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Chemistry Graduate Teaching Assistants: A Comparison of the Classroom Discourse within Expository and Problem-Based Learning Laboratories

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CHEMISTRY GRADUATE TEACHING ASSISTANTS: A COMPARISON OF THE CLASSROOM DISCOURSE WITHIN EXPOSITORYAND PROBLEM-BASED LEARNING LABORATORIES

by

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Graduate Teaching Assistants (GTAs) commonly function as instructors within undergraduate chemistry laboratories. This study sought to explore and describe GTA classroom discourse within two distinct instructional modes, using discourse analysis as the theoretical framework. The classroom discourse within a series of verification style labs was compared to the classroom discourse produced within a set of Problem-Based Learning (PBL) labs. The results suggest three primary findings: (1) the apparent relationship between the instructional mode and form of GTA classroom discourse, (2) the patterns in classroom discourse observed within a given instructional mode repeat, irrespective of content, and (3) the classroom discourse observed within the PBL labs exemplified a constructivist learning environment. The findings of this study may be used to guide stakeholders in generating discovery-driven and learner-centered classrooms where GTAs serve as instructors.

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Kelley M. Current

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CHAPTER I

INTRODUCTION

At the post-secondary level, faculty frequently view instruction as a necessary evil, taking time away from conducting research, publishing, and securing promotions. What the literature tells us, however, is that the instructional practices utilized by an instructor represent the single greatest source of variation in what students learn as a function of school attendance (Allen et al., 2011; Nye, et al., 2004). Instructional practices consistent with inquiry oriented instruction are favored among educational researchers because of their alignment with the constructivist model of learning.

Graduate Teaching Assistants (GTAs) frequently play the role of instructor within the undergraduate chemistry laboratory, a role that is essential to the functioning of many institutions of higher education (Smith, 1993). The topic of GTA instruction has not been explored widely in the literature generally or in relation to specific disciplines. In addition to being relatively unexplored, GTAs stand to be a very important population to study owing to: (1) the extensive amount of time they spend interacting with undergraduate students (O'Neal et al., 2007) and (2) their potential to influence higher education in the future when they find themselves in the role of professor. Today's GTAs may well be the gateway to the enactment of tomorrow's innovations in higher education.

Educational researchers have been calling for the adoption of inquiry instruction in higher education. Inquiry-oriented and student-centered curricula (problem-based learning (PBL) being one specific example) have been investigated by educational researchers and have shown a variety of positive learning outcomes for students (Hmelo-Silver et al., 2007). Educational researchers anticipated these results in accordance with constructivism, the dominant theory describing what learning is and what factors mediate it.

The Hole in the Literature and Research Questions

The aim of this study was to investigate differences in teaching assistant discourse (in-class talk between GTA's and students) across a set of conditions. The literature tells us that GTAs frequently play the role of instructor and that GTA classroom discourse is tied to undergraduates' willingness to enter and remain within the sciences (Sandi-Urena et al., 2011; O'Neal et al., 2007). Though GTAs have been shown to play a crucial role in keeping undergraduates in the sciences, very little attention has been paid within the research literature to their instructional practices. GTAs are an important population to study. GTAs spend extensive amounts of time interacting with undergraduate students. It is through these interactions that GTAs learn how to teach, and it is also these interactions that will shape the GTA's instructional practice once they find themselves in the role of professor.

The literature also shows us that classroom discourse is a crucial component of instructional practice for all those who teach (Cazden, 1988; Pianta et al., 2012). Within the body of literature focusing on instructional practice, the role that actual classroom discourse plays is frequently taken for granted, or as Cazden (1988) describes it, classroom discourse is viewed as being transparent. Thus, classroom discourse remains understudied despite its importance. With this in mind the following research questions are proposed:

1. How does classroom discourse differ from the expository/demonstration mode of instruction to the PBL mode of instruction?

2. What types of classroom discourse are characteristic of the expository/demonstration mode of instruction and the PBL mode of instruction?

Motivation for this Study

Though inquiry-oriented instructional practices are favored, have been linked to valuable student learning outcomes, and are consistent with the tenets of constructivism, there are still barriers to the widespread adoption of inquiry instruction. This is true for both faculty and GTAs alike. This study seeks to add to the chemical education literature concerning PBL and GTA instructional practices. The goal of this study was to investigate teaching assistant instructional practices, specifically classroom discourse, in two distinct instructional settings, the expository setting and the PBL setting, to begin to explore the relationship between classroom discourse and instructional mode as displayed among GTAs.

Overview of the Chapters

This chapter provides a brief description of the motivation, general form and research questions underlying this study. The next four chapters present a literature review, a description of methods and methodology, the results, and lastly a discussion of the findings and implications of this work.

Presenting a review of the literature, Chapter Two explores constructivism and its intersection with inquiry-oriented instruction. In chapter two, the central role that instructional practices play in generating a truly constructivist learning environment has been described. Inquiry instruction and teaching assistant practices, with a particular emphasis on classroom discourse, are also explored.

In Chapter Three an outline of how this study was conducted has been provided. This chapter begins with a description of this study as qualitative inquiry. The theoretical framework and data collection methods are then outlined. The role of the researcher and a discussion of the ethical considerations associated with this study have also been addressed in this chapter. Lastly, Chapter Three closes with a description of the data analysis procedures used.

In Chapter Four, the results of the study are presented. Both graphic and transcribed data are presented in tandem for the entirety of the data collected over the course of this study. Chapter Four closes by presenting the inter-coder reliability data collected for this study.

In Chapter Five, the conclusions and implications of this work are presented. The results and implications are tied back to the topics of instructional practice, constructivist learning, and institutional priorities.

CHAPTER II

INTRODUCTION

Chapter two functions as a literature review and is intended to provide the reader with a description of why this research is important and how it fits into the existing literature. This literature review begins by discussing the four primary modes of instruction (expository, demonstration, inquiry, and individualized instruction) and their complementary instructional practices. The literature review then moves on to describe constructivism, a widely accepted theory of learning among educational researchers. An idealized learning environment according to constructivist learning theory is mirrored by the instructional practices common to the inquiry-oriented setting. Though instructional practices are central to the enactment of a constructivist learning environment, instructional practices are very complex and require further description and categorization. The literature surrounding instructional practices is explored. With a solid description of the central role that classroom discourse plays (with respect to instructional practice) the literature review shifts focus describing the specific inquiry oriented setting and also the nature of the participants at play in this study. And lastly, the literature focused on value and potential associated with the study of graduate teaching assistants (GTAs) is discussed.

Modes of Instruction

The literature tells us that there are many different ways to combine instructional practices, environments, and curricular settings to create a learning environment. In the last fifty years, many authors have published on the topic of instruction. Some authors describe instruction that generates a specific type of learning experience. Tileston (2007) highlights the instruction that supports the creation of an active learning environment within the classroom. Ollingston (2008) functions as a review text, outlining instruction that supports topics ranging from the nature of science (NOS) to dynamic thinking.

Other authors writing about instruction decontextualize both the instructor and the setting, and instead focus on broad and more generalized descriptions of the topic. In *Strategies for Effective Teaching,* Ornstein & Lasley (2000) discuss how planning, enacting, assessing, and reflecting upon instruction connect to produce desired student outcomes. In Glanz's 2002 publication: *Finding Your Leadership Style: A Guide for Educators*, the author describes different types of leaders and explores how these leaders can best instruct and serve within education.

Still other authors have focused on instruction in particular courses or types of courses. Morton (1985) discusses instruction with respect to the foundations, selection and evaluation of which is most conducive to the instruction of high school level economics. Buffie, Welch, and Paige (1968) reviewed which instruction methods are most appropriate for the teaching of mathematics. In their 2010 publication, *Clinical Teaching Strategies in Nursing*, Gaberson & Oermann make explicit the types of instruction most useful to those teaching within the clinical nursing setting. Lastly, many authors describe instruction as it should be practiced by specific types of instructors. DeYoung (2003) describes instruction most useful to nursing instructors in the publication entitled *Teaching Strategies for Nursing Educators*. Glanz (2004) outlines instruction that would be of interest to the beginning instructor, particularly interested in managing classroom behavior.

With the vast number of different perspectives on instruction described in the literature, the core components of this topic are obscured. With so many variations regarding instruction and how it is conceptualized, a simple, efficient, and generalized means of categorizing instruction would be helpful. Womack (1989) provides such a categorization scheme. Womack (1989) outlines a total of forty-three means of instruction. Instruction ranges from the presentation of a formal lecture (a continuous verbal/visual presentation generated by the instructor and given to the entire class) to the construction of a panel (an informal but structured discussion among few, followed by an open group discussion). Though Womack (1989) has identified forty three means of instruction, they can be grouped into four categories, or modes, of instruction. The four essential modes of instruction according to Womack (1989) are: (a) expository, (b) demonstration, (c) inquiry, and (d) individualized instruction. For a description of some of instructional practices which fit into each of these four categories please see Figure 2.1., adapted from Womack (1989).

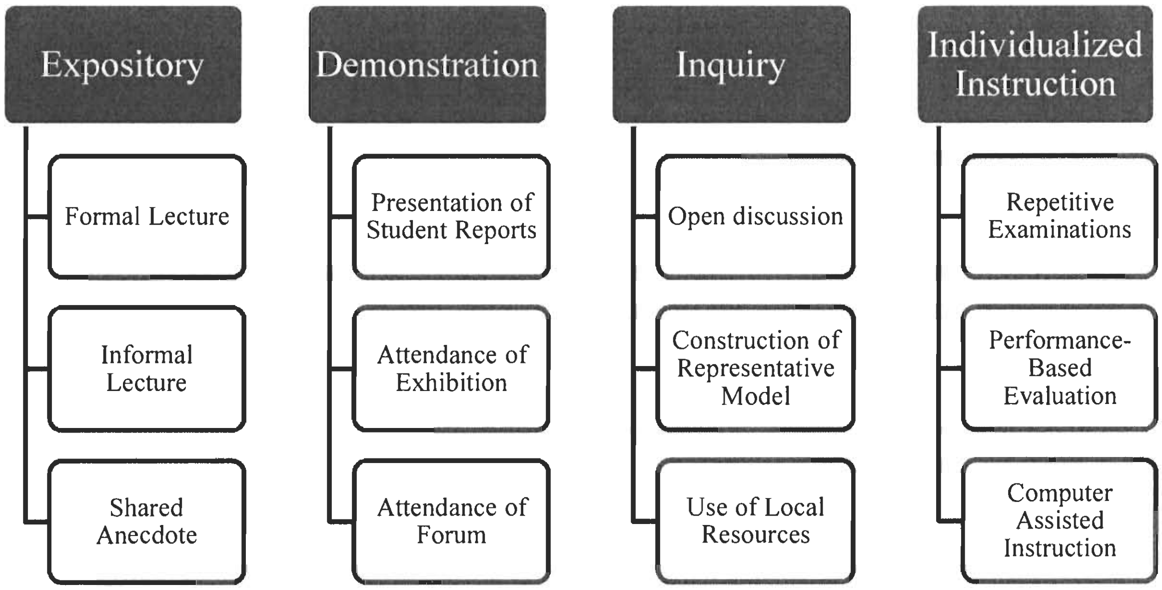


Figure 2.1. Modes of instruction and examples of instruction adapted from Womack (1989).

The inherent assumptions concerning: (a) the role of the instructor, (b) the role of the learner, and (c) assumptions about the learner make each mode of instruction distinct (Womack, 1989). Expository instruction is the most common mode of instruction employed in college classrooms today (Mervis, 2013). This type of instruction typically includes formal and informal lecture with occasional parables, anecdotes, and audio-visual presentations, and seeks to expose learners to what is to be learned (Swaak et al., 2004). Expository instruction assumes that the purpose of the course is to impart an essential body of knowledge to a relatively homogeneous (with respect to background preparation) group of learners (Jones et al, 1990). The instructor's role in an expository classroom is to function as the director of learning by dictating the method and pace by which content will be presented. In this mode of instruction the learner is required to meet specific benchmarks at specific times. Expository instruction, though common-place, is paired with several weaknesses. In the expository classroom, where the instructor functions as the hub of all learning, if the instructor is distracted or delayed, learning stops. This is particularly problematic in classrooms where disciplinary or classroom management issues arise frequently. Expository instruction is also plagued by one of the underpinning assumptions, because learners are rarely homogeneous with respect to their background knowledge or skill sets. These are some of the reasons why expository instruction so frequently produces variable learning outcomes (Womack, 1989).

Modes of instruction classified as demonstration include attending field trips, partaking in or viewing of dramatizations or recitals, and exploring exhibitions. The use of instructional demonstrations is predicated upon the assumption that learning occurs when the learner is capable of taking note of the salient features of a functional and accurate model of the phenomenon being studied. When utilizing this type of instruction, the role of the instructor is to prepare the demonstration and prepare the description of the demonstration such that all of the key components are brought to the learner's attention. Learners are expected to carefully attend to the demonstration and participate as required. Instructional demonstrations have some inherent weaknesses. Instructional demonstrations frequently require prior exposition, so that the learners realize to what components of the demonstration they should be attending. Instructional demonstrations that represent the phenomenon well can also be difficult to find and implement, limiting the functionality of this particular mode of instruction. And lastly, when instructional demonstrations are being used, the instructor must take care to assure that the necessary safety precautions are being heeded, which can limit the functionality of instructional demonstrations (Womack, 1989).

The inquiry mode of instruction involves learners solving open-ended questions under conditions where there are varying levels of support and structure to guide learners in this endeavor (Hmelo-Silver, 2004). Inquiry as a mode of instruction assumes that instruction is best when it provides an environment in which learners may learn self-directed critical thinking skills by following the instructions and working within the bounds of the classroom resources (Womack, 1989). The instructor in inquiry instruction functions as a guide, helping learners complete the tasks and reach goals at their own pace and with their own path. The learner is expected to generate questions and to apply initiative to find the answers. Learners are required to work within the bounds of the classroom resources. Inquiry instruction suffers from one primary weakness; it depends heavily upon the instructor to behave as a resource rather than as a director. This is challenging given that the vast majority of instructors learned in classrooms that were most frequently expository in nature. Anderson (2002) revoices this claim originally made by Womack, stating that preparing teachers to conduct inquiry-oriented classrooms is a most significant barrier blocking the widespread adoption of inquiry. McNeill & Krajcik (2007) again bring attention to this issue, stating that it is the lack of experience that instructors have with inquiry that drives the difficulty of incorporating inquiry as a commonly used mode of instruction.

Lastly, individualized modes of instruction are those in which learners are allowed to work through course material at their own pace and are encouraged to master each component of the content being presented (Gagne, et al.,1992). For individualized instruction, it is assumed that one or more of the previously mentioned modes of instruction may, from time to time, be utilized. Learners are assumed to be heterogeneous with respect to their skills and background knowledge. This heterogeneity is expected to increase over each learner's educational career. Individualized instruction is rooted in the idea that people will learn when given a chance to learn at a comfortable pace (Womack, 1989). Within the individualized instructional mode, the instructor builds the learning environment and learning goals to support the mastery of select learning objectives with minimal stress. The instructor also frequently functions as a facilitator, supporting and guiding learners as they use classroom resources to complete assigned tasks and answer their own questions (Hmelo-Silver, 2004). The most significant weaknesses of individualized instruction is associated with the instructor's ability to function as a guide or a facilitator, rather than as a director. The lack of familiarity with the teaching practices associated with this type of instruction function as a barrier to its use, acceptance, and application within the educational system (Womack, 1989).

Constructivism and its Parallels with Inquiry

As previously noted, inquiry is the favored mode of instruction among educational researchers because this mode of instruction is an actualization of a constructivist learning environment. In this section of the literature review, a description of constructivist learning theory and how it is mirrored by the inquiry oriented setting is provided.

Given the four most prevalent modes of instruction employed in college classrooms, inquiry instruction is favored among educational researchers (Dunlap & Martin, 2012). Inquiry involves learners solving open-ended questions under conditions where varying levels of support and structure are provided to guide learners (Alfieri et al., 2010). Inquiry is an umbrella term describing a continuum of curricular settings and instructional practices including, but not limited to; problem-based learning, guided inquiry, and discovery learning.

In the discovery-learning curriculum, learners are given target information and are expected to generate conceptual understanding within the confines of the tasks assigned, using only the instructional materials provided (Alfieri, et al., 2010). Assistance from the instructor is minimized within this setting (Alfieri, et al., 2010). Guided inquiry calls for learners to perform activities that allow them to discover concepts or principles in a structured setting prior to receiving a lecture describing that content (Meltzer & Espinoza, 1997). In guided inquiry, students are encouraged to design a means of answering an instructor-initiated question (Meltzer & Espinoza, 1997). In the guided inquiry setting, the instructor performs a variety of roles, first functioning as a facilitator and subsequently as a lecturer. Problem-based learning on the other hand, calls upon learners to answer ill-structured real world problems through collaboration and trial and error (Hmelo-Silver, 2004). Within problem-based learning, the instructor functions as a facilitator guiding the students as needed (Hmelo-Silver, 2004).

As a mode of instruction, inquiry displays a continuum of curricular settings and teaching techniques (three of which were described in the previous paragraph), yet the assumptions and aims of this instructional mode of teaching consistently align themselves with the tenets of constructivist learning. What is today considered to be constructivist learning developed out of the work of Piaget (1952, 1965), Brunner (1966) and Vygotsky (1978). A brief description of their contribution to constructivism is provided below.

In the 1920's, Piaget began studying children and their interactions with intellectual tasks. Being classically trained as a biologist, Piaget was interested in understanding how behavior within an environment changes and adapts to benefit the individual (Gage & Berliner, 1998). Piaget described the details of these developmental levels (sensorimotor stage, preoperational stage, concrete operational stage, and formal operational stage) in his 1977 publication *The Essential Piaget*. Piaget's most well-known contribution to the constructivist perspective has been the conception that knowledge is built in the mind of the learner (Gage & Berliner, 1998). Prior to the work of Piaget, it was assumed that knowledge could be transported intact from one mind to the next, an assumption that silently guided the form of educational practices and educational research until the 1980s (Bodner, 1986).

In contrast to Piaget, Brunner (1966) expanded the focus of constructivism beyond knowledge construction as mediated by developmental levels. For Brunner (1966), culture was central to knowledge construction because it exposed learners to the mental tactics by which they may describe, interact with, and understand the world. Brunner took issue with Piaget's emphasis on developmental levels and their importance for learning, a part of Piaget's work that was challenged by many (Brainerd, 1978; Scandura & Scandura, 1980; Siegler, 1991). Brunner (1966) instead characterized intellectual growth as an increase in the variety of possible responses that could be produced in a given situation and the acquisition of language such that reality could be described and predictions, extrapolations, and hypotheses could be generated (Gage & Berliner, 1998). Brunner recognized three stages of development through which learners progress (enactive, iconic, and symbolic), but claimed that culture was most responsible for the shaping of thinking and progressing learners through these stages (Gage & Berliner, 1998).

Vygotsky built on the work of both Piaget and Brunner, stretching constructivism further by exploring the role that socialization and child/adult interactions have on learning. Vygotsky, like Brunner, emphasized the importance of culture for knowledge construction as mediated by learner/instructor interaction (Berliner & Gage, 1998). In his 1978 publication, Vygotsky made the claim that the social environment played a special role in influencing the learner's ability to construct knowledge. Vygotsky delineated the distinction between the learner's actual development and potential development, and defining the learner's abilities when working alone as the learner's actual development while the learner's abilities when working with an instructor as the learner's potential development (Vygotski, 1978). The difference between a learner's actual and potential development was referred to as the zone of proximal development (ZPD) (Vygotski, 1986). The zone of proximal development has had significant implications for the implementation of constructivist learning. According to Vygotsky, learning is most productive when the learner is situated within the zone of proximal development and works cooperatively and collaboratively with those who are more knowledgeable, allowing the learner to go further than possible if the learner were working alone (Vygotski, 1986). For Vygotsky, the learner constructs knowledge best when challenged and simultaneously supported by an instructor in possession of the mental tools required for completion of the task put forth to the learner.

What is meant by and what constitutes constructivist learning has grown and evolved over time. The advancement of constructivism with respect to what it means to understand and what factors mediate the construction of understanding have led educational researchers to advocate for the use of those instructional methods which best align with constructivism. As a mode of instruction, inquiry situates the learner in an environment where the learner is tasked with answering open-ended questions with the support and guidance of an instructor. Constructivism posits that the learner is best served when individualized construction of knowledge is supported by the guidance of a more knowledgeable individual. As a mode of instruction, inquiry embodies the components of a constructivist learning environment (Brown & Campione, 1996; Brown & Palincsar, 1988). Today, constructivist instruction occurs when the instructor relinquishes a certain amount of control to the students by (Gage & Berliner, 1998) by:

(1) bringing out what students already suspect, know, believe, or are capable of,

(2) encouraging students to reflect on these actions, and

(3) supporting students by either confirming that they are on the right path or by occasionally telling the students what they need so that they may make progress.

Instructional Practices

Though inquiry-oriented curriculum theoretically embodies the components of a constructivist learning environment, it is the instructional practices that are at the root of actually producing a learning environment that exemplifies constructivism. This segment of the literature review describes the multifaceted concept of instructional practices by breaking them down into more narrowly defined categories.

As emphasized previously, there are four of modes of instruction (expository, demonstration, inquiry, and individualized instruction), each of which is consistent with a variety of instructional practices (lecturing, sharing anecdotes, etc.). But, given a single instructional mode, there still exists a great amount of variation in the instructional practices actually employed as a lesson is carried out (McNeill & Krajcik, 2007). The variation with respect to instructional practices is not trivial. Instructional practices and their significance have been highlighted in a recent review article published by Slavin, Lake & Groff (2009, p. 886) which states unequivocally that "curriculum differences appear to be less consequential than instructional [practice] differences" with respect to influence on student learning outcomes. The National Research Council's (2005) findings have also shown that variation in instructional practices are significant and are tied to improved student outcomes.

Though variations in instructional practices have been shown to be important, as a concept, instructional practices are still rather large and broadly defined. What exactly are instructional practices? To better describe instructional practices and how they may vary, Pianta, Hamre & Mintz (2012) have uncovered three basic components of instructional practice: (a) emotional support, (b) classroom organization, and (c) instructional support. These components have been linked to increased student achievement outcomes, were derived from reviews of constructs addressed in a variety of classroom observation instruments, and have been piloted extensively (Allen, et al., 2011).

Basic descriptions of these instructional categories are outlined in the Figure 2.2. Emotional support relates to those in-class actions that are used by instructors to assist students so that they may create positive relationships and interactions within the course. Classroom organization relates actions taken by the instructor that communicate the instructor's expectations and rules. And lastly, instructional support relates to instructor actions in class that provide students with feedback so that they may problem-solve with available resources. When an instructional mode is held constant, wide variation in instructional practices is often observed because varying levels of emotional support, classroom organization, and instructional support are provided (Pianta et al., 2012).

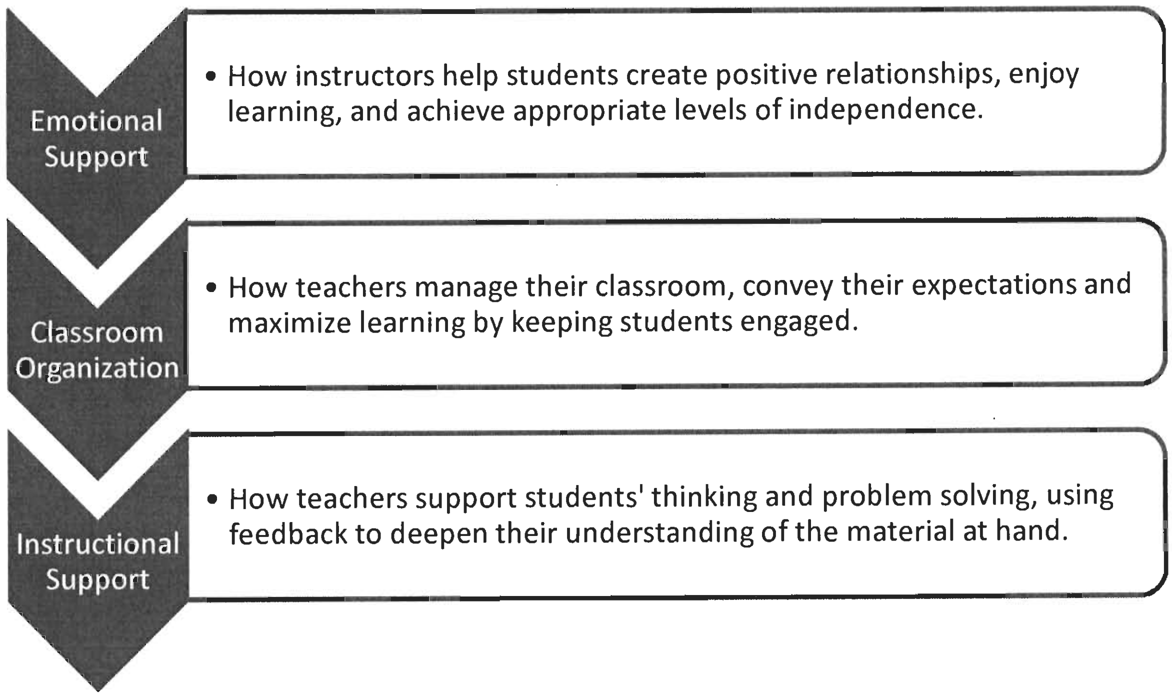


Figure2.2. Key components of instructional practice adapted from Pianta et al. (2012)

Instructional Practice and Classroom Discourse

With a more nuanced description of instructional practices, this section of literature review highlights the ways in which classroom discourse cross-cuts and impacts nearly all elements of instructional practice. What is prominent, based upon a review of the components of instructional practice, is the importance afforded to spoken language in the classroom. Each component of instruction is dependent upon the spoken language of the instructor. Instructional support, emotional support, and classroom organization are all founded upon the spoken language conveyed by the instructor to learners. The spoken language used by the instructor in class will henceforth be referred to as classroom discourse.

Generally, discourse can be defined as language used in everyday talk that is best viewed as situated in or influenced by the context and domains of social life in which the speaker exists (Phillips & Jorgensen, 2002). For the purposes of this literature review, the classroom is the context; this makes classroom discourse the focus. Descriptions of effective teaching found in the literature frequently suggest the central role played by classroom discourse without directly stating it. Both intervention and descriptive studies that focus on effective instruction highlight what is referred to here as classroom discourse, without discussing classroom discourse outright. The following two sections illustrate segments of the literature that investigate effective instruction by essentially focusing on classroom discourse.

Wiggins (2012) defines and highlights what it means to teach effectively by stating that classroom discourse that provides students with effective feedback is the key to improving learning outcomes. Wiggins defines effective feedback as the act of providing learners with descriptions of their performance that are: (a) goal-referenced, (b) tangible, (c) actionable, (d) user-friendly, (e) timely, (f) ongoing, and (g) consistent. Wiggins (2012) emphasized the variety of ways that instructors provided feedback to their students in a discussion that included but was not limited to classroom discourse. These descriptors of effective feedback are directly related to classroom discourse.

In another paper where classroom discourse was studied, Hmelo-Silver & Barrows (2006) described general types of classroom discourse used by a master facilitator (the instructor). This discourse included: (a) open-ended metacognitive questioning, (b) pushing for explanation, (c) revoicing, (d) summarizing, (e) generating and evaluating hypotheses, (f) encouraging construction of visual representations, and (g) checking for consensus among group members. Although not explicitly identified, classroom discourse was central to this study. Hmelo-Silver & Barrows (2006) instead focused on instructor beliefs.

There have been authors who have focused directly on the exploration of classroom discourse. Courtney Cazden is a foundational author and researcher who has focused on the study of classroom discourse. According to Cazden (1988), discourse is the primary mode of communication used by instructors to teach and learners to learn. The differences in how/when something is said by an instructor can be the difference between excellent and impaired instruction; it is for this reason that classroom discourse should not be considered transparent when issues of instruction and learning are being considered (Cazden, 1988). Cazden (1988) states directly that there exists an underlying pattern that classroom discourse follows unless a deliberate action is taken. This underlying pattern suggests a default mode for classroom discourse. This pattern is referred to as the initiation-response-evaluate (IRE) sequence (Bellack, 1966).

The IRE sequence aligns well with the assumptions and aims of an expository mode of instruction, but is less consistent with the assumptions and aims of the inquiry mode of instruction. Recall that expository instruction assumes that the purpose of instruction is to impart an essential body of knowledge by having the instructor function as the director of learning, dictating the method and pace of content presentation (Swaak, et al., 2004). Inquiry instruction, on the other hand, assumes that instruction is best when it allows learners to be self-directed, exercising critical thinking skills while the instructor functions as a guide, and helping learners complete tasks and reach goals at their own pace with their own path (Hmelo-Silver, 2004).

The IRE sequence affords the instructor a great deal of control over the specific content that is covered and the pace at which the content is covered. The level of control that the instructor has when employing this type of classroom discourse is well aligned with the concept of expository teaching. However, the IRE sequence is not well aligned with inquiry instruction (Gilkison, 2003). Gilkison (2003) notes that categories capable of sufficiently denoting the types of instructor/learner discourse present within an inquiry setting could not be categorized using the IRE sequence and were not sufficiently defined in the literature. Gilkison (2003) conducted a qualitative study and, using an inductive intuitive approach, generated a set of categories that were capable of describing the classroom discourse in an inquiry setting. According to Cadzen (1988,) what would appear to be minor changes in the structure and form of classroom discourse are capable of producing substantial social and cognitive effects.

Problem-Based Learning

With a solid description of the central role that classroom discourse plays with respect to instructional practice, the literature review shifts focus, describing the specific inquiry oriented setting, problem-based learning (PBL), that is of interest in this research project. Within the Problem-Based Learning (PBL) context, students are asked to provide solutions to an ill-structured problem by collaborating with peers and enacting their self-directed learning skills in order to determine what is required to solve the problem at hand (Hmelo-Silver, 2004). Within the PBL setting, the instructor functions as a facilitator, guiding and supporting students' learning without functioning as the hub of understanding and knowledge (Hmelo-Silver, 2004). The PBL setting was designed to achieve the following goals: (a) to foster student creation of an extensive and flexible knowledge base, (b) to assist students in developing and enacting problem-solving skills, (c) to assist students in developing and enacting self-directed learning skills, (d) to foster student collaboration/teamwork skills, and lastly, (e) to allow students the space to develop the intrinsic motivations to learn (Barrows & Kelson, 1995).

According to Ram (1999), there are five stages that learners experiencing PBL progress through: (a) introduction, (b) inquiry, (c) self-study, (d) reconsideration, and (e) presentation. During the first stage, the introduction stage, learners are given a role and an ill-structured question to investigate. In the inquiry stage, learners are encouraged to explicitly outline what they already know and what they need to know. In the self-study stage, learners use their resources to collect the information, which was deemed necessary in the previous phase. In the reconsideration of hypothesis phase, learners use their experimental data to re-evaluate their hypothesis and research plan. In the final phase of the PBL experience, learners present their research plan along with results and conclusions, emphasizing what they would do differently were they to repeat the process.

The instructor's ability to effectively serve as a facilitator is crucial to the PBL setting functioning at each stage so that the goals of PBL can be met. A major portion of functioning as a facilitator revolves around the instructor's use of classroom discourse. Hmelo-Silver (2004) describes the job of the facilitator as being an expert learner, capable of modeling strategies for thinking and learning while also helping students to move through the stages of PBL. Hmelo-Silver (2002) describes how an expert facilitator accomplished this feat. By implementing metacognitive questioning strategies and questioning students to the point that the limitations of their understandings were revealed, the instructor was able to function as a facilitator. This brief description describes what it means for an instructor to function as a facilitator while also highlighting the importance of classroom discourse. An instructor's ability to enact classroom discourse that is consistent with the tenets of facilitation can quite literally make or break the ability of the PBL setting to function as intended and achieve the goals previously outlined (Roehrig & Kruse, 2005).

The PBL setting has been shown to produce a variety of favorable learning outcomes in line with goals outlined above. Dochy, Segers, Van den Bossche, and Gijbels (2003) conducted a meta-analysis focused on the effects of PBL. It was found that learners who experienced PBL demonstrated no significant increase in declarative knowledge relative to their counterparts who experienced expository instruction. But, learners in the PBL setting did fare better than students from the expository instructional mode when measures of knowledge application were assessed and compared. Patel, Groen and Norman (1993) compared expository and PBL learners, and found that the PBL students were better able to utilize a hypothesis-driven reasoning strategy when faced with a novel problem. Learners from the expository setting did not apply hypothesis-driven reasoning strategies when faced with novel problems. Experts, faced with novel problems, have been shown to employ reasoning strategies rooted in first principles (Norman et al., 1994). Learners enacting reasoning strategies that imitate those of experts represent a rather encouraging finding in support of PBL. In a carefully structured crossover experiment, learners who were exposed to both PBL and expository instruction over the course of a semester were able to generate "more integrative and explanatory essays" with the concepts that were taught with the PBL approach as opposed to the expository approach (Capon & Kuhn, 2004; Hmelo-Silver et al., 2006, p.

103). Sandi-Urena, Cooper, and Stevens (2012) conducted a study of the PBL setting and found that learners in this environment demonstrated improved problem-solving skills as well as increased self-regulation of metacognitive strategies, despite being in a setting lacking explicit instruction of these skills.

What these studies show is the extent to which this setting is capable of producing student outcomes aligned with the goals of PBL. Interestingly, few of the studies outlined above took time to describe or emphasize the centrality of classroom discourse within the PBL setting. The focus has been primarily on student outcomes while instructor practices (i.e. actual classroom discourse) have been largely ignored. The majority of studies on PBL and its effects focus on student outcomes.

Graduate Teaching Assistants

Given the importance of classroom discourse generated by instructors, this literature review closes by describing the value, the potential, and the untapped resource represented by the study of GTA classroom discourse. GTAs frequently play the role of instructor within the undergraduate chemistry laboratory (Sandi-Urena, et al., 2011). The graduate teaching assistantship (GTAship) is often seen as a means of supporting a graduate student and as a necessary evil that reduces the time that the graduate student could be spending in the research lab (Sandi-Urena et al., 2011). In reality, however, the instructional practices employed by GTAs are essential to the functioning of many institutions of higher education and are essential to the teaching of science generally (Smith, 1993). The majority of undergraduates who are ultimately awarded a degree in science, technology, engineering, and mathematics (STEM) attend doctorate-granting institutions which employ veritable armies of GTAs to instruct introductory courses (National Science Board, 2006).

A study conducted by O'Neal et al. (2007, p. 24) asked the question, "What influences do TAs have on underclass students' plans to major in or leave the sciences?" The researchers surveyed undergraduates, finding that undergraduates do not report that their GTA's are cause for them to continue with or leave STEM fields (O'Neal et al., 2007). Though students did not cite GTAs directly, the reasons that students cited as factors that influenced their desire to either continue or leave STEM fields (classroom climate, course grades, and learning about careers) are those which are directly related to and mediated by the instructional practices of GTAs. This finding is in line with similar work conducted by Seymour & Hewitt (1997) in the landmark publication *Talking About Leaving*. In this work, in-depth interviews were used to explore undergraduates' rationales for leaving STEM majors. In short, GTAs' instructional practices impact undergraduate students' desires to remain in the sciences.

In addition to affecting student's selection of major and persistence within it, GTAs' instructional practices have the potential to form genuinely constructivist learning environments within early undergraduate laboratory courses. Earlier in this literature review, the connection between instructional practices (classroom discourse in particular) and the enactment of a constructivist learning environment was discussed. The success or failure of an inquiry-oriented laboratory course taught by a GTA depends on the instructional practices employed by the GTA (Roehrig & Kruse, 2005) and whether or not they are aligned with the constructivist learning model. With mounting evidence of the value and benefits resulting from inquiry-oriented instruction like problem-based learning (Hmelo-Silver et al., 2007) and ever-increasing interest in the use of this type of instruction in undergraduate labs (Roehrig & Kruse, 2005), the potential research opportunities that this setting poses to educational researchers is great.

Lastly, GTA instructional practices represent an untapped resource for educational researchers because so little is known about GTA instruction with respect to what it influences and what influences it. Recent research suggests that instruction plays a role in the growth and development of graduate students throughout their graduate careers (Dunn-Haley & Zanzucchi, 2012). Those authors who have explored the subject report that GTAs begin teaching as they were taught and alter their instructional practices through self-reflection and training (Dunn-Haley & Zanzucchi, 2012). Feldon, et al. (2011) reported results indicating that the act of instructing students engaged with an inquiry lesson served to provide a sort of dress rehearsal for the application of methodological research skills. This research suggests the value that inquiry instruction has for GTAs on their path to becoming independent researchers.

While little is known about GTAs in general, less still is known about their instruction within specific disciplines. Chemistry is one of the few disciplines where GTAs, as a population, have been explored. Sandi-Urena and colleagues have been one of the few groups to investigate chemistry GTAs (Sandi-Urena et al., 2011). The Sandi-Urena group has investigated chemistry GTAs and their instruction with respect to the ways in which inquiry instruction from within the PBL setting influences GTA epistemological and metacognitive development (Sandi-Urena, et al., 2011). The rationale underpinning this study was that laboratory instruction capable of providing GTAs with an intellectually stimulating environment that provided opportunities for ‘research-like’ thinking would help GTAs to further develop their research skills (Sandi-Urena, et al., 2011). GTAs who instructed PBL labs demonstrated epistemological growth (Sandi-Urena, et al., 2011). This research aligns with Feldon, et al.'s (2011) findings that inquiry instruction is beneficial for GTAs and went further by demonstrating how GTAs sharpen their epistemological beliefs when instructing a PBL lab. Given the impact that GTAs have on undergraduates, the mounting interest in inquiry oriented labs, and the potential benefits that the teaching of inquiry labs has for GTAs, it seems only natural that research focused on GTAs and their teaching within inquiry settings will increase.

Summary and Research Questions

Of the four primary modes of instruction (expository, demonstration, inquiry, and individualized), inquiry is favored among educational researchers because of its alignment with constructivist learning and the instructional practices and classroom discourse that are compatible with it. Inquiry calls for the facilitation of learning; it calls for open discussion between instructor and learner, where the learner is supported in the construction of his or her own knowledge and understanding of a topic. PBL is a five-stage method that can be categorized in the inquiry mode of instruction. For PBL to function as planned, the instructional practices implemented by the instructor must use classroom discourse (a topic which cross-cuts instructional practices at large) to facilitate learning.

At present, little is known about GTA instruction within either expository or inquiry-styled instructional settings. Given what is known about GTA instruction, and given the impact that GTA instruction has on current undergraduate STEM experiences and current GTA research skills development, along with the small amount of literature focused on GTA instructional practices and classroom discourse, this study addresses the following research questions:

1. How does classroom discourse differ from the expository/demonstration mode of instruction to the PBL mode of instruction?
2. What types of classroom discourse are actually characteristic of the expository/demonstration mode of instruction and the PBL mode of instruction?

Chapter 3

Rationale

faculty at the post-secondary level frequently view time spent on instruction as a barrier to conducting research and securing promotions, yet instructional practices represent the single greatest source of variation in what students learn as a function of school attendance (Allen, et al., 2011; Konstantopoulos &Hedges, 2004). As a mode of instruction, inquiry is favored among educational researchers because of its alignment with constructivist learning, as well as the types of instructional practices and classroom discourse that emanate. Graduate Teaching Assistants (GTAs) frequently play the role of instructor in the undergraduate chemistry laboratory. This role is essential to the functioning of many institutions of higher education (Smith, 1993). Few publications exist within the literature focusing on the instruction of GTAs, while still fewer focus on chemistry GTA instruction. Because of the importance of the role the GTA plays as an instructor and the ever-increasing popularity of inquiry as a mode of instruction, the study of GTAs instructional practices within the inquiry setting is timely:

1. How does classroom discourse differ from the expository/demonstration mode of instruction to the PBL mode of instruction?
2. What types of classroom discourse are characteristic of the expository/demonstration mode of instruction and the PBL mode of instruction?

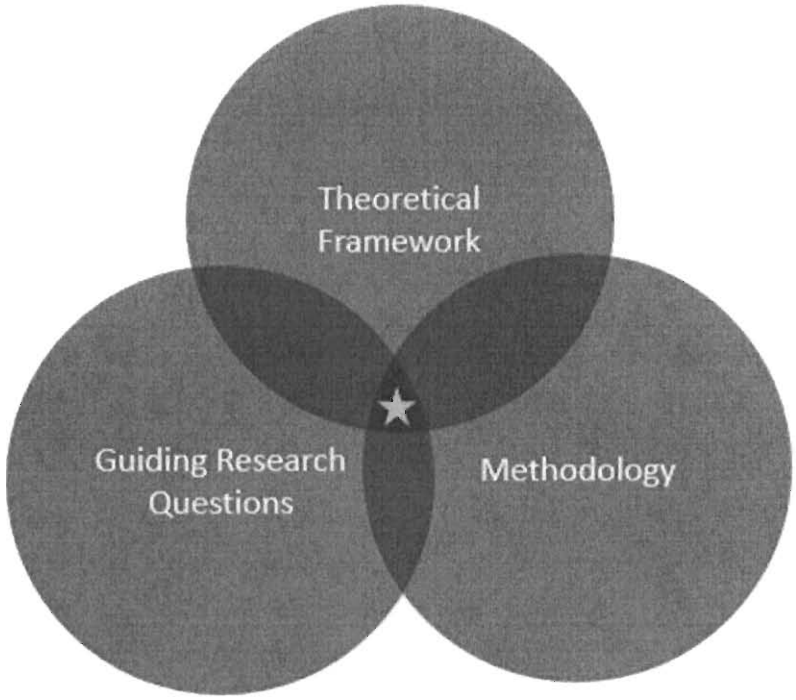


Figure 3.1. Venn diagram illustrating the connections between guiding research questions, theoretical frameworks, and methodology within a quality chemical education project. (Adapted from Bodner & Orgill (2007)).

In Chapter Three, the methodology of this research project will be described. The chapter presents topics in the order that the researcher selected them during the research process. First qualitative inquiry is discussed, the nature of the participants is described, and the theoretical framework is outlined. With the type of inquiry, the participants and the theoretical framework outlined, the specifics of the data collection process, the role of the researcher, ethical concerns, the process of coding, and the data analysis procedures are explored. *Figure* 3.1. illustrates the intersection between the three components of a chemical education research project to be described in this chapter.

Qualitative Inquiry

This research project utilizes qualitative inquiry methods. There are many authors who have written descriptions of what qualitative inquiry is, the purpose that it serves, and how it should be conducted. Researchers have also noted that many of these texts focused on qualitative inquiry as a means of conducting research do not provide a concise and all-encompassing definition of qualitative inquiry (Creswell, 2007). Patton (2002) emphasizes that qualitative inquiry is not singular or monolithic in its research methods and approaches. Denzin & Lincoln (2005) have provided a basic description of what qualitative inquiry is:

> Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible…they turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. (p. 3)

There are nine characteristics commonly described as key elements of qualitative inquiry, but authors do not all cite the same characteristics as being crucial components of a qualitative inquiry. The Table below, adapted from Creswell (2007), indicates, for each author, those elements that are key components of qualitative inquiry.

Table 3.1.

Characteristics of qualitative inquiry as described by select authors

Characteristic	**LeCompte & Schensul (1999)**	**Marshall & Rossman (2006)**	**Hatch (2002)**	**Creswell (2007)**
Data collection from a naturalistic setting	X	X	X	X
The researcher is the instrument			X	
Multiple data sources are required	X	X		
Data analysis is inductive and recursive	X	X	X	X
Research focuses on the perspectives and meanings made by participants	X		X	X
Acknowledgement that human behavior and belief are related to their socio-political context	X			X
Research design is emergent as opposed to being pre-figured		X	X	X
Researcher reflects on their role in the inquiry process		X		X
A holistic view of social phenomenon is considered		X	X	

The lack of agreement on the primary components that describe a qualitative inquiry among foundational authors suggests that a continuum of qualitative inquiries exist. Patton (2002) writes that, "different purposes, situations, questions, and resources will affect the degree to which such qualitative ideals as naturalistic inquiry, a holistic perspective, and inductive analysis can be realized in practice" (p. 76).

In prefigured technical qualitative inquiry, researchers utilize technical, scientific, and standardized strategies to set analytic categories and codes before analyzing data. On the other end of the continuum are emergent intuitive qualitative inquiries where categories are not predetermined; the researcher instead relies on his or her ability to generate categories based on their immersion in and interpretation of the data. Template analysis, the strategy used in this research project, refers to the reliance on preset codes that the researcher may revise as the analysis progresses (Marshall & Rossman, 1999).

Creswell (2007) emphasizes how qualitative work flows from the researcher's philosophical assumptions and worldviews. The research questions posed, the types of data collected, and the modes of handling and interpreting data are all rooted in the researcher's worldview and chosen paradigm. Guba (1990) defines paradigm or worldview as: "a basic set of beliefs that guide action" (p. 17). Patton (2002) defines the paradigm with more depth as "a way of thinking about and making sense of the complexities of the real world… [where] paradigms tell us what is important, legitimate, and reasonable" (p. 69). Patton (2002) goes on to describe how adherence to a paradigm facilitates taking action, but obscures the rationales and assumptions that underlie the action. It is the paradigm to which a researcher ascribes that allows him or her to distinguish hard data from soft data, empirical evidence from anecdote, and the objective from the subjective (Patton, 2002). The paradigm that a researcher adheres to either limits or defines the types of questions asked and the methodologies utilized in the answering of those questions. It becomes crucial that qualitative researchers make explicit their paradigmatic and philosophic perspectives, so that biases caused by their personal patterns of perception may be placed in full view of future interpreters of their work.

For those who adhere to the pragmatist worldview, it is the outcomes of one's research, the consequences, situations and actions of research, on which the primary focus of the researcher lies. Patton (1990) describes those researchers with the pragmatist worldview as those who are in interested in what works. In this way, methodological appropriateness supersedes methodological orthodoxy (Patton, 2002). The pragmatist asserts that lines of inquiry should be judged against their stated purposes, resources, research procedures utilized, results, and interpreted findings, all within a given setting and an intended audience (Patton, 2002).

Patton (2002) describes himself as a pragmatist who:

> Takes issue with … [those] who believe that naturalistic inquiry is the only valid and meaningful way to study human beings, [but is equally opposed to those] who assert that randomized control experiments are "the standard against which other designs for impact evaluation are judged. (p. 72)

Upon recognizing the interplay that exists among paradigmatic allegiances, lines of inquiry, and choices of methodology, it becomes clear why variation exists in the descriptions of the key components of qualitative inquiry among foundational authors. Each of these authors possesses a unique set of paradigmatic and theoretical loyalties that frame those components of qualitative inquiry that they find to be most crucial.

Study Design

This study is a qualitative inquiry, where data cataloging individual participants' teaching of a given group of students was collected for an entire semester. During this semester, the instructional mode shifted; labs early in the semester were expository/demonstration oriented in nature, while labs later in the semester were inquiry oriented. The digital recordings of each participant's instruction were then analyzed in a manner that would allow for the research questions to be answered. In the following sections of this chapter, a description is provided outlining how this study was constructed and carried out.

Participant Information

In this investigation, chemistry GTAs were the target population. Though they are the target population, chemistry GTAs are very diverse; they come to WMU from across the globe with a variety of cultural and socioeconomic backgrounds and express a range of career aspirations and research interests.

To date, seven GTAs, teaching in either the general chemistry one (Chem 1110) or two (Chem 1130) laboratories, have participated in the study of GTA discourse in the PBL labs. Though seven GTA participants have taken part in the data collection, data from two of the participants has been analyzed utilizing the data analysis processes outlined later in this chapter. Because some data collection strategies proved unsuitable for addressing our research questions, some data collected from GTAs was not of a high enough quality to be analyzed. This unfortunately means that multiple segments of data that were collected have not been the focus of analysis for the research questions.

In Table 3.2., an outline of the number of GTAs and the labs taught is provided. The data that has been analyzed for this research project came from two of the semesters in Table 3.2. Please note that the semesters in the following table have *not* been placed in any particular order.

Table 3.2.

Semesters in which PBL labs were taught by participating GTAs

Semester	Number of GTAs	PBL Labs
A	3	Sensors & Bio-Diesel
B	4	Sensors & Bio-Diesel
C	1	Sensors
D	2	Sensors

For the two participants who have been the focus of this study, one participant (GTA1) had taught this course (including the PBL labs) before. The other participant (GTA2) had not taught the PBL labs or this chemistry course prior to this semester. This was not GTA2's first semester teaching at WMU nor was it GTA 2's first time teaching first year general chemistry students.

Theoretical Framework

With an understanding that this research project is qualitative in nature and focuses on chemistry GTAs, the discussion of the theoretical framework surrounding this study can now be addressed.

Basic Description and Function

There are three components that, when in concert with one another, form the essential components of a sound chemical education research study. Be it qualitative or quantitative, these three components include: (a) a theoretical framework, (b) a set of guiding research questions, and (c) a methodology suited to the research questions

(Bodner & Orgill, 2007). While the readers of this manuscript are familiar with the alignment of one's research questions and methodology, the purpose of the theoretical framework may be less clear.

Particularly in qualitative research, the selection and explication of one's theoretical framework is key. A theoretical framework is described by Bodner & Orgill (2007) as: "a system of ideas, aims, goals, theories, and assumptions about knowledge; about how research should be carried out; and about how research should be reported" (p. vvi). Within science education, there has been a push for the investigation of significant research questions under replicable conditions that utilize methods capable of collecting empirical evidence that directly address the research questions and flow from an explicit chain of reasoning (Shavelson & Towne, 2002). Crucial to the development of a chemical education research study, considered rigorous by this standard, is the selection and adherence to a theoretical framework.

The theoretical framework guides the design, data collection and data analysis procedures utilized in an investigation. Bodner & Orgill (2007) compare the theoretical framework in chemical education research (CER) to that of the selection of an analytical instrument in bench chemistry research. A bench chemist selects analytical instruments that yield data aligned with the aims and requirements of the particular experiment or investigation underway. For instance, a bench chemist seeking to calculate the binding constant of a sensor-analyte complex would be unlikely to utilize a Karl Fisher instrument. It is the assumptions, capabilities, and types of findings yielded from instruments and theoretical frameworks alike which dictate the appropriate selection of each across various contexts. Just as no competent bench chemist would use a gas chromatograph to determine the density of methanol, no competent chemical education researcher would use a phenomenologic approach to investigate how and why a particular system functions as it does. (Phenomenologic approaches center on describing the essence of lived experiences while a systems theory perspective seeks to address the crucial components of why a system functions in the manner observed (Patton, 2002)).

Discourse Analysis

To produce CER of the highest quality, a theoretical framework well suited to the researcher's guiding questions is required. The theoretical framework that frames and bounds this qualitative research project is discourse analysis. While discourse analysis has many functions and is used for a variety of purposes, most broadly it is useful for the study of language and its organization (Stubbs, 1983). Where linguistic methodologies and inquiries tend to focus on language no more complex than a clause or a sentence, discourse analysis focuses on larger units of discourse, such as conversation exchanges or written text (Stubbs, 1983). Discourse analysis is frequently used to frame studies that investigate the patterns present in naturally occurring spoken language (Stubbs, 1983). Data that consist primarily of language emanating from social contexts, where social conversations are involved, may be interpreted using discourse analysis, depending on the research questions and aims of the researched.

Discourse analysis is used as a theoretical framework across many disciplines, including sociolinguistics, philosophical linguistics, psycholinguistics, and computational linguistics (Brown & Yule, 1983). Among these fields there also exist three versions of discourse analysis: (a) Laclau & Mouffe's Discourse Theory, (b) Critical Discourse Analysis, and (c) Discursive Psychology (Jorgensen & Phillips, 2002).

Across these fields there exists a continuum of assumptions underpinning the application of discourse analysis. Each field has struck a balance between focusing on the distribution and regularities of linguistic forms used by speakers and the consideration and elucidation of common rules used by speakers and listeners to communicate (Brown & Yule, 1983). Sociolinguists focus on the elements of social context displayed in discourse, and emphasize the patterns and types of discourse used over long stretches of discourse. On the opposite end of the spectrum, computational linguists concern themselves with very short and constrained bits of discourse in an attempt to generate models depicting the function of discourse at its most basic level (Brown & Yule, 1983).

The different versions of discourse analysis vary based upon their supporting assumptions. Laclau & Maouffe's discourse theory states that discourse is used to construct the social world where meaning is always subject to change and where the dominance of a particular social perspective across a culture as evidenced by discourse is explored. Critical discourse analysis is also focused on social interaction, but claims that discourse represents only one facet of that social world. Discursive psychology does not focus on the large-scale discourse of interest to Laclau & Maouffe's discourse theory and critical discourse theory. Discursive psychology instead focuses on the individual's flexible and dynamic use of discourse (Jorgensen & Phillips, 2002).

Those who study discourse, by any version, and focus on the patterns within long stretches of discourse do not consider their work in isolation of the findings of computational linguists but do not assert (as computational linguists often do) that discourse is entirely guided by rules as hard and fast as the laws of the physical sciences (Brown & Yule, 1986). The discourse analysts focusing on long stretches of spoken language appreciate the regularities, rather than the rules, of discourse (Brown &Yule, 1986). These regularities are based on the frequency with which a particular discourse technique is used within a given environmental condition. That which qualifies as regularity is hinted at by Givon (1979) when the following question is posed and addressed: "What is the communicative difference between a rule of 90% fidelity and one of 100% fidelity? In psychological terms, next to nothing. In communication, a system with 90% categorical fidelity is a highly efficient system" (p. 28). In other words, the discourse analyst focused on lengthy segments of discourse is interested in discourse techniques used in a given environment that are both noticeable and amenable to categorization (Brown &Yule, 1986). Thus the discourse analyst working with long segments of data seeks the regularities so that those regularities may be explained with respect to their context and form (Brown & Yule, 1986).

Discourse Analysis Considerations

According to Stubbs (1983), there are three decisions which must be made when conceptualizing a study using discourse analysis: (a) the length or size of the units of discourse to be studied, (b) whether these sequences occur naturally or are engineered by the researcher, and (c) whether or not factors of a non-linguistic nature will take part in the study. These three crucial decisions begin the process by which the researcher formalizes both the unit of observation and the unit of analysis.

The selection and explication of the unit of analysis is a crucial component of any qualitative inquiry. Trochim (2006) defines the unit of analysis as the 'who' or 'what' on which a study focuses. The unit of analysis is the component of a qualitative research project on which findings are presented (Trochim, 2006). Alternatively, the unit of observation represents the form or type of data collected. For discourse analysis, the three decisions outlined above by Stubbs (1983), inform the unit of observation. By deciding how the data will be systematically divided and what will be considered during the analysis, the researcher is defining their unit of observation in a manner consistent with the tenets of the chosen theoretical framework.

Discourse Analysis in the Classroom

For decades, linguistic methods, such as discourse analysis, have been employed in the study of classroom discourse between students and teachers (Sauntson, 2011). The discourse analyst working with long segments of data collected from within a classroom setting seeks to uncover the regularities with respect to context and form within the classroom (Brown, Yule, 1986). At the heart of all studies of classroom discourse is the drive to better understand the social aspects of the classroom so that factors influencing student achievement can be identified and manipulated (Cazden, 1988).

Sinclair & Coulthard's model, a commonly accepted means of describing classroom discourse, borrows from Bellack's (1966) initiate/response/evaluate (IRE) model of classroom discourse. In this model the instructor begins the cycle by questioning the learner, the learner then attempts to answer the question, after which the instructor either corrects or affirms the learner's response. Unfortunately, these descriptive models of student-teacher discourse were derived from expository or demonstration oriented classrooms, leaving the IRE model unusable in the categorization of classroom discourse generated in inquiry-oriented settings (Gilkison, 2003). The type of instruction at play (expository, demonstration, inquiry, individualized instruction) qualifies as a definable circumstance that is capable of influencing the discourse techniques used within a given environment by a given individual (Womack, 1989; Brown & Yule, 1983).

Data Collection Methods

This qualitative inquiry, focused on chemistry GTAs, was bounded by discourse analysis and also required specific data collection steps. The specifics of these steps and the theory supporting them are described in this section.

Theoretical Underpinning

Data collection began with purposeful sampling, which is defined by Patton (2002) as the selection of participants who are capable of providing information-rich cases that align with the research questions. Participants were allowed to self-select into the research study. Purposeful sampling refers to the selection of participants based upon their fit with a set of dimensions (Patton, 2002). The key dimensions which an individual needed to possess to take part in this study were as follows: (a) GTA status, (b) teaching a general chemistry laboratory featuring PBL in the curriculum, and (c) willing to self-select into the study and allow recording of their teaching discourse. These three characteristics formed the basis for sampling because of their direct ties to the questions posed and research goals of this project.

Being a GTA was a requirement for participation in this study because the researcher was interested in collecting data from members of the population most commonly employed as laboratory instructors. Chemistry graduate students are frequently used to instruct undergraduate laboratories (Sandi-Urena et al., 2011). While undergraduates are occasionally employed in the teaching of undergraduate labs, these undergraduate TAs are by far the exception, not the rule. It was ultimately decided by the researcher that the incorporation of undergraduate TAs added a level of complexity not warranted by the research questions or aims of this research study. Because the research study sought to investigate members of the population most likely to go on to serve in an instructional capacity in an undergraduate chemistry teaching setting later in their career, and because it was unclear how the incorporation of undergraduate TAs in the study would support this aim, undergraduate TAs were not included in the study.

The GTAs eligible for participation in this study also needed to be teaching in a section that incorporated both the expository/demonstration type labs and the PBL style labs. In order to make comparisons between the patterns of discourse across the two different types of curriculum, within each participant as is called for by the research design, it became important for each participant to instruct in both curricular settings. A comparison across curricula could not be made in a section where only one type of curriculum (expository/demonstration) was present.

Lastly, each GTA in an appropriate teaching section needed to agree to participate in the study, self-selecting in. Because this work involves human subjects, approval by the Human Subjects Internal Review Board (HSIRB) was required. For a copy of the narrative of this study, approved by WMU's HSIRB, please see the appendix.

Procedures

The data collection procedure utilized in this study was observational in nature. A digital record of the participant's instruction within a single section and for the entirety of a semester was collected. This digital record was collected with an audio or video recorder. Each participant taught two to three sections of the same laboratory each week. The researcher and each participant selected which section, for both individuals, would be most convenient for data collection. For the entirety of this semester, each participating GTA met with the researcher before each lab of the semester. During these meetings, the researcher readied the audio and or video recorder by turning it on and pressing the hold button. In situations where the video camera was used, the researcher placed the video camera in a strategic place in lab to capture as much of the lab space as possible. In situations where the audio recorder was used, the researcher assisted the teaching assistant in situating the tie clip microphone near the teaching assistant's lapel. After participating in a brief discussion with the teaching assistant about conceptual points in the lab where students routinely struggle and potential prompts and strategies that the teaching assistant could deliver to assist students, the researcher left the audio recording device with the teaching assistant for them to wear as they taught, recording all teaching assistant discourse for the lab period. After the completion of the class, either the teaching assistant or the researcher turned off the recording device. The researcher then promptly removed the data file from the recording device. After removing the data file from the device, the researcher labeled and backed-up the data file. This process was repeated once each week, with each participating GTA in the same section, for the entire semester. This provided a digital record of the participating GTA's classroom discourse in one course, for one section, over the course of a semester.

Role of the Researcher

With a description of the type of study, the theory that guides it, and the means by which the data was collected, it becomes important to outline the role that the researcher played in this study. In this section, literature descriptions of appropriate researcher roles are described and the specific role taken on by the researcher in this study is outlined.

The researcher in this project is well positioned to carry out this study because of her background in chemistry, her status as a former GTA at WMU, and her professional relationship with many of the participants in this study. While these qualifications supported the researcher in gaining access to participants, collecting data, and answering the research questions at hand, they also served to introduce bias into the study. The researcher had the benefit of an insider position, which has the potential to generate conflicts of interest capable of invalidating the study. Special precautions had to be taken by the researcher to prevent the researcher's preconceived notions and ideas about the outcomes of the study from coloring the actual results and findings of this work. To avoid this, the researcher looked to the literature for descriptions of appropriate researcher roles taken by other researchers in similar positions. The researcher also kept a detailed log of the analysis as it progressed, specifically documenting analytic decisions as they were made.

Marshall & Rossman (1999) suggest that the role taken on by a researcher is greatly influenced by the types of data collection implemented. In studies where the primary source of data is observational (like this one), researchers typically behave as either a participant observer or a nonparticipant observer (Marshall & Rossman, 1999). Participant observers have "first hand involvement" in the setting that they are studying (Marshall & Rossman, 1999, p. 137). Such immersion allows the researcher the opportunity to generate understanding from their experiences within the setting (Marshall & Rossman, 1999). Nonparticipant observers on the other hand, do not become a part of the setting in which they are interested in studying; they instead seek to be viewed as the "unobtrusive observer" (Marshall & Rossman, 1999, p.128). Studies that collect observational data from classroom settings typically function as nonparticipant observers (Marshall & Rossman, 1999). For this study, the researcher has functioned as a nonparticipant observer, having no special role in the classroom.

The researcher also, over the course of conducting this study, generated and maintained a record of the steps taken during the analysis of the data. Bias and errors are minimized by the precise documentation of the analytic steps taken by the researcher such that a future researcher could repeat the analysis of the collected data and identify the same functional relationship outlined by the original researcher (Yin, 2003). Yin (2003) recommends that as the researcher progresses through the analysis that the researcher note and develop the procedures for data analysis which were used in sufficient detail that an auditor would be able to repeat the procedures of the researcher and arrive at the same results as the original researcher. In an attempt to do this, the researcher has kept what Richards (2005) calls a log trail. The log trail serves to: (a) note when and how the researcher has worked on the research project, (b) record rationales for changes that have been made as the data collection and analysis have progressed, and (c) speculate as to the potential influence that these changes will have on the findings of the research project. The log trail kept by the researcher for this project helps to mitigate the researcher's biases and preconceived notions.

Ethics

In this section, regarding the ethical considerations that were considered and acted upon over the course of this study, three primary topics have been addressed. First, the implications of the researcher's status within the department has been discussed. Also, because the maintenance of participant confidentiality is crucial to a study of this sort, the steps taken to achieve and maintain participant confidentiality are described. And lastly, issues surrounding the trustworthiness of this study are addressed.

Native Status

The researcher's native status has a number of ethical implications for this study. In this research study, the researcher can be consider to be native, she is a graduate student working within the WMU Chemistry Department. While there are many positive aspects associated with conducting a research study within one's own setting (participants are easily accessible, minimization of some aspects of data collection, and the potential to co-create trusting relationships), there are also some negative aspects that must be guarded against (dilemmas which are ethical or political in nature, and challenges regarding the maintenance of participant anonymity) (Marshall & Rossman, 2011).

Participant Anonymity

Maintaining participant confidentiality is key to ethically conducting any research project falling under the category of human subjects research. Because of the relatively small size of the Chemistry Department at WMU, extra precautions were taken by the researcher to assure participant confidentiality. These extra precautions included: (a) consistently removing data files from recording devices, so that participants did not have access to the data collected from other participants, (b) removing phrases or refrains from transcribed participant quotes which are persistently and uniquely used by that participant, (c) collecting data from multiple participants during multiple semesters, and lastly, (d) concealing the precise semester and lab dates on which data was collected.

Ethical and Political Dilemmas

In addition to participant anonymity, the researcher was also prepared for dilemmas of a political or ethical nature. At times during this study, participants and other interested parties raised concerns regarding the scope and aims of the data collection within this study. The researcher and her advisor took time to assuage all concerned, emphasizing that the data being collected was for research purposes only (not for the purposes of GTA evaluation) and that raw data would be shared only with those who had a legitimate research focus (this includes direct group members, the researcher's advisor, and the inter-coder). The researcher also emphasized the strides that were taken to adhere to the narrative of the study, previously approved by the HSIRB.

Study Trustworthiness

To close this section the four primary criterion of trustworthiness associated with qualitative work are presented. These four criteria include: (1) credibility, (2) transferability, (3) conformability, and (4) authenticity (adapted from Berg, (2009) and Mertens, (2005)). These four criteria have been considered throughout the design of this research study and have been briefly described below. By considering the criteria, the researcher conducted a study that was ethical with respect both to participant treatment and study quality.

A qualitative study that has the characteristic of credibility is one where the data has been collected in such a way that participants are strongly encouraged to elaborate and participate in repetitive interactions with the researcher (adapted from Berg, (2009) and Mertens, (2005)). The research design of this study encompasses both of the aforementioned components of credibility. The short meetings with participants prior to teaching functioned as repetitive interaction with the researcher; while the consistent in-class data collection methods supported significant and persistent participation on the part of participants.

Transferability is used as an estimate of how readily findings from one study can be generalized to other situations and settings (adapted from Berg, (2009) and Mertens, (2005)). So that the future research consumers can make a judgment of this work's transferability for themselves, a detailed description of the time, place and context of the participants in the study has been included previously in this chapter.

To establish conformability, the researcher must demonstrate that the data and the interpretations of the data have not been simply constructed in the mind of the researcher (adapted from Berg, (2009) and Mertens, (2005)). From a practical standpoint, the researcher who can establish conformability must build all conclusions on a platform consisting of salient points taken directly from the data source. The researcher then must demonstrate that this building process took place. In an attempt to satisfy the requirements put forth by conformability, ten percent of the data has been subjected to inter-coder reliability checks and the results chapter of this thesis has been written specifically to highlight the 'building process' that took place.

And lastly, in an attempt to establish authenticity, to present a balanced view of all perspectives and values, the researcher has displayed the iterative process that occurred (adapted from Berg, (2009) and Mertens, (2005)). In the section entitled role of the researcher, the process of journaling, where the researcher is responsible for displaying, discussing, and setting aside the pre-supposing blinders that stop the data from speaking for itself has been described as implemented.

Methodology

This section begins with a description of the code list and the literature which was instrumental in generating the code list. Finally, the steps that were used to systematically and accurately apply this code list to all of the raw data will be described.

The Code List

In order to characterize the discourse on the expository/demonstration lab days and the inquiry days, the researcher began by searching the literature for a study that sought to describe in sufficient detail the types of discourse that occurs between GTAs and students within the inquiry-oriented mode of instruction (preferably the problem-based learning setting). A research paper by Gilkision (2003) sought to "describe the approaches used by tutors in PBL tutorials" (p. 6). Gilkison (2003) conducted an exploratory case study analysis seeking to describe typical GTA-student discourse in the PBL setting and found that existing categories suited to describing both instructor and student classroom discourse were not readily compatible with the discourse occurring in the PBL setting. This finding supported the need for an exploratory study focusing on the typologies of discourse taking place between GTAs and students in the PBL setting. By reading and re-reading transcripts and listening and re-listening to recorded audio data, Gilkison found consistent patterns in the classroom discourse within the PBL setting.

The categories of interactions, described in the Gilkison (2003) paper, between GTAs and students formed the basis of the initial coding scheme used in this research project. Each category of interaction proposed by Gilkison (2003) was utilized in this research study as a potential code, or a potential type of discourse that a GTA teaching within the PBL labs could utilize. This study takes the form of a qualitative, prefigured technical study that employs template analysis as the analytic method. The researcher performed a template analysis utilizing the Gilkison (2003) coding structure.

The codes that resulted from the Gilkison paper were defined in such a way that they were consistent with what Saldania (2009) defines as a process code. Process codes are essentially codes operationalized using specific observable activities. Because the researcher was studying a different course than Gilkison, adaptations were made to the code structure (consistent with template analysis) to allow the researcher to most efficiently and accurately apply the codes within her own research study. The codes have been defined as follows:

1. ***Elicitation (E):*** Questions/statements that are not content-oriented and focus on what the student has completed or has observed.
2. ***Prompting (P):*** Content-oriented questions/statements that encourage students to expand on or amend their ideas, provide an answer, or explain their thought process.
3. ***Giving Feedback (GF):*** Indicating verbally that a response or statement made by one or more students is or is not correct.
4. ***Informing (I):*** Making statements based on facts, ideas, or beliefs held by the teaching assistant that relate to course material, course content, or student actions.
5. ***Direct Learning (DL):*** Making statements about what a curricular experience is meant to convey or why they are being asked to perform a task.

Corbin & Strauss (2008) recommend the use of process codes for the researcher interested in the study of ongoing behaviors and actions which proceed in response to either environmental or situational conditions. This style of coding, focused on denoting actions that take place in varied contexts for the purposes of noting participants' responses to varied conditions, is directly in line with the aims of this research project.

Because process coding is not considered to be a stand-alone coding method but an initial type of coding, the researcher employed a second type of coding known as longitudinal coding. Using longitudinal coding, the researcher compared the appearance, disappearance, and change in process codes over time and across settings. Because this study focuses on patterns in GTA discourse over the course of a semester, the use of longitudinal coding was apt for uncovering patterns in GTA discourse across time and conditions within the same section.

So that procedural codes could be applied systematically and longitudinal data could be used to search for patterns in actions over time, the researcher developed a method by which the data could by systematically and consistently be broken down and coded. To do this, the researcher utilized a coding technique described by Martin & Bateson (2007) as time sampling. Using this strategy, the researcher divided the recording into sample intervals and at the end of each interval recorded whether or not each given process code was represented in that sample interval. Martin & Bateson (2007) also refer to this particular type of time sampling as one-zero sampling. It is noted whether or not a process code appeared, not how frequently within the sample interval that the process code appeared.

A crucial decision that must be made by any researcher utilizing a time sampling technique is the selection of the length of the sample units. In short, the researcher was required to specify precisely how the unit of analysis of this study was defined. Typically researchers utilizing this coding method select sample intervals that are a set amount of time. Though this would have been a simple method by which to declare the beginning and end of sampling intervals (or single units of analysis), the researcher decided to allow the sampling interval time length to vary to allow the sampling interval to be defined in more naturalistic terms. Because the researcher ultimately sought to categorize conversations between the GTA and students (and not just the application of discreet discourse techniques), a set of criteria was used by the researcher to approximate the start and finish of conversations between GTAs and students. These sampling intervals that have been divided up conceptually into conversations form this study's unit of analysis.

An operational set of standards, rooted in discourse analysis, were utilized by the researcher to determine when these conversations began and ended. The rules for the determination of the bounds of each sample interval were as follows: (a) discourse was between the GTA and a specific set of student(s) as indicated by the students recorded voices, (b) if removed from the rest of the audio the conversation was intelligible in its own right, and (c) discourse became increasingly structured as the conversation progressed. Conversations were distinct from one another when: (a) discourse indicating the end of a conversation was present, (b) non-verbal cues indicated the end of a conversation, (c) the GTA began repeating the same discourse and new student voices are recorded, or (d) more than 30 seconds of dead air was recorded. The start and finish of a unit was only marked when the unit fit the above criteria.

In early analysis of the data, the researcher found that some conversations between GTAs and students were simply not of interest to the researcher. These conversations met all of the rules outlined above in the previous paragraph, but the conversations focused on attendance, issues of grading, and personal comments. The researcher was most interested in documenting trends in GTA discourse where it related to the teaching of content for the day's lab. Thus, an additional categorical section was used to identify the nature of each conversation. Three categories are referred to as situational codes, and they were defined as follows:

1. ***P***: Situations dealing with conceptual, understanding, or procedural components of the lab (how to weigh, pour, when/how much to add, what to look for, step by step instructions).
2. ***CP***: Situations that deal with classroom-specific procedures (grading, attendance, announcements, locating equipment, turning in work, safety guidelines, time considerations, bounds of what will/will not be acceptable in lab, etc.)
3. ***N/A***: Situations in which the teaching assistant has a personal conversation.

At times, the researcher found that conversations had multiple categorical components. In these cases, the researcher noted all categorical components and only circled process codes that pertained to the conceptual, understanding, or procedural components of the lab.

The Steps of Coding

A set of standardized guidelines and procedures were applied in an iterative fashion to support consistent coding using the rules outlined above. Each data file was taken through a four-stage coding procedure. Because of the complexity of the coding system, iteration and documentation were built into the coding procedure to demonstrate systematic and equivalent application of process codes. The chart below is a graphic description of the stages of coding through which each data file progressed. For each stage, the type of coding, the outcome of that coding, any iteration, and the documentation of that process are described.

Table 3.3

Description of 5-stage coding process

Stage Number	**Type of Coding**	**Outcome**	**Additional Iteration**	**Documentation**
1	Process Coding	Data file is broken down into conversations and each conversation is assigned a situational code.	N/A	Note date: in log trail and on log sheet
2	Process Coding	Process Codes are assigned to each conversation.	Check time boundaries of units and situational codes.	Note date: in log trail and on log sheet
3	Process Coding	Process Codes assigned to each conversation are audited for consistency	N/A	Note date: in log trail and on log sheet
4 (only 2 data files)	Inter-Coder Reliability	Produce another round of coding for the purposes of comparison between the researcher's coding and an independent observer's coding.	N/A	Inter-coder's code book.
5	Longitudinal Coding	Graphically represent the results of the process coding resultant from each data file.	N/A	Note date: in log trail and on log sheet

For each data file a four-step coding process was utilized. The first three steps focused on process codes while the fourth step focused on longitudinal codes. Each data file has an associated log, in which the researcher noted the day or days over which each of the four analytic steps occurred for each data file. The coding procedure begins with blank worksheets, like the one depicted in Figure 3.1.

Elicitation /Prompting/Giving Feedback/Informing/Direct Learning		
Time	Situation	

Figure 3.2. Example of blank coding sheet for one conversation.

In the first step of the coding process, the researcher listens to the data file, noting on the pencil and paper worksheet (developed by the researcher and depicted in Figure 3.2.) where the conversation begins and ends using the time stamp on the data files. To support the researcher in making these determinations, a copy of the rules for determining when a unit begins and ends were open and available to the researcher during the coding process. Issues associated with these particular rules for dividing up conversations were noted through this process and were improved (to their current state) over the course of the data analysis. In the first step of coding the researcher is often also able to note what category/categories each unit fits into. The portion of the data file, excluding the initial in-class lecture is coded in this manner. A sample unit is provided in Figure 3.3.

Elicitation /Prompting/Giving Feedback/Informing/Direct Learning		
Time	Situation	
58:58 59:33	P	

Figure 3.3. Example of coding sheet for one conversation after step 1 of the coding process.

In the second step of the coding process, utilizing a pencil and paper worksheet, the researcher re-listened to the data file marking for each unit the process codes. For each process code present, a small bit of GTA discourse was noted which indicated why the process code was marked. In this attempt to justify the application of process codes, the researcher used a series of shorthand methods. To begin, only select parts of GTA discourse were written down by the researcher. These select bits of GTA discourse were labeled with a circled letter corresponding to a process code, such that in future when the researcher was reviewing the data collection sheets there would be a record as to why the researcher felt that a particular process code should have been applied.

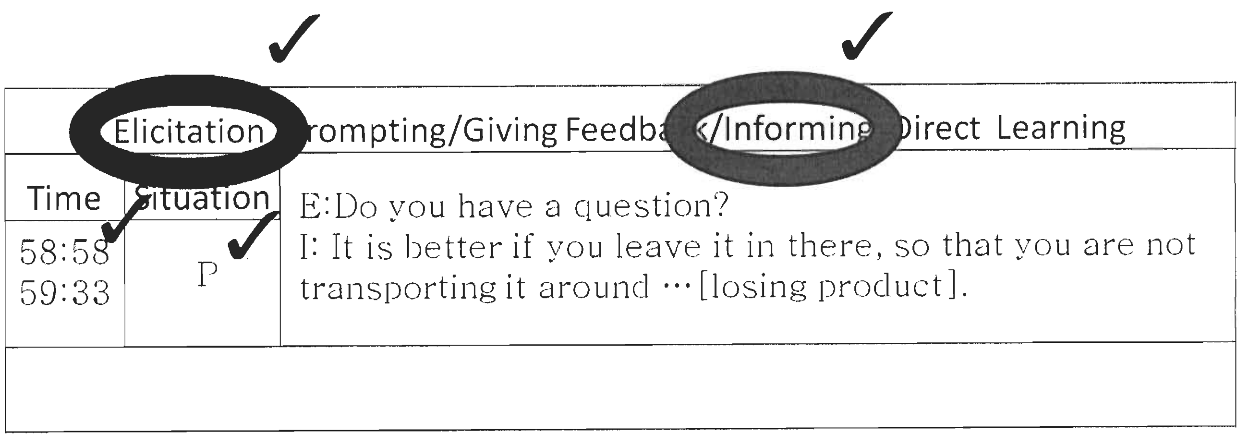
At times the researcher found that paraphrasing GTA discourse, as opposed to noting it verbatim, was best. Because of the nature of conversation, the writing of exact phrasing often becomes cumbersome and obscured the meaning of a particular statement. To mitigate this effect the researcher, at times, paraphrased GTA discourse. The researcher was careful however to note this paraphrasing in the log with brackets, to alert that paraphrasing had occurred. If the researcher only wrote part of the GTA's discourse, but utilized exact phrasing, an ellipsis was used to denote that GTA discourse was present in the tape but not noted on the data log.

In addition to noting and supporting process code, the researcher also carefully considered whether the boundaries and situation code assigned to each unit were consistent with the guidelines set forth in the previous section. If the situation code was properly assigned, a small check mark was placed by that code. If, however, the units did not, upon an additional hearing meet the criteria describing components of a unit, then an X was placed on the data sheet directly to the left of the unit. This X signaled to the researcher that this particular box on the worksheet was not to be counted; and should not be incorporated into the third phase of the coding procedure. A sample unit is provided in Figure 3.4.

Elicitation Prompting/Giving Feedback/Informing Direct Learning		
Time	Situation	E:Do you have a question?
58:58 59:33	P	I: It is better if you leave it in there, so that you are not transporting it around …[losing product].

Figure 3.4. Example of coding sheet for one conversation after step 2 of the coding process.

In the third step of the coding procedure, the researcher re-listened to each of the units in the data file, re-checking the adherence of the data to the process codes circled. If the codes circled matched what was in the data file, a small check mark was placed on the worksheet above the circled process code, indicating a match. The researcher did not complete the third step of the coding procedure within less than one week of the second step, in an attempt to avoid the researcher simply remembering the process codes applied to a particular unit. The second and third stages of coding also allowed the researcher an opportunity to check and re-check the unit boundaries (starting and stopping points in time) and also check and re-check that the type of conversation in the unit was consistent with the situational code marked for that unit. When and if discrepancies were found, alterations were made. These alterations were noted, for future reference. A sample unit is provided in Figure 3.5.



Elicitation/Prompting/Giving Feedback/Informing/Direct Learning		
Time	Situation	E:Do you have a question? I: It is better if you leave it in there, so that you are not transporting it around …[losing product].
58:58 59:33	P	

Figure 3.5. Example of coding sheet for one conversation after step 3 of the coding process.

In the fourth step of the coding process, select recordings were played for another graduate student (from the Mallinson Institute of Science Education), so that this individual could code the recording, using the codes and coding procedures outlined above. Not every data file was subjected to the fourth step of the coding process. Two randomly selected data files, one from the PBL and one from the expository/demonstration, were selected for this analysis. This step was taken to ensure that the results of the coding were reflective of that which was actually present in the data. The researcher sought to provide both herself and readers with some sort of assurance that these coding procedures were capable of accurately reflecting the content of the recordings collected.

The researcher and the inter-coder met multiple times. The researcher and the inter-coder began these meetings by reviewing all coding procedures and the code definitions. The inter-coder then coded the data files (one from a PBL lab and the other from an expository/demonstration oriented lab) that were selected randomly by the researcher. Any disagreements between the researcher and the inter-coder were noted in the inter-coder's logbook. Upon finding disagreements, the researcher and the inter-coder discussed rationales as to why they had selected their respective codes. In cases of disagreement, consensus was sought at the end of the coding process.

The researcher then took the inter-coder's logbook (containing all of the inter-coder's coding) and compared it to the researcher's own original coding of the data files. To compare the consistency between the two sets of codes the percentages of exact agreement (EA) and two variants of percentage of disagreement were calculated.

Percentage of Exact Agreement=EA/ (EA+D1+D) (should approach 80%)
Percentage of Disagreement with one process code difference=D1/ (EA+D1+D)
Percentage of Disagreement with more than one difference=D/ (EA+D1+D)

EA: number of units for which the process codes agree exactly
D1: number of units for which the process codes differ by the presence or identity of one process code
D: number of units for which the process codes differ by the presence or identity of two or more process codes

Figure 3.5. Description of inter-coder agreement calculations

As per Lombard et al. (2004), roughly 10% of the total data in the study has been subjected to inter-coder reliability and the aforementioned agreement and disagreement values were calculated. Though there are no hard and fast requirements, 80% agreement between the coder and inter-coder is widely accepted as the level of agreement that demonstrates the reliability of a coding system (Neuendorf, 2002). Other researchers recognize that 80% agreement may be unreasonable given the nature, aims, and setting of a given study. In applied settings, levels of inter-coder reliability are accepted when they are slightly below 80% agreement (Neuendorf, 2002).

The fifth step marked the end of the coding procedure. In the fifth step, the step focused on the longitudinal coding, the researcher graphically represented the process codes present in each data file. To do this, each conversation (without an X immediately to its' left) was given a number which corresponded to a row in an excel spreadsheet for the given data file. In this spreadsheet the columns were marked with process code names. For each given conversation and for each process code in that conversation, a one was placed in the corresponding row (the row for that particular unit) and column (for that particular process code). Also noted for each unit was the combination of process codes that occurred in that particular conversation. The researcher then, using Excel, created a set of graphs for each data file.

All combinations of process codes seen in the data were listed out. For each data file, a graph was created which indicated the percentage of conversations that displayed each combination of process codes. This graph allowed the researcher to depict the types of conversations present in any given data file for the purposes of comparing the types of conversations present in varied conditions. The code combinations were arranged on the x axis, such that code combinations which were consistent with expository instruction (i.e. fit well with the IRE model) were placed on the left hand side of the axis and code combinations which were inquiry-oriented (did not fit well with the IRE model) were placed on the right hand side of the x axis.

The creation and comparison of these graphs, across varying conditions constituted the longitudinal coding phase. In making comparisons between labs, based upon the frequency of types of conversations (as defined by code combinations), the researcher was able to search for overarching patterns in GTA discourse across two curricula with the group of students and semester held constant.

Data Analysis

This section presents a description of how the data were analyzed and interpreted. A description of how the graphs (each representing one class, for one GTA with one group of students) were constructed is presented.

The data analysis piece of this project focuses on the story that the graphs tell about the change in GTA discourse over the course of a single semester and between the two types of instruction, expository/demonstration and inquiry. In a given semester and for a given GTA, the graphs from labs that were expository/demonstration were compared to the graphs from labs that were inquiry-oriented. Independent of the type of lab from which these graphs arose are the percentage of conversations which displayed each combination of process codes. An example of such a graph is depicted in Figure 3.5.

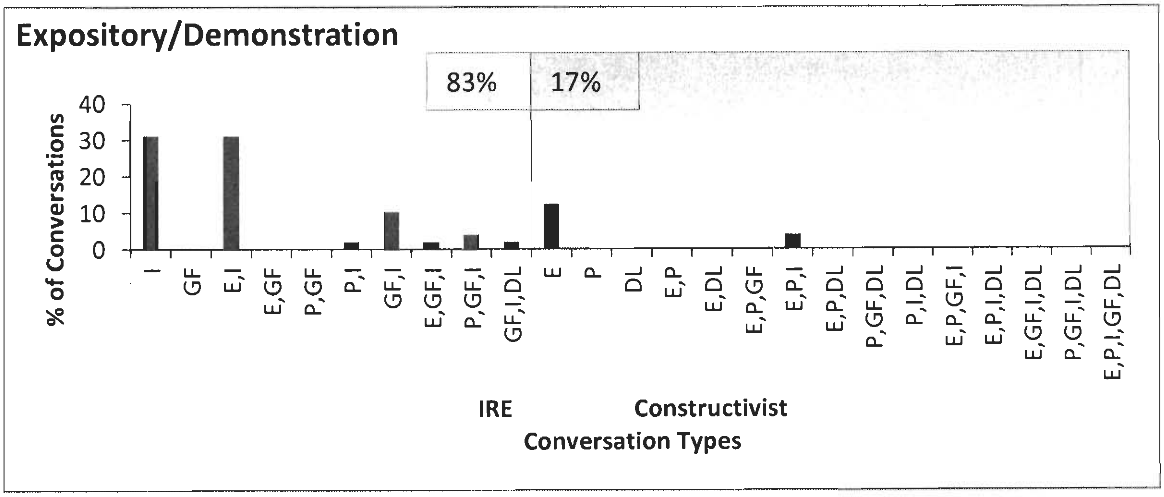


Figure 3.6. Relative amount of conversation types for a given lab period, given GTA, and given set of students.

This graph allowed the researcher to depict the relative proportion of particular types of conversations (as determined by the combination of codes) present in any given data file for the purposes of comparing the types of conversations present in varied conditions (expository/demonstration labs vs. inquiry labs). For these graphs, the types of conversations were arranged on the x-axis, such that the code combinations most consistent with expository instruction were placed on the left hand side of the axis (unboxed) and code combination that were inquiry oriented were placed on the right hand side of the x-axis (boxed).

The code combinations observed were placed into one of two categorical bins (consistent with expository/demonstration or inquiry-oriented instruction). The researcher also reviewed specific examples of each code combination and again, considering the assumptions, aims, and practices associated with each category, made a determination as to whether or not that unit was most consistent with expository or inquiry-oriented instruction.

Lastly, the researcher also considered how well each code combination approximated the IRE (initiate/response/evaluate) model of instruction. Those combinations of codes that were ultimately placed in the expository/demonstration category contained discourse similar to the IRE model; conversely code combinations placed in the inquiry category were consistent with the constructivist model (Bellack et. al., 1966). The chart below depicts the researcher's ultimate determination as to how to place each code combination observed in the data (this decision is also reflected in Figure 3.6.).

Table 3.4

Division of conversation types between the two categories: expository and inquiry

	Expository (IRE Conversations)		Inquiry (Constructivist Conversations)
I	Informing	E	Elicitation
GF	Giving Feedback	P	Prompting
E,I	Elicitation, Informing	DL	Direct Learning
E,GF	Elicitation, Giving Feedback	E,P	Elicitation, Prompting
P,GF	Prompting, Giving Feedback	E.DL	Elicitation, Direct Learning
P,I	Prompting, Informing	E,P,GF	Elicitation, Prompting, Giving Feedback
GF,I	Giving Feedback, Informing	E,P,I	Elicitation, Prompting, Informing
E,GF,I	Elicitation, Giving Feedback, Informing	E,P,DL	Elicitation, Prompting, Direct Learning
P,GF,I	Prompting, Giving Feedback, Informing	P,GF,DL	Prompting, Giving Feedback, Direct Learning
GF,I,DL	Giving Feedback, Informing, Direct Learning	P,I,DL	Prompting, Informing, Direct Learning
		E,P,GF,I	Elicitation, Prompting, Giving Feedback, Informing
		E,P,I,DL	Elicitation, Prompting, Informing, Direct Learning

	E,GF,I,DL	Elicitation, Giving Feedback, Informing, Direct Learning
	P,GF,I,DL	Prompting, Giving Feedback, Informing, Direct Learning
	E,P,I,GF,DL	Elicitation, Prompting, Informing, Giving Feedback, Direct Learning

Summary

This chapter has discussed how the researcher has taken audio and or video data files (collected from two GTAs over the course of a semester, teaching one section) and systematically coded them in a manner consistent with the tenets of qualitative inquiry using discourse analysis as a theoretical framework. Data files were collected from chemistry GTAs participating in this study, these data files were coded by the researcher and a series of graphs were produced, each representing a single GTAs teaching for one day with one group of students. These graphs were generated for each day that the GTA taught during a given section, for a given semester. In the following chapter the data from each participant will be explored in detail.

CHAPTER 4

INTRODCUTION

Chapter Three outlined the steps that were taken to collect and analyze the audio/video recordings of the participating GTAs. The instruction of each participating GTA was recorded over the course of a semester for a given laboratory section. Apparent differences between the instruction present in the expository/demonstration labs and the instruction present in the PBL labs were noted after reviewing the data from one semester. To clarify these differences, the data files were systematically divided into discrete conversations between the participating GTAs and students. These individual conversations were then coded, by noting the types of discourse which were/were not present in each conversation. The remaining data, Sets 2 and 3, were analyzed (or coded) in a similar manner.

In Chapter Four, the results of this analysis and the patterns that emerged from the data are presented. The data have been presented in the order in which they were collected and coded. The first semester of data that the researcher analyzed was collected from GTA1 and will henceforth be referred to as Set 1. The data files (each from an individual lab period) which together comprise Set 1 have been presented; graphic representations have been provided which describe the types of conversations which took place over the course of each lab day. Also provided are transcriptions of common conversation types. These transcriptions present the reader with concrete examples of various conversation types and code application examples.

The second semester of data collected from GTA1 (Set 3), and the only semester of data collected from GTA2 (Set 2) have been presented in a similar fashion, with a similar rationale. Graphs showing the overall breakdown of conversation types that occurred for each lab, as well as transcriptions highlighting select conversation types have been presented. Table 4.1. summarizes Set 1, Set 2, and Set 3 by defining the contributing participants and semesters. Exact semesters (ex. Fall 2009) have not been provided to maintain participant anonymity.

Table 4.1.

The participants who have contributed to Sets 1, 2, and 3

Set	Participant Identifier	Semester
Set 1	GTA1	A
Set 2	GTA2	A
Set 3	GTA1	B

Set 1

In the first set of data, Set 1, seven labs taught by GTA1 were audio/video recorded for one laboratory section over the course of semester A. During this semester, three expository/demonstration labs and five inquiry-oriented labs were taught. Four of the inquiry-oriented labs were PBL labs while the fifth inquiry lab was a guided inquiry lab. The results and patterns described in this section were based upon the patterns in each participant's discourse, as demonstrated by the appearance of the following codes:

1. ***Elicitation (E):*** Questions/statements that are not content-oriented and focus on what the student has completed or has observed.
2. ***Prompting (P):*** Content-oriented questions/statements that encourage students to expand on or amend their ideas, provide an answer, or explain their thought process.
3. ***Giving Feedback (GF):*** Indicating verbally that a response or statement made by one or more students is or is not correct.

4. ***Informing (I):*** Making statements based on facts, ideas, or beliefs held by the teaching assistant that relate to course material, course content, or student actions.
5. ***Direct Learning (DL):*** Making statements about what a curricular experience is meant to convey or why they are being asked to perform a task.

Labs 1 and 2: Expository/Demonstration-Oriented Labs

In Set 1, the first two labs of the semester were both expository/demonstration labs. The graphs from each of these labs are presented in Figures 4.1. and 4.2. The conversation types consistent with Bellack's (1966) IRE model of classroom discourse dominate during these two labs. During the first lab, 83% of the conversations were consistent with the IRE model and are found on the left side of the x-axis. Consistent with the first lab, 82% of the conversations in the second expository/demonstration-oriented lab are conversation types that are consistent with the IRE model and are found on the right side of the x-axis.

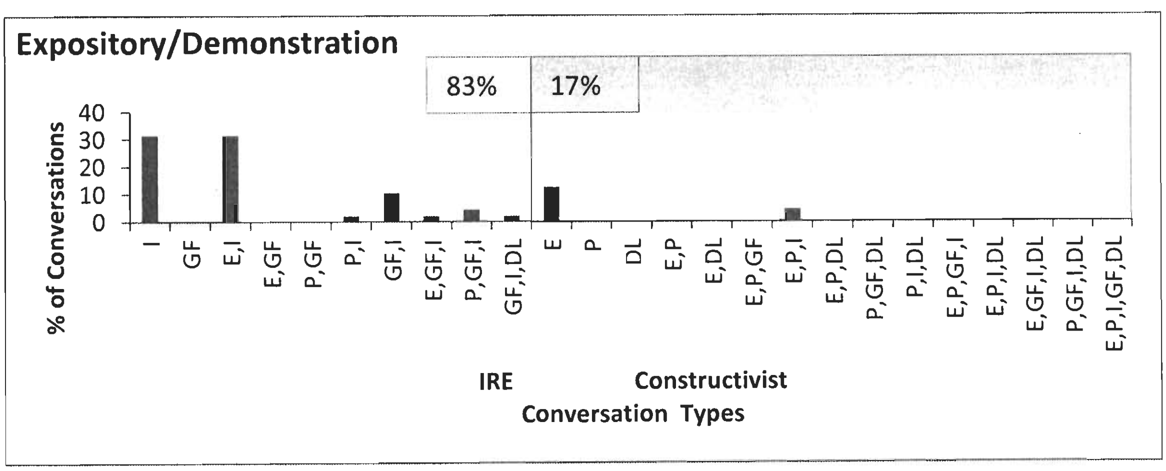


Figure 4.1. Results for first, expository/demonstration-oriented lab of Set 1, collected from GTA1 during semester A.

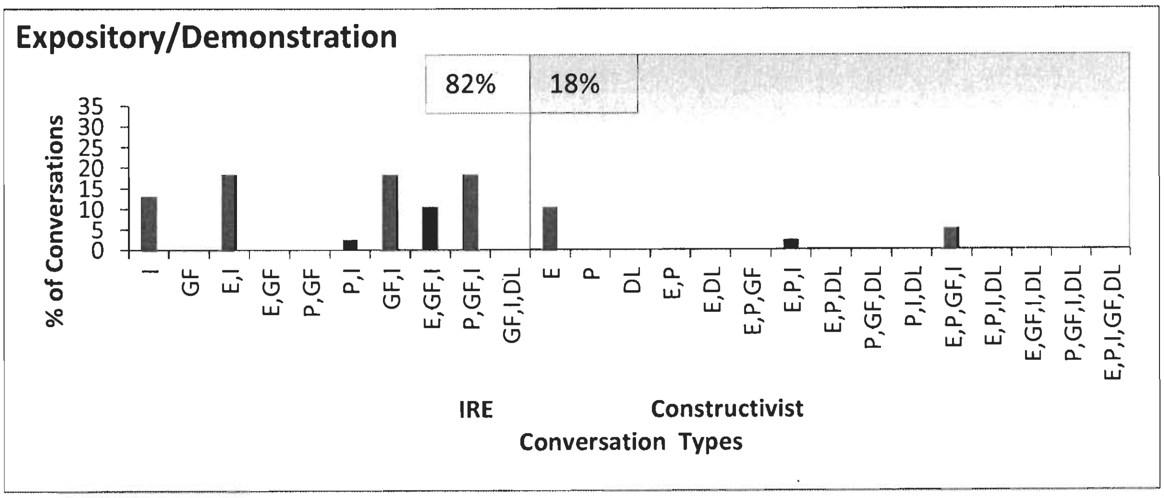


Figure 4.2. Results for second, expository/demonstration-oriented lab of Set 1, collected from GTA1 during semester A.

During the first two labs of Set 1, some of the most common conversation types were informing or informing and elicitation "I" indicates that informing was the only code present, and "EI" indicates that only elicitation and informing were present. To give the reader an example of these sorts of conversations Tables 4.2. and 4.3. are provided. In all transcriptions, student talk has been paraphrased.

Table 4.2.

Transcription of I conversation

Transcribed Example: Informing
TA: So all you are doing for looking these up, is find the inorganic [section], or the section that you need in the book, in this case inorganic. You find the names of each of your compounds and you look at the solubility. So, you look at, is it soluble in water, is this one not, maybe and acid versus not, stuff like that. And it should tell you an easy way to {informing} S: Well, we did number five already TA: it's really easy. Like, some people used to put melting point, and it's almost impossible to separate out metals with melting points because they stick together, I mean molten metal, it doesn't separate easily. It doesn't flow as nice, there's very few things that can contain it enough to let it. {informing}

Table 4.3.

Transcriptions of E,I conversation

Transcribed Example: Elicitation and Informing
TA: And you all got a chance to look at the book? {elicitation} You have not. S: We haven't yet. But, how much water do we need to add? TA: It [the lab manual] says twenty-five, I would try to do twenty {informing}. How much the of ammonium chloride left?{elicitation} S: What do you mean left? TA: What percentage? {elicitation} S: 13.6 percent TA: Okay, I would use more water, because you don't know how much sand is there and there [appears] to be a significant amount of sand. {informing} S: Alright TA: So, use more, use the whole thing, but you can do it, [add] like 15[ml and] stir it, 10 [ml and] stir it. You don't have to add it all at the same time. {informing}

Note how the conversations are centered around the GTA and how the focus of the conversations hinges on aiding students in working efficiently and adhering to proscribed procedures. The GTA-centered nature of these conversations and the codes present in these transcriptions are consistent with the IRE model. In the informing-only conversation transcribed in Table 4.2., GTA1 gives a series of precise directions as to how to complete part of the lab. In the E,I conversation, GTA1 collects information from the students about their sample and immediately directs them so that they may work as efficiently as possible. In both transcriptions, questions are asked and student responses are immediately evaluated, corrected, or further explored by the GTA. This type of discourse is consistent with the IRE model where the instructor inquires, the student responds, and the instructor then either corrects the student or fills in the gaps.

Lab 3: Guided Inquiry Lab

In the third lab of Set 1, a guided inquiry lab was taught, which was not a part of the PBL labs. The graph depicting the relative proportion of conversations of each type that took place in this lab is shown in Figure 4.3. Though still dominated by conversations consistent with the IRE model, there do appear to be larger percentages of conversations present in lab three that align with constructivist classroom discourse, relative to labs one and two. 33% of the conversations that took place during this lab were consistent with constructivist classroom discourse.

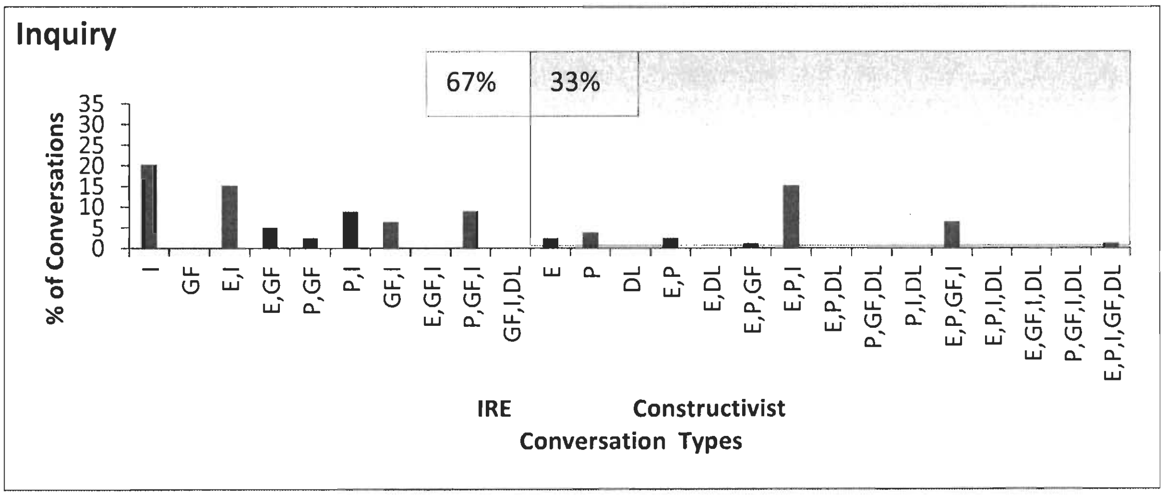


Figure 4.3. Results for third, inquiry lab of Set 1, collected from GTA1 during semester A

This lab was the first lab where the researcher began to see a hint of the differences in conversations which were present in an inquiry setting relative to an expository/demonstration-oriented lab. Conversations that consisted of elicitation, prompting, and informing were the most common type of conversation seen during this lab, which were consistent with constructivist classroom discourse. Transcribed in Table 4.4. is one such constructivist conversation, which is inconsistent with Bellack's (1966) IRE model.

In this conversation the GTA elicits, prompts, and informs the student. This conversation is inconsistent with the IRE model. The GTA is not simply collecting information from the students and evaluating its accuracy; the GTA is instead guiding the students by asking them what their plans are, giving them more time to think about a given section of the experiment, and directing their attention to what they need to consider in order to answer their research question. Table 4.4. depicts a conversation consistent with the tenets of constructivism.

Table 4.4.

Transcription of E,P,I conversation

Transcribed Example: Elicitation, Prompting and Informing
TA: So, how are things over here? {elicitation} S: good, I guess. TA : Good, so what are we thinking so far? {prompting} what are we going to do for number one and number two? and so on?{elicitation} S: [unclear] TA: So what are your plans? {prompting} S: So, we are going to get a 150ml beaker, the hydro soap, 100ml of water. Then we are going to use this pH strip to observe the color, to tell us the pH. TA: So, these are the pH strips. They are a little different because they have four little buttons on them, each one is a different color. It makes it much more precise. {informing} S: Right TA: So, instead of saying, oh that's basic or oh that's acidic, this actually tells you how much. Alright. {informing} S: Right. TA: Good, so what are your plans for [number] two? {prompting} S: Well we aren't sure yet. TA: I will come back, you want me to come back? {elicitation} I don't want to give away the answer to everybody at the same time. S: Well, what does it even mean? It just seems really easy? What do they mean make a procedure? TA: Yeah, but how are you going to do that? {prompting} it says mix them together right?{prompting} S: Yeah, so do we mix them in like three ml of water? TA: So, you have your beakers with like 100ml of water, and soap or water and detergent, right? {elicitation} So you have two beakers. It says: now mix those up

together and add them to your samples. {informing} Well, what are you adding them to? {prompting} Think about that, what are you going to add them to and how much soap and detergent are you actually going to use for each test, right? So, those are some things to think about. {informing}

Even though a shift away from IRE-consistent conversations is observed within this inquiry-oriented lab, the most common conversation type is still the one in which the GTA's classroom discourse serves to inform the student. 20% of the conversations from this lab are represented by the appearance of this code alone and are similar in form to the transcription previously outlined in Table 4.2.

Lab 4: Expository/Demonstration Oriented Lab

The fourth lab of the semester for Set 1 (taught by GTA1) was an expository lab. The graph for this lab is presented as Figure 4.4. Interestingly, the discourse in the fourth lab of Set 1 aligns itself with the previously described labs 1 and 2 (both expository/demonstration oriented labs). The conversations that have been classified as being consistent with the IRE model dominate the conversation landscape, making up 81% of the conversations that occurred.

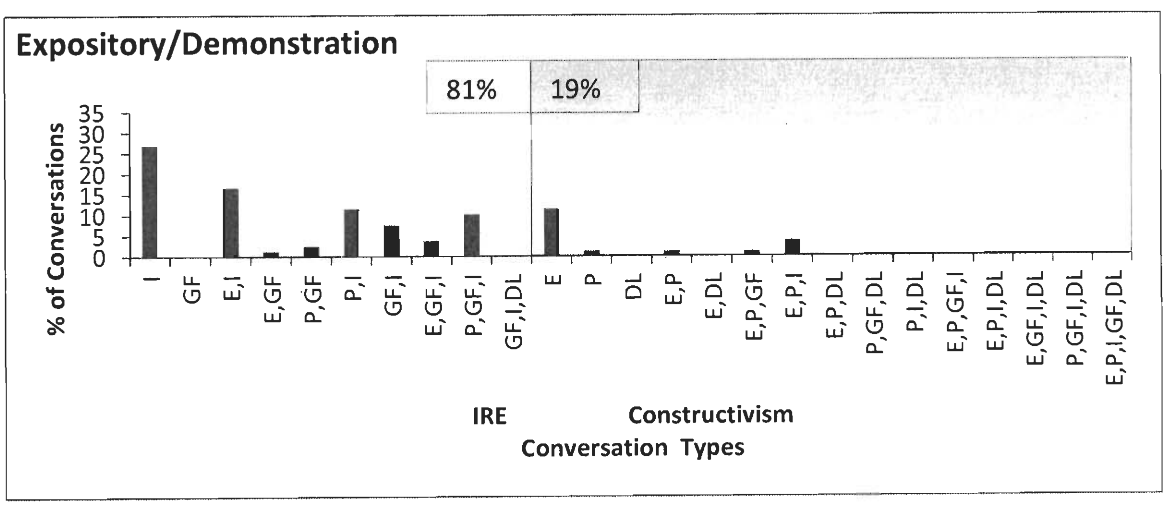


Figure 4.4. Results for fourth, expository/demonstration-oriented lab of Set 1, collected from GTA1 during semester A.

Again, conversations classified as either I or E,I played a major role during this lab. But other conversation types contributed to the dominance of the IRE model of classroom discourse too. Prompting and informing (P,I) conversations fit with the IRE model and were a common type of conversation in this lab. Transcribed on the following page in Table 4.4. is a P,I conversation. This conversation is driven by GTA1's desire to get the students to do the experiment in the most efficient manner possible. As in the transcriptions from labs 1 and 2 of this set, there is consistency with the IRE model in that the GTA is asking questions of students and immediately evaluating, correcting, or filling in missing gaps in students' answers.

Table 4.5.

Transcription of P,I conversation

Transcribed Example: Prompting and Informing
TA: So, how much HCl are you gonna need? {prompting} S: Huh? TA: How much HCl are you gonna need for the whole experiment?{prompting} S: 15 ml TA: Because you are adding 5 ml, but there is another part of the directions which says to add?....{prompting} another 5[ml] and then another 5[ml]. So, if you get about 30[ml] in your beaker, bring it back, [you can] work with it all. {informing}

Labs 5, 6, and 7: PBL Labs

Set 1 finishes with a series of PBL labs. Graphs depicting the relative proportion of conversation types present over the course of each lab have been presented in Figures 4.5., 4.6., and 4.7. These three figures have common elements. For each of these labs, conversation types considered to be constructivist in nature dominate the day's classroom discourse. In Figure 4.6., 55% of the conversations were considered to be constructivist in nature. In Figures 4.7. and 4.8. 70% and 60%, respectively, of the conversations aligned with the tenets of constructivism.

Some of the most commonly seen conversation types across these three days include: (a) elicitation, prompting, giving feedback, and informing (E,P,GF,I) and (b) elicitation, prompting, and informing (E,P,I). Because a sample of an E,P,I conversation has already been shared (see Table 4.4.), a sample of the E,P,GF,I conversation has been provided in Table 4.6.

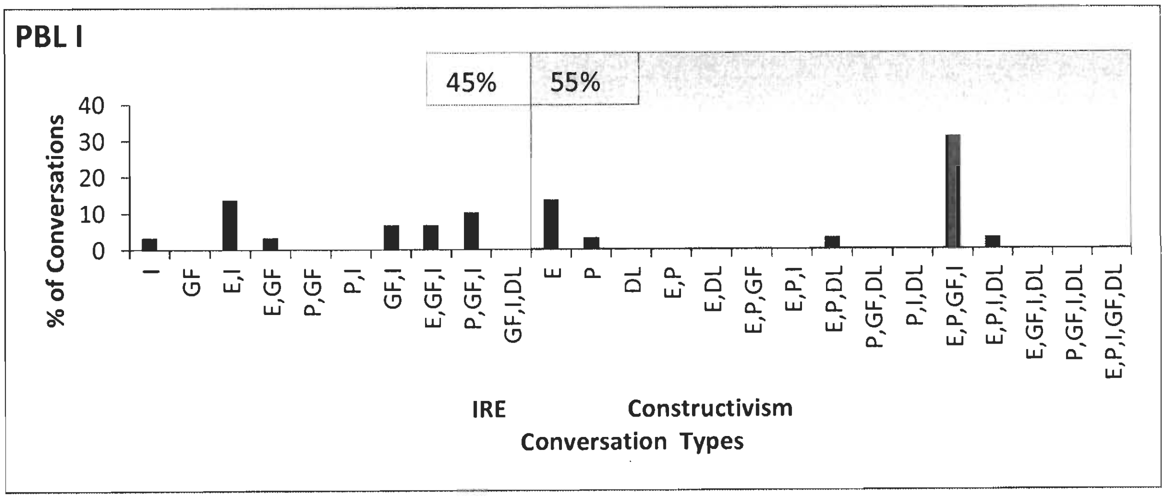


Figure 4.5. Results for fifth, PBL lab of Set 1, collected from GTA1 during semester A.

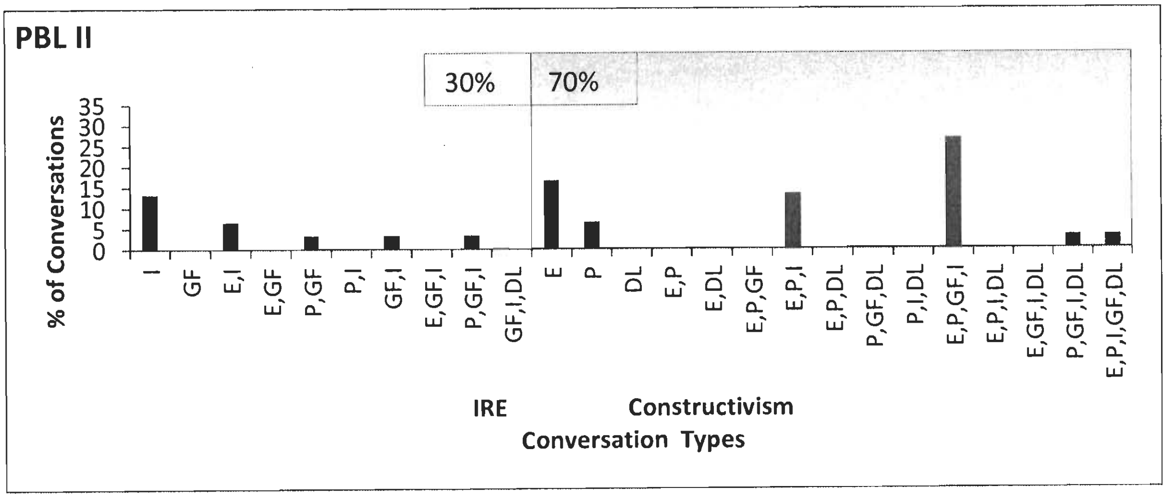


Figure 4.6. Results for the sixth, PBL lab of Set 1, collected from GTA1 during semester A.

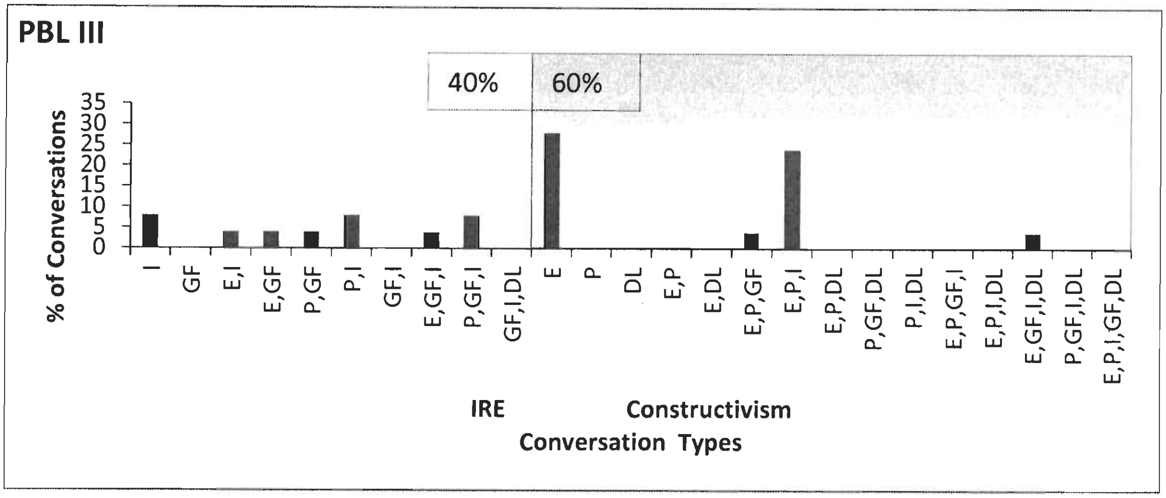


Figure 4.7. Results for seventh, PBL lab of Set 1, collected from GTA1 during semester A.

Table 4.6.

Transcription of E,P,GF,I conversation

Transcribed Example: Elicitation, Prompting, Giving Feedback, and Informing
S: So, we want to test fruit for pesticides, but we are not sure that they will be there. And, we want to know if acids and bases could clean the fruit. Do we just bring fruit with pesticides on them? TA: The fruit are coming from Meijer, so we don't really know. It's kind of random which one's actually have stuff on them.{informing} S: I know. TA: So really, if you are only going to test those you might not find those three pesticides. {informing} S: So, could we test it for pesticides, clean it, and test it again. TA: Yeah, there is no problem with that{giving feedback}, you just have to make sure that, like, maybe you circle a part with a Sharpie, and test that part. You just have to figure out how you are going to do that. {informing} How are you going to first test for pesticide, then try to clean it? {prompting} That will be an interesting [unclear]. I am not exactly sure how that is going to work. What kinds of acids and bases are you thinking? {prompting} S: like, HCl TA: I'm trying to think if that's... so you're looking at a time thing? That's what you want to look at? {prompting} S: No, we want to know how much pesticide there is. TA: Again we can't, what is one of the limitations of our sensor? {prompting} S: We can't quantify. TA: Right {giving feedback}

S: But, say that we use some acid or base to see whether or not the pesticide comes off the fruit?
TA: So if, if you are using like five ml of acid and ten ml of acid and then 15? {prompting}
S: We could see how much is needed to take the sensor off the fruit.
TA: So, I have a question then. So you are saying that you need to eliminate water? {prompting}
S: Yeah
TA: Most acids and bases are made in what? {prompting}... water, right? {informing}
S: Couldn't we just dry it?
TA: Well, if you dry it you are going to be wiping pesticide off, you could be wiping the acid off. I mean, you don't really know, right? {informing} What's your control? How do you know what you're wiping off? {prompting}
S: Is there a way to control it?
TA: Yeah, there are ways to control it, it's just getting to that point. That is something to think about. I am not too hot on the idea of trying the cleaners, only because you are adding in a lot of variables to it, with the water and the drying it a certain way and things like that. {informing} So it's, I don't mean to shoot down your ideas. They are really good ideas. {giving feedback} It's just we don't have the- it will also be hard to keep things over for a week. Think about it, we've gotta keep these things, is refrigeration going to affect it? If it is left out it would rot. So, you've gotta think about these things too, will it sit for a week. It's easier to work with things if you can do it in the time that we have in lab here, okay? {informing}
S: Okay, could we test the seeds?
TA: So, if you're testing the seeds to look for contamination, are you testing anything else? {prompting}
S: hum
TA: That's a good idea. There is nothing wrong with that one, I like that one. That's something that's doable in our time frame. {giving feedback}
S:[unclear]
TA: Well, if you are testing the seeds for pesticides how will you know if they were even exposed to pesticides in the first place? {prompting}
S: I guess we could test the fruit itself.
TA: Okay, so you could test a few things on each fruit if you want. {informing} What else could you test? And, by testing the fruit itself I assume that you mean the flesh of the apple, right? {prompting}
S: Yeah.
TA: Well, where does the pesticide get applied? What else could you test? {prompting}
S: The skin.
TA: The skin. {giving feedback} So that's a good question, you could [answer it] by testing different parts of the fruit. So, you have a few things that you can look at and choose from. No need to do all of them.{informing} Does that help a little bit?{elicitation}
S: Yep.
TA: Okay, I gotta move on. I'll be back.

In the E,P,GF,I transcription shown in Table 4.6., the prompting code appears frequently, and the students are leading the charge in the selection of a research topic and method. This is not something typically seen with classroom discourse consistent with the IRE model. In the transcript in Table 4.6., the GTA is challenging students to consider all of the constraints which are present in the lab. In this conversation, the GTA is not the leader, and is not in charge of the student's project as would be typical with the IRE model of classroom discourse. This is made clear when the GTA inquires about student's potential ideas and is sure to point out that they have their choice of topics after a brief discussion of the pros and cons for each. As represented in this transcript, the GTA is functioning as a more knowledgeable guide.

E,P,GF,I conversations are relatively common in the first two PBL labs (labs 5 and 6 for Set 1). Interestingly, by the third PBL lab (lab six of Set 1) roughly 25% of the conversations contain only elicitation (E) and are similar to the transcription provided in Table 4.7. These conversations tend to be very brief and are frequently ended by students because things are making sense to the students. In these conversations the GTA is again playing the role of a guide, checking in on students and making sure that things are working well.

Table 4.7.

Transcription of E conversation

Transcribed Example: Elicitation
TA: So, how are things going guys? Everything good?{elicitation} S: Yeah, the sensor is making more sense now. TA: Cool, let me know if you need anything

Set 1 Summary

Having explored data Set 1, there are some patterns that have emerged. For GTA1, for those labs that were theoretically defined as inquiry (one guided inquiry and three PBL), there were differences in the types of classroom discourse being used. These patterns are evidenced in both the transcriptions and the graphic data.

In the expository/demonstration-oriented labs, GTA1's discourse was very focused on getting students to complete the procedure or answer a given question in the lab manual. These conversations tended to be instructor centered, and often took the form of GTA1 telling students precisely what to write down or do, whether the students had asked a question or not. Conversations classified as I and E,I were the most commonly seen types of conversations.

In the inquiry labs, student ideas and needs tended to be what drove conversations. GTA1 acted as a guide by reminding students by prompting them to remember crucial facts (before potentially informing). When finishing conversations, the GTA often reminded students of their options or that which they needed to consider moving forward. These sorts of cues suggest the facilitative role played by GTA1 in the inquiry labs. In the inquiry labs, some of the most common conversation types seen were E, E,P,I, and E,P,GF,I.

In addition to the transcription data, the summary graphic provided in Figure 4.8. showed the general pattern of GTA1's discourse over the course of the semester. The squared points indicate the proportion of conversations that are consistent with the IRE model, while the diamond points indicate the proportion of conversations that are consistent with the constructivist model of classroom discourse. Over the course of the semester there was a trend. During the first two expository/demonstration-oriented labs, IRE-type conversations dominated. During the third lab, which was inquiry-oriented, the proportion of these (IRE-type) conversations was reduced. The fourth lab, another expository/demonstration-oriented lab, again showed dominance of the IRE-structured conversation. And lastly, during the final three PBL labs, constructivist conversation types either dominated or were nearly equivalent in proportion to those conversation types that were consistent with the IRE model.

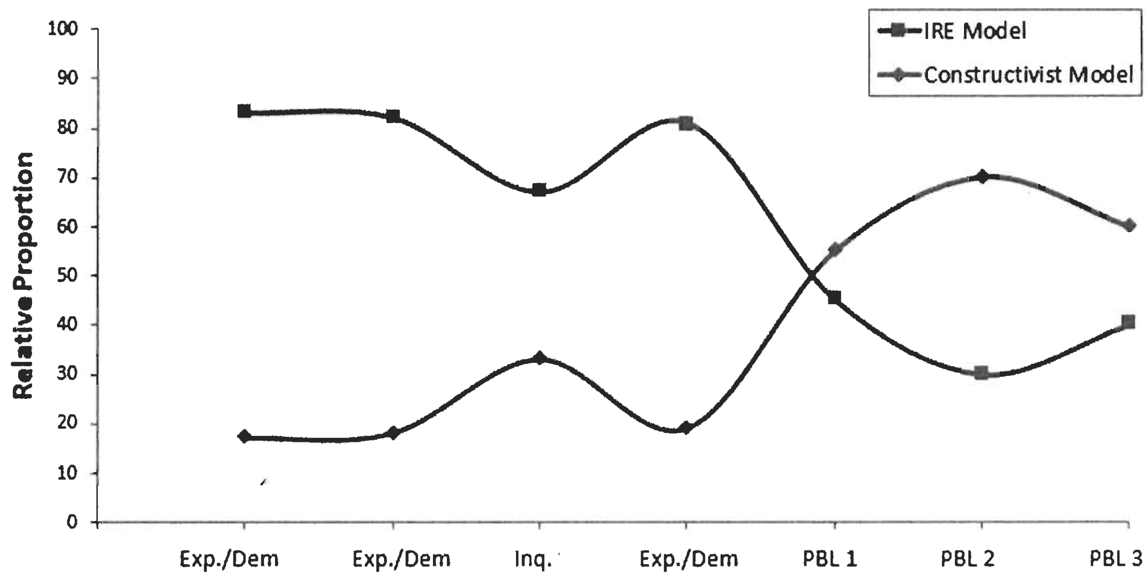


Figure 4.8. Set 1 summary graph.

Set 2

In the second set of data, Set 2, six labs taught by GTA2 were audio/video recorded in one laboratory section over the course of semester A. During this semester, three expository/demonstration labs and five inquiry-oriented labs were taught. Four of the inquiry-oriented labs were PBL labs while the fifth inquiry lab was a guided inquiry lab. The results and patterns described in this section were found using the analytic steps and techniques described in Chapter Three.

Labs 1 and 2: Expository/Demonstration-Oriented Labs

In Set 2, the first two labs of the semester were both expository/demonstration labs. The graphs from each of these labs are presented on the following page as Figures 4.9. and 4.10. During the first lab, 64% of the conversations were consistent with the IRE model and are found on the left side of the x-axis. Exceeding the first lab, 87% of the conversations in the second expository/demonstration oriented lab were conversation types that were consistent with the IRE model and are found on the right side of the x-axis.

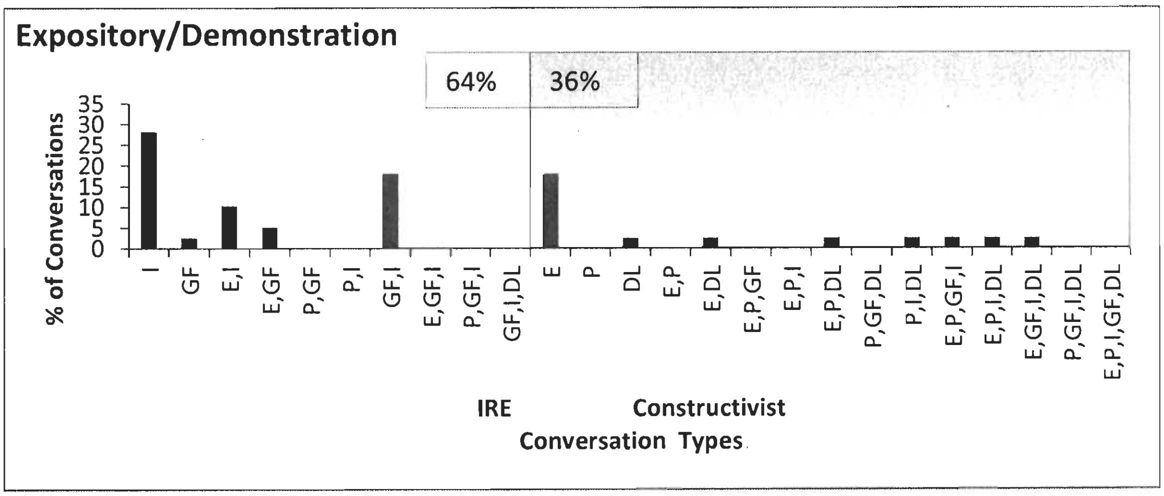


Figure 4.9. Results for first, expository/demonstration-oriented lab of Set 2, collected from GTA2 during semester A.

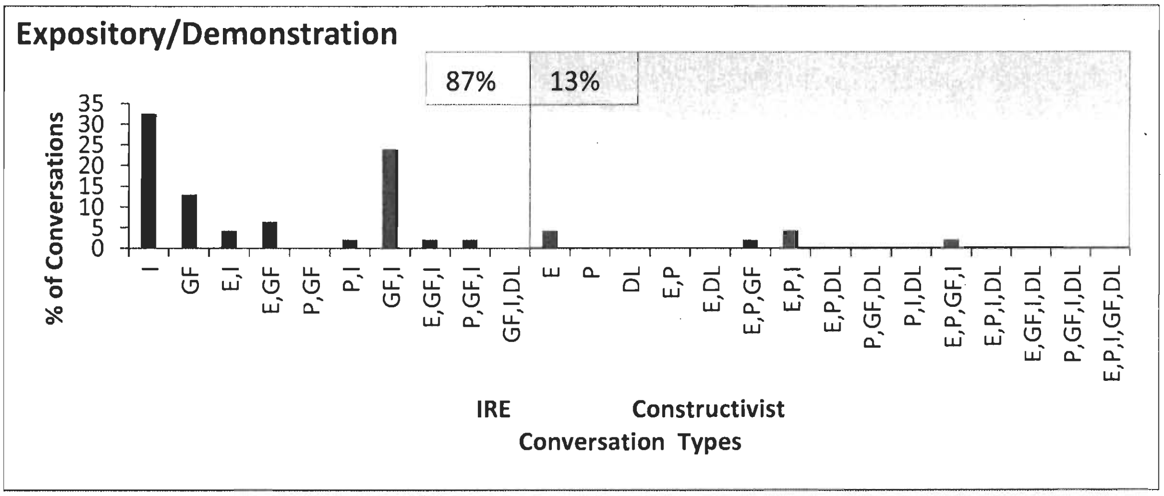


Figure 4.10. Results for second, expository/demonstration-oriented lab of Set 2, collected from GTA2 during semester A.

The classroom discourse of GTA2 for these first two labs was dominated by conversation types that were consistent with the IRE model of classroom instruction, though the abundance of IRE-type conversations were not as prevalent in the first lab as in the second. This is a direct reflection of the amount of pure elicitation that GTA2 was engaging in during the first lab compared to the second. GTA2 frequently resorts to the use of either pure informing (I) or giving feedback and informing (GF,I) styled conversations. In Table 4.8., a GF,I conversation has been depicted. In this transcription, the role that GTA2 was taking on is quite clear. GTA2 was not functioning as a guide, but rather was directing students so that they most efficiently and effectively carried out the procedure.

In Table 4.8., a transcription of a GF,I conversation has been provided. In this conversation, GTA2 was reviewing an already-graded lab report with a student. GTA2 was focused on what was wrong with the report and on cueing the student to notice common mistakes to be avoided in future.

Table 4.8.

Transcription of GF,I conversation

Transcribed Example: Giving Feedback and Informing
TA: Okay [student's name] let's see whether you will get 100 out of 100 or not... okay no, let's see what happened. S: Oh no. TA: Just see what happened. This is grams and this is milligrams so you can see what was wrong here. {informing} S: And this was not good either? TA: Yeah, this answer was actually wrong.{giving feedback} This is not the best way to finish this problem.{informing} If you need more of an explanation you could come to my office hours and I could help you with that, right? S: Yeah TA: But, I think you are doing a good job so keep it up. {giving feedback} S: Okay

The entire conversation depicted in Table 4.8. was centered around the desires and opinions of the instructor. This conversation was consistent with the IRE model of classroom discourse in that the GTA initiated an interaction with the student for the purposes of evaluating student responses that were, coincidentally, from the past.

Lab 3: Guided Inquiry Lab

In the third lab of Set 2, an inquiry-oriented lab was taught, which was not a part of the PBL lab series. The graph depicting the relative proportion of conversations of each type that took place in this lab is depicted in Figure 4.11. During this lab, the structure of the classroom discourse seems to have changed very little, if at all, from the previous two weeks. The classroom discourse produced by GTA2 during the guided inquiry lab was similar to the discourse produced in the first two expository/demonstration-oriented labs of Set 2. 71% of the conversations were consistent with the IRE model. This was the first instance where the researcher encountered a lab in which the classroom discourse did not shift away from the IRE model in an inquiry setting. The only detectable differences between Figure 4.11. and Figures 4.10. and 4.9. is the reduction in the proportion of GF,I and I conversations and the appearance of a wider distribution of conversation types. In Figure 4.11., there do appear to be a greater diversity of conversation types (relative to the previous figures in this set) being employed.

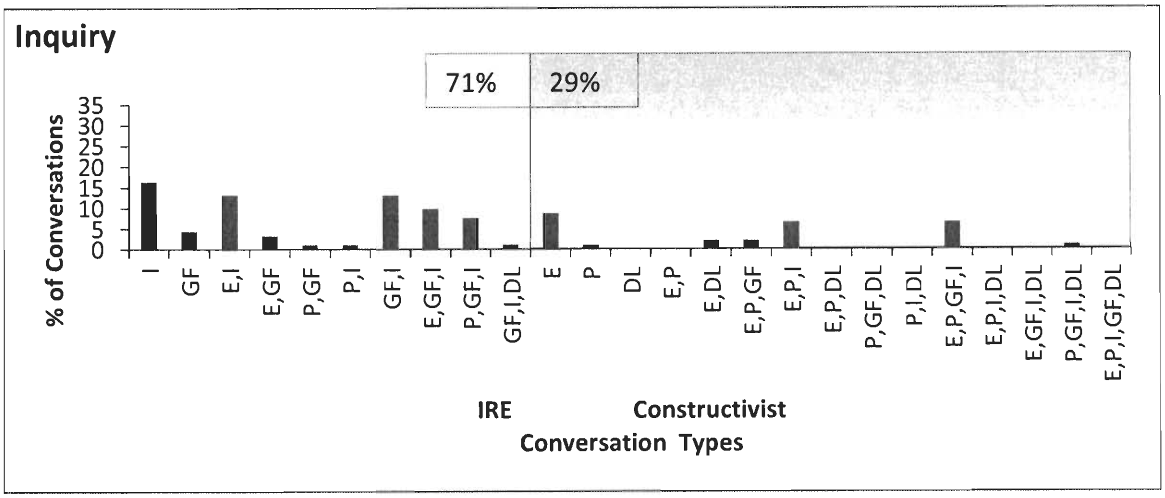


Figure 4.11. Results for third, inquiry-oriented lab of Set 2, collected from GTA2 during semester A.

A conversation type not previously seen in labs in Set 2 but seen in this lab period was the P,GF,I conversation type. Again, this conversation is highly GTA-centered and is shown in Table 4.9.

Table 4.9.

Transcription of P,GF,I conversation

Transcribed Example: Prompting, Giving Feedback, and Informing
TA: Alright [student name] and [other student name], alright okay I know your names. Part two okay, what are we going to do for part two? {prompting} S: Well, what if we haven't gotten that far yet. TA: Okay, let me ask you this, do you know what the hardness of water is? {prompting}

S: No, but we had a well in our old house and my Dad always used to put water softener in it to make it... well I don't know but he always talked about the water being soft. Does that mean it has a lot of iron in it, or something?
TA: Yep. {giving feedback}
S: So, soft water has a lot of iron in it!
TA: No wait, the softener is going to, like, precipitate the iron out of your water, that is what your father is doing. He is removing iron from the water. {informing}

In the conversation depicted in Table 4.9., GTA2 was discussing the topic of water hardness with a student. The student shared an experience that he had with water hardness and came to the wrong conclusion about the difference between hard and soft water. GTA2, upon realizing that the student was actually confused, immediately corrected the student by describing soft water using the student's example. This conversation was consistent with the IRE model in that GTA2 collected information from the student, the student responded, and GTA2 subsequently evaluated and corrected the student.

Lab 4: Expository/Demonstration-Oriented Lab

The fourth lab of the semester for Set 2 (taught by GTA2) was an expository lab. The graph for this lab is presented in Figure 4.12. The discourse in the fourth lab of Set 2 aligned itself with the previously described labs 1 and 2 (both expository/demonstration-oriented labs). The conversations that have been classified as consistent with the IRE model dominated the conversation landscape, making up 78% of the conversations that occurred.

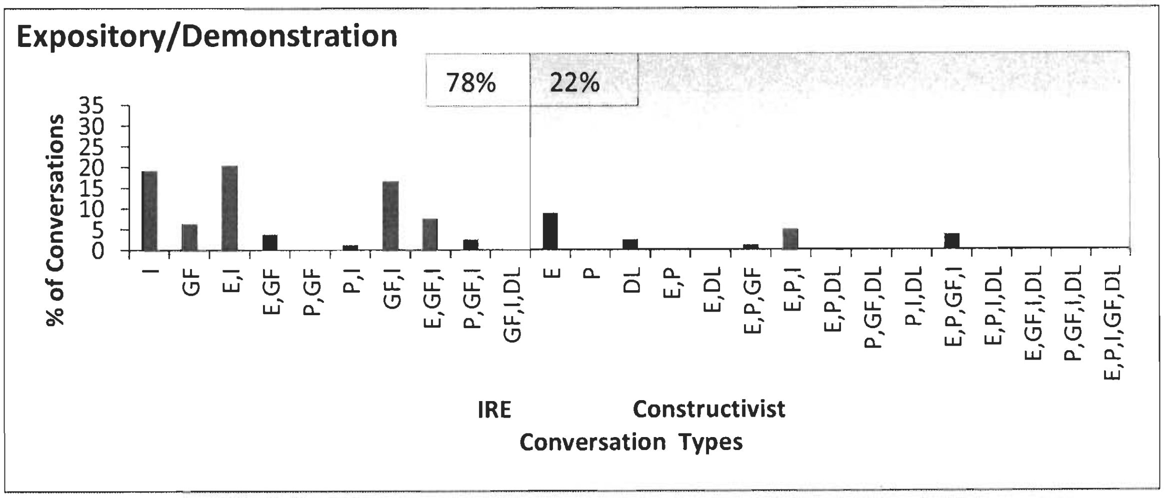


Figure 4.12. Results for fourth, expository/demonstration-oriented lab of Set 2, collected from GTA2 during semester A.

Conversations classified as either I or GF,I played a major role during this lab, which was similar to the pattern observed during the first and second labs in this set, shown in Figures 4.9. and 4.10. Other conversation types contributed to the dominance of the IRE model of classroom discourse as well. E,I conversations fit with the IRE model and were a common type of conversation in this lab. This conversation type had not been seen as frequently in the two previous expository/demonstration labs of Set 2.

Transcribed in Table 4.10. is an E,I conversation. This conversation comes in the form of an announcement made to the entire class. Just prior to this, GTA2 had found that a student was struggling with a particular laboratory exercise. GTA2 then made the following announcement, depicted in Table 4.10, to the entire class.

Table 4.10.

Transcription of E,I conversation

Transcribed Example: Elicitation and Informing
TA: Actually, this student just asked a question about the balancing of charges. If you put your charges as separated charges on the molecule, like minus here and plus here, you don't want to balance it. But, if you are working with something like R-COO^- and

Ca^{2+}, then what you need to do is recognize that two of these [$R\text{-}COO^-$] are needed to balance each one of these [Ca^{2+}]. But the other one is not like that, you don't want to balance it because it is a separate ion. {informing} Is that okay? {elicitation} Alright guys, if you have any more questions you can give them to me. I am going to collect the reports right now, but before that I am going to give you two minutes to complete the equations and give them to me.

As in the transcriptions from labs one and two of this set, there was consistency with the IRE model in that GTA2 was directly providing an answer to a question in front of the entire class. This is a teacher-centered action, primarily focused on getting students to indicate the correct answer on their lab reports.

Labs 5 and 6: PBL Labs

Set 2 finished with a series of PBL labs. Graphs depicting the relative proportion of conversation types present over the course of each lab have been presented in Figures 4.13. and 4.14. Though three labs took place during this PBL unit, there are only two labs presented in this section. The recording device was not set-up properly for the third lab (the hold-button on the audio recorder was not pressed or was inadvertently disengaged). Because of this no data from the third PBL lab taught by GTA2 can be presented.

The two figures that are presented in this section, which represent the first and second PBL labs of the semester, seem to display different patterns in classroom discourse. In Figure 4.13, 85% of the conversations took a form consistent with the IRE model. Nearly 50% of the conversations that took place in this lab were coded as either I or P,GF,I. Though this was a PBL lab, the discourse employed was frequently not consistent with constructivist instruction.

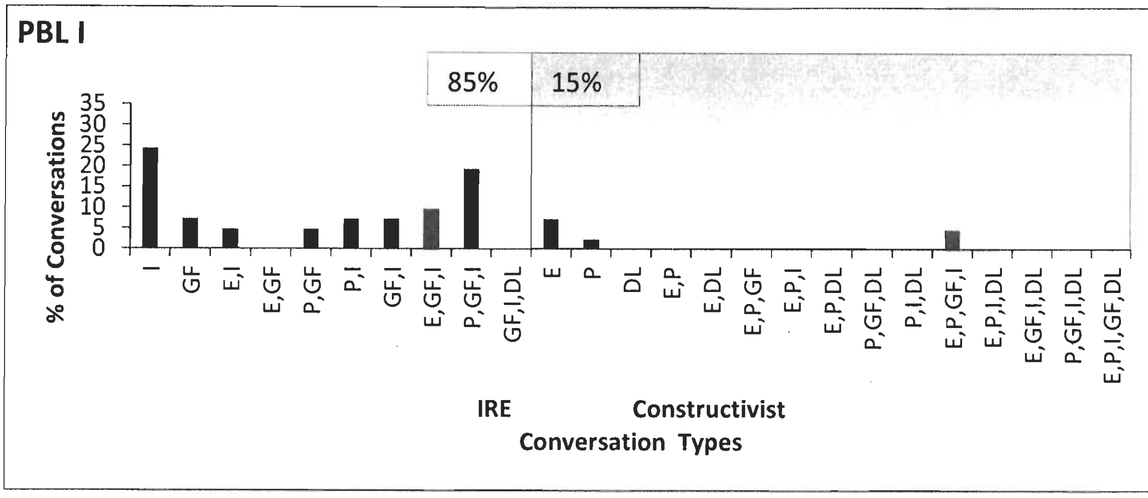


Figure 4.13. Results for fifth, PBL lab of Set 2, collected from GTA2 during semester A.

In Table 4.11., a transcription of a conversation which was purely informing has been depicted. Here GTA2 appeared to be responding to what the student had written on his or her lab report worksheets.

Table 4.11.

Transcription of I conversation

Transcribed Example: Informing
TA: Okay so, let's go over this. S: Okay. TA: So, if you have two here it means that on your carbon you will have 1,2,3,4,5. Can carbon have 5 bonds? No. Right here, it should be C-H.

In the conversation transcribed in Table 4.11., GTA2 had taken issue with a student response written on the student's lab report. The GTA then reminded the student that carbon has four bonds while pointing out that the student's carbon had five. GTA2 then indicates where and how the structure should actually have been drawn. The IRE model of classroom discourse is brought to life yet again in this transcription when the

GTA initiated a discussion about a student response and then closed that conversation by evaluating and correcting the student's response.

In the second PBL lab taught by GTA2, a different pattern in classroom discourse (not observed in the previous lab) emerged. Similar to the inquiry lab, depicted in Figure 4.11., the distribution of observed conversation types appears to have broadened. And though conversation types consistent with the IRE model still dominate, relative to other labs in this set, this lab has the largest proportion of conversation types aligned with the constructivist model of classroom discourse.

Table 4.12.

Transcription of E,P,GF conversation

Transcribed Example: Informing
TA: So, what's happening over here? {elicitation} S: We are stuck, all of our tests came back positive. Is that bad? It seems bad? TA: Well, what do you think it could be? {prompting} S: They could all be positive but, there could also be something else? TA: Something else like, what? {prompting} S:Oh, uh water. Maybe water is giving us a fake positive TA: Maybe {giving feedback}. Okay how can you handle that? What can you do? {prompting} S: Test again and try to dry things better? TA: Sounds good {giving feedback}. I'll be back to see it soon.

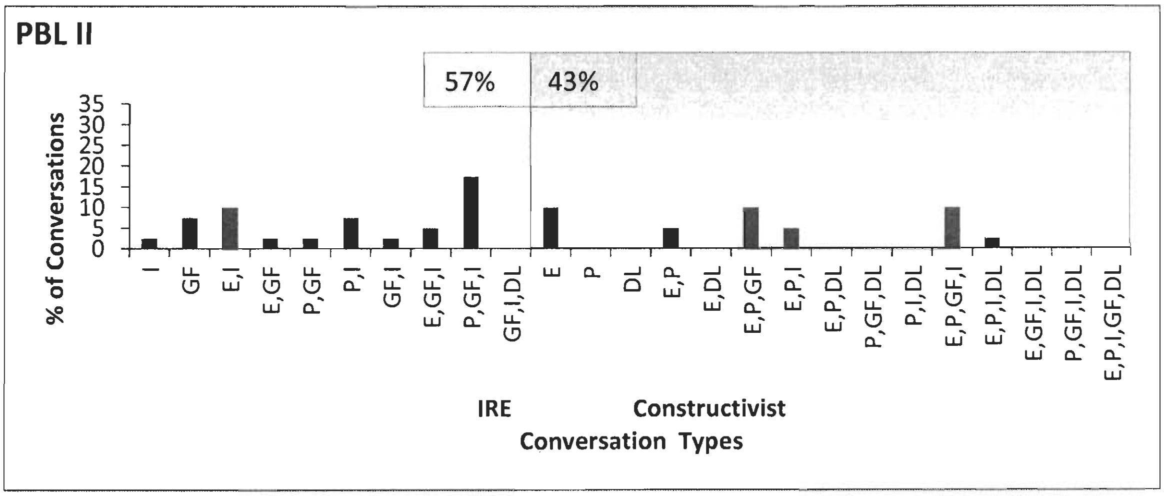


Figure 4.14. Results for sixth, PBL lab of Set 2, collected from GTA2 during semester A.

Set 2 Summary

Some patterns found in Set 2 align with the patterns in Set 1, and others do not. For GTA2, the differences in classroom discourse patterns between inquiry and expository/demonstration-oriented labs were difficult to see, if present at all. GTA2 appears to have utilized a wider distribution of conversation types in the inquiry labs as opposed to the expository/demonstration-oriented labs. This wider distribution did not, however, translate to an overall dominance of conversation types that were consistent with the constructivist model of classroom discourse.

In the expository/demonstration-oriented labs, GTA2's discourse, as seen in the transcriptions, was focused on preparing students to quickly/efficiently complete the procedure or address a question in the lab manual. These conversations tended to be instructor-centered. GTA2 is observed telling students precisely what to write down or do, whether the students had asked a question or not. This came in the form of both individual conversations and classroom announcements. Conversations classified as I, GF,I, and P,GF,I were the most commonly seen conversation types within the expository/demonstration-oriented labs.

In the inquiry labs, GTA2 continued using the conversation types consistent with the IRE model. Though these conversation types were present, other less GTA-centered conversation types (consistent with constructivist type conversations) were seen more frequently in the inquiry sections. When these types of conversations did occur, student ideas and needs drove the conversations. In these moments, GTA2 acted as a guide, cueing students to recall crucial facts, and frequently reminding them of their options. These sorts of actions are suggestive of the facilitative role that GTA2 played periodically in the inquiry labs within data Set 2.

In addition to the transcription data, the summary graphic provided in Figure 4.15. shows the general pattern GTA2's discourse over the course of the semester. The square points indicate the proportion of conversations that were consistent with the IRE model, while the diamond points indicate the proportion of conversations that were consistent with the constructivist model of classroom discourse. Over the course of the semester the trend is difficult to discern, if present at all. During the first expository/demonstration-oriented lab, IRE type conversations dominate (lab 1), but not to the extent that was seen in other expository/demonstration-oriented labs. In the second expository/demonstration oriented-lab (lab 2), GTA2 displayed a high number of conversations consistent with the IRE model. During the inquiry lab (lab 3), the proportion of these IRE-type conversations was reduced. The fourth lab, another expository/demonstration-oriented lab, again showed dominance of the IRE-structured conversation. And lastly, during the two PBL labs (labs 5 and 6), conversation types consistent with the IRE model either dominate or are nearly equivalent in proportion to conversation types that are constructivist in nature.

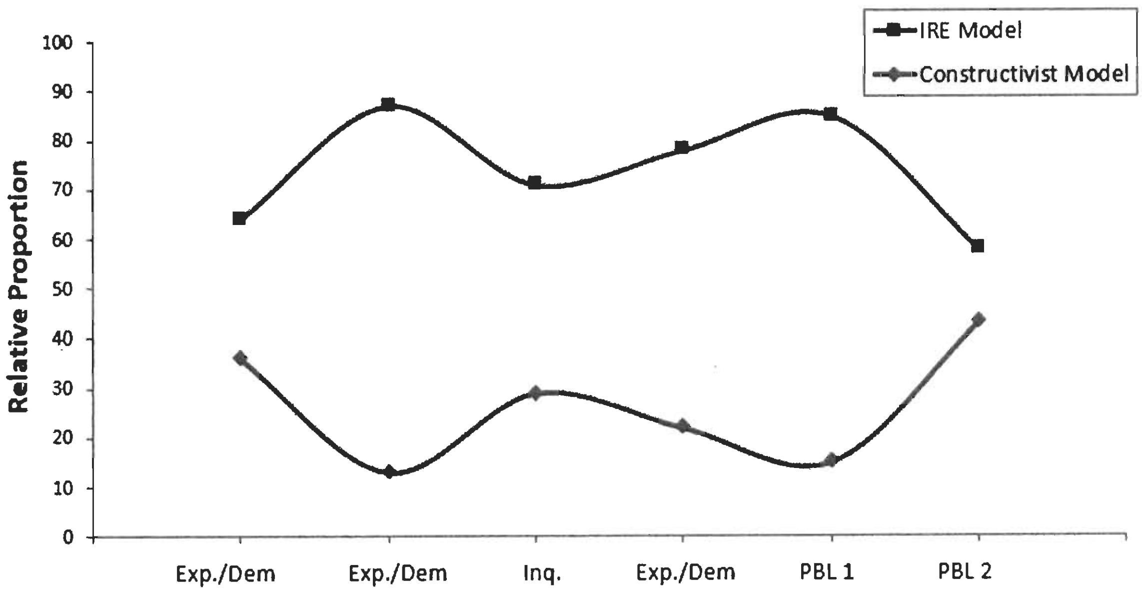


Figure 4.15. Set 2 summary graph.

Set 3

In data Set 3, seven labs taught by GTA1 were audio/video recorded in one laboratory section over the course of semester B. During this semester, four expository/demonstration labs and four inquiry-oriented labs were taught. All four inquiry oriented labs taught during this semester were PBL labs. The results and patterns described in this section were found using the analytic steps and techniques described in Chapter Three.

Labs 1, 2, and 3: Expository/Demonstration-Oriented Labs

In Set 3, the first three labs of the semester were expository/demonstration labs. The graphs from each of these labs are presented as Figures 4.16., 4.17., and 4.18. The conversation types consistent with the IRE model of classroom discourse dominated during these three labs. During the first lab, depicted in Figure 4.16., 79% of the conversations were consistent with the IRE model. Again during the second lab and shown in Figure 4.17., 76% of the conversations in this expository/demonstration-oriented lab were conversation types consistent with the IRE model. And lastly shown in Figure 4.18., 78% of the conversations in the third lab were those consistent with the IRE model.

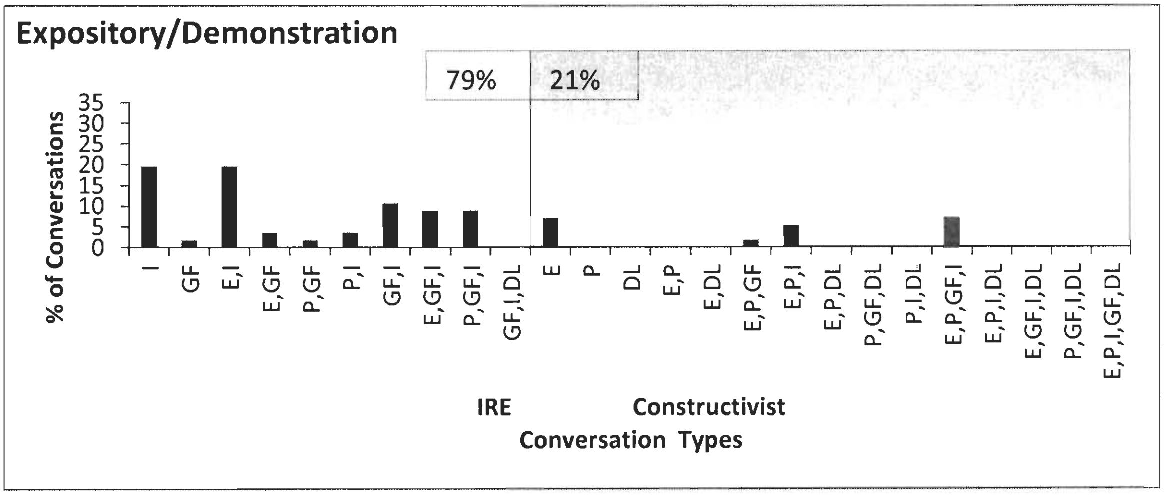


Figure 4.16. Results for first, expository/demonstration-oriented lab of Set 3, collected from GTA1 during semester B.

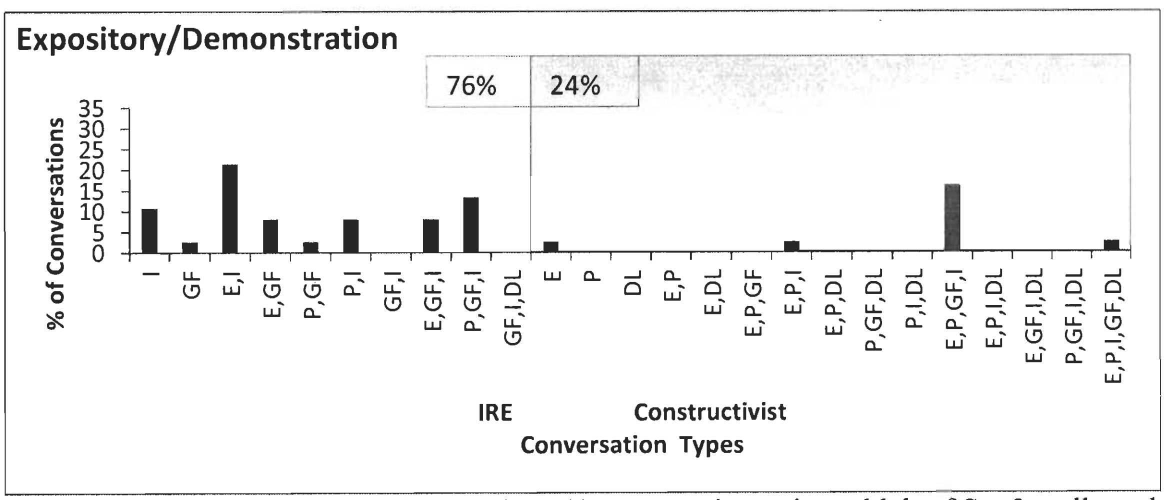


Figure 4.17. Results for second, expository/demonstration-oriented lab of Set 3, collected from GTA1 during semester B.

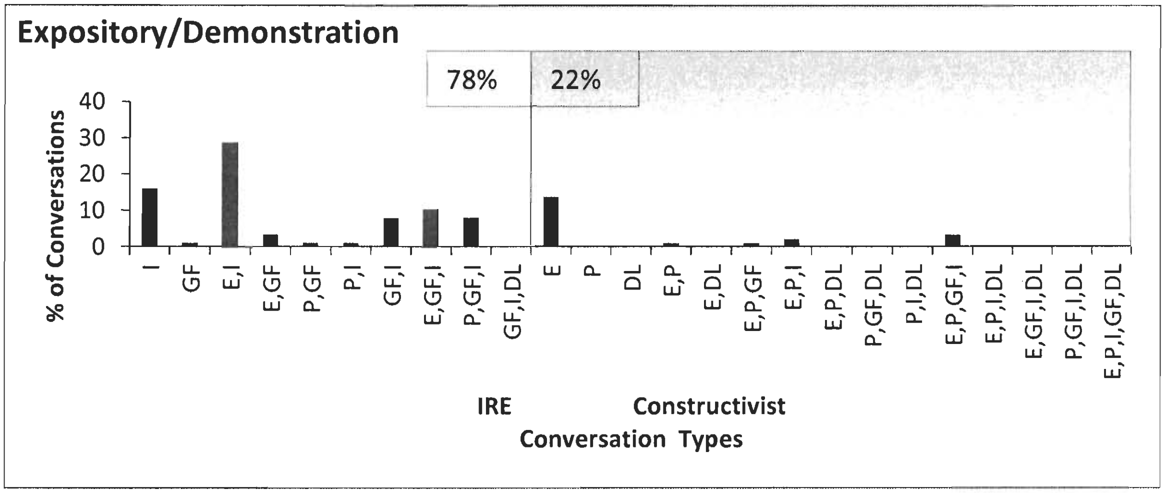


Figure 4.18. Results for third, expository/demonstration-oriented lab of Set 3, collected from GTA1 during semester B.

As was previously seen in the Set 1 data (also collected from GTA1), patterns in classroom discourse are being repeated within the expository/demonstration oriented labs displayed above in Figures 4.16., 4.17., and 4.18. GTA1 frequently employed conversations which took the forms of either I or E,I. The distribution of conversation types seen in these three figures also favors those which were consistent with the IRE model.

Seen in Table 4.13. is a transcription of one of the I conversations taken from the first lab of Set 3. This lab was dominated by similar conversations. In this instance, GTA1 was attempting to get students to complete their lab in the most efficient manner possible.

Table 4.13.

Transcription of I conversation

Transcribed Example: Informing
S: Uhm, does this look okay? TA: It's getting there, you still have some water around the edge. But you can, you have such a large watch glass, you can, you don't have to have it on there the whole time. There is going to be an initial splatter. {informing}

S: Okay.
TA: If you turn it down a little bit, it might work a little better. Then you don't have to have the watch glass on there the whole time. But if you want you could just leave it on there, cracked. I am trying to give you different techniques. {informing}
S:But, the procedure says to have the watch glass on.
TA: Okay, it will take a little bit, but it will be fine. {informing}

In Table 4.14., a transcription from the second lab of Set 3 is provided. In this lab, conversation types like this one dominated during the lab. In the conversation outlined in Table 4.14., GTA1 made certain that the student knew what he/she was to write down. This conversation revolved around getting the students to work accurately and efficiently. The focus was on getting the student to write the appropriate information in the correct space, making this conversation consistent with the IRE model.

Table 4.14.

Transcription of E,I conversation

Transcribed Example: Elicitation and Informing
S: What am I looking at?
TA: So, that one is hydrogen, which we already did. {informing}
S: We did this one?
TA: This is the one we did in class together.
S: Oh, I must have shown up late then. I did, I was a couple minutes late.
TA: Okay, so basically, so what we did, well have you done this part here? {elicitation}
S: Oh, that's what we are supposed to do, I didn't know we needed to write that stuff down.
TA: This is hydrogen, and [that is] hydrogen. {informing}
S: We don't have to write down all the lines that show up on here, do we?
TA: Well, this one there's four, the other ones, there are more than that. At this one, there are four, maybe five. {informing}

Though the second lab from Set 3 was dominated by IRE model conversation types, there were still a portion of conversations that were consistent with the constructivist model of classroom discourse. These constructivist conversations were quite complex in nature. Provided in Table 4.15. is a transcription of one such example. In this transcript, GTA1 guided the student, but also allowed them to find the answer for themselves. In accomplishing this the GTA questioned the students and provided key information only when required.

Table 4.15.

Transcription of E,P,GF,I conversation

Transcribed Example: Elicitation, Prompting, Giving Feedback, and Informing
TA: So, what did you end-up getting? {elicitation}
S: I said that NaCl was a yellow or an orange
TA: Mhm, it was lighter than the other ones {giving feedback}
S: Yeah it was. And for this one, well I figured that there was some lead in (unknown number) J30. There was only a little bit of purple.
TA: I mean, these three red lines, boom they
S:(unclear)
TA: It's easier if you look for the, the fewer amount of colors because there is only, only like this one especially. Like boom, that red line right there, it is a huge tell-tale a sign of which one it is. I mean, I don't think you have that one. {informing}
S: So, for J30, it would be like lead
TA: yep {giving feedback}
S: and it would have some....
TA: So, what gives it that funky line at the end? {prompting}
S: I think magnesium maybe but,
TA: So, if you are not sure then you look down here and you say, oh well, is this purple one here? {prompting}
S: Yeah, there is some purple right there
TA: It has that purple line there, right? They (the lines) will be in the exact same spot. {informing}
S: So, lead and palladium probably.
TA: Does anything else give this funky red double line, probably not. And there are only two. So yeah, there are only two combined. {informing}
S: So, they would combine lead and palladium? We could get lead again?
TA: Oh they might, I don't know, some groups had lead three times.
S: Okay
TA: Just the way it went.

In the third lab of Set 3, the discourse employed by GTA1 predominantly favored those conversation types consistent with the IRE model. I and E,I were dominant conversation types seen during this lab. A sample of one such conversation has been provided in Table 4.16. In this conversation, GTA1 directed the students, with respect to the procedure, to ensure that the students were working efficiently.

Table 4.16.

Transcription of E,I conversation

Transcribed Example: Elicitation and Informing
TA: How's it going? {elicitation}
S: Good, there are only a few steps left.
TA: Almost there, I'll be back in like, if I am not back, if I am not back by like 3:35 you guys can just like stick it on a hot plate. {informing}
S: Okay
TA: Be sure to turn it all the way up. {informing} And, you are at 25 not 30, right? {elicitation}
S: Yeah

Lab 4: Expository/Demonstration-Oriented Lab

In Set 3, the fourth lab of the semester was an expository/demonstration lab. The graph from this lab is presented in Figure 4.19. The conversation types that are consistent with the IRE model of classroom discourse do not dominate during this expository/demonstration-oriented lab. During this lab, 54% of the conversations were consistent with the IRE model.

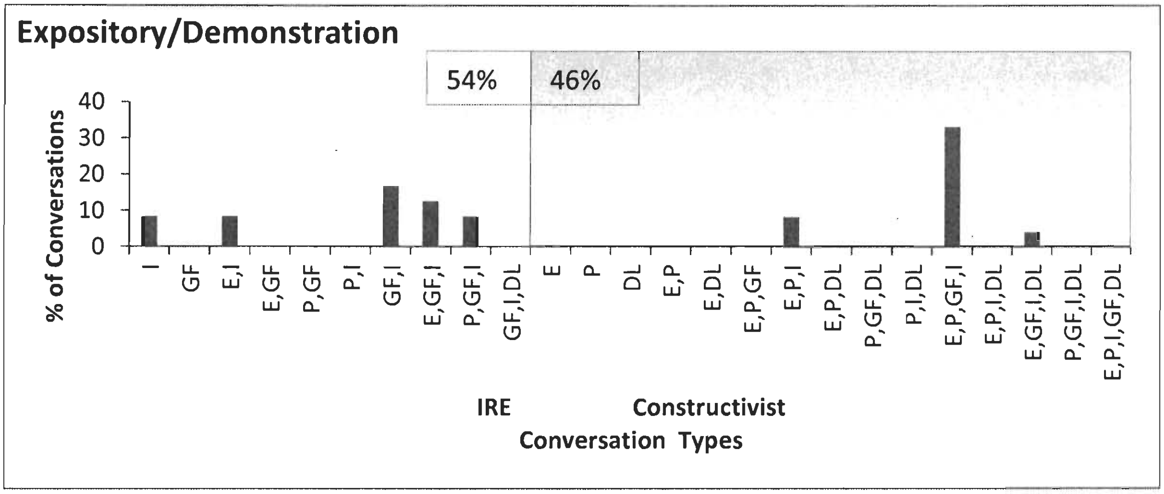


Figure 4.19. Results for fourth, expository/demonstration-oriented lab of Set 3, collected from GTA1 during semester B.

There were a large proportion of conversations (over 30%) where GTA1 utilized the following types of discourse within a single conversation: elicitation, prompting, giving feedback, and informing. This was an entirely unexpected result. Typically, in expository/demonstration labs such as this, GTA1 utilized only informing or elicitation and informing together. The context of the lab may provide an explanation as to why conversations like the following one (transcribed in Table 4.17.) were so prevalent during this lab. Though this lab has been defined as an expository/demonstration oriented lab, it does have elements of the inquiry setting. Student are given a task to complete and they are to use a method of their choosing to complete the task.

Table 4.17.

Transcription of E,P,GF,I conversation

Transcribed Example: Elicitation, Prompting, Giving Feedback, and Informing
TA: Okay, what's up? {elicitation}
S: Okay, boron, it has 3 valence electrons, how can this possibly work?
TA: Well, there is also a minus charge isn't there, well, you are adding in an electron right? {informing}
S: I don't know; does fluorine have something to do with it?

TA: No, {giving feedback} there is an electron in there right, BF_4 minus. So, there is another electron thrown into the mix. {informing}
S: Okay, is this other one correct though?
TA: Count up your electrons... how many from nitrogen? Oh, how many if you took nitrogen by its self, how many valence electrons? {prompting}
S: Five.
TA: How many from oxygen? {prompting}
S: (unclear)
TA: Huh?
S: Six.
TA: Yeah, so that would be eighteen plus five, that's twenty-three, twenty-four. {informing} How many electrons do you have on there? {prompting}
S: Well let me count... okay it looks like we have twenty-six.
TA: So, you have too many, right? {informing}
S: Yeah.
TA: So that little, that pair right there, it isn't there anymore. {informing} So what does it have to do? {prompting}
S: Make a double bond, but I really don't get it. There are still the same amount of electrons, who cares about the double bond?
TA: Yeah, but then nitrogen would have eight, oxygen would all have eight.
S: Okay, the octet rule.
TA: There you go. {giving feedback}

This was a dry lab which focused on drawing Lewis dot structures given a condensed molecular formula. Students did not complete a bench top procedure, and were not given a strict set of instructions to follow in order to complete this lab. This is counter to all other labs that have been previously referred to as expository/demonstration. Other previous expository/demonstration-oriented had a significant bench top component and were driven by a detailed procedure. In the conversation transcribed in Table 4.17., GTA1 acted as a facilitator by questioning students and supporting them with pertinent information, without simply giving the answer.

Labs 5, 6, and 7: PBL Labs

Set 3 finishes with a series of PBL labs. Graphs depicting the relative proportion of conversation types present over the course of each lab have been presented in Figures

4.20., 4.21., and 4.22. The three figures presented, which represent the first, second, and third PBL labs of the semester, display the patterns in classroom discourse seen over the course of the PBL lab series. In the first PBL lab (Figure 4.20.), classroom discourse consistent with the IRE model dominated. In Figure 4.20., 62% of the conversations were consistent with the IRE model. In Figure 4.21. conversation types consistent with the constructivist model dominated by a slight margin, where 53% of the conversations were consistent with the constructivist model. But, in Figure 4.22, the conversation types consistent with the IRE model were favored and made up 59% of the conversations within the lab.

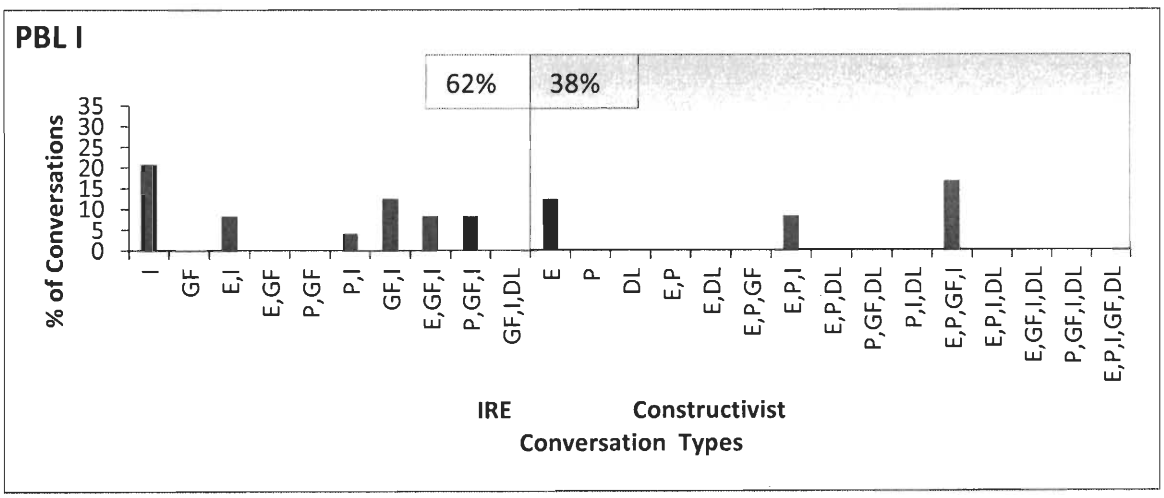


Figure 4.20. Results for fifth, PBL lab of Set 3, collected from GTA1 during semester B.

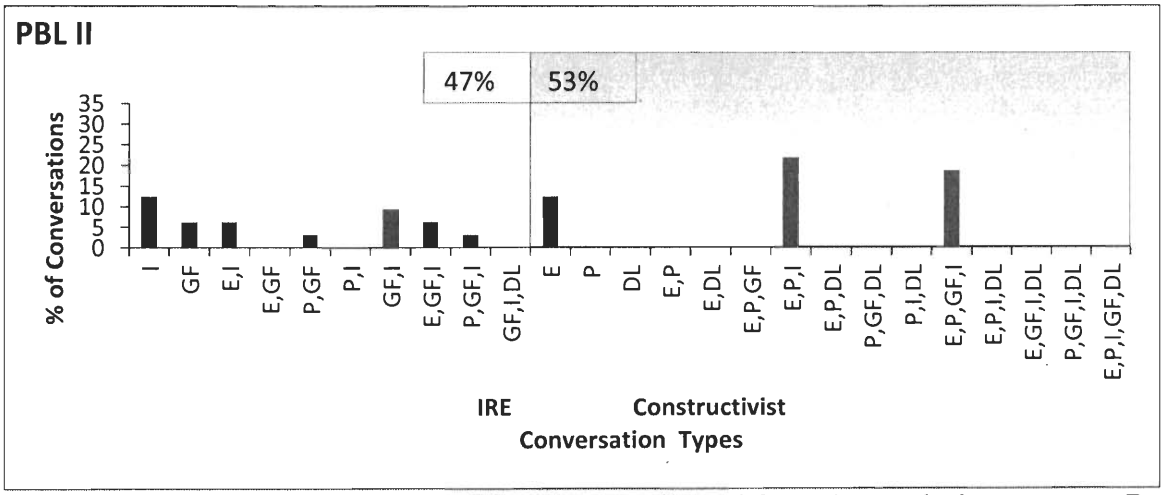


Figure 4.21. Results for sixth, PBL lab of Set 3, collected from GTA1 during semester B.

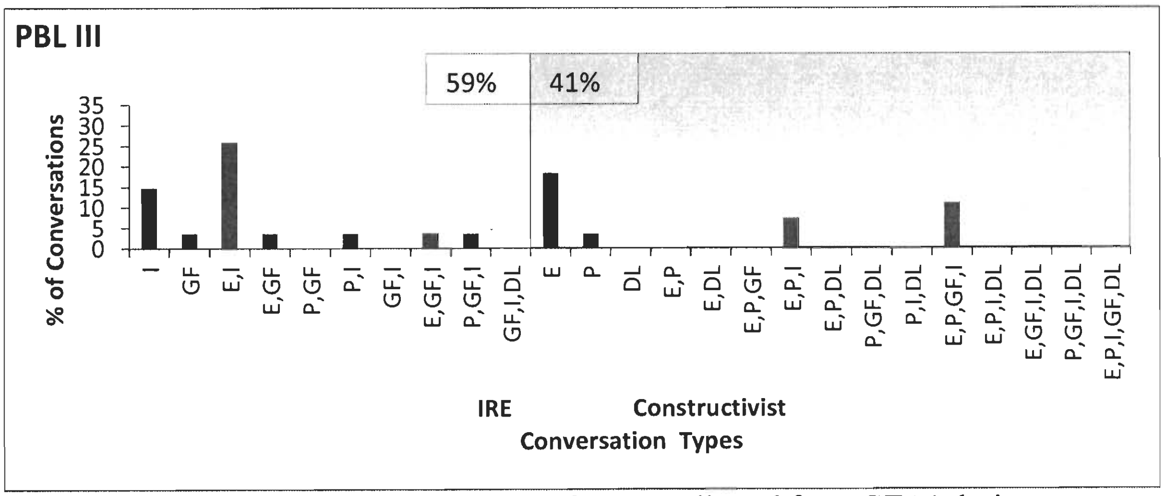


Figure 4.22. Results for seventh, PBL lab of Set 3, collected from GTA1 during semester B.

The most common conversation types indicated by the three previous figures have been transcribed in previous sections. Among these three labs, some of the most common conversation types include: E; I; E,I; and E,P,GF,I. Like those previous transcriptions, the E and E,P,GF,I conversations show the GTA acting as a facilitator and as a guide while the I and E,I conversations show the GTA telling the students how to work efficiently or correctly indicate answers on their lab reports.

Set 3 Summary

Having explored the data from Set 3, there are definite patterns present. For GTA1, differences in classroom discourse between inquiry and expository/demonstration-oriented labs were observed, but these difference were somewhat less sharply defined than what was seen in Set 1. In the initial expository/demonstration-oriented labs, conversation types consistent with the IRE model dominated the classroom discourse. GTA1 frequently employed GTA-centered discourse aimed at getting the students to write the correct answers or perform the lab experiment as quickly as possible.

However, in the final expository/demonstration lab, discourse consistent with the constructivist model dominated the conversation landscape. This may relate to the lab's structure. Having no directive procedure sets this lab apart from all other expository/demonstration-oriented labs explored in this study, and better aligns this lab with inquiry oriented instruction. This may account for the patterns in discourse observed within this lab.

In the final PBL inquiry labs, GTA2 continued with the pattern outlined in the fourth lab, where similar proportions of IRE-consistent and constructivist conversations were employed. At times, the IRE conversations dominated and at other times non-IRE conversations dominated, but ultimately similar proportions of each conversation type were employed during the PBL labs. This differs from what was seen in the first three expository/demonstration-oriented labs. Finally, a summary graphic provided in Figure 4.23. shows the general pattern GTA1's discourse over the course of Semester B. The square points indicate the proportion of conversations that were consistent with the IRE model, while the diamond points indicate the proportion of conversations that were consistent with the constructivist model.

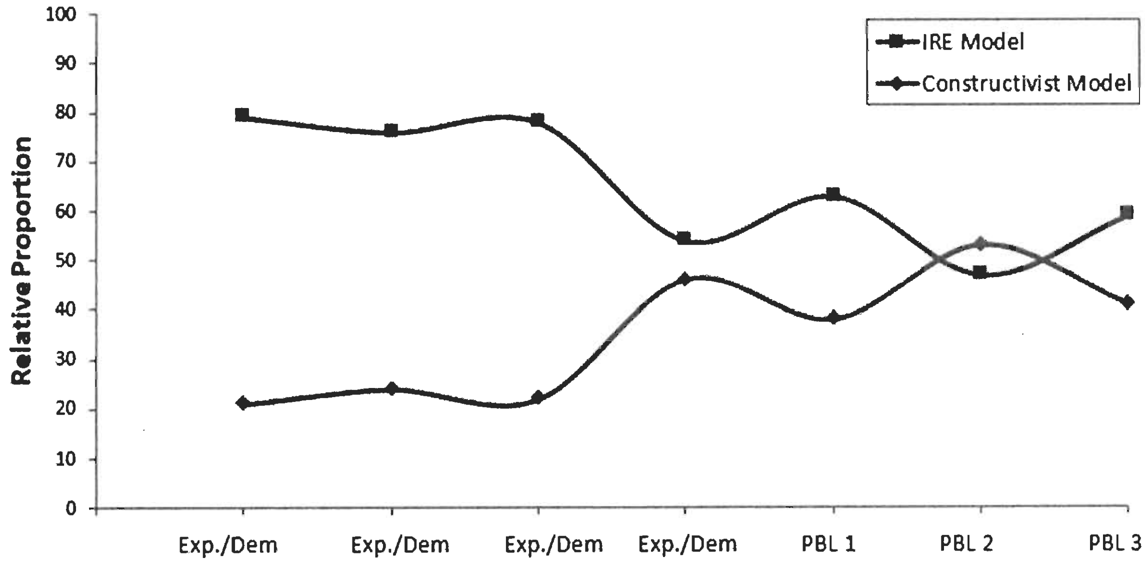


Figure 4.23. Set 3 summary graph.

Sets 1, 2 and 3: A Summary and Comparison

In Set 1 (GTA1, semester A), there were distinct differences in classroom discourse seen over the course of the semester. In labs which were expository/demonstration-oriented in nature, it was common for 80% of the conversation types employed to align with the IRE model. This was not the case in the inquiry-oriented labs. In the inquiry-oriented labs, there were either more conversation types consistent with the constructivist model, or similar proportions of IRE-consistent and constructivist conversations.

In Set 2 (GTA2, semester A), the same patterns in classroom discourse were again observed, but to a lesser extent. One of the expository/demonstration-oriented labs taught by GTA2 had a relatively large proportion of constructivist type conversations. Two of the inquiry labs were dominated by conversation types that were consistent with the IRE model. One of the PBL labs was also counter to the pattern previously observed in Set 1. In this PBL lab, conversation types consistent with the IRE model were observed in large proportion. The same can be said for the general inquiry lab within this data set. Only one PBL lab had more conversation types that were consistent with the constructivist model or where there were similar proportions of IRE-consistent and constructivist conversations. The remaining three labs were consistent with the patterns seen in Set 1. For two expository/demonstration labs and one PBL lab, the pattern previously identified in Set 1 was conserved.

In Set 3 (GTA1, semester B), the overarching patterns seen in both Sets 1 and 2 were repeated. When GTA1 was teaching labs that were expository/demonstration-oriented in nature, it was common for 80% of the conversation types employed to fit with the IRE model. During this semester that was not always the case, however, as one of the expository/demonstration-oriented labs was filled with discourse that was constructivist in nature. In the inquiry-oriented labs, there were either more conversation types that were inconsistent with the IRE model, or there were similar proportions of IRE-consistent and constructivist conversations.

Inter-Coder Reliability Data

To close this chapter, the inter-coder reliability results are presented. Two complete data files were coded by a graduate student from the Mallinson Institute for Science Education, according to the procedures previously outlined in Chapter Three. The results of this coding are presented below. In Figure 4.24., the graph which was the product of the inter-coder's work is presented. Directly following in Figure 4.25., the graph of the coding produced by the researcher is presented. The overall percentages of conversations that do and do not fit with the IRE model are similar. Also very similar are the distributions of conversations reported by each coder (both the inter-coder and the researcher). Finally, in Figure 4.26., a combination of Figures 4.24. and 4.25. have been placed on the same axes for ease of comparison. All three of these figures pertain to a PBL lab.

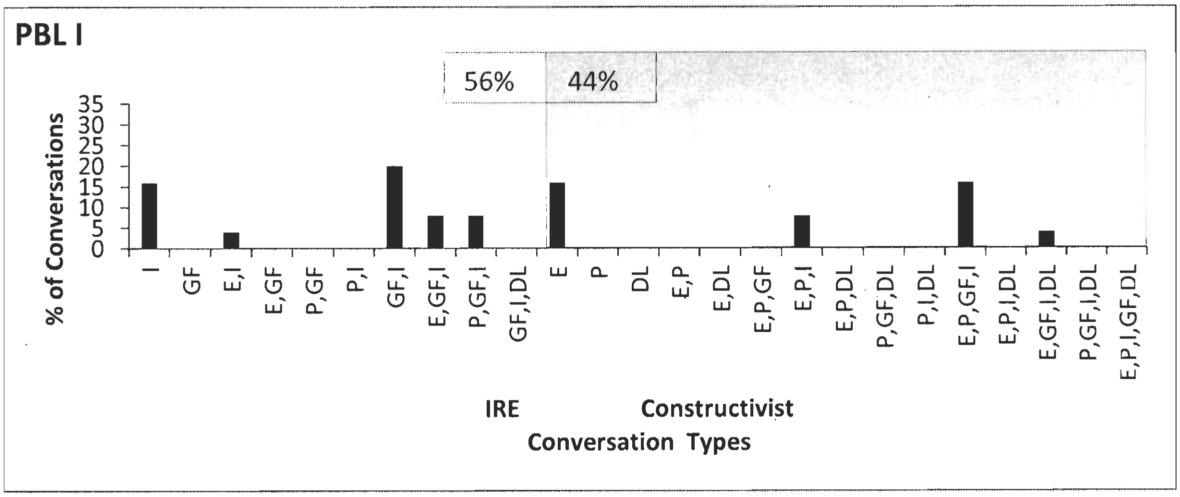


Figure 4.24. Graphic representation of inter-coder's coding of a PBL lab.

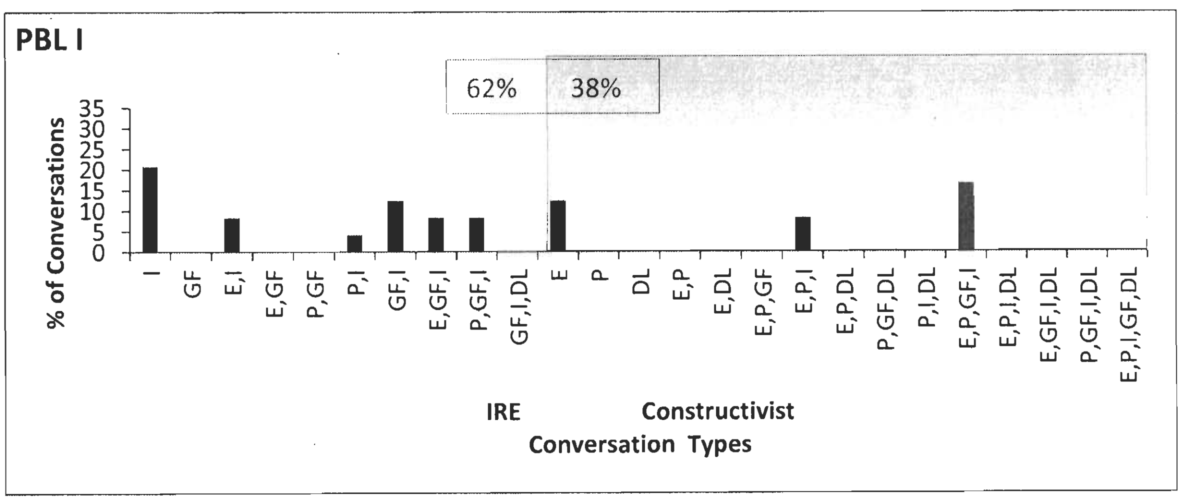


Figure 4.25. Graphic representation of researcher's coding of a PBL lab.

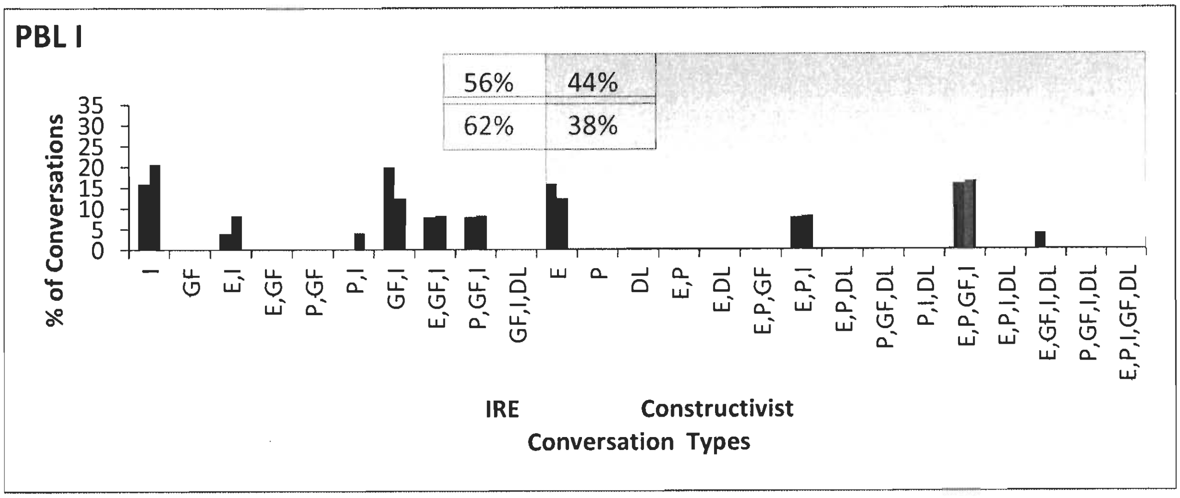


Figure 4.26. Graphic comparison of researcher's and inter-coder's coding of a PBL lab.

Additionally, an expository/demonstration-oriented lab was subject to inter-coder reliability testing. As in the previous example, the results of the coding for both the inter-coder and researcher are presented on separate axes in separate figures (Figures 4.27. and 4.28., respectively) before being combined in Figure 4.29. Again, the proportion of conversations that were consistent with the IRE or constructivist model was similar for both the inter-coder and the researcher and the overall distribution of conversation types was similar as well.

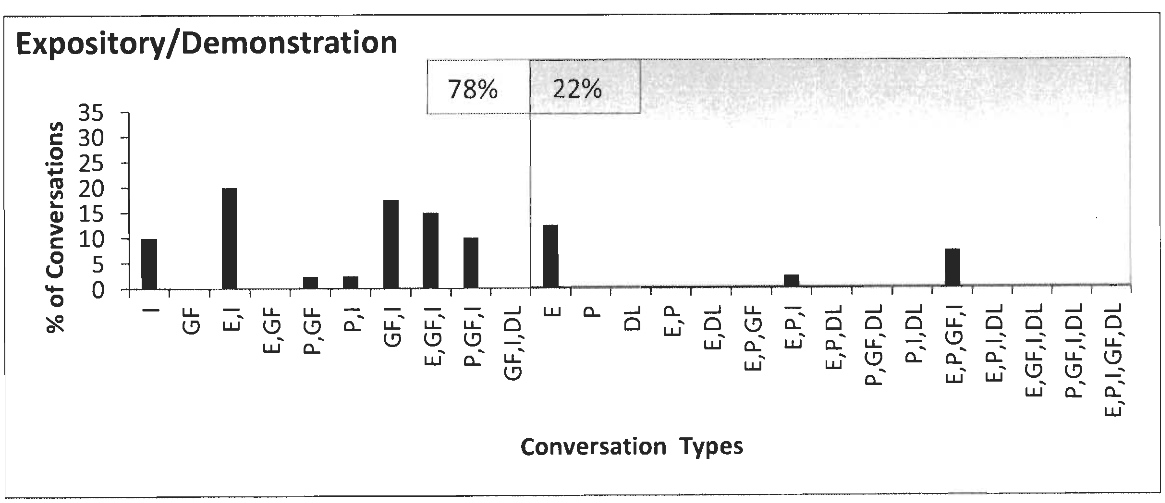


Figure 4.27. Graphic representation of inter-coder's coding of an expository/demonstration-oriented lab.

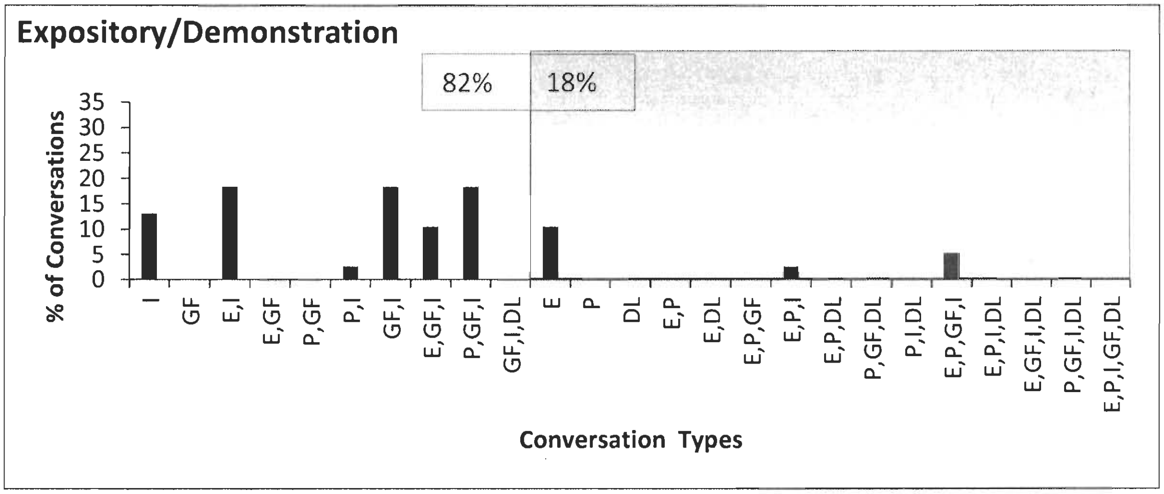


Figure 4.28. Graphic representation of researcher's coding of an expository/demonstration-oriented lab.

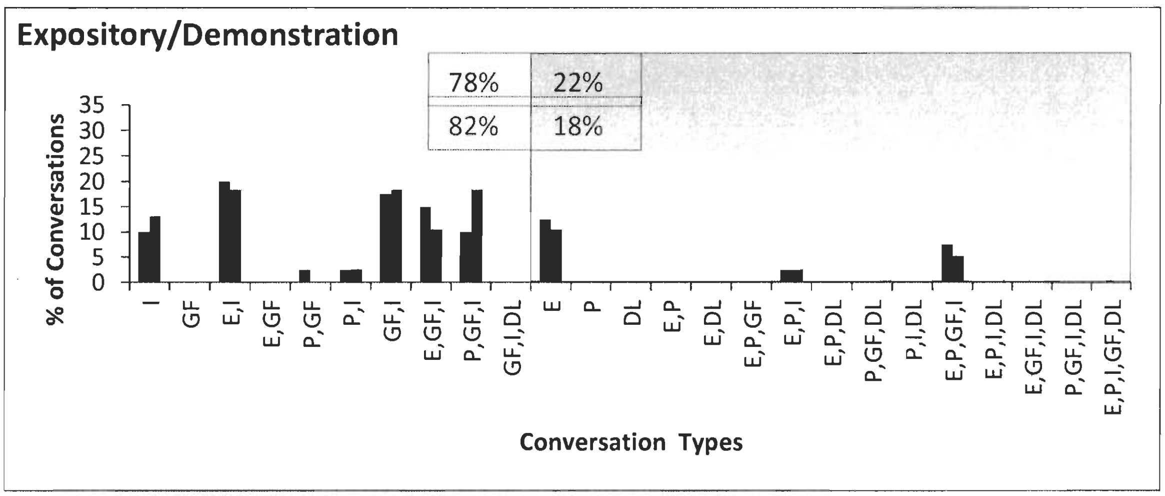


Figure 4.29. Graphic comparison of researcher's and inter-coder's coding of an expository/demonstration-oriented lab.

Though these figures are apparently consistent, quantifying that consistency for the purposes of comparing it to literature values is of value. In Chapter Three, the means of calculating inter-coder reliability were outlined. The formulas that were used to calculate inter-coder reliability have been reintroduced in Figure 4.30. For each lab that was subjected to inter-coder reliability testing, the following percentages were calculated:

(a) exact agreement, (b) disagreement with one process code difference, and (c) disagreement more than one process code difference.

> Percentage of Exact Agreement=EA/(EA+D1+D) (should approach 80%)
> Percentage of Disagreement with one process code difference=D1/(EA+D1+D)
> Percentage of Disagreement with more than one difference=D/(EA+D1+D)
>
> EA: number of units for which the process codes agree exactly
> D1: number of units for which the process codes differ by the presence or identity of one process code
> D: number of units for which the process codes differ by the presence or identity of two or more process codes

Figure 4.30. Review of how inter-coder reliability was quantified.

For the PBL lab that was subjected to inter-coder reliability, the results are presented in Table 4.18.

Table 4.18.

Inter-coder reliability quantification for the PBL lab

Percentage of:	**Percentage Value**
Exact Agreement	76%
Disagreement with one process code difference	12%
Disagreement with more than one difference	12%

These levels of agreement between the researcher and the inter-coder give an indication that the coding methods outlined in Chapter Three were robust, as they produced results that approximate the levels of agreement required. These results also indicated that data presented was not simply an artifact of the researcher.

Again, presented in Table 4.19. is the quantification representing the amount of agreement between the coding of the inter-coder and the researcher for the expository/demonstration-oriented lab.

Table 4.19.

Inter-coder reliability quantification for the expository/demonstration-oriented lab.

Percentage of:	Percentage Value
Exact Agreement	83%
Disagreement with one process code difference	17%
Disagreement with more than one difference	0%

Summary

Chapter Four presented the results of this study. There were some apparent differences between the typical classroom discourse present in the expository/demonstration-oriented labs and the PBL labs. These results suggest that the answer to research question 1: *How does classroom discourse differ from the expository/demonstration mode of instruction to the PBL mode of instruction?,* is that in the PBL setting, classroom discourse consistent with the IRE model is seen less frequently than classroom discourse that was consistent with the constructivist model. The opposite is also suggested for the expository/demonstration labs. The second research question: *What types of classroom discourse are actually characteristic of the expository/demonstration mode of instruction and the PBL mode of instruction?* has also been addressed. It appears that I, EI, GFI, and PGFI conversations were some of the most typical types of conversations across all of the expository/demonstration-oriented labs. In the PBL labs, it appears that the most common conversation types employed by GTAs were E; E,P,I; and E,P,G,F,I.

The data that have been presented in this chapter and which support these claims concerning the differences between classroom discourse in the expository/demonstration and PBL labs are not simply an artifact of the researcher. As evidence of this, inter-coder reliability was obtained and was found to be sufficient (Neuendorf, 2002). When considering the data set as a whole, there are apparent differences in GTA classroom discourse. In the following chapter, the specifics and significance of these trends is discussed.

Chapter 5

Introduction

In this fifth and final chapter the implications of the results, previously outlined in Chapter four, are discussed. There are three primary assertions that align with the answers to the research questions and can be made on the basis of this data:

1. There is an apparent relationship between the instructional mode (expository/demonstration vs inquiry) and the types of classroom discourse employed by the GTA.
2. These patterns in classroom discourse repeat within a given instructional mode, even when the nature of content being covered varies widely.
3. The patterns in classroom discourse observed in the inquiry labs frequently exemplify the constructivist learning environment, and were achieved with minimal interference on the part of the researcher.

In this chapter, brief segments of data supporting these claims will be presented. After each of the assertions, the implications that these assertions have for GTA's, departments, universities, and future students are discussed.

Assertion 1: There is an apparent relationship between the instructional mode (expository/demonstration vs inquiry) and the types of classroom discourse employed by the GTA.

In the previous chapter, data from a total of 20 different labs was presented. After analyzing this data, a pattern emerged. Labs that were inquiry oriented tended to be populated with conversations that were consistent with the constructivist model of classroom discourse. Expository/demonstration labs, on the other hand, were populated by conversation types consistent with the IRE model. 15 of the 20 labs that were analyzed for this project produced data that was consistent which this pattern, though this pattern did displayed itself in varying degrees between the two participants (GTA1 and GTA2). GTA1 had three of fourteen labs that did not fit the pattern. GTA2 had two of six labs that did not fit the pattern. Figures 5.1., 5.2., and 5.3. illustrate the relative proportion of conversations (for each given lab day) that were either consistent with the IRE or constructivist model of classrooms discourse. Overall, there are five lab days that do not fit with the aforementioned pattern of classroom discourse.

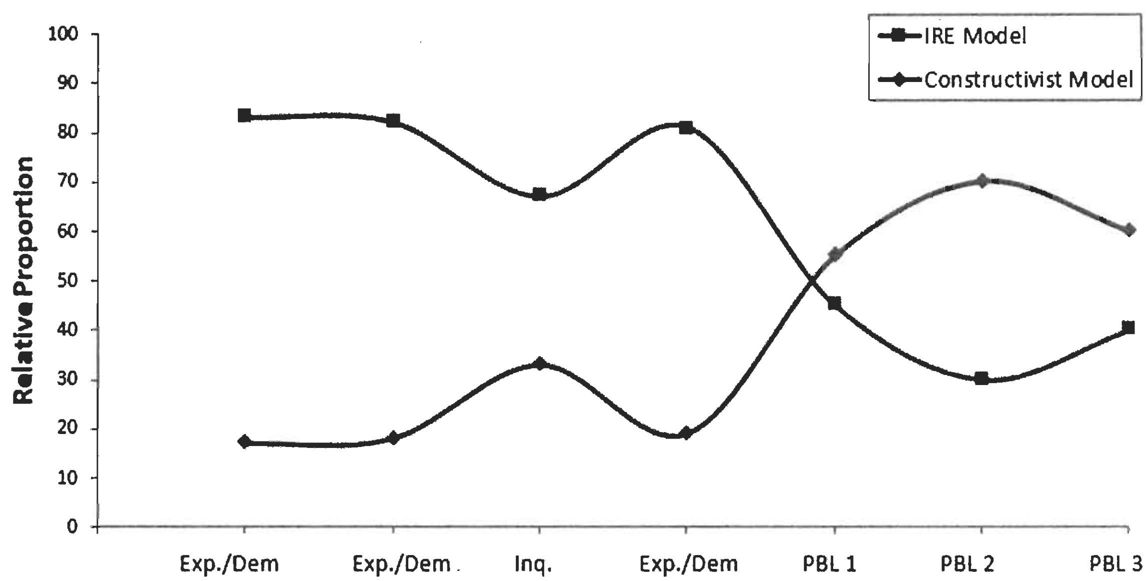


Figure 5.1. Relative proportions of IRE and constructivist conversations for GTA1 over the course of Semester A.

In Figure 5.1. there are no inconsistencies with the pattern that IRE styled discourse dominates on the expository/demonstration lab days. On the inquiry oriented days the proportion of conversations that are consistent with IRE are greatly reduced relative to the proportion of conversations that are consistent with the constructivist model. This is seen to some extent in the guided inquiry lab (lab day 3) and in the PBL labs.

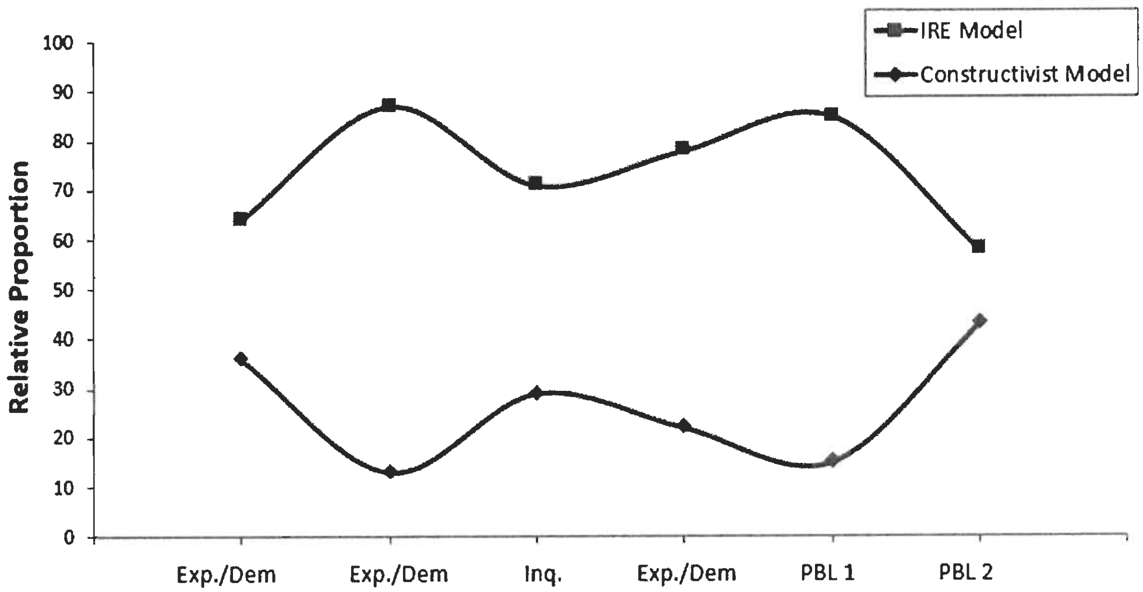


Figure 5.2. Relative proportions of IRE and constructivist conversations for GTA2 over the course of Semester A.

In Figure 5.2., there are two labs that are inconsistent with the proposed patterns in classroom discourse. Labs 1, 2, and 4 were all expository/demonstration-oriented labs. Lab 1 from this set had an unusually high proportion of constructivist conversation types, relative to the other expository/demonstration oriented labs. The inquiry-oriented labs also had one day that did not fit the pattern, lab day 5. The high proportion of IRE consistent conversations relative to constructivist conversations is atypical for a PBL lab.

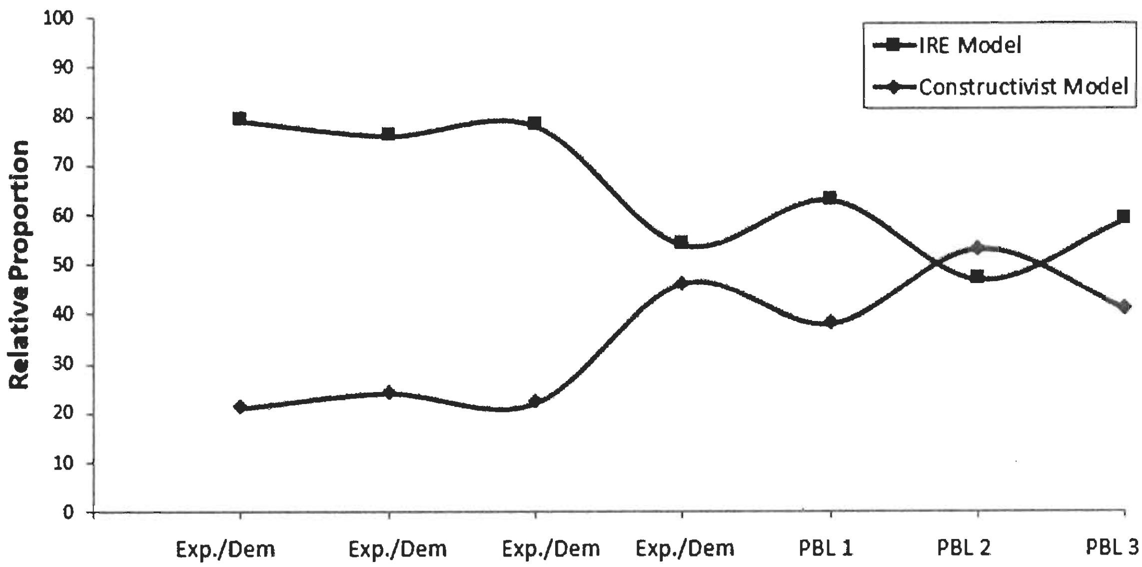


Figure 5.3. Relative proportions of IRE and constructivist conversations for GTA1 over the course of Semester B.

And finally in Figure 5.3. there were three lab days that did not fit with the aforementioned pattern in classroom discourse. The lab that was termed expository/demonstration but had inquiry elements (lab 4) exhibited a higher proportion of IRE-consistent conversations than would be expected. The final PBL lab also exhibited a higher proportion of IRE-consistent conversations than would be expected. Lastly, lab day 4 exhibited a higher proportion of constructivist conversation types.

Though there are some fluctuations between data sets 1 and 3, there is a pattern that emerges and supports the idea that when an inquiry mode of instruction is being utilized, there will be more constructivist conversations than would otherwise be present in an expository mode of instruction. The converse is true for the expository/demonstration-oriented labs. Data Set 2 is incomplete (the data from lab day 7 was not collected) but 4 of the 6 data points in this set do align with the pattern of more constructivist conversations in being present in inquiry settings and more IRE-consistent conversations being present in expository/demonstration-oriented settings.

Reasonably, one could ask what this means at the ground level. How precisely do these conversation types differ? In the last chapter, some of the most commonly seen conversation types within the expository/demonstration oriented labs were: E,I; GF,I; P,I; and I. These conversations (all of which are consistent with the IRE model) tend to be GTA-centered and focus on preparing students to indicate the correct answers or finish the laboratory experiment as quickly as possible. A sample EI conversation transcribed below highlights a few of these elements that make the conversation GTA-centered. This was the conversation type that made up 20% or more of the conversations in 6 of the 20 labs presented.

Table 5.1.

Transcription of E,I conversation

Transcribed Example: Elicitation and Informing
TA: And you all got a chance to look at the book? {elicitation} You have not. S: We haven't yet. But, how much water do we need to add? TA: It [the lab manual] says twenty five, I would try to do twenty {informing}. How much the of ammonium chloride left?{elicitation} S: What do you mean left? TA: What percentage {elicitation}? S: thirteen point six percent TA: Okay, I would use more water, because you don't know how much sand is there and there [appears] to be a significant amount of sand. {informing} S: Alright TA: So, use more, use the whole thing, but you can do it,[add] like 15[ml and] stir it, 10 [ml and] stir it. You don't have to add it all at the same time. {informing}

The conversation transcribed in Table 5.1. illustrates the level of control the GTA exhibited in the classroom. In this conversation, the GTA is collecting information from the students about their progress and results. The GTA is mining the students for information to get them through the lab as quickly as possible. There is minimal student input and minimal explanation of the chemistry being presented in the lab.

The inquiry labs, on the other hand, tended to produce different results. Some of the most common conversation types seen in the inquiry-oriented settings were: E; E,P,I, and E,P,G,F,I. These conversations were more student-centered and were inconsistent with the IRE model. In these types of conversations, students were frequently asked to explain their reasoning and put forth other options for moving forward. When students were unsure/unable to move forward on their own in the inquiry setting, the instructor guided them by questioning them further while also providing key suggestions and bits of information. Many of these elements are highlighted in the sample EPGFI conversation below.

Table 5.2.

Transcription of E,P,GF,I conversation

Transcribed Example: Elicitation, Prompting, Giving Feedback, and Informing
S: So, we want to test fruit for pesticides, but we are not sure that they will be there. And, we want to know if acids and bases could clean the fruit. Do we just bring fruit with pesticides on them?
TA: The fruit are coming from Meijer, so we don't really know. It's kind of random which one's actually have stuff on them.{informing}
S: I know.
TA: So really, if you are only going to test those you might not find those three pesticides. {informing}
S: So, could we test it for pesticides, clean it, and test it again.
TA: Yeah, there is no problem with that{giving feedback}, you just have to make sure that, like, maybe you circle a part with a Sharpie, and test that part. You just have to Figure out how you are going to do that. {informing} How are you going to first test for pesticide, then try to clean it? {prompting} That will be an interesting [unclear]. I am not exactly sure how that is going to work. What kinds of acids and bases are you thinking? {prompting}
S: like, HCl
TA: I'm trying to think if that's... so you're looking at a time thing? that's what you want to look at? {prompting}
S: No, we want to know how much pesticide there is.
TA: Again we can't, what is one of the limitations of our sensor? {prompting}
S: We can't quantify.
TA: Right {giving feedback}

S: But, say that we use some acid or base to see whether or not the pesticide comes off the fruit?
TA: So if, if you are using like 5ml of acid and 10ml of acid and then 15? {prompting}
S: we could see how much is needed to take the sensor off the fruit.
TA: So, I have a question then. So you are saying that you need to eliminate water? {prompting}
S: Yeah
TA: Most acids and bases are made in what? {prompting}... water, right? {informing}
S: Couldn't we just dry it?
TA: Well, if you dry it you are going to be wiping pesticide off, you could be wiping the acid off. I mean, you don't really know, right? {informing} What's your control? how do you know what you're wiping off? {prompting}
S: is there a way to control it?
TA: Yeah, there are ways to control it, it's just getting to that point. That is something to think about. I am not too hot on the idea of trying the cleaners, only because you are adding in a lot of variables to it, with the water and the drying it a certain way and things like that. {Informing} So it's, I don't mean to shoot down your ideas. They are really good ideas. {giving feedback} It's just we don't have the- it will also be hard to keep things over for a week. Think about it, we've gotta keep these things, is refrigeration going to effect it? if it is left out it would rot. So, you've gotta think about these things too, will it sit for a week. It's easier to work with things if you can do it in the time that we have in lab here, okay? {informing}
S: Okay, could we test the seeds?
TA: So, if you're testing the seeds to look for contamination, are you testing anything else? {prompting}
S: uhm
TA: That's a good idea. There is nothing wrong with that one, I like that one. That's something that's doable in our time frame. {giving feedback}
S:[unclear]
TA: Well, if you are testing the seeds for pesticides how will you know if they were even exposed to pesticides in the first place? {prompting}
S: I guess we could test the fruit its self.
TA: Okay, so you could test a few things on each fruit if you want.{informing} What else could you test? and, by testing the fruit itself I assume that you mean the flesh of the apple, right? {prompting}
S: yeah
TA: Well, where does the pesticide get applied? what else could you test? {prompting}
S: The skin
TA: The skin.{giving feedback} So that's a good question, you could [answer it] by testing different parts of the fruit. So, you have a few things that you can look at and choose from. No need to do all of them.{informing} Does that help a little bit?{elicitation}
S: Yep
TA: Okay, I gotta move on. I'll be back.

To shift away from the IRE model is to shift away from conversation types like the one outlined in Table 5.1. and towards that of Table 5.2. The transcription in Table 5.2. is an illustration of the open dialog present between the GTA and students within the PBL labs. In this transcription the GTA engaged the students by working with them and supporting them in the development of their project. In this conversation the GTA does not control the discussion or dictate students' future actions. The students take on the responsibility of designing the experiment and the GTA aids them in doing so by prompting them to explain their reasoning while occasionally providing information and tips.

This assertion, which states that there is an apparent relationship between the mode of instruction being employed and GTA discourse, is supported by the above which is essentially a re-answering of the guiding research questions. The research questions of this project were aimed at describing the modes of instruction and identifying any differences present. Outlined above are the general differences between the discourse with expository/demonstration oriented and inquiry labs.

These shifts, which have been both described and outlined, are interesting because of their connection to constructivism, certainly. But these shifts are also interesting because of how rapidly and frequently they occur. Based upon the graphic data presented in Figures 5.1., 5.2., and 5.3., the type of discourse being employed by a GTA can undergo dramatic changes from one week to the next. This was seen with both participants; large changes in the structure of their discourse occurred from one lab to the next, particularly when the mode of instruction changed.

Assertion 2: The patterns in classroom discourse repeat within a given instructional mode, even when the nature of content being covered varies widely.

Though the expository/demonstration labs and the inquiry labs were comprised of very different types of classroom discourse when compared to each other (even when they were taught back to back), there was an interesting level of homogeneity displayed among labs that were all either expository/demonstration or inquiry oriented. This homogeneity was note-worthy given how widely the content varied among some of these labs.

Consider for instance for GTA1- Set1 data. The first three labs are all expository/demonstration-oriented labs. Though the instructional mode is the same, there is a high level of consistency among the types of classroom discourse employed by GTA1 even when the content changes. In these three lab days the following topics are taught: atomic spectroscopy, separating chemical components of a mixture, and the determination of a chemical formula lab. These labs dealt with content that was very different. In one lab students are asked to conceptualize electronic orbitals and transitions, and in another lab, students are encouraged to consider solubility and how differential solubility can be used to physically separate a mixture. In the final lab, students use a variety of chemical and physical properties to determine the empirical and molecular formula of a given compound.

These labs could not be more different with respect to the content being covered, yet the types of conversations being employed during these two labs are very similar in structure. See Figures 5.4., 5.5., and 5.6. as examples of this. Shown in Figures 5.4., 5.5., and 5.6. are a series of graphs, all expository/demonstration labs taken from Set 1, which upon comparison show the extent to which the structure of classroom discourse is unaffected by the actual content of the chemistry lab. In these figures, four conversation types are consistently used: E,I; GF,I; P,I and I.

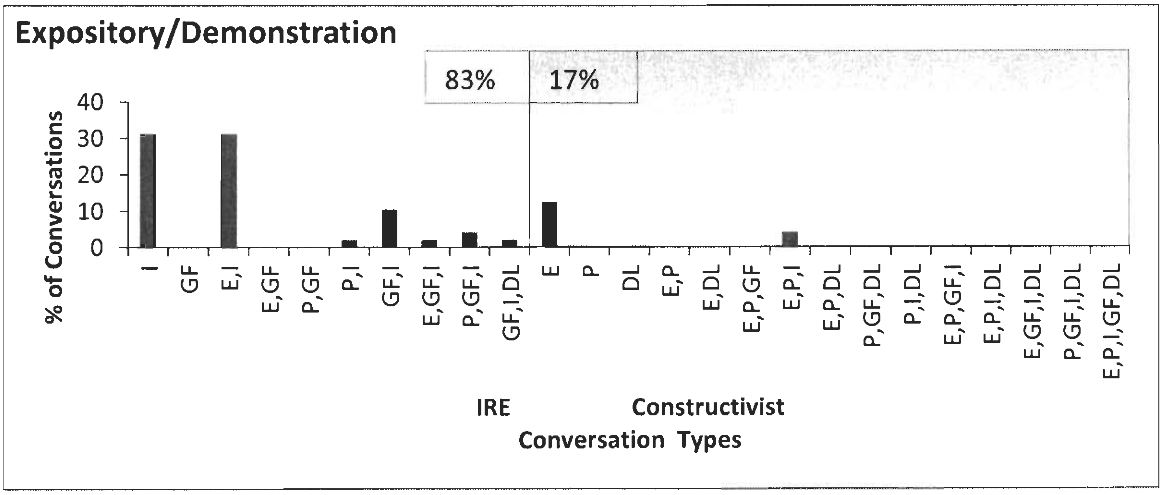


Figure 5.4. Results for first, expository/demonstration lab of Set 1, collected from GTA1 during semester A.

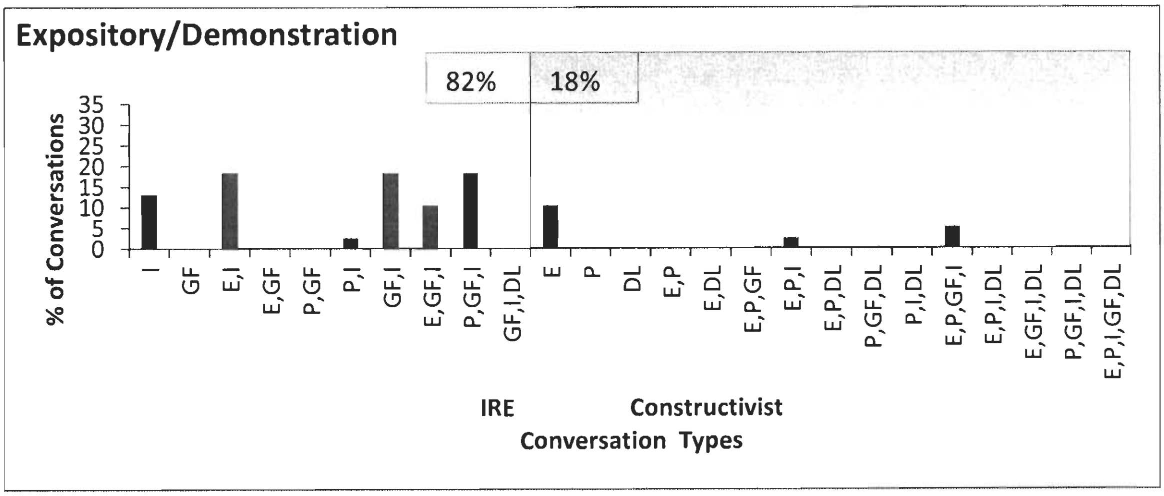


Figure 5.5. Results for second, expository/demonstration lab of Set 1, collected from GTA1 during semester A.

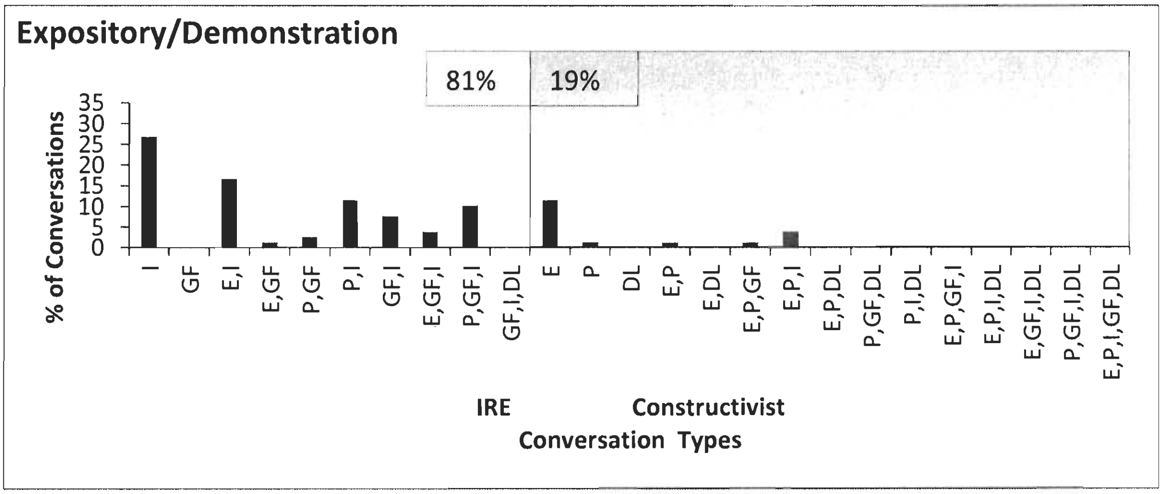


Figure 5.6. Results for third, expository/demonstration lab of Set 1, collected from GTA1 during semester A.

This same pattern can be seen in a series of PBL labs (Set 1) as well. There again appear to be a consistencies with respect to classroom discourse patterns among these labs. These labs have been depicted in Figures 5.7., 5.8., and 5.9. The most common conversation types that persist across the PBL series include: E; E,P,I; and E,P,G,F,I.

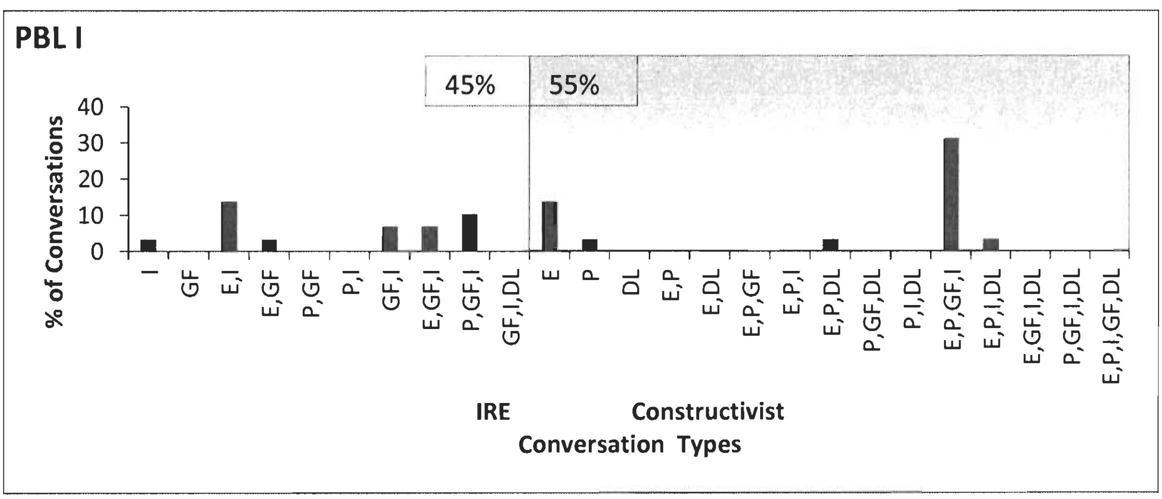


Figure 5.7. Results for first, PBL lab of Set 1, collected from GTA1 during semester A.

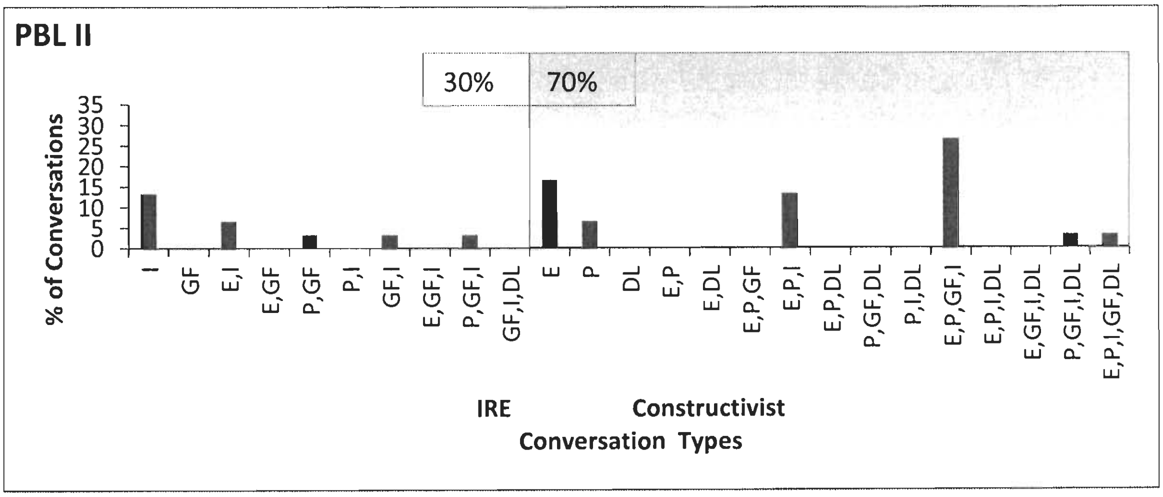


Figure 5.8. Results for second, PBL lab of Set 1, collected from GTA1 during semester A.

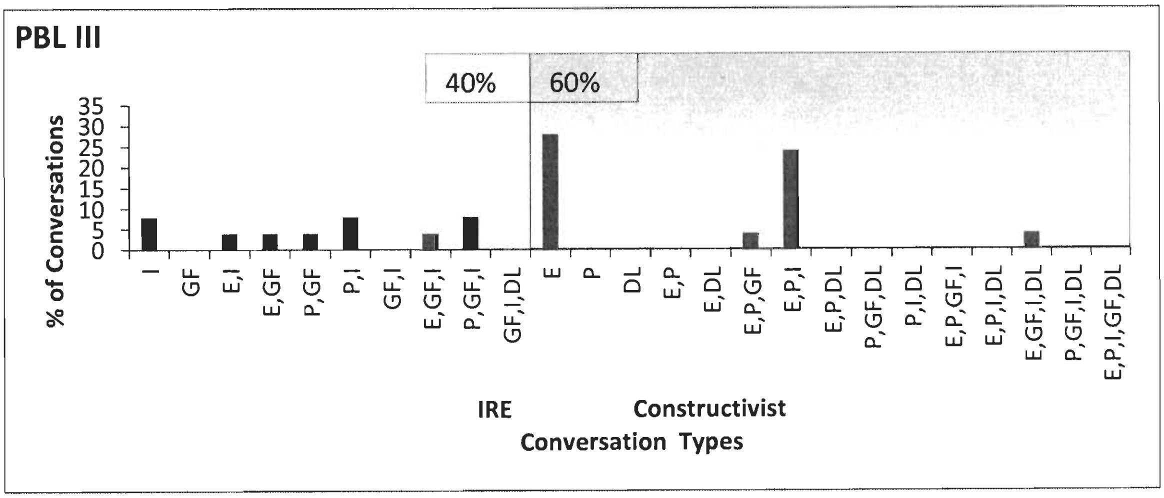


Figure 5.9. Results for third, PBL lab of Set 1, collected from GTA1 during semester A.

Assertion 3: The patterns in classroom discourse observed in the inquiry labs frequently exemplify the constructivist learning environment and were achieved with minimal interference on the part of the researcher.

With the previous assertions, the connection between classroom discourse and mode of instruction have been discussed. It appears that there is a connection between the mode of instruction and the type of discourse utilized by the GTA. When GTA discourse shifts away from the classical IRE model there are exciting implications. Shifting away from the IRE model allows classroom discourse to better align with the conceptualization of the constructivist learning environment.

What is meant by and what constitutes constructivist learning has evolved over the decades. The constructivist theory of learning outlines what 'understanding' is and which factors mediate it. According to the constructivist theory of learning, the learner is best served when individualized construction of knowledge occurs within the learner as he or she attempts to solve a problem with the sparing guidance of a more knowledgeable individual (Gage & Berliner, 1998).

What is often taken for granted among education studies, or is treated as transparent, however, is this "guidance" provided by a more knowledgeable individual (in this case, the GTA). Cazden, in 1988, commented on how infrequently educational studies focus on classroom discourse. Today, much emphasis is placed on curriculum design and actual classroom discourse is often overlooked.

In this study there are parallels between the classroom discourse observed in the PBL labs and the classroom practices which align with the basic tenets of constructivist learning. Recall Gage & Berliner's (1998) description of constructivist teaching. Gage & Berliner describe constructivist teaching practices as those in which the instructor relinquishes a certain amount of control to the students by:

(1) Bringing out what students already suspect, know, believe, or are capable of.

(2) Encouraging students to reflect on these responses and actions.

(3) Supporting students by either confirming that they are on the right track or by occasionally telling the students what they need so that they may make progress.

This data shows these theoretical components of the constructivist learning environment are more frequently actualized within our inquiry (problem-based learning) labs than within our expository/demonstration oriented labs. As was previously discussed, conversation types: E, E,P,I; and E,P,GF,I were consistently some of the most frequently employed conversation types within our inquiry labs. These conversation types are examples of constructivist classroom discourse.

The transcription presented in Table 5.3. shows the GTA simply checking in with students. This conversation is consistent with the principles of constructivism in that the GTA is relinquishing control. Instead of approaching the students and making corrections/suggestions or telling students how things are going, the GTA simply asks how things are going.

Table 5.3.

Transcription of E conversation

Transcribed Example: Elicitation
TA: So, how are things going guys? everything good?{elicitation}
S: Yeah, the sensor is making more sense now.
TA: Cool, let me know if you need anything

In Table 5.4. the GTA again is not in full control of the situation, and asks how things are going. Upon realizing that there is some definite confusion, the GTA does not jump in and control the situation, the GTA instead prompts the students giving them an opportunity to both explain and reflect on their reasoning. In this instance, the GTA also presents the students with key information so that they can progress.

Table 5.4.

Transcription of E,P,I Conversation

Transcribed Example: Elicitation, Prompting and Informing
TA: So, how are things over here? {elicitation} S: good, I guess. TA : Good, so what are we thinking so far? {prompting} what are we going to do for number 1 and number 2? and so on?{elicitation} S: [unclear] TA: So what are your plans? {prompting} S: So, we are going to get a 150ml beaker, the hydro soap, 100ml of water. Then we are going to use this pH strip to observe the color, to tell us the pH. TA: So, these are the pH strips. They are a little different because they have four little buttons on them, each one is a different color. It makes it much more precise. {informing} S: Right TA: So, instead of saying, oh that's basic or oh that's acidic, this actually tells you how much. Alright. {informing} S: Right. TA: Good, so what are your plans for [number] 2? {prompting} S: Well we aren't sure yet. TA: I will come back, you want me to come back? {elicitation} I don't want to give away the answer to everybody at the same time. S: Well, what does it even mean? It just seems really easy? What do they mean make a procedure? TA: Yeah, but how are you going to do that? {prompting} It says mix them together right?{prompting} S: Yeah, so do we mix them in like in like 3ml of water? TA: So, you have your beakers with like 100ml of water, and soap or water and detergent, right? {elicitation} so you have two beakers. It says: now mix those up together and add them to your samples. {informing} Well, what are you adding them to?...{prompting} think about that, what are you going to add them to and how much soap and detergent are you actually going to use for each test, right? So, those are some things to think about. {informing}

In Table 5.2., the GTA again is not in full control of the situation. In speaking with the students and better trying to understand their plans, the GTA does not direct the students but rather tries to get them to fully explain their ideas. But, upon realizing a potential issue with the student's proposed research design, the GTA prompts the students, giving them an opportunity to notice this issue for themselves. The GTA ultimately gives feedback and informs the students, but still finishes the conversation by reminding students that they have a few different ways that they can move forward.

The transcripts provided in Tables 5.2., 5.3., and 5.4. are conversations that were consistent with constructivism (as a learning theory) and were produced by GTAs who went through very minimal training prior to teaching these labs. There was not a significant amount of training or extra instruction the participating GTAs went through. By simply changing the mode of instruction, significant and promising changes in classroom discourse were produced.

Summary

This final section is intended to summarize the findings of this research project so that in the next section the implications of this work can be addressed. For the purposes of this research project, the researcher has endeavored to understand: (1) how classroom discourse differs from the expository/demonstration mode of instruction to the PBL mode of instruction and (2) what types of classroom discourse were actually characteristic of the expository/demonstration vs. the PBL setting.

With our participants we have observed that, for a given chemistry GTA and a given section, GTA discourse aligns well with the IRE model in the expository/demonstration labs, but departs from the IRE model of classroom discourse in the PBL setting. At the level of individual chemistry GTAs and students, this departure from the IRE model is characterized by the chemistry GTAs relinquishing full control of the discourse by: (a) bringing out what students already know/believe; (b) encouraging reflection and consideration of this knowledge; and (c) supporting the students with either confirmation or explanation. This shift in classroom discourse, generated by chemistry GTAs, embodies today's model of constructivist learning.

In addition to embodying constructivist learning, the shifts in the patterns of classroom discourse happened very rapidly and without significant investments in GTA training. Literally, from one session to the next, our participants demonstrated an ability to significantly change the structure of the conversations that they were having with their students. This change in classroom discourse structure approximated the embodiment of the constructivist learning environment and was also strongly suggestive of the relationship between instructional mode and classroom discourse. *The take home message from this study should be that there is a connection between instructional mode and classroom discourse, and that significant inputs of time and training may not be required (on the part of the department/university) to produce classroom discourse that is consistent with constructivism.*

Implications and Future

As of last year, the Association of American Universities has begun to generate a basic framework outlining how teaching practices may be improved across higher education (Mervis, 2013). Leaders at the National Institute of Health, one of the primary organizations responsible for providing funding to academic institutions across the nation, has also expressed a strong interest in the improvement of undergraduate STEM teaching (Mervis, 2013).

At present, institutions of higher education are ignoring decades of research which value and support instruction consistent with the constructivist model of learning. Both GTA's in this study exhibited variable amounts of constructivist classroom discourse.

According to a recent Science publication focused on *The Grand Challenges in Science Education*, the typical means used to teach undergraduates science are inefficient at best and unscientific at worst. There is a push for change in focus within undergraduate education at large. The focus needs to shift away from talent selection and toward talent development (Mervis, 2013). This shift (from selection to development) can be realized by re-structuring the learning environment in ways that align with the constructivist learning model. This study has shown that moving towards a problem-based or inquiry laboratory experience also helps move instructors toward a teaching style more in line with constructivism.

With a growing interest in the improvement and study of undergraduate education, this study provides interesting findings that have implications for GTAs, departments, universities, and future students. Departments and universities must make teaching and instruction a top priority. If the administration does not value high quality instruction and does not reward those who teach well while also assisting those who are struggling, there will be little incentive on the parts of professors and GTAs to improve their instruction. Professors and GTAs cannot be expected to invest time and effort honing a skill that is not valued by their own institution.

Once given the opportunity, professors and GTAs must take the reins and experiment with their own abilities to carry out inquiry-oriented instruction. In this study, we have shown the ties between the mode of instruction and classroom discourse. In order to improve one's own instruction or to better align it with the tenets of constructivism, the data from this study suggest that one should begin by finding/generating an inquiry-oriented lesson and carrying it out. Just putting the instructor in a 'new environment' by changing the lesson plan and the aims with minimal preparation on the part of the instructor has, for our participants, made a world of difference.

Lastly, and most importantly, these findings have implications for current and future students. As teachers, we hope to impart something more to our students than facts and figures. Many of us hope to make our students critical thinkers and more discerning consumers of scientific materials. Even when the content fades, we hope that the reasoning skills remain. With inquiry-oriented instruction, we create a safe space in which students can learn how the science of chemistry is conducted and judged. In our PBL labs specifically, students were put in the role of a chemist and were asked to design, carry out, and present an experiment of their choosing to their peers. In a world that is increasingly driven by science, it would be best to give students the basic skills they need to interact with our technologically advancing world. Interacting with this world requires both critical reflection and critical reasoning. Inquiry-oriented labs provide students with contextualized settings in which they may practice these very skills.

There are many stakeholders here: students, GTAs, professors, departments, and universities. Each of these entities have unique perspectives and interests. Ultimately, what we have shown here is the apparent connection between the mode of instruction and the resultant classroom discourse, which moves towards evidence-based practices and best outcomes for students. It is our sincere hope that these stakeholders will take the methods, results, and findings within this document and use them to the betterment of undergraduate education.

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APPENDIX

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: February 5, 2013

To: Megan Grunert, Principal Investigator
Lloyd Mataka, Co-Principal Investigator
Kelley Becker, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number 12-02-33

This letter will serve as confirmation that the change to your research project titled "Effect of Implementing PBL in General Chemistry Laboratory" requested in your memo received February 5, 2013 (to add a Student Disclosure Statement") has been approved by the Human Subjects Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: February 21, 2014

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: February 21, 2012

To: Megan Grunert, Principal Investigator
Lloyd Mataka, Student Investigator
Kelley Becker, Student Investigator

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number 12-02-33

This letter will serve as confirmation that your research project titled "Effect of Implementing PBL in General Chemistry Laboratory" has been **approved** under the **exempt** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: February 21, 2013

Walwood Hall, Kalamazoo, MI 49008-5456
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