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How Domain Differences Impact the Mode Structure of Expert Tutoring Dialogue

Whitney Layne Cade

Department of Psychology
Rhodes College
Memphis, Tennessee

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This Honors paper by Whitney Layne Cade has been read

and approved for Honors in Psychology.

Dr. Natalie K. Person
Project Sponsor

Dr. Chris Wetzel
Second Reader

Dr. Andrew Olney
Extra-Departmental Reader

Dr. Natalie Person
Department Chair

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CONTENTS

List of Tables and Figures

ABSTRACT

How Domain Differences Impact the Mode Structure of Expert Tutoring Dialogue

by

Whitney Layne Cade

While human-to-human dialogue in tutoring sessions has received considerable attention in the last 25 years, there exists a paucity of work examining the pedagogical and motivational strategies of *expert* human tutors. An established trend in the tutorial dialogue community is to study tutorial dialogues in a very fine-grained manner, at the level of the speech act or dialogue move. The present work offers a coding scheme that examines larger, pedagogically distinct phases as the unit of analysis, referred to as "modes", which exist in expert tutoring and provide the context needed to understand patterns of dialogue moves. The eight modes identified by this coding scheme are the Introduction, Lecture, Modeling, Scaffolding, Fading, Highlighting, Off Topic, and Conclusion mode, and each mode was reliably identified at or above the .8 kappa level. After determining how often modes occur and the amount of dialogue devoted to them in expert tutoring sessions, differences between the domains of math and science were investigated. Significant variance between the domains was revealed using this larger-grained coding scheme, particularly in how Lecture and Scaffolding are used in expert tutoring. While these two modes tend to dominate most tutorial dialogue in this sample regardless of domain, the differences in their frequency and the amount of dialogue devoted to each mode suggest diverse tutoring goals associated with each domain. Other

subtle differences in mode distributions draw attention both to the complexities of expert tutoring and the danger of generalizing tutorial structures across domains.

How Domain Differences Impact the Mode Structure of Expert Tutoring Dialogue

Introduction

Somewhere between making spitballs and passing notes, our experiences in the American education system have imparted the general sense that the standard classroom is not an optimal learning environment. Typically, there is one teacher with twenty-odd students, and each student represents different needs and expectations. Given these conditions, the teacher must perform what could be considered educational triage to save as many students as he or she can with blanket teaching tactics. However, as with all triage, someone inevitably gets overlooked.

The suspicions many of us harbored about classroom education as 16 year-olds is backed by a solid history of empirical support. When it comes to learning gains, the classroom is no match for one-on-one tutoring: students obtain more knowledge and skills from their experiences in tutoring than they do in a traditional classroom setting (Anderson, Corbett, Koedinger, & Pelletier, 1995; Bloom, 1984; Cohen, Kulik, & Kulik, 1982). In fact, according to Bloom (1984), accomplished tutors produce an effect size of 2.0 sigma when compared with the learning gains found in a classroom. Accomplished tutors also outperform untrained tutors (Cohen, Kulik, & Kulik, 1982) and Intelligent Tutoring Systems (ITSs; Corbett, Anderson, Graesser, Koedinger, & van Lehn, 1999) when it comes to student knowledge acquisition. These results raise the question of why: why do accomplished human tutors produce such high learning gains? One possible explanation is their use of pedagogical strategies as manifested in their tutorial dialogue.

So what, then, are these strategies? This is a question that researchers have been trying to answer for decades. To uncover those tutoring strategies that foster the most student learning, researchers have taken one of two approaches: either they have conducted laboratory research exploring theories derived from everyday experiences (e.g. Lu, Di Eugenio, Kershaw, Ohlsson, & Corrigan-Halpern, 2007), or they have observed tutoring in its natural setting (e.g. Person, Lehman, & Ozbun, 2007). There are obvious advantages to each. Laboratory experiments allow for greater control and the ability to empirically test every viable hypothesis, and observational studies allow the researcher to explore minutiae of the natural phenomenon. However, as it has been suggested that expert tutoring provides an enormously effective teaching model, much effort has gone into understanding the tutoring experience as it occurs in real life.

Of course, real life is messy. Tidy idealized models and neat operational definitions are subject to unraveling and reordering when exposed to the elements outside of the lab. This may explain how terms central to the exploration of expert tutorial pedagogy have become so ambiguous and diverse over time; the definitions of “expert” and “tutor”, for instance, have meant a variety of things in the tutoring literature. As of right now, very little is known about expert human tutors. In many of the previous studies, “tutor” has been defined as peer tutors, cross-age tutors, or paraprofessionals with some domain knowledge and no formal training (Cohen, Kulik, & Kulik, 1982). For many years, unskilled tutors were of high interest in the tutoring community, as these “normal” tutors still produced high learning gains despite a lack of sophisticated pedagogical techniques (Graesser, Bowers, Hacker, & Person, 1997). From these studies, researchers learned that tutors can classify their students’ abilities and adapt their teaching methods to these classifications (Derry & Potts, 1998) and use student errors and responses to adjust their tutoring (Fox, 1993; Schoenfeld, 1992). Tutors also respond to student errors with rehearsed scripts (McArthur, Stasz, & Zmuidzinas, 1990; Putnam, 1987), provide emotional support for students (Lepper, Woolverton, Mumme, & Gurtner, 1993), and increase students' feelings of competence (Lepper & Chabbay, 1993).

However, when analyses turned up little proof effective diagnosis of a student's flawed knowledge (Chi, Siler, & Jeong, 2004), discriminating feedback (Person, 1994; Person, Graesser, & Magliano, 1994), sophisticated pedagogy (Person, 1994; Person & Graesser, 2003), and other elements expected in tutoring sessions, some researchers then turned to expert tutors in hopes of determining whether these strategies and behaviors occur in sessions with more accomplished tutors.. This line of research presented its own difficulties as well, as it became necessary to operationally define "expert" and to recruit enough of these experts to establish a solid corpus. From 1987 to 2004, only 19 studies were conducted on expert tutors. Additionally, the majority of the studies included only one or two experts (Glass, Kim, Evens, Michael, & Rovick, 1993; Jordan & Siler, 2002; Lajoie, Faremo, & Wiseman, 2001), and several more did not specify the number of tutors in their study (Aronson, 2002; Lepper & Woolverton, 2002; Lajoie & Derry, 1993). At most, studies contained 5 or 6 tutors (e.g. Derry & Potts, 1998; Graesser, Person, Harter, & the Tutoring Research Group, 2000; VanLehn, Graesser, Jackson, Jordon, Olney, & Rosé, 2005). Other studies have been known to "borrow" or "recycle" experts from other studies, so that what we do know about expert tutors is based on a very small population of people that may have appeared in multiple analyses of expert tutors (Person, Lehman, & Ozbun, 2007). This makes the generalizability of these studies relatively questionable (Cade, Copeland, Person, & D'Mello, 2008).

As mentioned previously, the definition of "expert" has also varied across studies. In some research, an expert tutor is a person in possession of a Ph.D. with considerable teaching/tutoring experience (Evens, Spitkovsky, Boyle, Michael, & Rovick, 1993; Glass, Kim, Evens, Michael, & Rovick, 1999; Graesser, Weimar-Hastings, Weimar-Hastings, Harter, Person, & TRG, 2000; Jordan & Siler, 2002). In other studies, an expert is a graduate student who works at a tutoring center (Fox, 1991). This lack of consensus as to who is an "expert" tutor has made comparisons between tutoring studies more difficult, and it only when a finding is replicated repeatedly are researchers able to consider seriously its significance.

One thing that many, if not all, of the studies have in common is the level of analysis they engage in when examining elements of tutorial dialogue. Traditionally, dialogue has been coded at a very fine-grained level, at the level of the speech act or dialogue move, and only a few studies have departed from this minute level of analysis to look at the broader picture being painted. According to Forbes-Riley, Litman, Huettner, & Ward (2005), a dialogue move "attempts to codify the underlying intent behind a student or tutor utterance" (p. 226), which means that meanings can be assigned to dialogue as short as a single word or phrase. This type of intense detail has popularized dialogue moves in the field; if dialogues are subjected to close scrutiny, the thinking goes, more may be learned about tutoring.

A significant amount of research has been conducted to learn more about patterns of speech acts. Chi, Siler, Jeong, Yamauchi, & Hausmann (2001) categorized statements at the dialogue move level to study the dominance of the student or tutor in their tutoring sessions and the effect that dominance has on student learning. Chi et al. hypothesized that it is not exactly a specific combination of moves that creates a student's construction of knowledge, but rather, that tutor moves encourage the student to construct their own knowledge and that tutors can adjust their moves based on student responses in order to induce student knowledge construction. Forbes-Riley et al. (2005) correlated learning with specific student and tutor dialogue acts. In particular, they found that students' answers to long and short questions correlate with learning, and human tutors' restatements, negative feedback, and summaries negatively correlated with student learning. While these sorts of detailed findings are very informative in their own right, it may be time to question the context of these tutor and student moves. For instance, one may pose the question, "Is negative feedback always negatively correlated with student learning, or only during problem solving?" or "Do tutor moves always foster the student's self-construction of knowledge, or only during didactic lectures?" As we do not always know the general context of these moves, it may be premature to make sweeping generalizations about what does or does not promote student learning. Identical speech acts may serve different purposes when used at different times, and this may also be the key to understanding why expert tutors surpass their unskilled colleagues.

In the course of tutorial dialogue research, some researchers have sought to look at larger chunks of dialogue, though most of these larger-grained analyses are aimed at answering questions outside the realm of tutor pedagogy. For example, Shah, Evens, Michael, & Rovick (2002) coded tutor and students speech on certain dimensions to ascertain their immediate learning goals. They examined student initiatives, coding along dimensions such as communicative goal and degree of certainty. Simultaneously, the study looked at tutor responses and classified them into subcategories which included causal explanation, acknowledgment, and conversational repair. These categories have the potential to occur for sustained lengths of time, creating larger chunks of dialogue. Cromley & Azevedo (2005) did identify "problem solving episode" in their work which consisted of a problem being submitted for the student's consideration, and either a correct or incorrect answer being elicited from the student. Therefore, episodes were coded as either correct or incorrect, while student and tutor moves were coded within each episode. Analyses like these begin flirting with the idea of contextualizing smaller dialogue moves; however, none really capture sequences of dialogue moves that repeatedly occur together and the variety of contexts in which they may occur.

In summary, tutorial dialogue has been analyzed, essentially, in a very fine-grained manner for roughly two decades, and very few steps have been taken to put the little puzzle pieces of tutorial dialogue together and look at what the larger chunks depict overall. Likewise, few comparisons have been made between tutoring domains based on dialogue moves and larger-grained coding schemes; studies typically blend domains like math and psychology research methods together to create one corpus when dialogue moves prove not to differ between domains (Graesser, Person, & Magliano, 1995) or they study one domain and generalize only within that domain (Matsuda & VanLehn, 2005; Forbes-Riley et al., 2005). Of the sparse studies that even attempt to generalize across domains, even fewer attempt to outline what the domains specifically share in common. Rosenshine (1986) came closest when stating that explicit teaching serves specific functions such as guided practice and the presentation of new material, and that these functions are common when teaching both mathematical procedures and science facts. What is missing are analyses to see if larger segments of tutoring sessions differ in frequency and length between different tutoring domains; while dialogue move differences may wash out over the duration of a session, clusters of dialogue moves may be more prominent in different segments of a session.

Present Research

As of right now, there is a need to study the naturalistic tutorial dialogue of truly expert tutors and to examine this dialogue at a higher level of analysis. This research explores an annotation scheme that conceptualizes student and tutor dialogue move sequences in terms of reoccurring, larger phases of a tutoring session, which we have termed “tutoring modes,” or, “modes” for short, in previous work (Cade et al., 2008). These modes provide a context that has been missing from the smaller, more traditional dialogue move analyses, and a new context will hopefully demystify some of the harder to explain or complex findings. Likewise, significant domain differences (such as between math and science, which are examined here) which may have been previously invisible may come to light given a coarser level of analysis. If domains differ significantly in structure and mode usage, the discovery of these differences may help novice tutors and researchers who build ITSs to approximate more closely the performance of an expert tutor. In short, this work seeks to contribute a different approach to studying tutorial dialogue and domain differences.

An Overview of the Mode Coding Scheme

It may be the case that the exact meaning of a speech act in a tutoring session is tied to a larger, overarching teaching phase, and the relationship of a move to a mode may be an artifact of the tutoring domain. A mode, then, may be viewed as an overarching context or teaching phase, as well as a phase which gives structure to a sequence of tutor and student dialogue moves and to the session as a whole. As modes stretch over several dialogue turns, they encompass several dialogue moves at a time, which may occur in specific clusters that have been hitherto unnoticed, undifferentiated from clusters that occur in other contexts and in other domains. In the expert tutoring sessions that make up this corpus, eight mutually exclusive tutoring modes that encapsulate all of the dialogue in tutoring sessions were identified and coded. While these eight modes were partially data-driven (that is to say, they were derived from reoccurring patterns found during a qualitative exploration of the data), all have theoretical underpinnings that are not new to the tutorial dialogue field; in fact, many of these modes have been staple theories in educational and discourse literature (e.g. Rogoff & Gardner, 1984; Dillon, 1988).The eight modes are Introduction, Lecture, Modeling, Scaffolding, Fading, Highlighting, Off Topic, and Conclusion modes, and each will be discussed in the following sections.

Introduction, Conclusion, & Off Topic

While the Introduction, Conclusion, and Off Topic modes all occur at different times in a tutoring session (the beginning, end, and middle, respectively), all three categories share a common purpose and definition. These are modes that do not necessarily concern themselves with the learning process, but are often seen in tutoring sessions, and therefore, are worthy of acknowledgement when constructing a comprehensive coding scheme. Introduction, the mode that occurs as the student and tutor exchange greetings and define an agenda for the tutoring session, serves the function of orienting both parties towards the material as they begin the “settling in” process. Off Topic conversation, on the other hand, occurs when the tutor and student are not engaged in the tutoring lesson for a significant period of time. Likewise, the Conclusion serves to disengage the student and tutor from the lesson as they talk more about homework, class, and out-of-school activities. All three modes serve to build rapport between the student and tutor, which may be a key component in expert tutoring (Lehman, et al., 2008). An example of each of these modes can be seen in Appendices A, B, and C.

Lecture

Of all the expert tutoring modes, the Lecture mode may represent one of the most straightforward and familiar concepts. In Lecture mode, the tutor explicitly delivers domain information to the student by way of the traditional lecture. Thus, this mode is relatively tutor-centered. In the literature, lecturing goes by several other names; in some work, it is called the transmission/information delivery model, direct instruction, and didactic teaching, but all titles still refer to the same direct manner of dispensing factual information.

A variety of work has been done examining the effectiveness of lecturing with mixed results. Generally, there is an agreement that while lectures provide some knowledge, they are not the most effective means of producing learning gains. Lectures and discovery based learning have been found to be equally effective, but only if the student has a prior knowledge base that can promote meaningful learning rather than memorization (Ausubel, 1978). In contrast, Chi (1996) found no learning gains associated with “long-winded didactic explanations” in tutoring (p. 44). She hypothesized that, because lectures do not focus in on misunderstandings of the student, they are not as effective for promoting knowledge construction as question-asking from the student or hinting from the tutor does. However, Chi does concede that direct instruction from the tutor (presumably in shorter, more straightforward explanations) can lead to learning gains. This finding is replicated in other research. Short didactic lessons in response to student errors have been found to result in more learning than errors followed by hints and correct answers (Albacete, 1999). It may also be the case that the key to the effectiveness of short didactic lessons lies in the timing of their delivery; short lectures delivered "just in time" (i.e. when the student is in need of the information) may fill a necessary gap that long, scripted lectures do not.

Other studies have looked at whether expert tutors use direct instruction. For instance, Lu, Di Eugenio, Kershaw, Ohlsson, and Corrigan-Halpern (2007) found that expert tutors use less direct information delivery than either lecturers or novice tutors, although these results may be skewed by the small number of tutors found in their study (only one of each tutor type was used, creating a total of three tutors in the study). Rosé, Moore, VanLehn, and Allbritton (2000) suggested that Socratic tutoring, a sophisticated tutoring style associated almost exclusively with expert tutors, does produce more learning gains than didactic teaching, and thus that expert tutors are more likely to take an interactive approach to learning over a didactic, lecture-like one.

In summary, although evidence suggests that longer stretches of didactic teaching are not associated with learning gains, this point may be moot if the student lacks sufficient prior knowledge. Theoretically, expert tutors also do not rely heavily on didactic teaching, but given the above conditional statement, lectures may be seen as necessary if expert tutors suspect that their students lack a foundation of knowledge onto which they could build. An example of the Lecture mode can be found in Appendix D.

Modeling

Modeling is the first of the problem solving modes discussed here, and is considered fundamental to the tutoring process. In this study, modeling occurs when a problem is solved primarily by the tutor, though the tutor may enlist the student's help for small portions of the problem to keep them involved. Although the student is still "contributing" to the problem, it is the tutor who initiates all problem solving steps, keeping the student engaged in the process by asking questions of them. Wertsch and Stone (1979) used the term "proleptic instruction" when discussing this tutor-led, problem solving episode. In proleptic instruction, the student observes the tutor as he or she works out the problem, and takes part in simpler parts of the problem as the tutor guides the student. The tutor integrates explanation and demonstration to increase student knowledge construction in proleptic teaching, and different balances of both elements have been found in classrooms, apprenticeships, and tutoring.

Roehler and Duffy (1991) describe modeling as a type of scaffolding that demonstrates the desired behavior. They hypothesized that there were three types of modeling: think aloud (where the tutor shows the student how to think through a problem), talk aloud (where a tutor verbally walks through the problem solving steps), and performance modeling (showing a student how to solve a problem without verbal instruction). Roehler and Cantlon (1997) grouped these types of modeling into two main categories: making thinking visible, where the tutor speaks aloud as they think about how to solve a problem, and modeling of question and comment generation, where the tutor prompts the student to ask questions or make comments as the tutor walks through the steps of a problem. Each category serves a different purpose in trying to model problem solving, but both are effective ways of constructing knowledge when the student is not yet ready to independently solve problems.

Modeling is also a key component in the early stages of reciprocal teaching. Instructors are encouraged to explicitly model four strategies (summarizing, questioning, clarifying, and predicting) that aid in student comprehension before allowing the student to take more control of the learning process and try their hand at some of these strategies (Palinscar & Brown, 1984). Likewise, in the apprenticeship model, tutors encourage their students to observe, use, and practice implicit and explicit processes involved in the target behavior as the student works towards expertise in the cognitive task (Collins, Brown, & Newman, 1987).

As several of the discussed theories of modeling mention, student engagement in the modeling process is crucial to effective modeling. According to Bandura's theory of social learning (1977), a student must attend to the information, retain the presented material, perform the skill, and they must be motivated to learn the information. Thus, it is through observation, attention, and a tutor's explicit demonstration that modeling helps to construct a foundation of methodological knowledge in the student. An example of Modeling can be found in Appendix E.

Scaffolding

Next to Lecture, Scaffolding may be one of the most familiar concepts in the learning literature; it essentially represents the basic premise of teaching. The idea of expert support, from the initial phases of student learning to the point at which a student may independently perform the task of interest, has gained substantial recognition. The popularization of the term “scaffolding” has led to its overgeneralization and any tool that aides a student in task completion is said to “scaffold” learning (Puntambekar & Hübscher, 2005). It takes no stretch of the imagination to see how the term came to be overused; its everyday metaphor is particularly apt. A scaffold provides support so that workers can reach areas they previously could not, and when the structure is complete and can stand on its own, the scaffold is then gradually removed. Like the metaphor, tutors provide Scaffolding to help the learner understand and perform a task (Cade et al., 2008; Rogoff & Gardner, 1984).

The process by which the tutor provides this scaffolding hinges upon several factors. Successful scaffolding occurs when the tutor and learner have intersubjectivity. Intersubjectivity, “the process whereby two participants who begin a task with different understandings arrive at a shared understanding,” creates the common ground that is necessary for effective scaffolding (Berk, 2006, p. 260). In the beginning of true scaffolding, each participant must adjust their view of the goals and task at hand so that each party is invested in the task and the goals of problem-solving are calibrated to the needs of the learner. Once intersubjectivity has been established, student and tutor work towards the goal of student mastery by engaging in scaffolding. In the classical view of scaffolding, the tutor dynamically assesses the student’s grasp of the concept and calibrates their support based on the student’s performance (Puntambekar & Hübscher, 2005). This classic view originates from Vygotsky’s theory of the “zone of proximal development”, where the student has mastered only enough of a skill to work on the problem with the aid of a more knowledgeable expert (1962). Therefore, the tutor must be able to gauge the student's skill level to provide the correct amount of support (Rogoff & Gardner, 1984).

Puntambekar and Hübscher (2005) write that while the tutor's dynamic assessment of student understanding is an idea theoretically propagated in the community, it is not being actively implemented; diagnosis of a student's progress and the consequent continual adjustments that tailor tutoring to the student's needs have been replaced with "blanket scaffolding." In their view, there is no diagnosis beyond the initial comprehension gauging as human tutoring becomes increasingly replaced with intelligent tutoring systems that must meet the needs of a diverse student population. Dynamic scaffolding and assessment, then, should be the goal of any intelligent tutoring system, and better tutoring models based on the techniques of expert tutors may make for carefully tailored scaffolding episodes in intelligent tutoring systems.

While no research would entertain the idea of disconfirming the existence of scaffolding in human tutoring, the most effective approach to scaffolding and related tutoring philosophies are hotly debated. Initial theories on scaffolding were first recorded by Vygotsky (1962), but Jerome Bruner introduced the term "scaffolding" when discussing how mothers engaged their children in joint activity with mutual attention to a task (Bruner, 1975; Wood, Bruner, & Ross, 1976). More recent work on scaffolding, however, studies every minute aspect of the scaffolding process and its local and broader contexts. Roehler and Cantlon (1997) introduced a list of five diverse types of scaffolding that they noted in their own analyses, all of which fade as the student assumes responsibility for their own learning. They agree that scaffolding is a complex process that varies with differing student knowledge and skill, but firmly assert that students who are tutored in this socially constructed environment have a distinct advantage over those who are not due to the responsibility transfer from tutor to student, which is unique to the scaffolding process. Gaskin, Rauch, Gensemer, Cunicelli, O'Hara, Six and Scott (1997) saw scaffolding strategies as happening in gradated support "levels", although the authors ascribe to the traditional process of scaffolding knowledge so that certain gradation levels tend to occur into certain orders (such as from intensive scaffolding to a more hands-off approach). Recombining a variety of these scaffolding levels in different circumstances, according to the authors, allows students to function at a higher intelligence level as they "internalize knowledge of content, strategies, and thinking dispositions, and how to put them to use productively," (p. 71). These highly desirable outcomes, however, cannot happen with an untrained or inexpert instructor (Bliss, Askew, & Macrae, 1996).

Lepper, Drake, and O'Donnell-Johnson (1997) assembled several tutors of expert caliber to study their exact tutoring techniques and the philosophical approaches put to practice in their tutoring sessions. From their body of data, they observed that expert tutors have a number of differences from non-expert tutors in their means of structuring their scaffolding. Lepper et al. (1997) proposed that, while the general model of scaffolding calls for a tutor to begin the problem-solving by doing most of the work in order to instruct the student in methodology, expert tutors handle problem-solving not by providing most of the answers, but by following the Socratic tutoring method. Tutors will ask leading questions that cause a student to inform themselves of the method and discover the process of completing the task on their own, which confers greater responsibility on them for their own learning right from the beginning.

Clearly, then, Scaffolding is a process that is prominent in accounts of the tutoring process. Tutoring and teaching models that include this process, such as Rogoff and Gardner's (1984) modeling-scaffolding-fading paradigm, have been prominent components of tutoring theory since their inception due to the intuitive and robust nature of Scaffolding and its effect on student learning. An example of the Scaffolding mode can be found in Appendix F.

Fading

Unlike Modeling and Scaffolding, Fading transfers the responsibility of problem solving onto the student (Johnson, 1992). Traditionally, fading is thought to occur at the end of scaffolding; it is the point at which the tutor has almost completely phased out the scaffolds and allows the student the maximum amount of control in the problem solving process. During a fading episode in reciprocal teaching, students part from the tutor and attempt to tutor each other, thus simultaneously fading and teaching the cognitive skills they just acquired (Palinscar & Brown, 1984). It is not always immediately clear, however, that a student is ready to fade. Rogoff and Gardner (1984) describe the preparation of a student for fading as "a subtle process involving successive attempts by the participants to assay the novice's readiness for greater responsibility and negotiations of the division of labor," (p. 107). However, student errors do not necessarily mean that a student is not ready to fade. By intervening to prevent errors in Scaffolding or in Fading, the tutor may actually be hindering the development of the ability to detect and correct errors in the student (Burton & Brown, 1979). Fading, then, is about allowing the student to solve a problem with very little intervention on the tutor's behalf so that they may obtain mastery of the skill.

This general consensus on the definition of Fading was used to inform the definition of fading in this study. Here, Fading is said to occur when “the student works an entire problem with virtually no aid from the tutor, although the tutor may comment from time to time on their progress,” (Cade, et al., 2008, p. 472). An example of the Fading mode can be found in Appendix G.

Highlighting

Highlighting, the last mode discussed here, is a more data-driven category. During problem solving, the tutor may set the problem aside temporarily to discuss with the student what the problem is asking for and/or outline the information provided by the problem. In this mode, the tutor also may break down the steps involved in the problem solving method, create a “game plan” outlining how to generally work the problem, and refocus the student on the problem’s procedure when he/she has strayed from the correct method and its underlying purpose. Elements of this mode can be seen in Palinscar and Brown’s (1984) reciprocal teaching strategies. One of the strategies, clarification, involves identifying a mistake in comprehension and then taking the necessary steps to eliminate this mistake. The tutor is intended to model this strategy for the student so that the student can eventually replicate the clarifying strategy on their own; in this study, we are merely identifying those moments when that strategy is taking place, noting its marked departure from regular problem solving activities. An example of the Highlighting mode can be found in Appendix H.

Methods

Participants

Before recruiting any tutors for this study, we first decided to operationally define the term “expert.” As mentioned previously, tutoring “experts” have run the gamut in experience and domain knowledge, ranging from PhDs to graduate students. To obtain tutors with highest levels of experience, knowledge, and reputation, we decided that a tutor had to meet four criteria to be considered truly expert: they had to be licensed to teach at the secondary level, have five or more years of tutoring experience, be employed by a professionally tutoring agency, and come highly recommended by school personnel who specialize in providing support to students who are struggling academically.

Ultimately, we recruited ten expert math and science tutors through local tutoring agencies and schools to participate in this study. We then asked these tutors to select students from their clientele that were struggling academically, and to notify us when they were planning to meet for a tutoring session so that we could record their time together. Forty of the tutors’ students consented to participate in our study. While one student was receiving tutoring in order to obtain a GED, the other student participants were in grades 7 to 12. Roughly 42% of our students were female, and 58% percent were male. All of the students were in academic trouble and actively sought out tutoring. Each student participated in a maximum of two tutorial sessions, while each tutor participated in between two and eight tutoring sessions. The tutors were compensated for each tutoring session filmed.

Materials and Apparatus

Tutor Consent Form. The tutor’s consent to participate in these recorded tutoring sessions was obtained with the Tutor Consent Form. A copy of said form is attached in Appendix I.

Student Consent Form. Likewise, the student's consent (as well as their parent's consent) to participate in this experiment was obtained with the attached form, which can be found in Appendix J.

General Tutor Questionnaire. This questionnaire assesses the tutoring philosophies and teaching/tutoring history of the tutors. This was administered to the tutor prior to any tutoring, and was only administered once. See Appendix K for the full general tutor questionnaire.

Sony DRV tapes. These tapes are compatible with the digital camcorder, and were used to record the sessions.

Digital camcorders. Using a Canon Optura 300 digital video camcorder (standard settings) , each session was recorded onto DVR tapes.

Tripod. The digital camcorders were mounted on an accompanying Samsonite 1100 tripod. The tripod was fully extended and placed on the ground for each session. In one session, the camera was placed on a counter at tripod height to accommodate for the room layout.

All other materials pertaining to learning (books, scratch paper, notes, worksheets, diagrams, etc.) were supplied by either the student or tutor. As we were merely observing normal interactions, we tried to have as little impact on the session as possible.

Procedures

Recording

Upon receiving the time and location of the tutoring session, a researcher was dispatched with the post-tutoring questionnaire and filming equipment (camera, tripod, and blank DVR tapes) to the location at the time of the tutoring session. The site of the tutoring session was determined by the tutor and student, and so filming locations ranged from student or tutor homes to public libraries. Prior to any filming, the tutors were given an informed consent and a general tutor questionnaire to ascertain their tutoring philosophies. Students were also given an informed consent form to be signed by themselves and their parent/guardian if they were a minor. Completed student and tutor consent forms were collected before the session (if they had not already been received) or the session would not be filmed.

All sessions took place in a private room regardless of the general locale, and this room was furnished with, at a minimum, a table and two chairs. As the student and tutor settled into their positions around the table, and with only the direction to sit near each other or on the same side of the table, the digital camcorder was mounted on the tripod facing the dyad so that both the tutor and student were visible in the viewfinder. The camera was close enough so that their facial expressions, voices, gestures, and sounds were all captured. When the tutor indicated that they were ready to begin, the researcher began recording and promptly left the room. The researcher remained just outside of the room at all times in case he or she was needed. When the session was complete, the tutor came to get the researcher, who then ended the recording. The post-tutoring questionnaire was then administered to and collected from the tutor (which is not included in this paper), and the session was ended.

In all, 50 tutoring sessions were recorded in this manner, each roughly one hour in length. After being recorded, each session was then captured and saved using Sony Vegas 5.0. Names spoken by the tutor or student were muted to protect our participants' anonymity. Each session was then transcribed using the transcription aid Voicewalker 2.0.

Coding

Two knowledgeable researchers examined a subset of the tutoring transcripts, looking for recurring sections of dialogue that served different general purposes in the sessions. After several passes through the subset of transcripts and numerous category sortings (Corbin & Strauss, 1990), the final annotation scheme with the eight mode categories described in the Introduction was settled upon. Once a coding scheme that fully characterized the overarching patterns in the transcripts had been established, the researchers created a series of guidelines that would be used in coding the transcripts. The guidelines specific to our method of coding are as follows:

- All modes begin with a tutor's speaking turn. Generally speaking, tutors control the course of the task and related information (Shah, Evens, Michael, & Rovick, 2002; Graesser, Person, Magliano, 2005), and so it makes sense for a mode to be initiated by the tutor.
- Consequently, all modes must end with a student's speaking turn.
- An Off Topic mode must be at least 15 dialogue turns long. After 15 turns, the tutor and student are not merely sidetracked or making short personal inquiries, but are in a completely different stage of thinking that has abandoned the task at hand.
- The Highlighting mode can only occur during problem-solving.
- There is no "full" problem-solving in Lecture mode. Problems encountered in a Lecture must be hypothetical in nature, although the tutor and student can

work out a few defining steps of a problem to bring clarification to a discussion.

- A single problem worked by tutor, student, or through joint effort can only be categorized as one mode (Modeling, Scaffolding, or Fading). When two or more problems are worked one after the other using the same mode, both problems are considered part of one larger mode. Thus, Modeling cannot be followed by the Modeling mode, Scaffolding cannot follow Scaffolding, etc.

After eight passes through randomly selected transcripts, the judges obtained reliability for each of the eight modes (note: 10 science tutoring sessions were collected after reliability had been achieved). After obtaining reliability for our coding scheme, all 50 transcripts were coded in accordance with the established guidelines.

Results

Using Cohen's kappa, the inter-rater reliability was calculated for each of the eight mode categories. The unit of analysis for this coding scheme was the turn level. It took eight passes over randomly selected transcripts to obtain at least a kappa of .8 in each category. The reliability statistics of each mode are reported in Table 1.

A simple frequency analysis revealed that 750 modes occurred in the 50 tutoring sessions. On average, then, there were 15 modes per session. In the end, 31 math and 19 science sessions were filmed for a total of 50 sessions.

For each session, the proportion of occurrence for each mode was computed. Because some modes are inherently longer (span more turns) than others, the proportions were calculated in two ways: unweighted by turns and weighted by turn. The unweighted analysis indicates how frequently a mode occurred in the corpus, and the weighted analysis examines how many turns a mode consumes in the corpus. So, for example, a particular mode like Off Topic may make up only 11% of the modes in a corpus, but may take up only 5% of the corpus' turns; both pieces of information offer different perspectives on a mode's relative importance. Table 1 lists the descriptive statistics for both types of mode proportions.

Table 1. Weighted and Unweighted Mode Differences Between Math and Science.

Mode	**Kappa**	**Domain**	**Unweighted**		**Weighted**	
			Mean	*Standard Dev*	*Mean*	*Standard Dev*
Introduction	1.0	*Math*	.0638	.0212	.0342	.0371
		Science	.1066	.0494	.0270	.0356
Lecture	.81	*Math*	.1887	.1241	.1619	.1656
		Science	.2738	.1525	.5293	.3388
Modeling	.975	*Math*	.0945	.0771	.0990	.1225
		Science	.0291	.0623	.0262	.0759
Scaffolding	.878	*Math*	.3224	.0947	.5677	.2265
		Science	.2046	.1275	.2945	.2837
Fading	.964	*Math*	.0630	.0711	.0306	.0407
		Science	.0842	.1255	.0241	.0465
Highlighting	.8	*Math*	.1307	.0905	.0487	.0479
		Science	.0271	.0601	.0110	.0309
Off Topic	.83	*Math*	.0787	.0910	.04	.063
		Science	.1701	.1120	.06	.046
Conclusion	1.0	*Math*	.0583	.0284	.0181	.0399
		Science	.1045	.0531	.0229	.0499

In subsequent analysis reports, significant and/or insignificant findings that involve Introduction and Conclusion will not be reported. As these differences between other modes are prone to the noise of data collection error (such as not turning on the camera in time to capture the complete Introduction) and Introduction and Conclusion modes are not by definition learning-focused modes, their results are less meaningful than the findings concerning other learning modes.

Unweighted

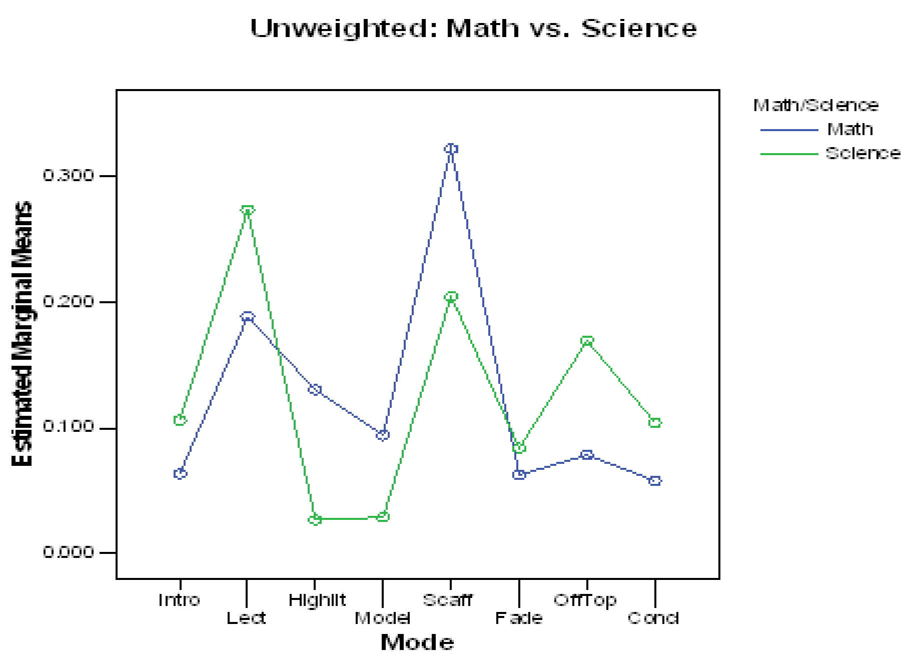
A repeated measures ANOVA revealed that there were statistically significant differences in the sheer frequency of each of the modes in the corpus, $F(7, 336) = 31.745$, $Mse = .009$, $p < .001$, $\eta_p = .398$. For the descriptive statistics for each mode, see Table 1. In the mode main effect, Lecture and Scaffolding were the most frequently occurring modes, together comprising 49.4% of all mode observations across the corpus. Bonferroni posthoc tests confirm that the occurrence of Lecture and Scaffolding were equal to each other, and significantly higher than the other modes ($p < .02$). Modeling also occurred more frequently than the Off Topic mode ($p < .05$). The overall pattern indicates that Scaffolding and Lecture tend to dominate tutoring sessions in general.

However, this main effect ignores the greater interaction between mode and domain, $F(7, 336) = 9.081$, $Mse = .009$, $p < .001$, $\eta_p = .159$. In looking at the mode distributions just within the domain of math, we see some interesting patterns emerge. Scaffolding occurs more than all other modes, bar none ($p < .05$). Though Lecture takes place less than Scaffolding, it does occur more than Fading and Off Topic ($p < .05$ & .01), but is not significantly different than Highlighting or Modeling ($p > .05$). Highlighting, Modeling, Fading, and Off Topic are all not significantly different from each other ($p > .05$).

Science tutoring sessions have a slightly different distribution than math sessions. When looking at the mode frequency in science sessions, we see that Lecture, Scaffolding, and Off Topic are not significantly different from each other ($p > .05$), but while Scaffolding and Lecture occur significantly more than all other modes ($p < .001$), Off Topic occurs only more than Highlighting and Modeling ($p < .01$) and is equivalent to Fading ($p > .05$). Highlighting, Modeling, and Fading are not significantly different from each other ($p > .05$).

When looking at the interaction between domain and mode usage, several differences emerged. In the domain of math, there are significantly more instances of Highlighting ($p < .001$), Modeling ($p < .01$), and Scaffolding ($p < .001$). Science, on the other hand, has significantly more Lectures ($p < .05$) and Off Topic ($p < .01$) modes. The usage of Fading is not significantly different between the domains.

Figure 1. The Unweighted Graph of Math vs. Science



Weighted

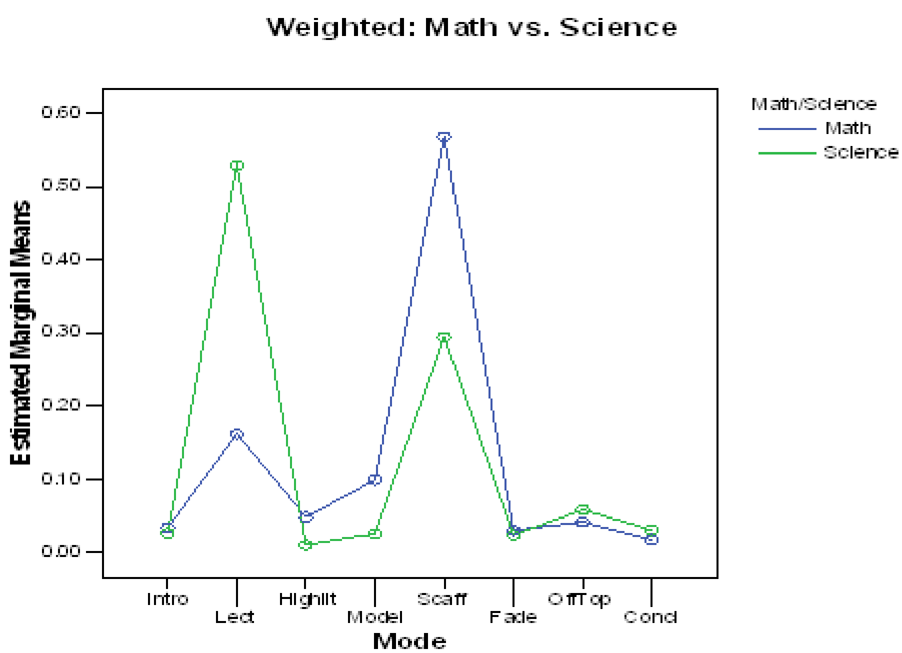
The descriptive statistics for the mode proportions within each domain that were weighted by turn also appears in Table 1. A repeated measures ANOVA revealed that there were statistically significant differences in the occurrence of each of the modes when the number of turns devoted to them in the corpus were taken into account, $F(7, 336) = 61.93$, $Mse = .021$, $p < .001$, $\eta_p = .563$. Here again, we see that Scaffolding and Lecture dominate the number of turns in the corpus; collectively, they consume 77.7% of all the turns comprising the corpus. Scaffolding is not significantly different than Lecture in the number of turns devoted to each, but both occur significantly more than every other mode ($p < .001$).

There is also an interaction between mode and domain for the weighted analysis, $F(7, 336) = 17.726$, $Mse = .021$, $p < .001$, $\eta_p = .270$. After weighting the math sessions with turns, a similar pattern emerges. Again, Scaffolding consumes more turns than any other mode ($p < .001$), taking up over 56% of all math dialogue turns. Lecture, Highlighting, Off Topic, and Modeling are not significantly different from each other ($p > .05$), but Modeling comprises more turns than Fading ($p < .05$). Otherwise, Fading is not significantly different than the other modes (Lecture, Highlighting, Off Topic, $p > .05$). Math, then, is characterized by its large amount of Scaffolding.

Once science sessions are weighted, we see that Scaffolding and Lecture consume more turns than all other modes ($p < .02$ & $.001$). Combined, they take up more than 82% of all turns in the science sessions. All other modes are not significantly different from each other ($p > .05$).

When looking at how many turns are devoted to each mode between the domains, we see that science has significantly more turns consumed by Lecture ($p < .001$) than is seen in math. Math, however, devotes more turns to Highlighting ($p < .01$), Modeling ($p < .05$), and Scaffolding ($p < .001$) than science does. The number of turns spent in Fading and Off Topic in math and science do not significantly differ ($p > .05$).

Figure 2. The Weighted Graph of Math vs. Science



Discussion

Studying expert tutoring at a larger grain size has a number of benefits. Not only can previous theories on expert tutoring be tested by combining this higher order coding scheme with the more traditional dialogue moves (Cade et al., 2008), but informative patterns seem to emerge when examining different corpora under this slightly coarser lens. Here, we can see clear differences emerge between the domains of math and science when looking at mode frequency and time devoted to each mode. Additionally, the general distribution found in these analyses will also be considered alongside domain differences. While an examination of the general mode distribution somewhat obscures the more detailed and accurate picture painted by the mode distributions when divided along domain lines, it provides a useful baseline against which domain-specific distributions may be compared.

Mode Frequencies

The number of times a tutor utilizes a mode offers a vast amount of information on the individual importance of the mode. A tutor's choice to use a mode could be likened to the number of times a mechanic chooses to use a particular tool; both the tutor and the mechanic decide to use their tool at the precise moment that it is needed. Noting the number of times it is used, then, gives us some idea of how essential that tool is to its user. Therefore, looking at the differences in mode frequency between domains refines our knowledge of which pedagogical elements are considered vital to each subject domain.

When thinking about the general purpose of tutoring, one typically believes that it should contain some sort of information delivery from the more knowledgeable person to the student, and that it should contain some exposure to this information's application. The general findings here support this intuitive definition of tutoring. When generalizing across domains, Lecture and Scaffolding modes prove to be the modes that occur the most frequently in the corpus, making up nearly half of all 750 modes found. Scaffolding and Lecture, then, make up the essence of tutoring as they fit this broad perception of what it means to tutor.

While many researchers may disagree on the usefulness and prevalence of substantial, organized blocks of didactic teaching (Chi, 1996; Lu et al., 2007; Rosé et al. 2000), it must be remembered that students who lack a foundational knowledge base may not benefit from interactive learning quite like those who have mastered the basic informational components of a lesson (Ausubel, 1978). With that in mind, the students involved in this experiment must be considered. The tutors in this study often assist those students who are in academic jeopardy and are now “resorting” to tutoring as an intervention. This indicates that most (if not all) of the students lack the required informational knowledge to successfully and solely engage in more interactive forms of problem solving. The Lecture mode, then, is the tutor’s best course of action; not only does it deliver information in a straightforward manner precisely when it is needed, but it also does so in a very prompt and deliberate fashion. It makes sense then that, when working under the time constraints of a tutoring session, Lectures seem to be a favorite tool of the tutor for maximizing the amount of information conveyed within the given time constraints. This may be where lectures in tutoring differs from classroom lectures; while classroom lectures are delivered regardless of whether the student is ready for the information, these “just in time” lectures seen in expert tutoring are given just when the student needs the information the most. While the theory may not be popular, direct instruction clearly has a place in expert tutoring.

The amount of Scaffolding found, however, should come as no surprise. Theories of interactive learning are possibly the most abundant sort of theories in the literature, with many tutoring models like Socratic tutoring (Collins, Warnock, Aeillo, & Miller, 1975), coaching (Brown & Burton, 1978), and anchored instruction (Crews, Biswas, Goldman, & Bransford, 1997) inspiring an overall tone of interactivity in tutoring. Clearly, too, tutors use Scaffolding with a specific purpose. Scaffolding allows a non-threatening and adjustable middle ground between tutor expectation and a student's removal from the problem solving process. In Scaffolding, tutors can keep a student involved while actively gauging the student's skill level so that the scaffolds can be adjusted accordingly. While this obvious use of Scaffolding is only suggested here by the frequency of its appearance, active knowledge gauging has previously been found to be lacking entirely from tutoring (Chi, Siler, & Jeong, 2004). A deeper look into the moves that comprise Scaffolding may yield some clue as to how much a tutor is diagnosing a student's knowledge within this mode. Regardless of the inner workings of Scaffolding, the increased use over other techniques like Modeling and Fading does reveal a preference for a sensitive and collaborative phase of problem solving.

What may actually come as a surprise to some of the constructivists is the fact that, in the general analysis, Lecture and Scaffolding do not significantly differ from each other in frequency. Though it is clear that Lectures are certainly needed, the sheer preponderance of Lectures, equal to the most frequent problem solving phase, may seem puzzling. Why are there so many Lectures (or so few Scaffoldings in comparison)? In all likelihood, there are several answers to this question. In my earlier work on modes (Cade et al., 2008), I examined the likely mode transitions that were determined from a probability formula that corrects for baserate biases (see D'Mello, Taylor, & Graesser, 2007, for more details on the formula). It was determined that there was a bidirectional relationship between Lecture and Scaffolding; once in Scaffolding, one of the next likely modes to occur is Lecture, and vice versa. It was hypothesized that Lecture and

Scaffolding may often co-occur because this represents a pedagogical pattern applied whenever the tutor moves onto a new subsection of the lesson. A tutor may start with a Lecture and then move on to the Scaffolding mode to assess and foster a student's comprehension of the material. Also suggested was the idea that Lecture can be used as a remedial "rescue tool", where a struggling student is removed from Scaffolding to have their knowledge supplemented with a Lecture. This hypothesis would fall very much in line with Ausubel's (1978) study which found that interactive problem solving moments are less effective without a strong knowledge base. That is, tutors often have to supply this knowledge base for students.

The nonsignificant difference between Scaffolding and Lecture could also be an artifact of the coding scheme; because modes are intended to capture long, continuous stretches of dialogue that are only interrupted by a tutor's change in teaching goals, several problems may be solved in the course of one Scaffolding phase. This may mitigate the Lecture-Scaffolding pattern because it does not represent one problem worked on collaboratively per Lecture, but rather, roughly one stretch of collaboration per Lecture. A further examination of the number of problems solved in Modeling, Scaffolding, and Fading may yield a different, interesting arrangement of problem-solving modes around the large number of Lectures. The fourth and perhaps most important hypothesis explaining the equally large numbers of Scaffolding and Lecture may have to do with the fact that the corpus is a blend of domains, and if one domain is heavy on the Lecture while the other relies deeply on Scaffolding, it may appear that Lectures and Scaffolding modes are equally balanced. As subsequent analyses suggested, this reason may be the most valid of all.

In the domain of math, we see that Scaffolding almost completely dominates the tutoring landscape, occurring significantly more than every other mode, including Lecture. This suggests that math tutoring places a greater emphasis on problem solving than was previously suggested by the general mode distribution. This seems only natural, as much of math is learned through working problems. However, Lecture still has a place in math tutoring as it occurs more than the Fading and Off Topic modes. So, tutors still rely on Lectures more than they do the Fading process of problem solving to ensure that their students comprehend the subject matter, but they do not employ it as often as they do Scaffolding. Tutors also provide more Lectures than they provide Off Topic conversation, demonstrating that tutors would prefer to stay on task rather than build rapport; Off Topic conversation has its place in tutoring, providing levity and establishing a common ground between the tutor and student, but it does not occur as much as the more learning-oriented tutoring modes.

The repeated measures ANOVA also indicated that Lecture, Highlighting, and Modeling do not significantly differ in the domain of math tutoring. This may indicate that tutors use a variety of methods to prepare a student for Scaffolding; each of these three modes has the connotation of information delivery and heavy tutor assistance. While Modeling and Highlighting provide direct information on problem solving techniques and how to integrate that information into the problem solving process, Lecture provides the basic knowledge foundation that will be used later in problem solving. Each of the three modes feeds into Scaffolding in a different way: Lecture provides the information, Modeling provides the techniques, and Highlighting resets the student on the correct problem solving path or gives the student a quick supplement of information to help the student unravel the problem's difficulties. The moderate use of Modeling is particularly interesting. The fact that the tutor does not overly rely on Modeling may reflect an expert tutor's desire to ensure that the student is involved during problem solving and is not a passive, unwilling participant. In a tutoring beliefs questionnaire (see Appendix K), many of our tutors reported believing in the power of practice when proficiency and mastery are the goals of learning, and this seems to be reflected in the high frequency of Scaffolding, the moderate frequency of Modeling, and the low frequency of Fading. The tutors seem to be aware that their students are struggling academically and are in need of a large amount of intense help that must span a short amount of time. This awareness would then lead tutors to employ hands-on exercises that give the student several opportunities to engage in supervised and supported practice. Consequently then, Modeling seems to occur just enough to demonstrate particular problem solving methods.

Science, on the other hand, has quite a different mode distribution than math tutoring. When tutoring science sessions, tutors do not use Scaffolding, Lectures, and Off Topic modes a significantly different number of times. While the use of Scaffolding and Lecture have obvious pedagogical implications, the utility of Off Topic conversation may be a little less intuitive. While Off Topic conversation has cropped up every now and then, entangled in a web of other significant and nonsignificant results, Off Topic seems most likely to be used when the domain being taught relies on intense information delivery. Therefore, Off Topic conversation may be most practical when the amount of information being dispensed is beginning to create a substantial cognitive load that may interfere with further information delivery (Clark, Nguyen, & Sweller, 2006). Further analyses of the lectures may reveal if these cognitive breaks occur at the end of lessons, thus allowing for an appropriately timed break between chunks of information. As will be discussed in the section below, science tutoring certainly fits the profile of tutoring laden with information.

We also see in science that Highlighting, Modeling, and Fading are not significantly different from each other and occur in relatively low levels during science tutoring sessions. It is not terribly hard to see why these three modes fall by the wayside in science tutoring; with the emphasis on didactic teaching and interactive problem solving, there would not be time for much else. A little more surprising is the low level of Highlighting, especially given that Scaffolding occurs frequently in science tutoring. By definition, Highlighting only occurs during problem-solving activities (i.e., they are usually embedded between Scaffolding modes; Cade et al., 2008). The Highlighting mode provides a way for tutors to elucidate the constraints of particular problems, emphasize relevant information, and alert students to appropriate problem solving strategies. Highlighting differs from Lecture in that Lecture is more theory-driven in its explanations of domain topics, and refers to problem solving in only a hypothetical sense. This may explain why so little Highlighting occurs in science tutoring despite the appearance of several Scaffolding modes; much of the problem solving in science is theoretically based, and so the Lectures serve to provide this information and Highlighting thus loses its priority status. Student difficulties with problem solving in science may also be handled in a less organized, distinct way than Highlighting calls for, and so an analysis of dialogue moves in science Scaffolding may reveal a more subtle method that tutors use to redirect their students to the correct path.

Time Spent in Each Mode

Another method of measuring the importance of each mode is to look at how much time is spent in each mode. Though a mode may appear frequently or infrequently in tutoring sessions, this does not bear on how much time the tutor devotes to a mode; a mode that appears once but consumes a considerable amount of time could be thought of as more vital than a mode that appears half a dozen times, but is rarely sustained for a notable amount of time. Time on task differs from the number of times a task is initiated in that it indicates a certain level of content that mere frequency cannot; while mode frequency demonstrates how necessary it is to utilize each mode's function in a tutoring session, the time a tutor is willing to spend in each mode hints at the intricacy, depth, and importance of the mode as it requires the most valuable asset tutors have: time. Although time is not measured in minutes or seconds here, the number of turns consumed by each mode can be used as a viable measure of time. Previous research has found that tutors use two or more dialogue moves in 50% of dialogue turns, but students typically use only one at a time (Person, Lehman, Ozbun, 2007). These fairly steady speaking rates makes dialogue turns a decent measure of time, and also does not overly inflate the amount of time a tutor purposefully devotes to a mode with pauses, silence, stuttering and other incidental verbal mistakes like a minutes-and-seconds measure would; turns contain only the pure content of the mode. Also, measuring the amount of time devoted to each mode with dialogue turns allows us to measure, in a very rough sense, student and tutor participation. Though within each mode the number of tutor and student turns will be equivalent (as mentioned in the rules of coding in the Methods section), a mode that is substantially longer than another also necessarily involves more dyadic participation, making this particular measure of time doubly meaningful.

Again in the general mode distribution, we see Scaffolding and Lecture collectively taking up over three-quarters of all turns in the corpus, and consuming significantly more turns than every other mode. The pattern seen in the frequency analysis is reinforced in the turn analysis; not only do Scaffolding and Lecture frequently appear in the tutoring sessions, but they also comprise a significant number of the turns. While it may not be surprising that Scaffolding, an inherently interactive mode to begin with, consumes so many turns, it may come as a surprise that Lecture consumes so many turns that it rivals the most collaborative mode in the coding scheme. This could be for several reasons. Part of the turn-taking that occurs in Lecture could be due to the social pragmatics that take place when one person owns the conversational floor. Since Lecture is mostly a tutor-centered mode, the student may feel compelled to interrupt and give verbal feedback to show that he or she is paying attention. Likewise, tutors are more likely to attempt to elicit this feedback by asking small questions of the student to ensure that students are engaged. While dialogue moves like comprehension gauging questions have not been strongly linked to student achievement and serious problems have been found with student feedback mechanisms (Person, 1994; Glenberg, Wilkinson, & Epstein, 1982; Weaver & Bryant, 1995), these questions may serve the basic purpose of keeping the student's attention. This also gives them the opportunity to interject when they do not understand a concept, which has been correlated with student achievement (Chi, Bassock, Lewis, Reimann, & Glaser, 1989). It may also be the case that Lectures are simply more interactive than they have been painted in the literature; an analysis of dialogue moves would help to sort out the exact nature of Lecture. Before further analyses are done on Lecture or any mode, it is important to establish whether this large effect is obscured by domain differences.

In the math domain, we do not see the same level of Lecture that the general mode distribution indicates. It is Scaffolding alone that monopolizes 56% of all turns in the math corpus, much more than any other mode. In fact, Lecture does not take up significantly more turns than Highlighting, Off Topic, or Modeling. This is particularly intriguing given the math mode frequency discussed previously. Before, Lecture was not significantly different in the number of times it appeared from Highlighting or Modeling, and since it also does not occupy more turns than either of these two modes, it can now be inferred that these modes occur at about the same rate and length. These three "instructional" modes may each be equally important to the tutor, as he or she is willing to spend about the same amount of time on all three and to use them at similar rates. This demonstrates that math tutors do not rely on one particular mode to convey information, and instead, they spread the instruction throughout the session, giving it in upfront or as-needed Lectures, in preparation for problem solving with Modeling, or in rescuing students from conceptual roadblocks with Highlighting while they are in the midst of Scaffolding. The mode occurrence analysis also showed that Lecture happens more than the Off Topic mode, but here we see that they occupy the same number of turns. It can then be inferred that, though Lecture occurs more than Off Topic conversation, the Off Topic mode lasts for longer periods of time when it does occur. The Lectures that occur in math are not even as long as the conversations that arise when the student and tutor become sidetracked; this may serve to debunk the myth that didactic tutoring must necessarily be “long-winded” (Chi, 1996). Lecture is not even significantly different in the number of turns it occupies from Fading, a notoriously short problem solving mode that lends itself to long, silent lapses of conversation as the student works out a problem on their own. As Lecture actually occurs more than Fading, it can be assumed that Fading actually takes up more turns at a time than Lecture when it is utilized. In sum, we see a de-emphasis of didactic teaching in math tutoring sessions, much more so than is hinted at in the general mode analysis. This meshes nicely with previous research that found expert tutors tend to lecture less than less experienced tutors and lecturers (Lu et al., 2007); within math tutoring, there are many ways to teach a lesson.

As mentioned previously, it is Scaffolding that seems to characterize expert tutoring in math. Scaffolding absorbs significantly more dialogue turns than any other mode, which speaks to the valuable and time-consuming nature of problem solving activities during math tutoring sessions. Over 55 percent of the dialogue exchanged between the tutors and students occurred in the Scaffolding mode. This may be because collaborative problem solving, with its continuous trading of ideas and its constant confirmation that tutor and student are on common ground, simply requires more dialogue exchange than any other mode. However it comes to be such an all-consuming mode, the sheer volume of dialogue dedicated to Scaffolding demonstrates how vital it is in knowledge construction, convergence towards shared meaning, and perhaps in debugging student knowledge. With all of its dialogue interchange, Scaffolding presents the opportunity for students to expose their misconceptions and for tutors to detect the misconception and actively work to correct it. Because of this sensitivity to flawed knowledge, tutors can calibrate the help they offer and their feedback to their students’ pedagogical and motivational needs. While there is not much evidence for this sort of sophisticated diagnosis of student errors in knowledge during normal tutoring (McArthur et al., 1990; Putnam, 1987; Person, 1994), a move analysis within Scaffolding may reveal that it *is* a component in expert tutoring.

While the frequency pairwise comparison revealed that Modeling and Fading do not significantly differ from each other in the number of times they are used by the tutor, the weighted analysis found that Modeling takes up significantly more turns than Fading. While neither mode is particularly interactive, Modeling is a tutor-centered mode and is therefore subject to the social pragmatics discussed earlier. Since Modeling can also include steps where the tutor prompts the student for some small calculation or asks the student for some sort of minimal input, this also increases the likelihood that Modeling will consume more turns than Fading. Fading may have some tutor input, such as short, corrective hints or words of encouragement as the student works the problem (usually silently), but it is generally not a mode that encourages interaction. It makes sense, then, that Modeling should take up more turns than Fading. The time constraints incurred by one-hour tutoring sessions may also prevent the tutor from spending too long in Fading. For obvious reasons, tutors prefer spend time instructing and assisting their students through interaction, not passively watching students solve problems. Not only are most students unable to problem solve on their own when they enter these tutoring sessions, but it may not be seen as the best use of time when there is so much ground to cover and so little time in which to cover it. Tutors seem to prefer Scaffolding as a way to gauge their student's ability to solve problems; if this ability can be demonstrated in Scaffolding, then the tutor will simply move on to another problem or subtopic. Fading can essentially be accounted for with homework assigned from the student's classroom teacher, and the tutor does not view his or her role as that of the babysitter who ensures that the student does his or her homework. As most of our tutors are paid for their services, it seems reasonable to believe that they would want to give the student the benefit of all they have to offer.

The turn analysis for science yields a very different distribution. In science, Lecture and Scaffolding consume significantly more turns than every other mode, and all other modes take up an equal amount of turns. The ramifications of this analysis paint an unexpected picture of science expert tutoring. In layman's thinking, mastery of science appears on the surface to be a matter of fact memorization; if a student can remember the vocabulary and general theories, then he or she can "get by." It would follow, then, that the dominating mode in science tutoring should be Lecture. When looking at how much time a tutor spends Scaffolding in science, however, this myth appears to be debunked. Scaffolding and Lecture take up an equal number of turns, and from this, it becomes apparent that problem solving has a place even in science. Since Scaffolding and Lecture also occur a similar number of times, we can deduce that they are roughly the same average length as well. From working on formulas for chemical reactions to reciting the ways an organism can become mutated, problem solving remains a vital component of expert science tutoring.

Earlier, it was hypothesized that Off Topic is used in science to provide moments of levity and shared camaraderie, which may prove necessary when a tutoring session is full of direct instruction. The turn analysis reveals that, while these Off Topic moments may appear fairly frequently, they do not all together rival the more popular Scaffolding and Lecture modes in terms of length. The Off Topic mode in science, then, may provide only a brief break in activities before the tutor and student settle back into the work at hand.

Low levels of Modeling, Highlighting, and Fading are also notable in science, as all occur infrequently and take up few turns when they do. Even the moderately interactive nature of Modeling and Highlighting cannot overcome their low sheer frequency to make them consume more turns; they are simply not a priority in science tutoring. Much of the process of problem solving may be demonstrated in Lecture, which could teach a student to theoretically think through a problem using the information that is being delivered. The student could then imitate this process in their science problem solving, most likely during Scaffolding; such demonstration erases the need for Modeling. This would also preclude the necessity for Highlighting, with its intense knowledge repair moments and redirection of the problem solving process onto the correct path; when dealing with open-ended theory that was modeled when it was first taught, there would be little need to engage in Highlighting. Likewise, Fading inherently takes up few turns and, for all the reasons mentioned when discussing math tutoring, would be a rare sight in any tutoring session.

Math vs. Science

While knowing the distribution of modes within each domain is invaluable information, particularly when attempting to imitate the distribution in tutoring or with an intelligent tutoring system, it remains important to underscore how domain differences can radically alter the structure and goals of a tutoring session. Every domain may have a unique blend of knowledge and skills (manifested here in observable differences in mode patterns) and so it is important to be sensitive to those differences so that overgeneralizations do not impact the efficacy of any tutoring that is modeled after expert tutoring.

In math sessions, Highlighting, Modeling, and Scaffolding appear significantly more than they do in science sessions and also consume more turns. It is not too surprising that these three modes seem to demarcate math from science; they are mainly concerned with problem solving and may work as a substitute for the more didactic Lecture. While science has been shown to incorporate problem solving into its tutoring structure, problem solving is perhaps most obvious in mathematics, where conceptual understanding is generally demonstrated and practiced by working problems. Math relies heavily on problem solving to reinforce the larger concepts taught in class; science is more readily discussed on the theoretical level (though it is also easily converted into practical application problems). Therefore, it is only natural that modes which are heavily concerned with demonstrating and debugging the problem solving process should occur more frequently and take up more turn in math than in science. Likewise, it is logical that wherever Scaffolding is most prevalent, Highlighting would be sure to follow. Both modes are essentially designed to complement each other, with Highlighting serving as an instructional aid to Scaffolding where the tutor can set aside the problem, sort out the difficulties that are being encountered, and then place the student back into the problem with his or her knowledge disentangled and a clear path laid out for him or her. While Highlighting, Modeling, and Scaffolding do appear in science, the level at which they appear cannot rival the amount of time spent on each of them in math tutoring.

The use and length of Fading does not significantly differ between the domains. As mentioned previously, tutors do not have enough time to carefully watch the student solve a problem; they appear to favor hands-on activity or direct instruction over taking a passive role in the student's learning. This stands in contrast to some theories of expert tutoring, such as Socratic tutoring, which suggest that tutors prefer to let the student construct their own knowledge, acting as only a nurturing sounding board for ideas (Lepper et al., 1993). In this corpus, very little of this can be seen. Whether a lack of Fading is due to the type of student included in this study or to time constraints (as a very astute colleague of mine once observed, "tutors are not paid to Fade"), very little Fading was detected during expert tutoring in these analyses.

Science devotes significantly more turns to and more frequently employs the use of the Lecture mode. While math tutoring may rely on several interactive modes to convey information, science is laden with facts, processes, and theories, and requires a more straightforward approach to information delivery. The most efficient method used to convey this information is the Lecture mode, which, while unpopular in the tutoring literature, does seem to effectively transfer the information that the student needs to build an adequate knowledge base for problem solving. As seen in the mode distribution for science, Scaffolding is another popular mode for this domain, and so while Lecture may be used more in science, the lessons learned in Lecture are still put to the test with Scaffolding problems. It is important to keep in mind that Lecture may be more prominent in science than in math, but it does not preclude the need for other modes.

Science also has more occurrences of the Off Topic mode, although the number of turns spent in Off Topic does not differ between math and science. The exact purpose of the Off Topic mode is highly debatable, but the current thinking is that tutors use Off Topic to establish a social common ground with the student, to give him or her a break from the lesson, or to fill a conversational void when the student is problem solving. Conversations that arise in the Off Topic mode not only have to do with choir or basketball practice, but also pertain to a student's classroom or homework activities. Therefore, Off Topic occasionally serves a purpose that is not quite pedagogical, but may still help the student plan a study schedule for a test or devise a scheme for completing all of his or her homework. Further investigation into the Off Topic modes will need to be conducted to learn their precise purposes, but for now, we know that they lasts for equal lengths of time in math and science, but occur more often in science tutoring sessions.

Conclusions

While tutoring has been studied extensively in cognitive psychology, very little work has been done on the tutoring techniques of expert tutors. Several theories of how expert tutors should behave have been proposed, but with varying definitions of who is an "expert" and how these expert tutors should be studied. Likewise, most aspects of tutoring have been examined at a very fine-grained level, the level of the dialogue move or speech act. Larger chunks of dialogue defined by specific constellations of these dialogue moves serve both to give a contextual definition to these individual speech acts and to demonstrate the existence of larger patterns in expert tutoring sessions. By stringently defining the term "expert", conducting a naturalistic study, and creating an 8-part coding scheme that captures these broader phases of a tutoring session, the stage has been set to deeply investigate the intricacies of expert tutoring so that they may be implemented in real life tutoring, as well as in Intelligent Tutoring Systems. However, part of the intricate nature of tutoring revolves around a sensitivity to the tutoring domain; the number of times a mode is used and the amount of time spent within a mode are all subject to change depending on the domain being taught. This study looked at the differences between science and math, two domains for which students commonly receive tutoring.

In the domain of math, Scaffolding was found to dominate, suggesting that tutors prefer interactive, collaborate problem solving to the more didactic Lectures. Math tutors also utilize Highlighting to help their students plan their problem solving and to rescue them from "stuck states," (Burleson & Picard, 2004) Modeling to demonstrate the problem solving process, and Lectures to provide the student with the necessary information that they will need to solve the problems they encounter. Expert tutors generally do not have the time to engage their students in Fading, where the student solves the problem on their own. Instead, tutors would rather be actively teaching or assisting in problem solving in order to cover the maximum amount of subject matter. In science, tutors rely on Lectures to build the student's foundation of knowledge, which prepares them for Scaffolding, another popular mode in science tutoring (although math devotes more dialogue turns to Scaffolding). These differences demonstrate the pitfalls of overgeneralizing dialogue patterns to specific domains; the general mode analysis found a pattern of mode use that blends these distributions together and distorts the more specific picture that each domain analysis painted.

As with most research, this study is not without its limitations. Only a few analyses were run here, and so many questions remain to be answered. One such question deals with tutor differences; as it stands, each tutor works in only one domain, and differences between tutors have not been accounted for as of yet. While each tutor has to meet the same qualifying standards to be considered an "expert tutor", giving each tutor a shared baseline of similarity, these differences must be assessed to rule out differences between domains based on tutor differences. Likewise, the corpus used in this study is somewhat limited in the subtopics covered by the tutors (e.g., algebra, biology, chemistry), and an expansion of this corpus would ensure that a wider range of subtopics in each domain are represented. There are also many aspects of these findings that suggest a departure from traditional theory, but further investigation is needed to confirm or disconfirm the implications of this study. Many of the tutoring theories and models introduced at the beginning of this work should be tested directly before being embraced or dismissed, and while coding schemes of differing granularity such as moves and modes may be the vehicle through which these models may be tested, such a task has yet to be accomplished.

In the course of this paper, several additional avenues of study have been suggested. Chief among these suggestions have been the blending of dialogue moves and modes in order to look at which moves define a mode, and whether move distributions differ between modes. Adding domain as another dimension to these subsequent analyses seems also necessary, as domain differences have been found to effect distributions in mode analyses. Finding the specific combinations of moves that make up a mode will serve to give deeper meaning to both the move and mode coding schemes.

The ultimate goal of all this work was to impact present-day tutoring and the structure of ITSs. An intelligent tutoring system is already being constructed with the findings of preliminary mode analyses, but further work must be done to incorporate domain differences in mode usage and length. Likewise, work has been done to combine moves and modes together and find a mode transition detector, an automatic way of detecting when tutors transition out of a mode and into another. Work like this, which can add substantially to the sensitivity of an intelligent tutoring system, will hopefully also contribute to a system’s efficacy, bringing intelligent tutoring systems closer to producing the learning gains found in expert human tutoring.

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APPENDIX A – INTRODUCTION (EXAMPLE)

1. T: Did you bring the book, or did you forget the book?
2. S: No ma'am. Uh.
3. T: You left the book. Oh, that's ok, I have a book, so, no big deal. Umm, you tell me since last time we saw each other, that was last Tuesday, uh, did you have a test or a quiz?
4. S: Uh, I had a quiz today, uh.
5. T: How did it go?
6. S: I feel like it went good. It just…like I, I just went too slow. And we had a limited time period [because-]
7. T: [How much time] did you have to do it?
8. S: Uh, not a lot. We were on, like, club schedule.
9. T. Mm hmm
10. S: And, we didn't, we did not have a lot of time, and . . . we could only answer 8 of 'em [out of ten.]
11. T: [8 out of 10?]
12. S: Yeah, I, like [I was going slow.]
13. T: [Do you think you did that correctly?]
14. S: Mm hmm. 'Cause I went, like, I at least had to, get those right, so I wouldn't make lower than that.
15. T: So you said that you did 8 out of 10?
16. S: Yes, ma'am.
17. T: And, umm, if you like, like you said you did 8 of them correctly, umm, you're

going to get that quiz back tomorrow, you think?

18. S: Umm, probably Thursday.

19. T: Thursday.

20. S: Yeah.

21. T: Bring it back next time so we can look over that, okay?

22. S: Okay.

23. T: This way I'm gonna, umm, I'm gonna go over that and I'm gonna see how did you do. So, last time we started chapter, chapter 4, yes?

24. S: Mm hmm.

25. T: Where are you right now?

26. S: Uh, we're, we're starting 4-4 (Chapter 4, section 4).

27. T: 4-4… So far so good? How is the 4-1 and 4-2 and 4-3 sections?

28. S: Easy, easy.

29. T: Easy… So what we're doing here. <tutor flips through book> 4 is multiplying matrices. Everything, okay? <clears throat> Excuse me <clears throat>.

30. S: <flips through book>

31. T: Uhh . . . determinants. So did you start 4-4 today?

32. S: No Ma'am, we're starting tomorrow.

APPENDIX B – CONCLUSION (EXAMPLE)

1. T: Ok, will you look and see if page 183 is something you need?
2. S: Yes ma'am.
3. T: On that e-mail.
4. S: 183. <looking at e-mail> I think we-
5. T: We need to do it?
6. S: Yes ma'am.
7. T: Alright, we need to get there then. Umm, alright I want you to practice the umm, the Louis structures.
8. S: Yes ma'am.
9. T: I want you to get all the rest of the notes we've gone over this last time in this, in your head, ok?
10. S: Yes ma'am.
11. T: You're gonna watch the video, as much as you can between now and well you're not gonna be taking that home actually right now.
12. S: Yes ma'am.
13. T: Umm, I, I'll get it to you as soon as I can. So maybe, hopefully I'll be able to, so Wednesday you can watch it.
14. S: Alright.
15. T: But in the mean time read through all this stuff, umm, and recopy your notes.
16. S: Yes ma'am.
17. T: Ok?
18. S: Umm, copy down and make sure can do the Louis structure?

19. T: Mm hmm. Ok and you want, try to everything that we've gone over so far needs to sink in your head. And then we're gonna go, we still have to go over that, so I have to make notes for myself now.
20. S: I do too. So I need to-
21. T: We need to go over Vesper Theory. We need to go over Vesper Theory, we need to review Louis structures, I told you we'd try a few more, make sure that you've got it down in your head. <writes>
22. S: Yes ma'am and then metallic, metallic bonding or review that metallic bonding?
23. T: Yeah we'll review all the notes.
24. S: Alright.
25. T: I wanna make sure you know how to do Louis structures at least by then.
26. S: Oh alright.
27. T: And, ok, and then you're starting your nomenclature.
28. S: Yes ma'am.
29. T: And polyatomic ions. Alright you got it? Those 3 things that you've gotta work on?
30. S: I need to study the cellular structures, study metallic bonds, and then study, get ready for that
31. T: The nomenclature.
32. S: The nomenclature.
33. T: Don't worry about Vesper, only you and I are gonna look at Vesper for our own sake. That's what we're gonna spend most of Wednesday doing.
34. S: Alright.

35. T: Ok?

36. S: Thank you.

37. T: Alright, good.

38. S: Thank you very much.

39. T: Good.

40. S: Little, little slow.

41. T: Huh?

42. S: Took me, a little slow today.

43. T: No, you were good.

APPENDIX C – OFF TOPIC (EXAMPLE)

1. T: This is the, this was I thought a harder test than the first one they ever gave. Ok, yeah we're gonna start right here. We're not gonna worry about it, will just split 'em up. I'll give you that one. Ok, C and D. Real hard ones, real hard one there. Ok, now. Alright let's talk about types of problems, ok? Alright…SMU is waiting on you now, you gotta get there. Ok?
2. S: Yeah.
3. T: The really good kid I worked with for years and years, she's like my other daughter almost. She's going to SMU, she's so happy. She went down there.
4. S: Really?
5. T: Yeah, yeah, in fact that's who I had dinner with last night. But yeah they love it. So you wanna get there.
6. S: The girl, but do I know?
7. T: Oh, what'd you say? In fact there's uh…somebody else, there's like 5 of them going to SMU.
8. S: Really?
9. T: We've got one of 'em that's going there, then three of them.
10. S: <laughs>
11. T: Ok, that's ok. You don't know her, I think she's at St. Louis.
12. S: Yeah.
13. T: Her sister's are going there.
14. S: I think I'll be the first person in the afternoon, the earliest person.
15. T: Sure.

16. S: I think I’m going be the first person from <school’s name> ever.

17. T: Yeah.

18. S: And I don’t know if that’s gonna be helpful or not, but.

APPENDIX D – LECTURE (EXAMPLE)

1. T: So, why is the electron transport pathway divided into so many small reactions?
2. S: So… so it can, uh, produce, uh, ATP.
3. T: Every little bit of ATP is a small amount of energy, right? So I want to get enough energy for 1 molecule of ATP and I don't want to waste any extra energy, so, if I do a big reaction I, I might just give off too much extra heat. I mean, energy that doesn't go into ATP goes up into heat. Now, you're doing that anyway, right? If you go out and do a whole lot of exercise, what do you start to feel?
4. S: Sweaty.
5. T: Yeah. You start to get hot, you start to sweat, exactly. Because I'm capturing ATP energy, I'm capturing the energy in ATP, but I'm giving off a little extra energy every time. So, while I'm capturing energy into ATP, I'm still not a 100% efficient. So, I'm still giving off some heat, heat loss. Energy that was in that glucose is being lost. I'm getting 36 ATPs and I'm still giving some energy away every time. So, by breaking it into these small reactions, I keep from giving away 90% of my energy out of the glucose molecule all at once. Ok? So if that much energy is in there, then I can make these 36 ATP's and still lose some as heat, ok? And, no, and no machine is 100% efficient. I mean, <stutters>, it would be impossible to have this transfer occur without some loss of heat, but the point is I don't want to lose anymore than I have to. I want to capture as much of that energy as I can into each of these little steps. Well that made sense, huh? Cool. Alright. Uh, <reading> "the process at which most of the energy is converted into ATP." We just talked about that, right? <reading> "What role does oxygen play in the process?"

6. S: Hmm.

7. T: Back to your picture.

8. S: It's still on the, ok, yeah. It's in the electron transport chain.

9. T: Ok? [So, what's its job?]

10. S: [It's straight in,] uh, take away that electron.

11. T: That last one, right?

12. S: Yeah.

13. T: So we would say that it's the final electron acceptor. [Final electron acceptor].

14. S: [Ok, I remember,] I remember writing that down.

15. T: Alright. Well, now I've written it down for you. So, you got it – right there. That's oxygen, that's his job. And, when this guy, then this oxygen takes that electron, guess what you got to do? <breathes in>. You got to breathe more oxygen in so the next guy has somebody to go to, and then the next guy has somebody to go to, and then the next guy. So you got to keep bringing oxygen in all the time, right?

16. S: <nods>

APPENDIX E – MODELING (EXAMPLE)

1. T: Right, so now you have, the quadratic formula will work on any secondary equation, any. So I'm gonna come back and factor it in just a minute. Okay, well actually let's factor it. You could take out a 2.
2. S: Uh huh.
3. T: Okay if you took out a 2, then this isn't really that bad.
4. S: Yeah.
5. T: Okay. Now if you take out just a number, you're just reducing it. Don't panic [about that].
6. S: [Aren't you] supposed to put that number back in though, at the end or something?
7. T: No. Nuh-uh.
8. S: You just leave it out?
9. T: Yeah. Okay? You're just reducing it. Like I could divide like every single person in here, every single term in there by 2, and I've even divided 0 by 2. I'm just reducing it. So now I've got X, X. Now I'm looking for 2 numbers that multiply to negative 3 and add to negative 2. That's gonna be a negative 3 and a 1 isn't it? So I'm gonna put minus 3 [plus 1].
10. S: [Plus 1].
11. T: When I set this equal to 0, I'm gonna get 3, and I'm gonna get negative 1. Just, I mean, I'm just gonna show you. If I had done this the opposite of B. 4 plus or minus the square root of 16, minus 4 times 2, times negative 6 all over 2 times 2. I could've gotten 4 plus or minus 16 uh, 8 times 6, 48, and if I used my calculator I would get 64.

12. S: Mm hmm.

13. T: Over 4.Yeah. Well that's 8. See it's a perfect square, so I would have 4 plus 8 over 4 and 4 minus 8 over 4. Well 12 over 4 is 3?

14. S: Uh huh.

15. T: And negative 4 over 4 is negative 1. I'm just saying. I just want you to know. That, that now is in the picture.

16. S: Mm hmm.

17. T: That's why you learned the quadratic formula. It's another option. You usually use it when you can't factor, but allot of kids use it when there's a coefficient here, and they don't want to waste their time trying to factor. Okay? But you can only do that on an equation. Okay. Now, so see that's where you ran into that right there, so your answer should've been3 and negative 1. Yeah. Okay. Now this right here, awww. This is interesting. That's really interesting. What she wants, did she talk to ya'll about if you have a difference of 2 squares, difference of 2 things? If you take out a negative 1 you can turn him around?

18. S: Mm hmm. I remember she went over that problem today.

19. T: Yeah. Okay. Now I'll tell you something else you could do. You could have cleaned it up, and then factored it, started over. See if that looks confusing to you, let's distribute. Would you have 3X and ?

20. S: Minus [6X]?

21. T: [Minus] 6X minus 2 plus N, and did ya'll ever do 4 terms by pairs?

22. S: I don't think so.

23. T: Oh, okay. Alright. Well then okay you couldn't.

24. S: But couldn't you, I mean?

25. T: Cause you can't mix those 3X and N.

26. S: Oh. Yeah.

27. T: Yeah. They're all different. The X and the N. No. You can't. Okay. What she really wanted you to do though is to take out, see you had a 3X times N minus 2. That's why I wondered if you ever did pairs. If you took out a negative 1, that would change to a plus 1, and that would turn it around.

28. S: Mm hmm.

29. T: That's what I'm talking about. When you do it by pairs if these 2 match, that's 1 factor and these 2 become the other factor, but that's a tricky one. Um, if she gave this to me on a test, I would probably multiply those out, and see who gives me that when I multiplied it out. You know what I'm saying? When we [multiplied]

30. S: [Yeah]

31. T: That out we get 3X. I don'[t, I really don't think that's, I just think she's kind of

32. S: Yeah, so I could just go through and

33. T: See write that right there.

34. S: Uh huh.

35. T: And then when you foil that you're gonna get 2XN. Well you don't have 2XN, so scratch that one. See? You see what I'm doin?

36. S: Uh huh.

37. T: 3XN I've got it, but I've only gotten a minus 6 X. I don't have these two. Forget him. Follow me? See what I'm doing? 3XN? Got it. Outsides? Got it. Insides? In, and the last's last.

38. S: Okay.

39. T: That's what I'd do <name, 30:29:16>.

40. S: Okay.

APPENDIX F – SCAFFOLDING (EXAMPLE)

1. T: [Yeah.]
2. S: [I can] eliminate the Xs first.
3. T: That's what I would do. It's already, it's set up, you don't have to do anything.
4. S: So I add those 'cause those… I would subtract, wouldn't I?
5. T: Uh, signs are different, [so-]
6. S: [So] go ahead.
7. T: Yeah, yeah, and sometimes the negative can't be helped, I mean, you're just going to get it, but.
8. S: So that'd be 2X?
9. T: Uh, oh, I'm sorry, I'm looking at the wrong, I'm looking at the wrong one. Yeah, you're right.
10. S: So subtract.
11. T: I was looking at the Y's, I'm sorry. Yup, you were right.
12. S: Alright, so that would be….. negative 2 minus 7. So it'd be negative 9?
13. T: Ok. Negative 2 minus 7? Instead of subtracting right there, what could I do?
14. S: Make it a 2 plus… plus a negative 7.
15. T: Mm hmm. I'd say it could be.
16. S: And that's going to be….. 9. Negative 9.
17. T: If we were dealing with money-
18. S: Mm hmm.
19. T: What would it be?
20. S: Negative 5.

21. T: Ok. If you have a negative in front of that, [would] that mean you have that or that you owe that?
22. S: [Mmm,] I owe that.
23. T: Ok. And so, that would also be? If that 7 has a negative, [like] the 2, so you would….. would you owe that [or] would you have that?
24. S: [Mmm], [yeah] I would owe that.
25. T: Ok, so if you owe me 2 dollars and you owe, you know, someone else 7 dollars, now how much do you owe?
26. S: I owe them 9.
27. T: So, this would be?
28. S: 9, negative 9.
29. T: Ok.
30. S: Alright.
31. T: Good.
32. S: <works, then sneezes>
33. T: Bless you.
34. S: Thank you. So Y equals 3.
35. T: Ok.
36. S: So plug it in for either one of those….. <works> X equals negative 5. Alright so, negative 5 plus 3 equals negative 2. And negative 5 minus….. hmm…… Hmm, like that?
37. T: Ok. True or false?
38. S: False. Negative 5 minus 6 equals negative 11. So that's wrong.

39. T: Ok.

40. S: Ok, let’s see. Where do I have to go back to?

41. Figure out where [it was?]

42. T: [<clears throat>] Well just kind of work back through, ok? Umm, we’re not sure about this, so let’s go, we know that’s right. We subtracted 3, that’s negative 5, ok. So then let’s work our way over here. Alright. So just go back and check when you got negative 3Y and negative 9, check that part right there.

43. S: Ok. So worse I’ll check to where I got this?

44. T: Mm hmm, mm hmm.

45. S: Alright so.

46. T: How did you get negative 3Y?

47. S: Positive Y minus a negative Y. Negative 2 Y. And so, that would make that a positive, right?

48. T: Mm hmm.

49. S: So that means Y plus 2Y.

50. T: Mm hmm.

51. S: That’s 3Y, positive [3Y.]

52. T: [Mm hmm] mm hmm. That’s what’s frustrating about, thing about these things, it’s the little-

53. S: Mm hmm.

54. T: -Little mistakes.

55. S: Alright, so then that would be negative 3.

56. T: Mm hmm.

57. S: <works, then says to self> Let’s see, this one’s… 3…… negative 2.

58. T: Mm hmm.

59. S: So then we add, right?

60. T: Mm hmm.

61. S: Equals a….. 1.

62. T: Ok.

63. S: Ok. So let’s see….. 1 plus negative 3 equals negative 2.

64. T: Mm hmm.

65. S: And then, negative 3, let me write this one down. And then….. <works> That’s true.

66. T: Ok. [Alright, very good.]

67. S: [Since this one.] Ok, so-

68. T: Good job.

69. S: We got it…… Should I work on this one ‘cause there’s a little star next to it?

APPENDIX G – FADING (EXAMPLE)

1. T: Yeah PRL. Yeah so write that and then fill ‘em in. Right?
2. S: Sure.
3. T: Ok.
4. S: So you’re gonna say 3.14 for pi and then you’re gonna multiply it times the radius. Which in this is 13.5.
5. T: Right.
6. S: 13.5 and then you’re gonna say 32.
7. T: Ok.
8. S: Equals…
9. T: Ok. So she doesn’t have you leave answers in terms of pi? She wants the decimals. Is that right?
10. S: Oh, yes ma’am. She keeps it exactly how it is in the calculator.
11. T: Ok.
12. S: Like how it comes out or she’ll say round to the nearest tenth or like-
13. T: Ok. And she always wants you to use 3.14, not the pi button?
14. S: Yes.
15. T: Ok, yup. Ok.
16. S: Ok. And then you’re going to say plus -
17. T: Mm hmm.
18. S: -3.14 times the radius, 13.5. Times the slant which is 32.
19. T: Right.
20. S: And then you’re gonna get 1928.745.

21. T: Ok.

22. S: That’s it.

APPENDIX H – HIGHLIGHTING (EXAMPLE)

1. T: So let’s look at one that’s a trapezoid.
2. S: Alright.
3. T: And work with that.
4. S: Alright. So, oh man. <works on problem> So, they’re gonna have different… well all the faces are different.
5. T: You’re right. Because this one is 9 and 10, this one’s 12.
6. S: 12, 11.
7. T: 10.
8. S: Right.
9. T: This one’s gonna be [8 and 10.]
10. S: [8 and 10.]
11. T: And then [7 and?]
12. S: [7 and] 10.
13. T: And 10. Good call. Well in this one unfortunately, I guess it’s like uh, one of the net one’s, where we’re pretty much gonna have to figure out each side.
14. S: And then add ‘em up.
15. T: Yup.
16. S: Yeah. <talks to self>

APPENDIX I – INFORMED CONSENT FOR TUTORS

Project: An Analysis of Expert Tutors

Principal Investigator: Dr. Natalie Person
Department of Psychology
Rhodes College
901-843-3988
person@rhodes.edu

Funding Agency: Office of Naval Research

The purposes of this research project are to (1) document the teaching practices of expert human tutors, (2), identify the particular tactics, actions, and dialogue moves that are used by expert tutors, (3) contrast the practices of expert tutors with less skilled tutors, and (4) produce a comprehensive roadmap of expert human tutoring.

I, ___________________________, hereby agree to participate as a paid volunteer in the above named research project "An Analysis of Expert Tutors".

For all student participants:

1. I know that I will be asked to participate in several videotaped human-to-human tutoring sessions.

2. I understand that the information collected in this study will be kept confidential within the limits of the law.

3. I understand that at any time I am free to refuse to participate or answer any question without prejudice to me, that I am free to withdraw from the study at any time, and that Rhodes College does not have any funds budgeted to compensate for injury, damages, or other expenses.

4. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

5. I understand that each tutoring session will last approximately one hour and that I will be paid $150 per hour for participating.

6. I understand that the written transcriptions, videotapes, learning materials, and testing materials from my tutoring sessions may be analyzed by credible researchers other than the experimenters who are videotaping the tutoring sessions.

7. I understand that my transcripts and videotapes may appear on a password protected web-site that can only be accessed by credible researchers.

8. I understand that all personal identifying information (e.g., my name) will not accompany my transcripts or videotapes.

9. I understand that because the tutoring sessions are being videotaped, my face will appear on a videotape.

Signature______________________________ Print Name __________________________ Date _________

If you have any questions regarding your rights as a research participant, please contact the Chair of the Human Subjects Committee and Institutional Review Board at Rhodes College (901) 843-3516.

APPENDIX J – INFORMED CONSENT FOR STUDENTS

Project: An Analysis of Expert Tutors

Principal Investigator: Dr. Natalie Person
Department of Psychology
Rhodes College
901-843-3988
person@rhodes.edu

Funding Agency: Office of Naval Research

The purposes of this research project are to (1) document the teaching practices of expert human tutors, (2), identify the particular tactics, actions, and dialogue moves that are used by expert tutors, (3) contrast the practices of expert tutors with less skilled tutors, and (4) produce a comprehensive roadmap of expert human tutoring.

I, ____________________________, hereby agree to participate as a volunteer in the above named research project "An Analysis of Expert Tutors".

For all student participants:

10. I know that I will be asked to participate in at least one videotaped human-to-human tutoring session.

11. I understand that the information collected in this study will be kept confidential within the limits of the law.

12. I understand that at any time I am free to refuse to participate or answer any question without prejudice to me, that I am free to withdraw from the study at any time, and that Rhodes College does not have any funds budgeted to compensate for injury, damages, or other expenses.

13. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

14. I understand that each tutoring session will last approximately one hour and that I will receive academic help for participating.

15. I understand that the written transcriptions, videotapes, learning materials, and testing materials from my tutoring sessions may be analyzed by credible researchers other than the experimenters who are videotaping the tutoring sessions.

16. I understand that my transcripts and videotapes may appear on a password protected web-site that can only be accessed by credible researchers.

17. I understand that all personal identifying information (e.g., my name, my school) will not accompany my transcripts or videotapes.

18. I understand that because the tutoring sessions are being videotaped, my face will appear on a videotape.

Signature______________________________ Print Name __________________________ Date _________

Parent signature for students who under 18 years of age ___________________________________

Parent Printed Name ____

If you have any questions regarding your rights as a research participant, please contact the Chair of the Human Subjects Committee and Institutional Review Board at Rhodes College (901) 843-3516.

Student Information

Name	
Street Address	
City, State, Zip	
Phone number	
Age	
Gender	
Grade	
School	

For experimenters only:

Session ID:

Tutor ID:

Student ID:

Date:

APPENDIX K – GENERAL TUTOR QUESTIONNAIRE
1. Personal Information

Name:	
Race:	
Gender:	
Age:	
Years Tutoring:	

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2. Education History

Degree	Institution	Focus (Major/Minor)	Dates (yy-yy)

Professional Development Related to Teaching/Tutoring
(Please include any certification, specialization, training, and professional development workshops—if applicable)

Name of Program	Description	Dates (yy-yy)

3. General Information

Please type an X in the box that applies.

3a. Number of students you currently tutor:

1-2	3-5	6-10	11-15	Other:

3b. Total hours you currently tutor per week:

1-5	5-10	10-20	20-30	Other:

3c. Average number of hours spent with each student you tutor per week:

1	2-3	3-4	4-5	Other:

3d. Total number of students you've tutored in your career:

0-20	21-40	41-60	61-80	81-100	Over 100

3e. What kinds of outside resources do you utilize in your tutoring (e.g., online subscriptions, memberships, questions/curricula, etc.)?

3f. How much do you charge for an hour-long tutoring session?

3g. Do you have the same rates for all students? If no, please explain.

3h. How many years of tutoring experience do you have?

---

4. Job History
(Please list all of your work experiences (including professional tutoring experiences) as you would on a resume—beginning with your current position.)

Title	Employer	Brief Description	Dates (mm/yy-mm/yy)	Hrs/ Week

5. Student and Subject History

For each category (row), we want to know the **percentage of students** you have **ever** tutored that fit each demographic description.

- In each box, type in the percentage of students you have tutored who fit that description.
- If you have never tutored a student fitting a particular category then leave it blank. For percentages in the "Other" categories, please provide a description.
- Each row should sum to 100% with the exception of the "Special Needs" category

Example: "Out of all the students that I have tutored in my entire career, approx. 20% attended public schools, 70% of them went to private schools, and 10% were home-schooled." so in the Type of School category, you would type in the respective percentages (i.e., 20, 70, & 10) under the corresponding categories.

Student Demographics:

Gender	M	F

Grade	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	Other:

Environment	Rural	Suburban	Urban

Socio-economic status	Low	Low-Mid	Middle	Up-Mid	Upper

Type of School	Public	Private	Home

Race/ethnicity	Caucasian	African American	Asian	Native American	Hispanic	Pacific Island	Other

Special Needs	Learning Disability (Please specify)	Gifted	Other

Subject Matter

For the total time you've tutored, specify the **percentage of time** you've tutored in each subject area.

Example: "About 50% of the time I've ever tutored, I tutored students in Algebra." so you will mark 50% in the Algebra box and so on.

Mathematics	Advanced Algebra	Advanced Calculus	Algebra	Arithmetic/ Basic Math	Calculus	Computer Science	Geometry	Trig.
Science	Astronomy	Biology	Chemistry	General Science	Geology/ Earth Sciences	Physical Science	Physics	

Other							

6. Pedagogical Philosophy

6a. Briefly describe your philosophy of teaching?

6b. What are the most important factors that determines whether or not a student will be successful?

6c. Why do you think some students succeed in school while others do not?

6d. Do you believe academic success is more a result of ability or effort? Please elaborate.

7. Instructional Methods

7a. What kinds of pedagogical/teaching techniques do you use when you tutor? If you rely on multiple strategies, please explain each one individually.

7b. In a typical tutoring session, what determines the procedure/ protocol you follow during tutoring. For example, do you improvise based on the students needs or follow a set curriculum?

7e. When tutoring, how do you know when to move on to something new?

7i. How do you as a tutor/teacher motivate students to learn?

7j. What strategies do you use for dealing with students who appear unmotivated or frustrated?

8. Additional Questions

Please indicate your personal opinion about each statement by marking an X in the appropriate box.

	Strongly Disgree	Moderately Disagree	Disagree more than agree	Agree more than disagree	Moderately Agree	Strongly Agree
9a. I feel that I am making a significant educational difference in the lives of my students.						
9b. If I try really hard, I can get through to even the most difficult and unmotivated students.						
9c. I usually know how to get through to students.						
9d. Most of a student's school *motivation* depends on the home environment, so I have limited influence.						
9e. There is a limited amount that I can do to raise the basic performance level of students.						
9f. I am uncertain how to teach some of my students.						
9g. I feel as though some of my students are not making any academic progress.						
9h. My students' peers influence their *motivation* more than I do.						
9i. Most of a student's *performance* depends on the home environment, so I have limited influence.						
9j. My students' peers influence their academic *performance* more than I do.						
9k. When a student does better than usual, many times it is because I exert a little extra effort.						
9l. The amount a student can learn is primarily related to family background.						
9m. I have enough training to deal with almost any learning problem.						
9n. When a student gets a better grade than he/she usually gets, it is usually because I found better ways of teaching that student.						
9o. When I really try, I can get through to most difficult students.						
9p. A teacher is very limited in what he/she can achieve because a student's home environment has such a large influence on his/her achievement.						
9q. Teachers are not a very powerful influence on student achievement when all factors are considered.						
9r. If a student masters a new concept quickly, this might be because I knew the necessary steps in teaching that concept.						
9s. If parents would do more for their children, I could do more.						
9t. If a student did not remember information I gave in a previous lesson, I would know how to increase his/her retention in the next lesson.						
9u. The influences of a student’s home experiences can be overcome by good teaching.						
9v. Even a teacher with good teaching abilities may not reach many students.						

9w. When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends on his or her home environment.						
9x. Some students need to be approached differently so they are not subjected to unrealistic expectations.						
9y. My teacher training program and/or experience has given me the necessary skills to be an effective teacher.						