both tutors and tutees gain from tutoring sessions. However, tutors' benefits may be enhanced or limited depending on the type of behaviours they perform during the tutoring sessions. Although behaviours enhancing both tutor and tutee learning can be promoted by training, generalized tutor training models that are often used do not take into account tutors' preexisting perceptions of tutoring, which may guide their instructional behaviours. The goals of this multiple-case study of three chemistry tutors are to characterize their perceptions of tutoring, their behaviors during tutoring sessions, and the connections between their perceptions and behaviors. Data was collected through interviews in which tutors' perceptions of tutors and tutoring were probed and through video recordings of three to four sessions for each tutor. Interviews were analyzed using a thematic analysis approach. Video recordings of sessions were analyzed using a list of codes corresponding to different types of behaviours that had been reported in prior tutoring studies. Analysis of the interviews indicated that tutors' perceptions of tutoring did not overlap fully across all the three tutors. Cross-case analysis indicates that tutors' perceptions of tutees and of the role of tutor were reflected in the instructional behaviours the tutors enacted during the sessions. The results of this study may be used to improve tutor training programs, particularly through examining individual tutor's perceptions of tutoring as this may help anticipate natural instructional preferences of tutors.

Introduction

Historically, peer tutoring has been defined across cultures as students learning from other students (Allen, 1983). Today, tutoring is omnipresent at the college level and plays a critical role in supporting the success of undergraduate students in chemistry (*e.g.* Bailey, 2010; Ding and Harskamp, 2010; Krajcik and Yager, 1987; Webster and Hooper, 1998). In the United States, undergraduate students enrolled in chemistry courses often have free access to tutors through formal channels such as the Peer-Led Team Learning programme (Gafney and Varma-Nelson, 2007) and institutional learning centres where students may ask teaching assistants for help with specific assignments outside of class (Bailey, 2010). However, they may also hire a private tutor for a small hourly fee. These private tutors are upper-level undergraduate students majoring in chemistry or chemistry graduate students. They are conducting this private tutoring independently of the department. The agenda for the tutoring session depends on the tutee's and tutor's pre-arranged agreement.

Despite the presence of tutoring on college campuses and within chemistry departments, few studies have investigated processes associated with positive impacts of tutoring in chemistry at the postsecondary level. Most tutoring studies have been conducted at the K-12 level and have focused on reading and mathematics. Moreover, studies on processes of tutoring have often been conducted under controlled, experimental conditions using tutors with low content knowledge (*e.g.* Chi, Siler, Jeong, Yamauchi, and Hausmann, 2001; Ismail and Alexander, 2005; King, Staffieri, and Adelgais, 1998; Roscoe and Chi, 2004) rather than more naturalistic settings with knowledgeable tutors and curricula and behaviours not controlled by external entities.

Most processes studies have been focused on identifying tutors' and tutees' effective behaviours. However, it has been suggested that tutors' perceptions of tutoring can influence how tutors behave during tutoring sessions (Foot, Shute, Morgan, and Barron, 1990) and that the relationship between perceptions and behaviours should be further explored (Roscoe, 2007; Roscoe and Chi, 2007, 2008). The present study addresses this suggestion by investigating the relationship between chemistry tutors' perceptions of tutoring and their instructional behaviours during tutoring sessions.

Behaviours underlining tutoring effectiveness

Extensive research on peer tutoring has demonstrated its positive effect on both the tutees (Cohen, Kulik, and Kulik, 1982; Fantuzzo, King, and Heller, 1992; Topping, 1998; Topping, Peter, Stephen, and Whale, 2004) and the tutors (Cohen *et al.*, 1982; Roscoe and Chi, 2007, 2008). Roscoe and Chi (2007) have labelled the latter outcome the tutor-learning effect. Interestingly, meta-analyses conducted on this effect have measured small effect sizes and identified inconsistencies

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between studies (Cohen *et al.*, 1982; Cook, Scruggs, Mastropieri, and Casto, 1985; Mathes and Fuchs, 1994; Rohrbeck, Ginsburg-Block, Fantuzzo, and Miller, 2003). Roscoe and Chi (2007, 2008) have argued that these results can be explained by studying the behaviours tutors enact during tutoring sessions. In particular, they identified two categories of behaviours based on their reviews of studies exploring the relationships between tutor behaviours and tutor learning: knowledge-telling (KT) behaviours and reflective knowledge-building (KB) behaviours (Fuchs, Fuchs, Bentz, Phillips, and Karns, 1996; Roscoe, 2007; Roscoe and Chi, 2008). The act of providing unelaborated confirmatory feedback would be considered knowledge-telling for example as this behaviour may not require the tutor to build on or restructure their ideas (Roscoe, 2007). However, tutors may engage in knowledge-building behaviour by elaborating upon a tutee's response, which require the tutor to retrieve and reframe their understanding of the topic to fit the answer provided by the tutee (Graesser, Person, and Magliano, 1995). Studies have shown that KB behaviours are linked to tutor and tutee learning while KT behaviours only result in shallow learning for tutees (i.e., learning of factual knowledge) and no learning for tutors (Roscoe, 2007; Roscoe and Chi, 2007, 2008). Moreover, other studies have demonstrated that tutors typically use KT over KB behaviours (Bailey, 2010; Berghmans, Neckebroeck, Dochy, and Struyven, 2013; Ismail and Alexander, 2005; Roscoe and Chi, 2007). These results suggest that chemistry tutoring sessions could be more effective for both the tutor and the tutee if strategies to promote tutors' use of KB behaviours could be identified.

Although there is evidence that tutor behaviours can be influenced by training (Bailey, 2010; de Smet, van Keer, de Wever, and Valcke, 2010; Fuchs, Fuchs, Bentz, Phillips, and Hamlett, 1994; Ismail and Alexander, 2005; Kofod, Quinnell, Rifkin, and Whitaker, 2008), research in this area also indicates that training is not always effective. For example, it has been demonstrated that without reminders of their training, tutors have a tendency to shift away from the prescribed practices and revert to more familiar teaching methods, such as straight explanations of the material (Dufrene, Noell, Gilbertson, and Duhan, 2005; King *et al.*, 1998). One possible reason for this rather underwhelming effect of training programs on tutor behaviours may come from their structure. These programs, which are often run at the institutional level, cater to a diverse population of tutors and thus have a tendency to provide general tutoring guidelines and best practices (Bailey, 2010; de Groot and Button, 2008, Topping, 1988). Moreover, these programs typically do not take into account prospective tutors' perceptions of tutoring, even though these perceptions may drive tutors towards certain behaviours (Allen, 1983; Foote *et al.,* 1990; McKellar, 1986). Therefore, chemistry tutoring sessions could be more effective for tutors and tutees if tutor training programs leveraged chemistry tutors' perceptions of tutoring, as these may influence tutors' use of KB behaviours (Roscoe, 2007; Roscoe and Chi, 2007).

Tutors' perceptions of tutoring

Four components of tutor's perceptions of tutoring have been investigated in the literature: their perceptions of their role as tutors and the purpose of tutoring (Bailey, 2010; Colvin, 2007; Galbraith and Winterbottom, 2011; Moore, 2009), characteristics of effective tutors (Jelfs, Richardson, and Price, 2009; Xiao, 2012), characteristics of tutees (Bailey, 2010), and characteristics of effective tutoring (Falchikov, 2001; Lepper, Drake, O'Donnell-Johnson, 1997; Topping, 1996; Wood, Bruner, and Ross, 1976).

In general, tutors see themselves as providers of academic help to students in need; in particular, they feel that they should give feedback to students and assess their knowledge (Bailey, 2010; Colvin, 2007; Galbraith and Winterbottom, 2011). Tutors often attributes themselves many roles. For example, high school biology tutors in Galbraith and Winterbottom's (2011) study identified themselves as "setting an example (for their tutees), easy to communicate with, being an authority figure, a motivator, and a friend." However, this diversity of role perceptions may cause some role strain and role confusion which in turn affect their actions during the tutoring sessions (Colvin, 2007).

Jelfs *et al.* (2009) investigated perceptions of effective tutoring by 457 college students and 602 tutors using a survey containing 51 descriptors of good tutors; these included "a good tutor gets students to interact" and "a good tutor is an expert in their subject." A factor analysis on these descriptors revealed different set of factors for the students and the tutors. Tutors' factors included *active learning, transmission of knowledge*, *supporting learning, subject expertise*, *pastoral care* (*i.e.* caring for students), and *vocational guidance*. The latter three factors were common to those identified with students but also included *critical thinking* and *promoting interaction*. Interestingly, they found differences in the distribution of tutors across these factors. For example, science tutors were more likely to value *student support* and over *transmission of knowledge* when compared to humanities tutors. Similar factors were found in Xiao's (2012) study, where tutors' and students' perceptions of the tutor's influence on students' motivation to learn English in a distance-learning university environment were unpacked through essays.

Bailey's (2010) study did not directly examine chemistry tutors' perceptions of their tutees, but these were revealed extemporaneously during the interviews. The 'walk-in', or non-appointment tutors described their tutees as lacking in critical knowledge, being unprepared for the tutoring sessions, and unaware of what they do not know. In contrast, the appointment-based 'learning centre' tutors were not as explicit with describing their tutees, instead describing strategies that may address tutees' deficiencies, such as taking the lead if the tutee was not prepared.

There are several gaps in the literature regarding tutors' perceptions of tutoring. First, it has been found that tutors' perceptions of tutoring vary with disciplines. Unfortunately, only one of the aforementioned studies (Bailey, 2010) have been conducted explicitly on chemistry tutors; the other studies were concerned with other science domains (Galbraith and Winterbottom, 2011; Jelfs *et al.*, 2009), communications

(Colvin, 2007), language (Xiao, 2012), and dentistry (Moore, 2009). Second, some of the aforementioned perceptions of tutoring were not directly addressed. For example, much of the literature on the characteristics of effective tutoring is focused on observations of what makes tutoring effective (e.g. Lepper et al., 1997, Wood et al., 1976) or establishing a learning environment conducive to it (e.g. Falchikov, 2001; Topping, 1996) rather than tutors' perceptions. Finally, few studies (Bailey, 2010; Moore, 2009) have investigated tutors' perceptions as determinants of tutoring behaviours.

Conceptual framework

Practical theories are complex conceptual and belief networks that constrain instructional practices (Beijaard and Verloop, 1996; Buitink, 2009). They include beliefs about teaching and learning, the roles of the instructor and students, as well as knowledge of instructional methods, and their role in teaching specific content (Buitink, 2009). All instructors, independent of their level of experience, enter a teaching environment with personal practical theories. They have been developed through various avenues such as experiences as students, reflections on own or others' teaching, and experiences as instructors in various settings (Beijaard and Verloop, 1996). The similarities between teachers' and tutors' practical theories are intuitive since tutoring is often considered as an offshoot of teaching (Allen, 1983; Colvin, 2007).

The conceptual framework that guided the design and analysis of this study (Fig. 1) contextualize the relationship between practical theories and instructional practices in tutoring. The main thrust of the framework is that tutors' perceptions of tutoring influence their assumed role (Moore, 2009), which, in turn, affect the enactment of their role (Allen, 1983; Bierman and Furman, 1981; Foot *et al.*, 1990; Roscoe and Chi, 2007). Based on the work of Roscoe and Chi, we focus on the relationship between tutoring perceptions and two different types of tutoring behaviours, KT and KB, since these behaviours have been previously connected to enhanced learning for both tutors and tutees (Fuchs *et. al.*, 1994; Fuchs *et al.*, 1996; Ismail and Alexander, 2005; Roscoe and Chi, 2004).

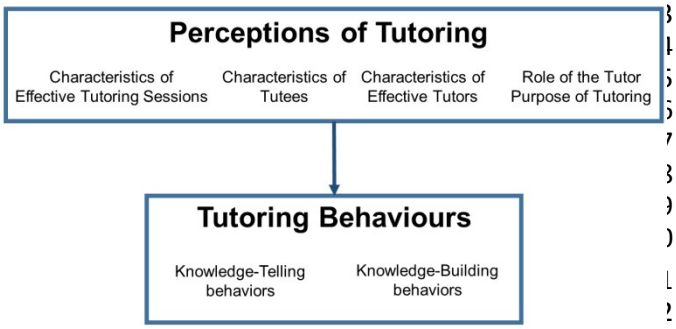

Fig. 1 Conceptual framework

Purpose of the study

The goal of this study was to characterise untrained chemistry tutors' perceptions of tutoring and examine the extent to which these perceptions are related to their behaviours during tutoring sessions. In particular, the research questions for this study are:

1. What are tutors' perceptions of tutoring?
2. To what extent do tutors' perceptions of tutoring relate to their behaviours?

The findings from this study may aid in making chemistry tutor training programs more effective by providing a way for trainers to predict natural behavioural tendencies of future chemistry tutors based on an assessment of their tutoring perceptions. Tailoring the training to address these natural tendencies (either enhance them if productive or diminish them if unproductive) may result in enriched learning experiences for both tutors and tutees.

Methods

Methodological approach

The study took place at a research-intensive university in the Midwestern United States. Chemistry tutors were recruited through direct e-mail contact. Emails were obtained from bulletin boards and list that tutors use to advertise their services. We chose tutors who were not part of a structure (e.g., tutoring program) in order to capture the natural behavioural tendencies, uninformed by training. This population will help us capture the clearest link between perceptions of tutoring and behaviours during tutoring sessions. Consent was obtained from both tutors and tutees as required by the approved Institutional Review Board protocol. Pseudonyms are provided to protect their anonymity.

A multiple-case study approach (Yin, 2009) was used in this study to examine the processes of tutoring across different contexts that are similarly bounded (Miles and Huberman, 1994, p. 29). In this study, each case (Table 1) was bound by the participating tutees and the courses that they were taking when the observations were made.

Study participants

The study was limited to a convenience sampling method due to the voluntary nature of tutoring. Three tutor-tutee(s) pairs agreed to participate in the study. Characteristics of the tutors are provided in Table 1. The tutees were students enrolled in the general or organic chemistry courses offered at this institution.

Data collection

Roscoe and Chi (2008) suggested that the connections between role perceptions and behaviours may be explored through the use of interviews of tutors and observations of tutoring sessions. We chose this approach and added one short survey.

Tutor	Gender	International student	Tutor training	Graduate level	Tutoring experience	Teaching experience
Chuck	Male	No	No	2nd	1.5 years	1 year (Laboratory)
Patricia	Female	Yes	No	2nd	0.5 years	1 year (Laboratory)
Trent	Male	No	No	3rd	3 years	3 years (Laboratory, recitation)

Table 1 Characteristics of tutors

Tutors were first asked to respond to an online survey which provided us demographics and background information regarding prior tutoring experience and training (Table 1). The tutors were then interviewed using questions adopted and modified from Colvin (2007) and Hall, Draper, Smith, and Bullough (2008). The following is a partial list of questions from the semi-structured interview protocol that examined different aspects of their perceptions of tutoring (see Appendix A for the complete list of questions and interview materials):

- What is tutoring?
- What is the role of the tutor?
- What are the characteristics of good/bad tutees?
- What are the characteristics of good/bad tutoring sessions? (characteristics of effective tutoring sessions)
- What are the characteristics and actions of good/bad tutors?

Each interview lasted 45-60 minutes and was carried out before the first video-recorded session.

The tutoring sessions, which typically lasted 60 minutes, were video recorded. In order to minimize the researchers' influence on behaviours, tutors and tutees were not given tutoring topics or behavioural cues. Reaction to the presence of the camera or research team (Albrecht, 1985) was decreased through the use of small video cameras. Most tutoring sessions took place in a small interviewing room, which contained a circular table, four chairs, and a whiteboard.

Analysis

Interviews were coded to identify emerging patterns (Miles and Huberman, 1994). Two researchers independently coded the interviews to address reliability of code definitions, and a coding dictionary was compiled in order to increase the dependability of the results (Patrick *et al.*, 2011).

Observation videos were analysed using a coding dictionary compiled from studies on tutoring behaviours; these include explanations (Graesser and Person, 1994), feedback (Chi *et al.*, 2001), questions (Lang, Dumais, Graesser, and Kilman, 1992; Lehnert, 1978), and scaffolding behaviours (Chi *et al.*, 2001). Each code was classified as KT or KB. Appendix B provides the list of codes and their classifications. For example, behaviours in which tutors provided elaboration onto confirmatory feedback was coded as KB feedback, as this involves further construction of knowledge (Graesser, Person, and Magliano, 1995), while unelaborated feedback (e.g., you are correct) was coded as KT feedback since it did not require more explicit construction (Roscoe, 2007). However, some behaviours could not be characterised as KB or KT (Appendix B3), such as common ground questions, which ask how well the tutee has understood or could follow the material (Graesser and Person, 1994). Moreover, explanations and elaborated feedback were further categorized as *conceptual*, *procedural*, *factual*, and *bridging* (Appendix B4). For example, statements are considered as procedural if tutors engage students with algorithmic steps for problem-solving (Fuchs et al., 1994). In contrast, *bridging* statements are coded if tutors connect procedural statements to conceptual underpinnings of the material. Videos were coded by two researchers to address reliability.

Inter-rater reliability for interviews and observations were measured using pooled kappa (de Vries, Elliott, Kanouse, and Teleki, 2008). A pooled kappa above 0.80 was achieved for both sets of data.

Results

Before presenting individual cases, we first identify the prevalent types of behaviours that were observed across all tutoring sessions and follow with a presentation of the results for each individual case.

Prevalent behaviours

Table 2 Dominant behaviours observed across all sessions; percentages describe average percentage of tutor behaviours across all tutoring sessions

Tutor	Types of tutor behaviour					
	Explanation	Feedback	Question	Metacognition	Scaffolding	Other behaviours
Chuck	*27% ± 17%*	*28% ± 11%*	*24% ± 5%*	6% ± 3%	8% ± 5%	7% ± 5%
Patricia	*53% ± 5%*	*9% ± 3%*	2% ± 1%	*29% ± 8%*	4% ± 4%	2% ± 1%
Trent	*27% ± 6%*	*32% ± 5%*	9% ± 3%	12% ± 5%	*18% ± 5%*	2% ± 1%

Tutor	Tutee(s)	Subject	Session	Topics
Chuck	1 male	General chemistry	C1	Molecular geometry, Lewis structures, polarity
			C2	Molecular geometry, Lewis structures, hybridisation
			C3	Phase diagrams, crystal structures
Patricia	1 male	General chemistry	P1	Ideal gases
			P2	Molecular orbital theory
			P3	Molecular geometry
Trent	2 females	Organic chemistry	T1	No specific topics
			T2	
			T3	
			T4	

Table 3 Characteristics of recorded tutoring sessions

The analysis of the frequency of occurrence of tutoring behaviours across all sessions observed revealed that providing explanations and feedback were two of the top three prevalent behaviours for all three tutors (Table 2). This result is aligned with prior studies (Chi *et al.*, 2001; Graesser et al., 1995; Moore, 2009). The third most prevalent behaviour varied by tutor (Table 2) and included questioning, being metacognitive, and scaffolding.

Chuck

Chuck, a second year graduate student with some tutoring experience (Table 1), was tutoring a General Chemistry student (Table 3). Session 1 (C1) and session 2 (C2) took place on consecutive days, and session 3 (C3) occurred three weeks after C1. Topics for each session are presented in Table 3.

Tutoring approach. Chuck required his tutee to email him questions or problems he was struggling with before the tutoring sessions. He then used this information to prepare by reviewing the appropriate content or solving the provided problems himself. He highlighted that he adjusts his level of effort to match the one of the tutee. During the tutoring sessions, he likes to sit side-by-side with the tutee so that they can both see what each other is writing.

Perceptions of tutoring.

Purpose of tutoring and role of tutor. Chuck believed that the purpose of tutoring is mainly to help students better understand the material. In particular, he emphasized that his role is to promote conceptual understanding rather than performing tasks: "understand what they're doing instead of just getting the homework done." However, he also mentioned that he and his tutee would be "trying to get as many [homework problems] done as possible." This appearing contradiction may be explained by his recognition that his role depends on the students' reasons for taking the course:

Chuck: "If it's like a low-requirement, like just like a pre-requirement for their degree, then just get through the class. If they're a chem major, get them to understand it."

He thought that tutors should provide students with different approaches to solving problems, make them comfortable with the material so that they may be able to work on their own, and help them develop an appreciation of the content:

Chuck: "hopefully, they're comfortable with the material they're expected to know, you know, for their final, and … I guess kind of appreciate it, you know, know why we're doing it, why it's important..."

He asserted that he was also there to answer his tutees' questions and thought that tutees may improve their performance on exams by reproducing the skills learned during tutoring sessions.

Perceptions of tutees. Chuck asserted that they should prepare themselves for tutoring by looking over the material; if a tutee was "going at it cold," tutoring may not be as effective and they may not be receptive to the material. Also, students should be "willing to learn," which includes being willing to do problems on their own, ask questions of material that they do not understand, and to not expect to be "fed the answers."

Characteristics of tutoring. In Chuck's opinion, tutoring is effective because it is focused on one student. This 1:1 ratio allows tutors to become familiar with their tutees' needs and adapt their tutoring approach accordingly. Effective tutoring according to Chuck happens when everything "clicks":

Chuck: "I mean the person just, you know, gets to a point where I don't really have to explain much 'cause I like it when people really understand things ... either that or have them, not understand something but then kind of find their way with … little … guidance; … kinda have them realize it's not that bad to guess and then figure it out, you know? So it's kind of one where I'm not as … involved, kinda have them … figure it out and realize for themselves that it's not really that bad."

These characteristics of effective tutoring somewhat align with his perceptions of the purpose of tutoring, with regards to developing the tutee's autonomy.

Characteristics of effective tutors. Chuck felt that good tutors are approachable. It is important to him that tutees feel comfortable asking him any questions:

Chuck: I "tell them, even if you think it's a stupid question, it's OK to ask; I mean, I'm, like, you hired me for a reason, I'm here, you know, to answer your questions. I'm hoping that I'm easy to talk to and they're not, I guess, afraid of sounding stupid."

Other characteristics of a good tutor according to Chuck included being knowledgeable of the content and flexible with scheduling. Interestingly, he highlighted how limited understanding of the content can become problematic when tutoring. In particular, he explained that he may not be able to implement one of his

Session	Tutor's speech dominance*	Type of tutor behaviour					
		Explanation		Feedback		Question	
		% total codes	Subtype†	% total codes	Subtype†	% total codes	Subtype†
C1	87%	24%		30%		30%	
C2	69%	12%		38%		22%	
C3	94%	45%		17%		21%	

† **Subtype:** Knowledge-telling Knowledge-building Common ground question Hint

* **Tutor's speech dominance** = number of characters spoken by tutor/number of characters spoken by tutor and tutee

Fig. 2 Chuck's behaviours across all sessions

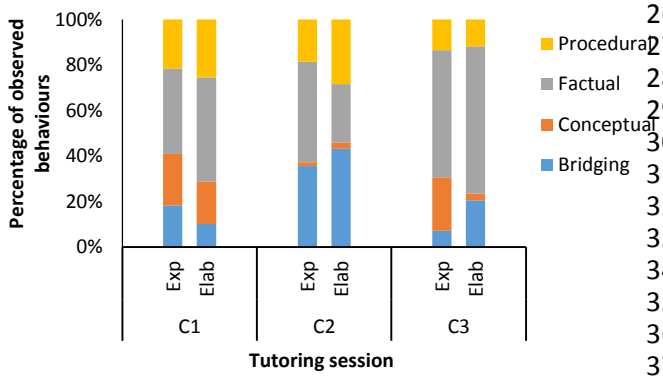

Fig. 3 Types of explanations and elaborated feedback provided by Chuck during each tutoring session. 'Exp' and 'Elab' represent explanations (KT and KB) and elaborated feedback (KB), respectively

instructional strategies, i.e. showing different problem solving approaches, with content he is uncomfortable with:

Chuck: "Some things are more difficult to explain, something that I probably, you know, don't understand as well as other things; … it's known as a challenge 'cause you might not know as many different ways to teach it. You might have learned it one way, but it's all you know…so it will be more difficult [to come up with other approaches]."

Tutoring behaviours. Fig. 2 provides an overview of Chuck's dominant behaviours (explanation, feedback, and question) for each session in terms of speech dominance and the proportion of subtypes (KB/KT, etc.) of behaviours. Speech dominance was calculated by dividing the number of characters in the transcript corresponding to the tutor's speaking turns by the total number of characters in the transcript. This was carried out to mitigate the effects of speech pace and variability of turn length. Other studies have used similar measures of speech dominance. For example, Rosé, Bhembe, Siler, Srivastava, and VanLehn (2003) used number of words. Percentages of explanations, feedback, and questions were proportions of the number of tutoring behaviours coded as the aforementioned. The pie charts illustrate the proportion of explanation, feedback, or question behaviours as KB, KT, or as common ground and hints with regards to questions.

His conversational dominance and the type of behaviours he enacted varied from session to session (Table 2). During the first session (C1), Chuck dominated the conversation. He was teaching his tutee about molecular geometry and hybridization through examples. He walked through all possible molecular geometries of each electronic geometry up to octahedral by asking the tutee to go through the same sequence of steps for each example: the tutee is first asked to draw Lewis structures (counting valence electrons, calculating formal charges, finding electron configurations, filling in orbitals, and identifying geometry) and then determine the hybridization of the central and outer atoms (promote electrons, identify and count sigma/pi bonds, combine/draw orbitals). This session includes a mixture of explanations, close-ended questions (KT under questions and common ground questions), and elaborated feedback (KB under feedback), all from Chuck (Fig. 2). Most explanations and elaborated feedback in this session are factual and procedural (Fig. 3).

In the second session, Chuck asked his tutee to solve the molecular geometries of several structures. Compared to C1, he was behaving as a guide on the side in C2 as demonstrated by the drop of conversational dominance from 87% in C1 to 69% in C2 as well as the sharp decrease in the number of explanations (from 24% in C1 to 12% in C2) and increase in feedback (from 30% in C1 to 38% in C2). Moreover, the majority of feedback is unelaborated (Fig. 2). Chuck's explanations and elaborated feedback are largely focused on helping the tutee understand the concepts behind the process of determining molecular geometry as demonstrated by the high proportion of bridging explanations/elaborations (Fig. 3). The following excerpt provides an example of this focus on conceptual understanding:

Chuck: So (the hybridization of those bonds) would be?
Tutee: That would be pi.

Chuck: Pi bonds, right. So this means that, since we have 4 sigma bonds, they'll be equivalent, right, so that's why here we made 4 sp^3 hybrids, because those are all the same types of bonds.

The third session addressed new topics that were independent of the topics covered during the first two sessions (Table 3). In this session, Chuck largely dominated the conversation (Fig. 2). He took on a lecture approach as demonstrated by the larger percentage of explanations, limited feedback, and larger proportion of common ground questions (Fig. 2); most explanations and feedback contained factual information (Fig. 3).

Perceptions of tutoring and observed behaviours. Chuck's tutoring behaviours align in some aspects with his perceptions of tutoring and do not in others.

First, his perceptions that the purpose of tutoring and his role as a tutor are to promote tutees' conceptual understanding were not fully reflected in his behaviours. Conceptual explanations and bridges between concepts and procedures comprised less than half of the explanations and elaborated feedback across all tutoring sessions (Fig. 3).

Second, although he made the assertions that tutors should be adaptive with their instruction and that tutoring should allow students to approach problems from different angles, his instructional tactics did not support these assertions. This was evident in C1 and C2, in which the tutee was given similar molecular geometry questions to solve using the same method. On the other end, this strategy was aligned with his perception that students' ability to repeat skills learned during tutoring sessions will lead to higher performance on exam. He may thus intentionally use the same approach to ensure that the tutee is able to reproduce it on an exam.

Third, the change in Chuck's approach in C3 seems to be influenced by weaknesses in his understanding of the materials. In C1 and C2, Chuck demonstrated command of the materials: he provided problems for his tutee to solve, and clear explanations without hesitations:

Chuck: (regarding AX5 geometry) Because, think of it as like steric, the things are like squished, so we remove one that would give us the most space in return. Right, so in here, you look at the picture, they remove the top one, right, because there's, um, there's 90 degrees right here, so that's the one that's the closest to it, right, so that would remove the top one first. (C1)

However, in C3, he defaulted to a lecture-style instruction, did not provide problems, and commented, on several occasions, about his lack of understanding certain aspects of the materials:

Chuck: "Yeah, I don't know if I can really explain this one to you to be honest"

He also seemed to have difficulties providing explanations:

Chuck: "So if you want, you can actually figure out this 52%, right, so let's say you have a box, give the box a dimension, right, you know, call it, like, one. Then, express the cube, express the sphere as a, you know, a function of it, right? So if you look at this one, right, uh...this might actually be pretty, I'm a little bit rusty on the, on the, uh, on the actual packing efficiency of the, the volume occupied, again if you break it down, you can figure it out."

These behaviours are aligned with his description of the role of content knowledge mastery and tutoring: a tutor with limited content knowledge may not be able to provide the tutee with different explanations or approaches to solving problems.

Patricia

Patricia is a second year, international graduate student with little tutoring experience (Table 1). For the observed sessions, she was tutoring a General Chemistry student (Table 3). Patricia's sessions were irregular; the first and second session (P1 and P2) were approximately five weeks apart, while the second and third session (P2 and P3) were five days apart.

Tutoring approach. Patricia's preparation for tutoring was based on her tutee's requests, such as homework or aid with lab questions. In the case of homework, she attempted the homework herself before the session. She often made quizzes for the tutee to take during their sessions, and these quizzes were made to supplement the material being covered.

Perceptions of tutoring.

Purpose of tutoring and role of tutor. Patricia believed that the purpose of tutoring is to help students keep up with the course content as they may have missed or misunderstood some information provided during class as well as enhance students' grade and understanding of the content. She explained that tutoring provides a partner for the tutee to learn from and that it can help the tutee develop into more independent problem solver. She saw her role as helping tutees with the content in two differ ways: one, by telling them about content they do not know:

Patricia: "I think tutoring is … not teaching, but telling what you know and to the, to the student, or to another person who doesn't know much more than you. I think it's not teaching, but something, uh, something like you know something, you know more things than the other person and just telling them."

Second, by providing guidance and validation to students on their ways of thinking about the content:

Session	Tutor's speech dominance*	Type of tutor behaviour					
		Explanation		Feedback		Metacognition	
		% total codes	Subtype†	% total codes	Subtype†	% total codes	Subtype†
P1	95%	59%		8%		20%	
P2	95%	50%		12%		30%	
P3	93%	51%		6%		37%	

† **Subtype:** Knowledge-telling Knowledge-building Attention Comprehension Memory

* **Tutor's speech dominance** = number of characters spoken by tutor/number of characters spoken by tutor and tutee

Fig. 4 Patricia's behaviours across all sessions

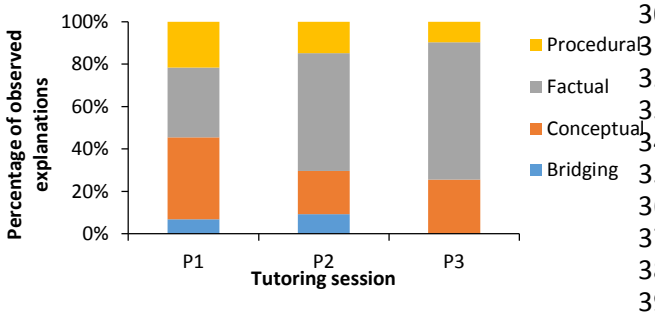

Fig. 5 Types of explanations and elaborated feedback provided by Patricia during each tutoring session. 'Exp' and 'Elab' represent explanations (KT and KB) and elaborated feedback (KB), respectively

Patricia: "… sometimes that means they don't, um, that doesn't mean they don't know the thing, but they have a different idea, but they don't know whether they should, so they will exchange ideas to, tell you, uh, how I can do this, whether I can do this, it's right or wrong, so sometimes I'll exchange my ideas to them."

She also mentioned that her role is to assist with students' homework and laboratory reports.

Characteristics of tutees. Patricia believed that tutees should be prepared for tutoring, but she did not specify how the tutee may do so apart from being ready for the quiz that she provided for the session. She also felt that tutees should review what was accomplished during the session after the session. During her interview, she described tutees as lacking content and mathematical knowledge and that the latter can become an hindrance to the tutoring process. Interestingly, she perceived she contrasted Chinese students to students of other nationalities:

Patricia: "I have 2 students, one is a Chinese student, and one is not American, but I don't know what's the nationality of this student. So, I, for the Chinese student, I know that, in China, they just teach us directly, so they don't ask them questions, um, so I always, I just teach them how to do this. But for the other student, I always ask them questions to let them think. Because I think they can know, they can figure out by themselves, if I can give them some suggestions, some hints for the questions, so I always teach them different ways."

Characteristics of tutoring. With regards to effective tutoring, she asserted that tutoring should allow for the exchange of ideas and that a session where only the tutor speaks is not effective. She felt that both tutor and tutee should learn from tutoring:

Patricia: "I think sometimes they can teach me some things, I, you know, someone has, everyone has their own ideas, but they should learn something new from others, so they always give me some ideas, which way I can teach in, uh, other lab or recitation."

Finally, she indicated that effective tutoring encourages students to understand the knowledge rather than relying on memorization:

Patricia: "I think the student … remembers these formulas … these definitions, but they can't use these definitions or formulas to their questions. So I think a good tutoring is to let them learn, not remember."

Characteristics of effective tutors. Apart from being knowledgeable, Patricia described effective tutors as energetic, willing to help, and able to communicate well. They should be able to monitor their tutee's progress during the tutoring session and keep track of content coverage in lecture and the laboratory. She also felt that tutors should be prepared to answer their tutee's questions and not "figure out the questions during the tutor session". Her perception that tutoring should help develop student's autonomy in problem solving was also reflected in her description of effective tutors: Tutors should "let the student figure out basic chemistry

problems by themselves." Interestingly, she thought that the effectiveness of a tutor is measured by his/her tutee's grades.

Tutoring behaviours. Patricia seemed to exhibit consistent behaviour across all sessions (Fig. 4): she lectured the tutee on the various topics addressed in the sessions. This lecturing style is demonstrated by the high speech dominance (over 93% of total characters in the transcripts were own by Patricia in any given session) and the nature of her behaviours: she provided mostly KT explanations (Fig. 4) and a third (P1) to two thirds (P2 and P3) of these explanations were factual (Fig. 5).

The other dominant type of behaviour, metacognition, was dominant by a specific subtype, i.e. calls to attention, which accounted for 16%, 19%, and 26% of all behaviours observed in P1, P2, and P3 respectively. These calls to attention often referred to what 'they,' the problem- or exam-writers, may require the students to know, such as the values of STP, or perform, such as writing electron configurations. Although these instances of behaviours were not interactive in nature, these may still be considered as KB behaviours as these require tutors to evaluate and make judgments on what they deem as important information (Roscoe, 2007).

Apart from behaviours illustrated in Figure 4, Patricia assigned quizzes to her tutee in P1 and P2. However, she provided limited feedback on the tutee's performance in each quiz. For example, after completion of the quiz in P1, Patricia does not confirm whether the tutee was correct or not, instead moving into an explanation on how to solve the gas law problems.

Perceptions of tutoring and observed behaviours. It seemed that Patricia's perceptions of tutoring and her behaviours were dissonant. In her perception interview, Patricia indicated that an effective tutor and tutoring session provided an opportunity for the tutee to exchange ideas with a knowledgeable peer and to become independent. She had clearly stated that an ineffective session was one where only the tutor talked. However, in all three sessions that were observed, she largely dominated the conversation, which left little room for the tutee to share his ways of thinking about the material. Moreover, the explanations she provided throughout the sessions were mostly factual and thus not promoting students' understanding, even though she had stated in her interview that behaviours that encourage memorization should be avoided. Highlighting to students what is important for them to know and what they should be able to do as she did extensively also reinforce rote learning. Patricia's limited feedback on her tutee's quizzes also illustrated the dissonance between her perceptions and behaviours; although she felt that she provided validation and opportunities to "exchange ideas," she would return to her usual mode of tutoring without providing clear feedback on the tutee's performance.

Interestingly, she had mentioned in her interview that she adapted her instructional style to her perceptions of her tutees' instructional preferences. In particular, she had indicated that since Chinese students are often taught directly, she typically told them about the materials rather than asking them questions. The tutee in these sessions was Chinese and thus her behaviours reflected these perceptions. Although there was little behavioural evidence in this study that supported her perceptions of the tutoring role as interactive, this should not be taken as evidence against her perceptions of interactive peer tutoring since we were not able to observe her with tutees from other nationalities.

Trent

Trent is a third year graduate student with extensive teaching and tutoring experience (Table 1). In the session we observed, he was tutoring two students about organic chemistry. He was the only tutor in this study to have more than one tutee in the same session. Trent's tutoring sessions were mostly regular; although the first sessions (T1 and T2) were almost one month apart, while the last three sessions (T2, T3, and T4) were one week apart of each other.

Tutoring approach. Trent does not typically prepare for his tutoring sessions. He asked his tutee for questions or difficulties they have with each aspect of the course (lecture, laboratory, assignment) and address these in turn during the sessions. During the observed sessions, he spent a significant amount of time drawing molecular structures on the whiteboard in front of the tutees. This contrasted with the other tutors in this study who were seated at a table, close to their tutees for the entirety of each tutoring session.

Perceptions of tutoring.

Purpose of tutoring and role of tutor. Trent perceived that the purpose of tutoring is to supplement course components (e.g., lecture, recitation) by reinforcing topics introduced in these settings. In particular, he thought that tutoring is intended to provide an opportunity for students to ask clarifying questions. He felt that students may not ask questions in class because of concerns about how other students may perceive them; however, he thought that the relationship developed between the tutor and the tutee makes it easier for tutees to share their struggles. Overall, he thought that tutoring is intended to help students develop conceptual understanding and study skills. He expected that these gains would lead to greater students' success on standardized exams such as the national medical test.

Trent: "I think that we should be trying to achieve with them ultimately learning how to review the material correctly, how to study for something and ultimately just to pick up some of these concepts because some of them are important and they will become important in classes that they will take in the future."

Session	Tutor's speech dominance*	Type of tutor behaviour					
		Explanation		Feedback		Scaffolding	
		% total codes	Subtype†	% total codes	Subtype†	% total codes	Subtype†
T1	57%	22%		33%		25%	
T2	56%	35%		25%		16%	
T3	51%	22%		36%		17%	
T4	65%	29%		33%		14%	

† **Subtype:** Knowledge-telling Knowledge-building Executing skills Complete reasoning Other

* **Tutor's speech dominance** = number of characters spoken by tutor/number of characters spoken by tutor and tutee

Fig. 6 Trent's behaviours across all sessions

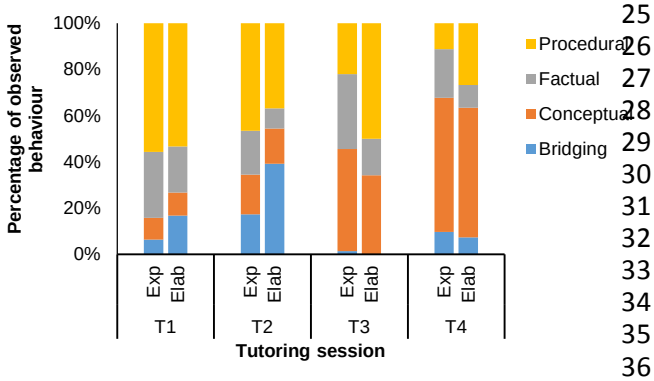

Fig. 7 Types of explanations and elaborated feedback provided by Trent during each tutoring session. 'Exp' and 'Elab' represent explanations (KT and KB) and elaborated feedback (KB), respectively

Trent felt that his role was to address the tutee's questions by providing examples and problems related to the object of confusion for them to work on. Through the process of solving these new problems, the tutor can identify the tutee's strengths and weaknesses and help them developed the latter. He felt strongly, however, that it was the responsibility of the tutee to identify their questions as the following interview excerpt illustrates:

Trent: "But ultimately they [tutors] are just there to answer a question and it's all up to the tutee to guide where they need help because as a tutor you don't have time to observe them and watch them do your homework and so it's up to them, that a little bit of extra effort and say "we get this. I need more practice on this, can you help me with this example."

Characteristics of tutees. Trent felt that tutees should be prepared for tutoring by having identified their strengths and weaknesses and, as a consequence, come with many questions. They should not expect to solely be given answers. He perceived ideal tutees as those with personalities that are conducive to his views of tutoring. He felt that tutees that are more introverted may be more afraid to ask for help, which could make tutoring more difficult in two ways. First, as the tutor, he would not be able to actualise his role of answering tutees' questions. Second, if the tutee was not able to ask questions, the tutoring
session would not progress as the tutee would not be able to guide him towards his/her learning needs.

Characteristics of tutoring. Trent's perceptions of effective tutoring aligned with his views of an ideal tutee and his goals for tutoring. He described the characteristics of an effective tutoring session in the following manner:
Trent: "I guess a good tutoring session is one in which the student is prepared because if they're not prepared, it really bogs down your time because they're like 'well I just need my answers' on a homework […] so, a good characteristic of a tutor session then would be, uh, lots of questions. And so they're asking questions, their curiosity sparked, you're really getting the juices flowing, so to speak, and they really are interested in what's going on, and they wanna learn more."

Characteristics of effective tutors. He characterized effective tutors as knowledgeable, good communicators, approachable, and interested in helping students. Knowledge and communication skills aid with effective tutoring in that students may lose confidence in tutors that do not have a strong grasp of, or the ability to succinctly deliver the material. If a tutor was not able to deliver the material properly, such as through poor penmanship or by quickly shifting between topics, tutees may not be able to clarify their concerns and may confuse them further, thus defeating the purpose of

tutoring. Finally, he thought that an effective tutor should monitor tutee's understanding throughout the session.

Tutoring behaviours. Fig. 6 illustrates Trent's top three dominant behaviours across all sessions. Although his dominance was closer to parity, it should be noted that there were two tutees, so some portion of instruction time was conversation between the tutees (M=4%; SD=1%). Trent's tutoring sessions were guided by his tutees' questions and requests, many of which came from materials provided by the tutees, such as lecture reviews and laboratory assignments, as well as topics that they wished to address that did not have accompanying class material. Trent responded to his tutees by guiding them through problem-solving, reasoning and evaluating their answers on problems that they had solved before coming to his tutoring sessions, as well as providing explanations for important concepts, such as differences between substitution and elimination reactions. This structure for his tutoring sessions resulted in him using primarily explanations, feedback and scaffolding move throughout all four sessions as Table 2 indicates. Most explanations were considered KT as these were tutor-initiated (Roscoe and Chi 2007). Feedback alternated between elaborated (KB) and non-elaborated (KT) responses (Fig. 6).

The nature of the questions provided by the tutees led Trent to use different types of explanations and elaborated feedback (Fig. 7). During the first two sessions, tutees were mostly requesting help on various types of procedures: how to use the IUPAC nomenclature (T1), draw Newman projection (T1), to draw chair conformations (T1), calculate free energy (T2), and interpret spectra (T2). However, in the last two sessions, they requested help on concepts: how to determine if something is a good nucleophile (T3), determine minor and major products of a reaction (T3, T4), and to stabilize a carbocation with hydride and methyl shifts (T3); they also asked Trent to provide an overview of substitution and elimination reactions (T4). This shift from procedural to conceptual requests is reflected by the shift from procedural to conceptual explanations and elaborated feedback provided by Trent (Fig. 7).

Perceptions of tutoring and observed behaviours. Trent's behaviours were fully aligned with his perceptions of tutoring. Trent perceived that the goal of tutoring is to answer questions provided by the tutees and this is exactly what was observed in the sessions. The questions answered were all directly tied to content tutees had seen in the lecture and laboratory component of the course, also supporting his perceptions that tutoring is intended to supplement a course. Interestingly, there was a larger variation in the type of explanations and elaborated feedback he provided across the sessions when compared to the other two tutors. It seems that this variation was due to the nature of tutee's inquiries.

Cross-case analysis

What are tutors' perceptions of tutoring?

All tutors identified the enhancement of student conceptual understanding of content taught in student courses as the general purpose of tutoring. However, they perceived their role differently. Patricia and Chuck described their role as teacher of knowledge and skills while Trent described his role as question seeker (i.e., he expects his tutees to come to the tutoring sessions with questions that they formulated themselves).

All three tutors characterized good tutees as students who come prepared to the session, having identified the help they need. Trent and Chuck highlighted that students should not expect to have the tutor do their assignments for them. Patricia was unique in identifying that tutees have different instructional preferences.

They described differently the characteristics of an effective tutoring session. Patricia and Trent preferred interactive sessions in which tutee and tutor are constantly exchanging questions, answers or ideas. Chuck, on the other end, described an effective session as one where the tutee makes progress under limited guidance from the tutor.

Finally, the characteristics of an effective tutor that Patricia, Chuck and Trent provided all related to their character: they felt that an effective tutor is approachable, knowledgeable, and communicate well. Trent and Patricia added they s/he should be interested in the tutee's success. Patricia was the only tutor who provided pedagogical characteristics: an effective tutor should monitor their tutee's progress and have them solve problems on their own first.

To what extent do tutors' perceptions of tutoring relate to their behaviours?

Analyses across the three tutors of the relationship between their perceptions of tutoring and their behaviours during tutoring prompted us to make the following claims: 1) their perceptions of their tutees and 2) their perceptions of their role as tutor were related to their instructional behaviours.

Claim 1: Tutors' perceptions of their tutee were related to their instructional behaviours. Chuck and Patricia's behaviours during their tutoring sessions can be explained by statements about their tutee made during the interview. Patricia's didactic approach can be directly connected to her statement about preferences of Chinese students for expository teaching style. Even though she recognized during the interview that this approach is not the most effective, it seems that she valued more her perceptions of her tutee's preferred instructional style. Chuck indicated during this interview that he adapted his approach to his tutee's reasons for taking the course: if the tutee takes the course as a general education requirement, the focus is on passing the course while if the tutee majors in the course, the focus is on developing understanding. His tutee fits into the former and Chuck focused the first two sessions on drills with a clear goal for the tutee to be able to replicate these drills on an exam. He did not provide different approaches to solving these problems neither conceptual explanations even though he described these behaviours as part of his role as a tutor. For both of these tutors, their

perceptions of their tutees outweighed their perceptions of effective practices and influenced their behaviours during the sessions. In both cases, it led to more KT behaviours than would be expected from their descriptions of effective tutoring behaviours.

Claim 2: Tutors' perceptions of their role as tutor were related to their instructional behaviours. All three tutors saw their role differently: Patricia described her role as a dispenser of knowledge (e.g., telling them what they should know and lecturing about content they are confused about), Chuck as a skill builder (e.g., providing various problem strategies, working toward developing their autonomy) and Trent as a consultant (e.g., answering tutee's questions). These different perceptions are connected to their carrying out of the tutoring sessions: Patricia lectured, Chuck provided teacher-centred training, and Trent provided scaffolded explanations. It thus seems that inquiring about one's perception of their role as a tutor can provide insight into their enacted tutoring approach.

Limitations

The first limitation of this study is that the analysis was mostly focused on the verbal utterances of the tutors. Writings from the tutors as well as verbal and written content produced by the tutees were not included in the analysis.

A second limitation of this study, which is typical of case studies, is that the findings may not be easily generalizable since the data set is too small to empirically represent what may be observed in a larger population (Hodkinson and Hodkinson, 2001), even one as limited as chemistry graduate students working as peer tutors. However, the behaviours and perceptions of tutoring observed in this study have been observed in other studies, regardless of the exact nature of peer tutoring. The tutors' perceptions of tutoring is supported by the literature, while similar predominance of KT behaviours observed in this study have been observed in Bailey's study of 'learning centre' and 'academic department' chemistry tutors (2010) and in Berghmans *et al.*'s study of mathematics tutors (2013). Thus, this study fulfils the function of "offer(ing) important evidence to complement experiments", as asserted by Yin (2009, p. 16), expanding the literature and theories on tutor perceptions and behaviour as well as demonstrating relationships between them.

Conclusions and Implications

This study provides insight into the relationship between perceptions of tutoring in chemistry and tutoring behaviours. In particular, we found that tutors' perceptions of their tutees and their role as tutor are indicative of the instructional approach they enact during tutoring sessions. Although other studies need to be conducted in order to explore further this relationship, findings provided within this study along with prior research on the impact of practical theories on instructional practices at the college level suggest that tutor training program and, potentially, teaching assistant training program should assess and take into account their instructors' perceptions of their teaching environment as these may unravel instructors' tendencies and preferences for certain types of instructional practices.

Acknowledgements

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Investigating the Tutor Learning Effect: Relationships between Tutors' Perceptions of Tutoring and Tutors' Productive Behaviours

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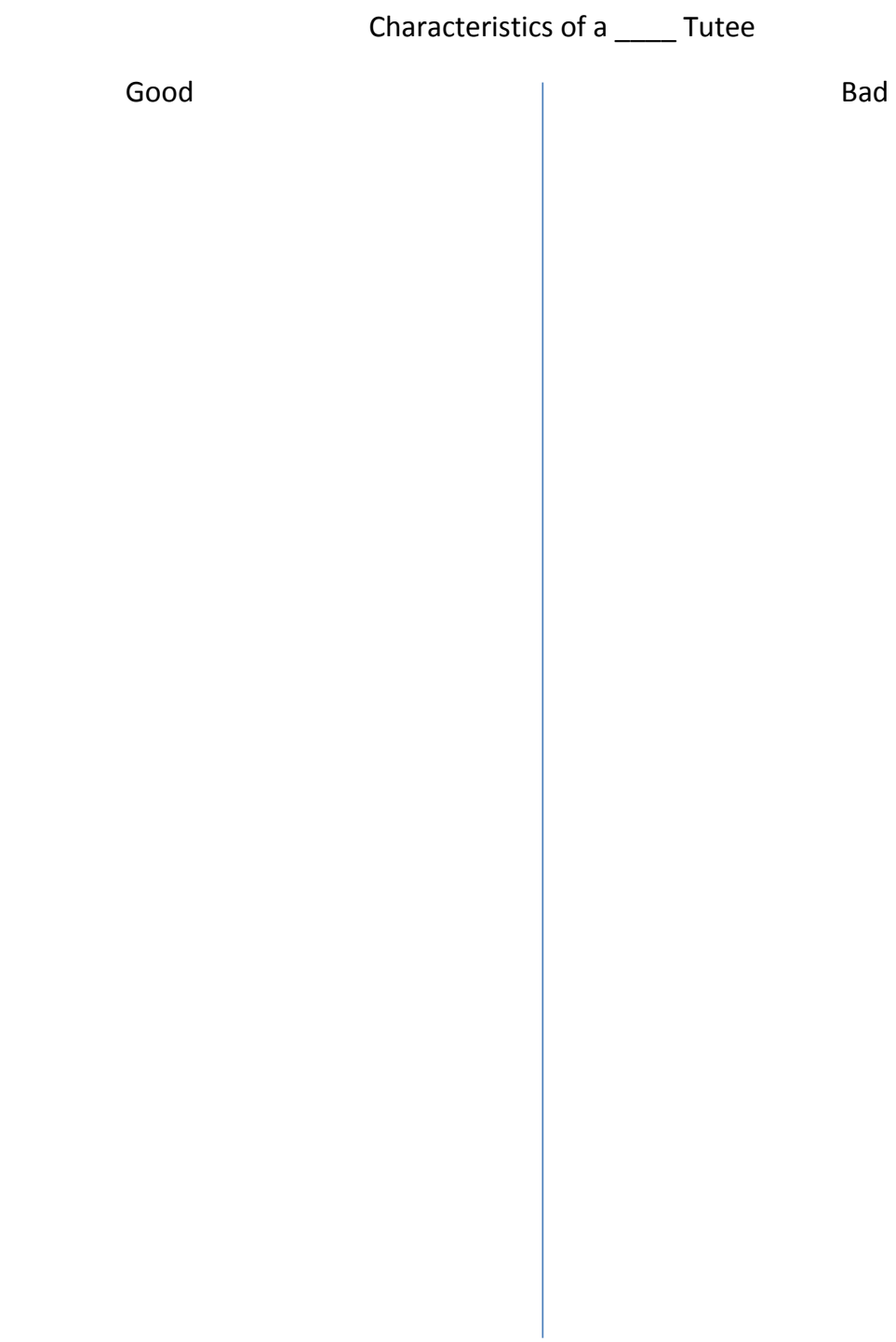
Table of Contents

Appendix A - Interview Materials

A1. Interview protocol to examine tutors' perceptions of tutoring

1) What is tutoring?
2) What is the role of the tutor?
3) Let's talk about a typical tutoring session with you.
    a. Where do you typically conduct your tutoring session?
    b. Do you typically prepare for a tutoring session?
        i. (if yes) How do you prepare?
        ii. (if no) Why not?
    c. Do you interact, prepare, or conduct the session differently with different tutees?
    d. What do you do in between tutoring sessions?
    e. Please describe a typical tutoring session from beginning to end.
4) What are the characteristics of good and bad tutees? Please use this chart (Appendix A1) to organize your thoughts.
5) What are the characteristics of good and bad tutoring sessions? Please use this chart (Appendix A2) to organize your thoughts.
6) What are the characteristics, skills, and actions of good and bad tutors? Please use this chart (Appendix A3) to organize your thoughts. If you can, use different colors of the pens provided to differentiate between characteristics, actions, and skills.
7) Please compare and contrast the characteristics, actions, and goals of tutors and teaching assistants (TAs). You may use this chart (Appendix A4) to organize your thoughts. If you can, use different colors of the pens provided to differentiate
8) Please compare and contrast the characteristics, actions, and goals of tutors and lecturers. You may use this chart (Appendix A5) to organize your thoughts.
9) What is the purpose of tutoring?
10) What do you think are the main goals of a tutoring session?
11) What are you trying to achieve throughout the entire semester?
12) In your opinion, what is the most important thing that you do as a tutor?
13) Do you find tutoring challenging? Why (or why not)?
14) Why do you tutor?
15) Do you think you get something out of being a tutor?

A2. Chart used to identify the characteristics of tutees



A3. Chart used to identify the characteristics of tutoring sessions

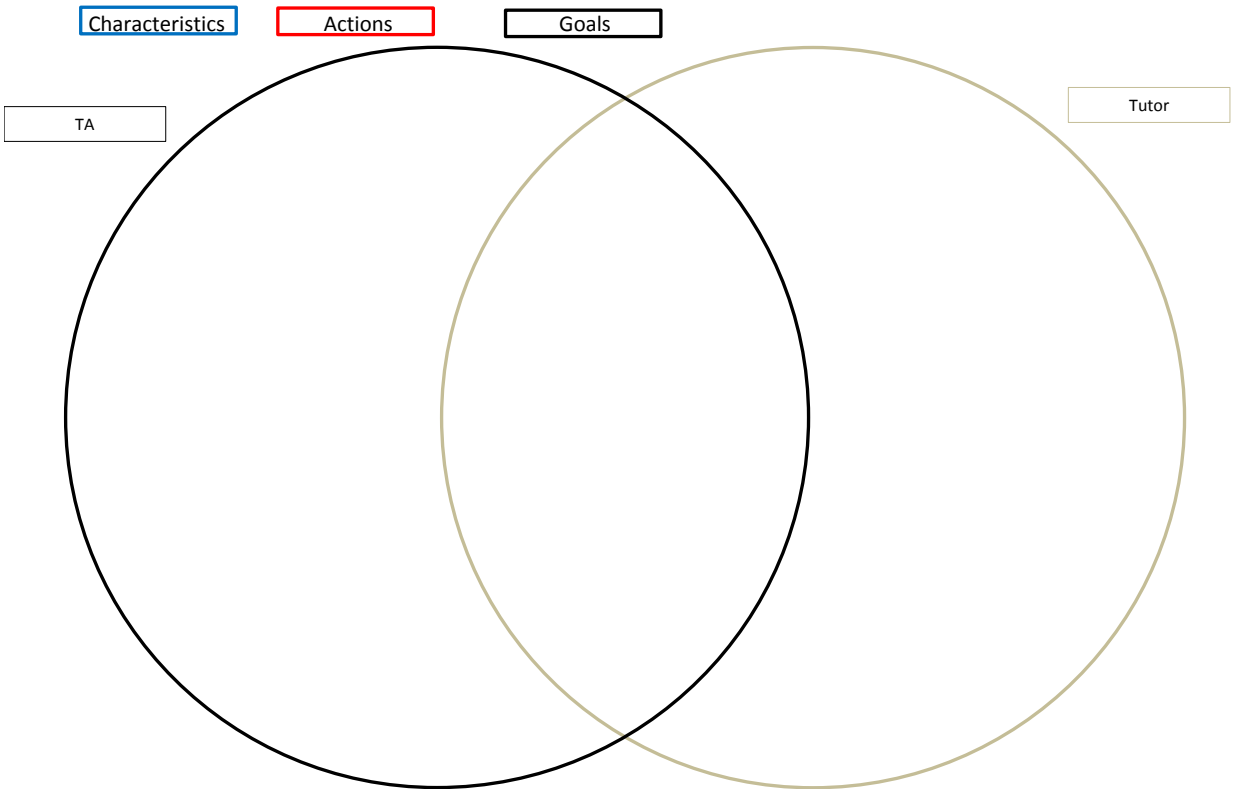
Characteristics of _____ Tutoring Sessions

Good	Bad

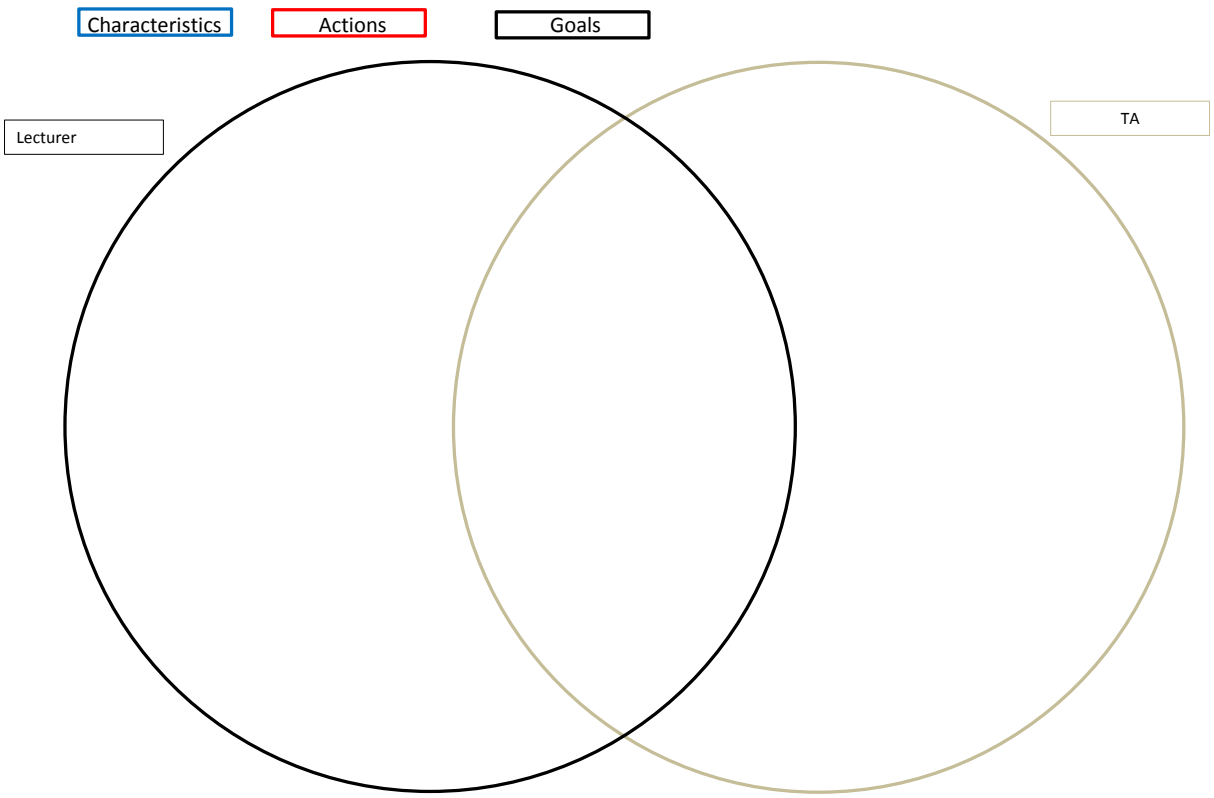
A4. Chart used to identify the characteristics, skills, and actions of tutors

Characteristics, Skills, and Actions of a _____ Tutor	
Good	Bad

A5. Chart used by interviewees to compare resource room teaching assistants (TAs) and tutors



A6. Chart used by interviewees to compare lecturers and TAs



Appendix B - Coding Book

B1. Codes used to examine tutors' behaviours, with operational definitions of knowledge-telling (KT) and knowledge-building (KB) behaviours

Tutor behaviour	KT definition	KB definition	Non KT/KB definition
Explanations	Didactic lectures with little tutee participation (Fuchs *et al.*, 1994; Fuchs *et al.*, 1996)	Responses to tutees' information-seeking questions (Roscoe, 2007)	N/A
Feedback	Unelaborated, yes/no responses (Roscoe, 2007)	Tutor elaborating on tutee's answer (Graesser *et al.*, 1995)	N/A
Questions	Questions that "did not contain or require any information beyond the text contents" (Roscoe and Chi, 2004)	Questions that "manifested logical reasoning, causal reasoning, or goal-oriented reasoning" (Graesser *et al.*, 1995)	Common ground question: Question that asks how well the listener is understanding or following along (Graesser and Person, 1994)

B2. Codes used to examine other knowledge-building behaviours

	Code	KB definition
Tutor's metacognitive behaviours	*Memory*	Tutor statements related to their own abilities to recall information (Roscoe, 2007)
	Comprehension	Tutor statements that focused on their own understanding of the material (Roscoe, 2007)
	Attention	Tutor statements that indicated their perceptions of what was important in the material (Roscoe, 2007)
Tutor's scaffolding behaviours	*Highlighting critical features*	Orienting tutee to important features of the problem (McArthur, *et al.*, 1990)
	Decomposing the task	Breaking up a complex task into simpler tasks (see Chi, *et al.*, 2001)
	Executing part/s of the skill	Carrying out part/s of an activity (Rogoff, 1990)
	Compare current problem with a previously-solved problem	Statements regarding similarities between current and previous problems (McArthur, *et al.*, 1990)
	Identifying/maintaining goal orientation	Tutor statements that keep the tutees on task towards a goal (Wood, *et al.*, 1976)
	Completing student reasoning	Correcting student errors without acknowledging errors (Graesser, *et al.*, 1995)
	Providing examples	Tutor statement that provides a relevant example (Chi, *et al.*, 2001)
	Evaluate solution	Evaluating the quality of student answers without confirming its accuracy (Graesser, *et al.*, 1995)
	Hints (as statements or as questions)	Tutor providing hints to the tutee in order to solve a problem (King, *et al.*, 1998)
	"What else" question	Tutor asks a probing question to have students expand on their responses (Graesser, *et al.*, 1995; King, *et al.*, 1998)

B3. Codes used to describe other, non-KB/KT behaviours

Tutor's non-KB/KT behaviours	Definition
Reading text sentence	Tutor reading text directly from a book or other source
Requests	Tutor requests the tutee to perform an action

B4. Types of explanations and elaborated feedback

Classification	Definition
Conceptual	Tutor engages the tutee with the conceptual underpinnings of the material
Procedural	Tutor engages the tutee with algorithmic steps for problem solving (Fuchs *et al*., 1994)
Bridging	Tutor engages tutee with procedural statements connected to underlying concepts
Factual	Tutor engages tutee with stand-alone definitions and facts

B5. Literature cited

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