Chemistry Graduate Teaching Assistant Identity Development

BY

LIANNE SCHROEDER
B.S., Colorado State University, 2003
M.S., University of Wisconsin-Madison, 2005

Thesis

Submitted as partial fulfillment of the requirements for the degree of Doctor of Philosophy in Learning Sciences in the Graduate College of the University of Illinois at Chicago, 2017

Chicago, Illinois

Defense Committee:

Donald Wink, Chair and Advisor
Alison Castro-Superfine
Joshua Radinsky
David Mayrowitz, Education Policy Studies
Renée Cole, University of Iowa
ACKNOWLEDGMENTS

I would first like to express my deepest gratitude to my family. I would not be where I am today without their unwavering support, encouragement, and understanding. I would like to thank my parents, Catherine and Nicholas Schroeder, for their unwavering faith and confidence in my abilities. They told me that I could do anything I could set my mind to, and now I have. Most especially I would like to thank my partner, Leon Grossman, for being the most understanding and patient person in the world as I struggled through the last few months of completing this dissertation. Without his love and support I could not have finished.

Also, I would like to thank my friend Keith Doyon for his encouragement to pursue this degree, for reading drafts of every major paper I wrote while pursuing my degree, and especially for reading several drafts of this dissertation and offering suggestions along the way to completing it.

I would like to express the deepest appreciation to my committee chair Prof. Donald Wink for his guidance throughout graduate school and this dissertation. He continually and convincingly conveyed a spirit of adventure for research and scholarship, and an excitement for teaching. Without his guidance and persistent help this dissertation would not have been possible. I can not imagine having a better advisor and mentor for my Ph.D study. I am also indebted to the patience and intellect of the members of my dissertation committee— Alison Castro-Superfine, Josh Radinsky, David Mayrowitz, and Renée Cole. Thank you for your guidance.

Last and certainly not least, I would like to acknowledge the chemistry graduate students who volunteered to participate in this research.
# TABLE OF CONTENTS

1.0 INTRODUCTION ..................................................................................1
  1.1 Structure of the Dissertation .................................................................4
  1.2 Understanding GTA Identity – An Overview ........................................4
  1.3 Purpose of the Study .........................................................................7

2.0 CONCEPTUAL FRAMEWORK ..........................................................8
  2.1 Identity .............................................................................................8
    2.1.1 Teacher identity ..........................................................................9
    2.1.2 GTA identity ...........................................................................11
  2.2 Frameworks for understanding identity ..............................................13
    2.2.1 Community of Practice .............................................................14
    2.2.2 Social Identification ...................................................................16
  2.3 GTA Teaching Identity within the Frameworks .....................................18
    2.3.1 GTA Teaching Practices .............................................................19
    2.3.2 Learning Environment Factors ...................................................21
      2.3.2.1 Content .............................................................................21
      2.3.2.2 Worksheet structure .............................................................22
      2.3.2.3 Mode of instruction ..............................................................22
      2.3.2.4 Social interactions ...............................................................23
      2.3.2.5 GTA observations ...............................................................24
  2.4 Research Questions ..........................................................................24

3.0 METHODOLOGY AND CONTEXT ....................................................27
  3.1 Case Study .......................................................................................27
    3.1.1 Defining the cases ...................................................................30
    3.1.2 Context .....................................................................................31
  3.2 Data Collection .................................................................................33
    3.2.1 Observations .............................................................................33
    3.2.2 Interviews ..................................................................................35
      3.2.2.1 GTA Interviews ................................................................35
      3.2.2.2 Professor Interviews ..........................................................36
    3.2.3 Journals .....................................................................................36
    3.2.4 Artifacts ....................................................................................37
    3.2.5 Data Collection Summary ..........................................................37
  3.3 Data Analysis ...................................................................................39
    3.3.1 Units of Analysis ......................................................................40
    3.3.2 COPUS ....................................................................................43
    3.3.3 Teaching Practices ....................................................................43
    3.3.4 Data representation .................................................................47
    3.3.5 Learning Environment Factors as Mediators of Practice ..............49
    3.3.6 Supporting Evidence in Interviews and Journals .........................51
3.3.7 Describing GTA Model of Teaching Identity ........................................52
3.4 Validity, Reliability and Limitations .......................................................53
3.5 Context .................................................................................................54
  3.5.1 GTA Training ....................................................................................55
  3.5.2 Departmental Context .......................................................................55
    3.5.2.1 Departmental Survey ....................................................................56
    3.5.2.2 Graduate Student Teaching Role ................................................57
    3.5.2.3 GTA Training ...............................................................................57
    3.5.2.4 How does teaching support graduate student development? ..........58
    3.5.2.5 GTA activities during teaching ....................................................58

4.0 CASE 1: Jane .........................................................................................60
  4.1 Case 1 Introduction .............................................................................60
    4.1.1 Jane’s data ......................................................................................62
    4.1.2 Jane’s practice .................................................................................63
    4.1.3 Jane’s identity: Overview .................................................................68

4.2 Learning Environment Factors that Mediate Practices ............................69
  4.2.1 Content mediates Jane’s teaching practice .........................................70
    4.2.1.1 Balancing reactions mediates prompting and validating ...............70
    4.2.1.2 Ionic compounds and oxidation numbers mediates explaining concept and direct answer ........................................................74
  4.2.2 Worksheet structure mediates Jane’s teaching practice ....................78
  4.2.3 Mode of instruction mediates Jane’s teaching practice .....................86
    4.2.3.1 Whole Class Instruction ...............................................................87
    4.2.3.2 Student Work .............................................................................92
  4.2.4 Social interaction mediates Jane’s teaching practice .......................95
  4.2.5 Jane's observation mediates Jane’s teaching practice .......................101
    4.2.5.1 Evidence of teaching practices in Jane’s journals .........................101
    4.2.5.2 Jane's observations about students working in groups ................103
    4.2.5.3 Jane's observations inform differences in teaching practices across sections .................................................................105
  4.2.6 Teaching Practice Summary .............................................................105

4.3 Jane's Teaching Identity .........................................................................106
  4.3.1 Jane's model of teaching identity: Helper .........................................106
  4.3.2 Jane's metapragmatic model of identity: Helping students help themselves .108
    4.3.2.1 Teaching practice and metapragmatic model of teaching identity: Content as mediator ..........................................................109
    4.3.2.2 Teaching practice and metapragmatic model of teaching identity: Worksheet structure as mediator ..........................................109
    4.3.2.3 Teaching practice and metapragmatic model of teaching identity: Mode of instruction as mediator ........................................110
4.3.2.4 Teaching practice and metapragmatic model of teaching identity: Social interactions as mediator .................................................................111
4.3.2.5 Teaching practice and metapragmatic model of teaching identity: GTA observations as mediator ...............................................................112
4.4 Case 1 Conclusions .............................................................................................................................................................................115
4.4.1 Case 1: What learning environment factors mediate GTA teaching practices? .................................................................116
4.4.2 Case 1: How are teaching practices, learning environment factors, and the GTA’s metapragmatic model of teaching identity related? ..........118
5.0 CASE 2: Edward ................................................................................................................................................................................................120
5.1 Case 2 Introduction .....................................................................................................................................................................120
5.1.1 Edward’s data .............................................................................................................................................................................122
5.1.2 Edward’s teaching practices .......................................................................................................................................................123
5.1.3 Edward’s identity: Overview .......................................................................................................................................................127
5.2 Edward’s Teaching Practices ..........................................................................................................................................................128
5.2.1 Content and worksheet structure mediates Edward’s teaching practice .......133
5.2.2 Mode of instruction mediates Edward’s teaching practice .................136
5.2.3 Social interaction mediates Edward’s teaching practice .......................139
5.2.4 Edward’s observation mediates Edward’s teaching practice .................144
5.2.4.1 Evidence of teaching practices in Edward's journals and interviews ...145
5.2.4.2 Edward's observation of differences between sections ......................146
5.2.5 Practice summary .............................................................................................................................................................................147
5.3 Edward's Teaching Identity ............................................................................................................................................................147
5.3.1 Edward's model of teaching identity ......................................................148
5.3.2 Edward’s metapragmatic model of teaching identity ...............................149
5.3.2.1 Teaching practice and metapragmatic model of teaching identity: Content and worksheet structure as mediator ..........................149
5.3.2.2 Teaching practice and metapragmatic model of teaching identity: Mode of instruction as mediator .................................150
5.3.2.3 Teaching practice and metapragmatic model of teaching identity: Social interactions as mediator .................................150
5.3.2.4 Teaching practice and metapragmatic model of teaching identity: GTA Observations as mediator ........................................151
5.4 Case 2 Conclusion .............................................................................................................................................................................152
5.4.1 Case 2: What are the learning environment factors that mediated GTA teaching practice? .........................................................153
5.4.2 Case 2: How are teaching practices, learning environment factors, and the GTA's metapragmatic model of teaching identity related? ..........154
6.0 DISCUSSION AND CONCLUSIONS .....................................................................................................................................................156
6.1 Addressing Research Questions .........................................................................................................................................................156
6.1.1 What learning environment factors mediate GTA teaching practice? ..........156
6.1.2 How are teaching practices, learning environment factors, and the GTA’s metapragmatic model of teaching identity related? ..............................158
6.2 Implications ........................................................................................................159
  6.2.1 Understanding learning environment factors as mediators .......................159
  6.2.2 Implications for GTA teaching identity ......................................................161
  6.2.3 Implications for GTA training and professional development ..................163
6.3 Future Research ..................................................................................................165
  6.3.1 Additional case studies ..............................................................................166
  6.3.2 Materials development ..............................................................................167
  6.3.3 Use cases to inform larger study ...............................................................167
  6.3.4 Understanding the students ......................................................................167

CITED LITERATURE .............................................................................................169
APPENDIX A .........................................................................................................178
APPENDIX B .........................................................................................................193
APPENDIX C .........................................................................................................196
APPENDIX D .........................................................................................................200
VITA ......................................................................................................................207
LIST OF TABLES

Table 1. COPUS Codes Used ................................................................. 34
Table 2. Interview Data ................................................................. 36
Table 3. Data Summary: Observations, Journals, Worksheets .......... 38
Table 4. Activity Types ................................................................. 42
Table 5. Practice Codes with descriptions ........................................ 46
Table 6. Evidence for learning environment factors as mediators of teaching practice ................................................................. 50
Table 7. Case 1 Activities ................................................................. 63
Table 8. Case 2: Activities ................................................................. 123
Table 9. Instances of encouraging students to go to board compared to instances of student at board .................................................... 144
LIST OF FIGURES

Figure 1. Nexus of multimembership .................................................................16

Figure 2. Define the case ..................................................................................32

Figure 3. Analysis logic ...................................................................................40

Figure 4. Example 1 of defining a practice ......................................................44

Figure 5. Example 2 of defining a practice ......................................................45

Figure 6. Example of COPUS representation ..................................................48

Figure 7. Example practice representation .....................................................49

Figure 8. Learning environment factors that mediate teaching practice ..........51

CASE 1

Figure 9. COPUS data from Case 1 .................................................................65

Figure 10. Case 1 practices ..............................................................................66

Figure 11a. Case 1 practices by week ...............................................................67

Figure 11b. Case 1 practices by activity ..........................................................68

Figure 11c. Case 1 practices by section ...........................................................68

Figure 12. Content mediates practices of prompting, validating, and correcting.....71

Figure 13. Example of prompting during balancing reaction .................72

Figure 14. Content mediates practices of explaining content and direct answer.....74

Figure 15. Excerpt showing explaining content .........................................75

Figure 16. Jane explains putting together ionic compounds with transition metals ..76

Figure 17. Example 1 of direct answer ...........................................................77

Figure 18. Example 2 of direct answer ...........................................................77

Figure 19. Worksheet mediates practice of direct answer .........................79
Figure 20a. Question from worksheet used in Week 6 ........................................80
Figure 20b. Interaction with student about question in Figure 20a ..................81
Figure 21a. Question from worksheet used in Week 6 ................................82
Figure 21b. Using direct answer to address question about Figure 21a ........82
Figure 22. Worksheet mediates checking-in ..................................................83
Figure 23. Question from worksheet used in Week 13 ...............................84
Figure 24. Jane using direct answer to address worksheet confusion ..........85
Figure 25. Jane using checking in .................................................................85
Figure 26. Practices by mode of instruction ..................................................86
Figure 27. Whole Class Instruction mediates practices ..............................87
Figure 28. Understanding check during Whole Class Instruction ...............89
Figure 29. Prompting during Whole Class Instruction ...............................90
Figure 30. Prompting during Student Work ...............................................91
Figure 31. Student Work mediates practice .............................................92
Figure 32. Correcting during group work ..................................................93
Figure 33. Correcting during Whole Class Instruction ...............................94
Figure 34. Interactions between GTA and students ..................................96
Figure 35. COPUS Maps for Observation 4 .............................................97
Figure 36. Example of being asked about question in Figure 23 ................100
Figure 37. Social interaction mediates practice ......................................100

CASE 2
Figure 38. Example of COPUS map for Case 2 ........................................124
Figure 39. Case 2 Practices .....................................................................125
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTA</td>
<td>Graduate Teaching Assistant</td>
</tr>
<tr>
<td>IRE</td>
<td>Initiate-Respond-Evaluate</td>
</tr>
<tr>
<td>STEM</td>
<td>Science-Technology-Engineering-Mathematics</td>
</tr>
<tr>
<td>COPUS</td>
<td>Classroom Observation Protocol for Undergraduate STEM</td>
</tr>
</tbody>
</table>
This study was designed to better understand how new chemistry graduate students develop a teaching identity as GTAs. Specifically, this study considered two cases of first year chemistry graduate students engaging in teaching for the first time. Data sources included interviews, journals, classroom observations, and artifact collection. Classroom observations were used to describe the practices of the GTAs and when combined with the journals and interviews were used to develop an understanding of their identity development.

The findings from the two cases produced descriptions of teaching practice, learning environment factors that mediated the GTA teaching practices, and two different models of teaching identity for the new GTAs. Both GTAs began teaching with models of teaching identity drawn from their own experiences as students. In Case 1, the GTA’s model of teaching identity was labeled as helper. In Case 2, the GTA’s model of teaching identity was labeled as leader.

I found that the discourse between the students and GTAs did not directly have evidence of teaching identity. In a chemistry classroom, the GTA-student talk is centered on atoms, molecules, and reactions. I found evidence for understanding metapragmatic models of teaching identity in teaching practices and their interaction with learning environment factors. Five learning environment factors were identified in this study: Content, Worksheet structure, Mode of Instruction, Social interactions, and GTA observations. The description of the learning environment factors has methodological implications for expanding the usefulness of the Communities of Practice and Social Identification frameworks. In addition, learning environment factors and GTA teaching identity should be considered when developing training and professional development for graduate students.
1.0 INTRODUCTION

Graduate Teaching Assistants (GTAs) are ubiquitous at most large universities and fill a large, but little considered, portion of teaching in higher education. In 1993, GTAs were responsible for over 30% of the instruction at universities (Butler, Laumer, & Moore, 1993) and this may well have increased in the last twenty-five years. As of 2008, more than half of undergraduate courses were taught by non-tenured faculty, which includes graduate teaching assistants (June, 2008). GTAs continue to be recognized as integral, but often neglected, participants in college chemistry instruction (Schussler, Read, Marbach-Ad, Miller, & Ferzli, 2015). Many disciplines have recognized a need for improving GTA teaching practice to support undergraduate education improvement (e.g. Belnap, 2005; Green, 2010).

It is typical for a chemistry GTA to have responsibility for facilitating discussion (or recitation) sections and laboratory sessions. These smaller sections of students provide the most contact between teachers and students. However, many GTAs receive little to no training in how to teach (Luft, Kurdziel, Roehrig, & Turner, 2004; Schussler, et. al, 2015). The cultures of university chemistry departments, especially at larger research institutions, have a history of undervaluing the benefits and importance of teaching chemistry: a perspective shared by professors and graduate students alike (Shannon, Twale, & Moore, 1998). With a graduate student’s focus on research coupled with performance pressure from supervising professors, it is unlikely that a GTA will spend time or energy developing an understanding of teaching and learning without express support for doing so. Indeed, there is a distinct conflict between science professors’ expectations of their graduate students for research and for teaching (Balinsky, 2007). Given the essential part that GTAs currently play in the chemistry education of undergraduate
students at research universities, it is worthwhile to consider how to support and train GTAs to provide quality instruction.

While concerns about training graduate teaching assistants have been discussed broadly across higher education (Carroll, 1980), as well as within chemistry specifically (Shakhashiri, 1977, 2012) there has been little progress over the last 40 years in improving or changing GTA teaching practices (Schussler, et.al 2015). Scherr and Close (2010) noted that a lack of quality training of GTAs perpetuates ineffective, traditional pedagogies. In the absence of training, GTAs rely on what Lorie (1975) termed “apprenticeship of observation.” This refers to the idea that in the absence of other information, a person will do what they have seen. In the case of GTAs, this means that a GTA will likely teach the way they were taught themselves as undergraduates.

Shakhashiri (1977) addressed the need for enhancing the effectiveness of graduate teaching assistants through training forty years ago. Nearly forty years later, GTA training remained an unresolved issue. As American Chemical Society president in 2012, Shakhashiri commissioned a report on graduate education (American Chemical Society, 2012). The results of the report covered a broad range of recommendations for improving graduate education in chemistry. These included recognizing the importance of teaching chemistry in the professional development of graduate students by recommending that programs incorporating teaching skills be adopted as part of the goals of graduate education. The report authors further recommended the establishment of postdoctoral teaching positions to support the development of future faculty.

Learning to teach can be an effective way to support developing epistemologies about science (French & Russell, 2002) and improve methodological research skills for the graduate students (Feldon et al., 2011). Gutwill-Wise (2001) observed during a study implementing a new
modular curriculum implementation in a college chemistry course that a GTA’s engagement with teaching (“I enjoy being a GSI (graduate student instructor)”) using the curriculum was correlated with the impression of the curriculum by the undergraduate students. That is, the more positive the GTA was about the curriculum, the more buy-in it received from students. Also, the GTAs were more likely to express that they enjoyed teaching when assigned to teach a traditional curriculum than GTAs assigned to teach a reformed project-based curriculum. These results prompted members of the research team to work on GTA training and professional development.

While there was no clear follow-up to the GTA issues raised by Gutwill-Wise, chemistry curriculum reform remains a critical issue in undergraduate chemistry education (e.g., Talanquer & Pollard, 2010). Talanquer and Pollard recognized the need for GTA training to be inclusive to laboratory reforms. In their work on laboratory reform they noted that:

“... the new focus and structure of the experimental activities, which now granted students the freedom to design their own strategies to solve a problem, were challenging to manage for many of our teaching assistants (TAs) who were used to more traditional lab formats. (Talanquer and Pollard, 2010, p. 82).”

They subsequently restructured the GTA training program for the course but have yet to publish any details to help others engaging in similar reforms. While the need for GTA training in cases of major curricular reform is acknowledged and sometimes addressed, there remains a lack of resources and research focused on the professional development of graduate students as teachers. Developments in science education are not easily applied to college science reform, not only because teaching is not valued, but also because professors and graduate students are unable to reconcile their identities as scientists and as teachers (Balinsky, 2007).
1.1 Structure of the Dissertation

Chapter 2 articulates the conceptual framework for this dissertation. This includes defining key concepts and conceptual frameworks that are the foundation of this study. Chapter 3 explains the methods used to collect and analyze data. Chapters 4 and 5 are in-depth case studies of the teaching practices and teaching identity of the GTAs: Jane and Edward. Chapter 6 discusses methodological implications of this study, offers observations and recommendations related to GTA training and professional development, and closes by exploring ideas for future research.

1.2 Understanding GTA Identity – An Overview

This study focuses on the learning that occurs when a new chemistry graduate student undertakes teaching as a chemistry GTA for the first time. Specifically, this study looks directly at how a GTA learns to be a teacher of chemistry in a university chemistry environment that offers little GTA training and support. Focusing on identity will help address how different graduate students may react differently to the same situation (Sfard & Prusak, 2005). Understanding this difference is important to consider when designing training and curricular changes.

This dissertation approaches identity from a learning sciences and social constructivist perspective. Identity develops on an individual level and in the interactions with others encountered in the social environment (Sfard & Prusak, 2005). Because of this duality, accounts
of individuals’ identities give us a window into the population of interest we are trying to understand (Horn, Nolen, Ward, & Campbell, 2008). The context surrounding an individual also provides another perspective on identity. Research suggests that the development of professional identity is critical to becoming a professional. In the context of chemistry graduate education, the development of professional identity must by necessity include teaching identity for those pursuing an academic career (American Chemical Society, 2012). Understanding teacher identity is extremely important to understanding the teaching profession (Enyedy, Goldberg, & Welsh, 2006) and as such understanding the GTA teaching identity is important to understanding teaching as a professional engagement in higher education.

A chemistry GTA does not learn in a vacuum, and like any learner, is not a blank slate to be filled. From the first day of graduate school, a chemistry GTA is surrounded by a community which may have multiple implications for the GTA’s learning. There are the other GTAs, both novice and experienced, other graduate students who no longer teach, professors, advisors, and of course the students. Each of these groups has the potential for impacting the new GTA’s experiences. Also, even with no experience teaching, a new GTA will have experiences in classrooms that will likely inform their own teaching. New chemistry GTAs have four (or more) years of experience in college chemistry classrooms as well as twelve years of experiencing typical classrooms and learning during their K-12 education. These experiences likely frame how a new GTA approaches teaching for the first time.

I chose to consider the development of GTA teaching identity rather than considering how well the GTAs are teaching. The limited literature in this field suggests that the GTA’s identity is important for the uptake of teaching practices and buy-in for curriculum reform. Gutwill-Wise (2001) encountered difficulty implementing a novel curriculum approach when the
graduate students didn’t support the process. When graduate students didn’t “buy-in” to the reform, the undergraduate students found the novel curriculum confusing and “bad.” Teaching identity has been considered in other disciplines (Sfard & Prusak, 2005). Mathematics (e.g., Belnap, 2005) and physics (e.g., Volkman & Zgagacz, 2004) have an existing body of research focused on the teaching identity of their graduate students. However, despite these being STEM disciplines, chemistry GTAs should be considered separately to understand the situations faced by chemistry GTAs that may be different. There a likely to be to differences between chemistry and other STEM GTAs that are related to the institutional expectations for chemistry courses and the extent of the instruction that GTAs engage in (Shannon et al. 1998).

As discussed above, the need for GTA professional development has long been a recognized area of interest in higher education (e.g. Carroll, 1980; DeChenne, 2012). Some believe that college instruction reform has been slow because it neglects to account for the significant role that graduate students play in the process (Luft et al. 2004). The teaching identity of K-12 teachers has been explored in some depth (e.g. Alsup, 2006; Cohen, 2008; Day & Kington, 2008; Eick & Reed, 2002; Trent, 2010; Trent, 2011). While K-12 teacher identity research may provide a foundation, research into GTA teaching identity has not been explored to any great extent (Speer, Gutmann, and Murphy, 2005; Schussler et. al, 2015). Because there is so little research doing with GTAs it is not clear that the work done in K-12 is transferable to the GTA context (Saroyan, Dagenais, & Zhou, 2009).
1.3 Purpose of the Study

The purpose of this study was to develop rich descriptions of chemistry graduate students teaching identity. This included how they engaged with teaching for the first time and how components of the course, including course expectations and social interactions between GTA and students, related to their engagement with the community of practice and the uptake of teaching practices. This study was conducted in a way to ensure that the GTAs participating knew that they were not being evaluated on their teaching. This was believed to provide the best opportunity to obtain an authentic description of GTA teaching identity. This was accomplished using a multiple case study methodology.

Case study provides a method for developing rich descriptions of chemistry GTA teaching identity (Yin, 2013). With a strong conceptual framework, case study allows rich description of GTA identity to be developed in context (i.e., “in the wild”; Hutchins, 1995). GTA identity development is likely unique to the individual graduate students; however, the rich descriptions provided by case study can “shed empirical light about some theoretical concepts or principles (Yin, 2013, p. 40).” It can further provide insight into the cases examined and the learning environment. These descriptions can support the literature about GTA teaching that is otherwise lacking for an effectively in depth understanding of the GTAs (Goetzen, 2010; Speer et al., 2005).
2.0 CONCEPTUAL FRAMEWORK

In this chapter I will articulate my conceptual framework and consider relevant literature. Identity is the central construct in my study of GTA learning to become teachers of chemistry. I first discuss the concept of identity, broadly defined, and literature related to teaching identity. I then introduce the two relevant frameworks that inform this study: Wenger’s Community of Practice and Wortham’s Social Identification. As I will show, these frameworks complement each other well for this study. I follow with defining identity within these frameworks. This is followed by introducing a specific definition of teaching practice and its meaning within the frameworks. The chapter ends with the guiding research questions and a brief discussion of the implications of this study.

2.1 Identity

Identity is a complex construct about how a person sees themselves and how others see them. It offers a lens for making sense of people’s actions in different contexts (McCarthey & Moje, 2002). Sfard and Prusak (2005) consider identity to be a set of reified, endorsable stories. Identity has been described as a lens of self (Helms, 1998) or being recognized as a certain “kind of person” (Gee, 2001). It has also been framed as a dynamic, recursive, discursive process (Enyedy et al. 2006). Lave and Wenger (1991) viewed identity through the relationship between the individual and the community. While identity has been defined in many ways, there are common characteristics within these perspectives of identity.
Identity is socially constructed. Identity is constructed internally from stories we tell ourselves about who we are and from the ways that we interact with other people (Sfard & Prusak, 2005). That is, identity is not simply the way that we define ourselves but is constructed in the interactions between ourselves and others (Bauman, 1996; Holland & Lave, 2001; Roth, 2004). It is continually being constructed and recreated in interactions as negotiated experiences (Sachs, 2005).

Identity is multifaceted. Wenger (1998) views identity through a nexus of multimembership. Gee (2001) describes a core identity and in addition recognizes that identity is not a singular construct but has many variations that may exist in specific environments. One of those identity variations described by Gee is an institutional identity. By being labeled as a teacher, an individual assumes that identity as part of their own individual identity. A teaching identity that is constructed, with or without a formal label, evolves as a teacher gains experience (Lasky, 2005). Teaching identity has implications for education research broadly. Teachers have the most direct interaction with students and are therefore inextricably linked to any educational changes (Stenberg, Karlsson, Pitkanen, & Maaranen, 2014) and can be related to other factors of interest in understanding teaching such as motivation, satisfaction, and commitment (Day, Kington, Stobart, & Sammons, 2006).

2.1.1 Teacher identity

Teacher identity plays a critical role in teacher development (Rodgers & Scott, 2008). Teacher knowledge of content is clearly important but fails to capture all that it means to be a teacher. Thus, identity offers education research a more inclusive construct that extends teachers’ knowledge and skills (Luehmann, 2007). Teacher identity provides a framework for teachers to
“construct their own ideas of ‘how to be’, ‘how to act’ and ‘how to understand’ their work (Sachs, 2005, p. 15).”

Teaching identity has been shown to be important for understanding how people learn to teach (Ye, Varelas, and Guajardo, 2011). Novice teachers’ developing identities shape how they engage with materials and teaching practices that are introduced to them (Horn et al., 2008). As novice teachers learn about pedagogy, assessment, or new approaches to teaching, their teaching identity influences how they engage in that learning (Nolan, Horn, Ward, & Childers, 2011). Therefore, when considering teacher practice, the development of training, and the education of teachers, issues of identity should be addressed (Stenberg et al., 2014).

Research on teacher identity in K-12 has been undertaken in the last decade (e.g. Alsup, 2006; Cohen, 2008; Day & Kington, 2008; Eick & Reed, 2002; Trent, 2010; Trent, 2011). For K-12 teachers, teaching identity is also their professional identity (Lampert, 2010). Chemistry graduate students are pursuing an advanced science degree and their professional identity likely focuses on their science practice (Bhattacharyya, 2008). For many teaching is not central to that experience and little attention has been paid to the teaching identity of graduate students (Speer et al., 2005).

While little research has been done to date, graduate student teaching identity has not been completely neglected. Graduate student teaching identity has been explored to some extent in higher education in mathematics (e.g. Belnap, 2005), physics (e.g. Volkman & Zgagacz, 2004), engineering (Winberg, 2008), and chemistry (e.g. Sandi-Urena & Gatlin, 2013). The next section explores the literature specific to graduate student teaching identity.
2.1.2 GTA identity

New graduate teaching assistants often teach from the first day of their first semester and it is likely that they will have similarities with first year (in-service) teachers (Speer et al., 2005). However, they will also have differences, because unlike in-service teachers, GTAs rarely participate in extensive training (e.g. Luft et al. 2004; Hardre, 2012). Early experiences are key for solidifying beliefs about teaching, developing teaching practices, and setting patterns of social learning for new teachers (e.g. Lortie, 1975; Zeichner & Tabachnick, 1985). A new chemistry GTA’s teaching identity will likely develop with only minimal instruction related to teaching and may be influenced by a negative perception of teaching in comparison to their identity related to becoming a chemist (Grier and Johnston, 2009). As such, it is likely that GTAs don’t commit to teaching in the same ways as a K-12 teacher.

Some recent attention has been paid to GTA professional development associated with their teaching, and by extension, with their teaching identity. Studies about GTA professional development typically focus on the efficacy of the training (e.g. Bond-Robinson & Rodriques, 2006; Gardner & Jones, 2011; Reeves et al. 2016). Research has also addressed issues of efficacy of GTA teaching to inform the development of GTA professional development (e.g. Kurdziel, Turner, Luft, & Roehrig, 2003). While both of these approaches are important for understanding and improving GTA teaching, they neglect to consider the impact that individual GTA identity has on teaching practices and the potential for the GTA identity to interact with the training that is being recommended by the studies.

Volkman and Zgagacz (2004) explored how the identity of a physics GTA was constructed in relation to other people in her life. The professor, other GTAs, and the students
were central to how the GTA’s identity developed in the context of a physics elementary education course.

Belnap (2005) explored the development of math GTAs’ identity in a calculus course. He described the GTA teaching identity as dependent on prior experience, supervisors and other GTAS, and the GTAs’ beliefs about teaching. The same factors are likely similar in the development of a chemistry GTA teaching identity; however, the specific context as well as the chemistry content are important to understand. Hands (2007) found that mathematics GTAs teaching an unfamiliar calculus course adopted teaching practices selectively and from varied sources, and that they would draw heavily on materials available from GTAs who had previously taught the course.

Sandi-Urena and Gatlin (2013) found that chemistry GTA self-image, a similar construct to identity, was dependent on individual factors such as previous experience, and external factors such as training and learning environment. Their treatment of the learning environment simplifies all the social interactions into a single aspect. The present study, through rich description, will include a more detailed exploration of the learning environment.

The cited studies have contributed to understanding graduate student teaching identity but there are gaps that this study will address. Belnap (2005) and Hands (2007) both approached their understanding of mathematics GTA teaching identity from the perspective of the GTAs themselves. While observational data from these studies was considered in a secondary role, this approached privileged the GTA self-description. Sandi-Urena and Gatlin (2013) did not include observation but relied only on interviews for their understanding of GTA self-image. In seeking to understand graduate student teaching identity, this study will consider the issue of identity with a different approach. It addresses GTA teaching identity by placing observation over
reflection and interview as a lens into teaching identity. Previous work has focused on GTA interviews and reflections. Using the approach of observation first, interview data second, this study will provide rich descriptions of the GTA teaching practices.

2.2 Frameworks for Understanding Identity

To observe identity in rich detail, I selected two particular frameworks to inform this study: Wenger’s Community of Practice and Wortham’s Social Identification. These two frameworks are synthesized to form a conceptual framework for this study with a strong definition of identity. Additionally, these frameworks provided tools for developing a systematic approach for finding and describing evidence in the cases.

Community of Practice provides a framework for describing how an individual develops an identity that includes membership in that community of practice. Community of Practice focuses on how a community is defined by a shared set of practices and how those practices are related to the individual identity of the members. An individual’s identity and its development can be seen in the practices.

Social Identification provides a framework for understanding how the GTA teaching identity develops as it relates to sociohistorical models of identity that have been encountered in their previous experiences and to their metapragmatic models of identity that develop in social interactions with the students. Social identification provides an approach for labeling the teaching identity of the GTAs using sociohistorical models.
These two perspectives on identity are complementary and together can inform improvements to undergraduate chemistry teaching by addressing issues of GTA identity from within the department (i.e. the community of practice) and from the broader social influences on identity. While community of practice provides a lens for observing identity change, it does not easily define the identity. Social identification provides constructs for defining, or usefully labeling, the identity.

2.2.1 Community of Practice

Wenger defines identity as “the ways we experience ourselves through participation as well as by the ways we and others reify ourselves (Wenger, 1998, p. 150).” People begin to see their individual selves in certain ways based on how they participate in the community. The ways that people see themselves influences the ways in which they engage in practices of the community, or whether they take up practices or not. Beyond how an individual sees him or herself, others experience an individual’s identity through interactions with that person; hence, it is a negotiated experience. Community membership helps a person define who they are by identifying “the familiar and the unfamiliar (Wenger, 1998, p. 149)”. Within a community of practice, learning is defined as a change in identity, which happens as what was unfamiliar to the new community of practice member becomes familiar.

Identity in a Community of Practice framework is a multifaceted construct that develops out of socially negotiated events with substantial contributions by the individual’s experiences and community membership (Wenger, 1998). Membership in a Community of Practice provides a facet of self by establishing the boundaries in which members have shared meaning and practices with others in the community. A boundary is the space in which the practice occurs; the
content, the practices, even the people who interact around the ideas and goals of the community. Boundary practices help make connections between multiple communities of practice. Boundary practices allow an individual to leverage their identity in one community (e.g. chemistry learners) when they begin to participate in a new community of practice (e.g. GTAs).

An individual’s facets of identity form a nexus of multimembership with different communities (Wenger, 1998). New GTAs are beginning to participate in several new communities of practice simultaneously, including graduate school, chemistry teaching, and chemistry research (Figure 1). One of those memberships is with a community of chemistry learners. It is likely that a GTA’s teaching identity will be informed by their identity as a chemistry learner (Kurdziel et al. 2003). Oleson and Hora (2014) explored faculty teaching practices and found that their prior experiences as learners were influential in their teaching practice. It is also likely that GTAs will draw on experiences and practices from being members of a community of chemistry learners as well (Wenger, 1998). This includes the GTAs being able to draw on content knowledge that they have developed and are now being asked to convey to students. In this study, the community of practice is defined as teachers of college chemistry, more specifically, teachers of college chemistry in the chemistry department at a Large Midwest University. This study assumes that this community of practice exists. Features of this community will be discussed in Chapter 3.
2.2.2 Social Identification

Wortham’s social identification provides the tools for labeling the identities that are explored through the observation of practice. Where Wenger’s Community of Practice posits that identity can be observed in practice, social identification provides a way to talk about the identity using models of identity (Wortham, 2006). A model of identity is either an “explicit account of what some people are like, or a tacit account that analysts can infer based on people’s systematic behavior (Wortham, 2006, p. 6).” Sociohistorical models of identity are widely held models of identity that have emerged over decades and that circulate across space and time (Lemke, 2000). Models of identity only exist empirically when used by people to identify themselves and others;
therefore, social identification happens in practice (Wortham, 2006). When a sociohistorical model of identity is enacted in a specific context, a metapragmatic model of identity can emerge. Metapragmatic models are grounded in sociohistorical models but develop into unique instantiations through social interactions.

As with anyone entering a new setting, new chemistry graduate students draw on and are impacted by sociohistorical models of identity for what it means to teach, specifically what it means to teach chemistry in college. These models of identity are drawn from their own experiences as chemistry learners. GTAs bring those models of identity with them into their first teaching experiences. As they interact with the community of practice and with the students in their classes, metapragmatic models of that identity can emerge.

Wortham (2006) drew on discursive tools such as signs and events of identification to describe the models of identity found in a classroom. Signs and events of identification emerged from the goal to “uncover systematic evidence of the types of social action” (Wortham & Reyes, 2015, p. 3). Signs are the indicators in the interactions that individuals and groups interpret in ways that lead to identification. Depending on the context, signs can be interpreted in different ways. For example, the slang phrase “No, duh!” might be interpreted as a joke if the metapragmatic model of identity suggests a friend or as sarcasm if the metapragmatic model suggests a bully. Signs can be observed by a researcher in interactions. An event of identification occurs when a sign or group of signs is interpreted to identify the person within a bounded time frame.

Wortham’s original study was grounded in a classroom discourse that explicitly addressed ideas about ‘how people are’ and the identities of the students. This is in fact why he was to clearly see the impact of social identification on learning. The context of this study does not
provide such a direct link between discourse and identity because the content is not related to 
human nature. Instead, the discourse in the classroom was centered around chemical content and 
procedures. Because the discourse in a chemistry classroom was different, a method was 
developed to systematically define and explore the observations. First, two analytic tools were 
used to systematize the data: Classroom Observation Protocol for Undergraduate STEM (Smith, 
Jones, Gilbert, & Wiseman, 2013) and dividing the observations into activities. These will be 
discussed in detail in Chapter 3. Second, instead of focusing on signs in the discourse, the 
analysis led to the emergence of learning environment factors as mediators of teaching identity 
and teaching practice.

The next two sections describe the conceptual framework for this study that was 
synthesized from these separate frameworks. This is accomplished by defining GTA teaching 
identity and describing the learning environment factors that mediated. This is followed by 
defining GTA practices for the scope of this study.

2.3 GTA Teaching Identity within the Frameworks

I developed my definition of GTA teaching identity from the frameworks described 
above. For this study, I defined GTA teaching identity as the model of identity that is drawn on as 
a resource by the GTA at the start of the semester. The metapragmatic model of identity is 
enacted in the classroom and is observable in the teaching practices of the GTAs as they interact 
with learning environment (e.g. the artifacts, students, etc.).
2.3.1 GTA Teaching Practices

A practice, broadly defined, is a way of interacting with others and the environment. Practice is a “process by which we can experience the world and engagement with it as meaningful (Wenger, 1998, p 51).” Identity can help us understand “why different individuals act differently in the same situations (Sfard & Prusak, 2005, p. 14).” Community of Practice suggests that the inverse is also true: Practices in different situations help us understand different identities.

Teaching practice is a concept that can be used to describe several different levels of teacher activities and preparations. One conception of teaching practice is that it is a high level instructional strategy (Grossman, Hammerness, & McDonald, 2009; McDonald, Kazemi, & Kavanagh, 2013; Windschitl, Thompson, Braaten, & Stroupe, 2012). For example, at this level teaching practice could include aspects across time and space encompassing what a teacher wants students to be able to accomplish (e.g. inquiry learning), the types of preparation in which teachers engage, and the ways that teachers interact in a classroom (e.g. Reeves et al. 2016). Teaching practice has also been conceptualized at a smaller scale, that is in the actions taken by a teacher in class (Lampert, 2010).

For this study, practice is defined as the ways that a GTA interacts with the student(s), at the unit of turn, during a class session. Defining practice at this level is similar to how Boerst and Sleep (2007) used “techniques for teaching.” Practices are descriptions of what the GTA is doing while engaging in instructional activities with the students or class. It is at the scale of the minute-to-minute interactions between the GTA and students that I defined practice so that I could understand teaching identity at the level of the class meetings and semester (Lemke, 2000).
In defining teaching practice, I assumed that the different kinds of interactions are repeated regularly and the interaction is intended to accomplish an instructional goal. While I cannot know the GTA’s goal from observation, I inferred the goal from the context of the interaction.

Practices are shared by community members with new graduate teaching assistants. New math GTAs rely on more experienced GTAs and their supervising professor for practices of teaching calculus (Belnap, 2005). Similarly, physics GTAs share practices with each other (Volkman & Zgagacz, 2004). However, the literature lacks a systematic exploration of GTA teaching practice, especially within specific disciplines (Westlander, 2014). Westlander (2014) began to address this lack in physics through an extensive analysis of physics GTA-student interactions during physics problem solving.

Expectations of the community of practice are also embedded in the artifacts that are provided to graduate students. These artifacts represent a reification of practice (Wenger, 1998). Within a community, practices become reified in the form of artifacts that distribute practices to others, allowing members of the community to share and influence the practices of other members. In the case of a newcomer to a practice, artifacts allow established members to provide new members with a way to begin participating in the community. In this study, artifacts may include worksheets, grading rubrics, quizzes, and exams.

Identity develops from both the practices that are used and also from those that are not used (Wenger, 1998). It is through the observation of how practices are enacted that a metapragmatic model of identity can be identified, and how a change in identity can be observed. Through observing teaching practice, a graduate student’s teaching identity development can be described.
2.3.2 Learning Environment Factors

Studies have commonly cited the learning environment as a key component to GTA identity. Belnap (2005) found that the teaching context, that is the course and the students (i.e. learning environment), to be the most influential factor in math GTA identity development. Sandi-Urena and Gatlin (2013) also described the learning environment as important for GTA self-image. However, the learning environment is commonly simplified to a single construct. The use of community of practice and social identification framework enable the observation of specific learning environment factors. Community of Practice and Social Identification contribute to understanding GTA teaching identity and teaching practices. These frameworks help understand different learning environment factors that emerged as mediators. Three learning environment factors were found that relate to the community of practice: content, worksheet structure, and mode of instruction. Two learning environment factors, social interactions and GTA observations, draw on social identification.

2.3.2.1 Content

The content of the course is defined by the community of practice and so the shared understanding of the content provides a shared point of understanding between the community of practice and the new GTA. Content is a boundary object that can facilitate the interconnection between the community of practice of knowing chemistry and the community of practice of teaching chemistry (Wenger, 1998). Content itself contributes to the development of identity (Latour, 1999; Wink, 2017).

Chemistry graduate students have extensive prior experiences learning chemistry and that knowledge provides an overlap with the content of the new community of practice that they are
entering. Content knowledge is important for teaching and previous research has shown that graduate students are likely to privilege content knowledge over any other skills for teaching (Volkman, Abell, Zgagaca, 2005). Indeed, without training, graduate students may actively reject the need for anything other than experience and intuition to be effective teachers (Luft et al. 2004).

2.3.2.2 Worksheet structure

Worksheets are artifacts that facilitates the sharing of expectations between the community of practice and the GTA. They provide a structure that supports the GTA in deciding on teaching practices. Worksheets can vary from having minimal structure, which would provide an open environment for the GTA to decide on teaching practices, to being highly structured, which could support specific GTA teaching practices.

2.3.2.3 Mode of instruction

The community of practice has established structures that inform the teaching practices. Modes of instruction are commonly part of the university system. The university department (e.g. Chemistry, Math, etc.) defines the context in which a graduate student’s teaching identity develops (Moore, 2005). The mode of instruction, whether it is lecture or group work, is grounded in the historical context of college classrooms. The mode of instruction can also be influenced by the professor, through direct instructions to the GTA or through the worksheet structure.

Mode of instruction also relates to the GTA’s prior experiences. As graduate students become teachers for the first time, they likely draw on their experiences as students, using role
Role models provide ways for the newcomers to start participating in the practices (Wenger, 1998). These role models can be from the individual’s past experiences and from the community of practice that they are entering. The community of practice, including chemistry professors and experienced GTAs, also provide new graduate students with role models. GTAs might interact with professors and other GTAs during weekly meetings or through graduate course work. GTA interactions with potential role models in the broader community of practice were not addressed in this study because there was not data to support these analyses. The GTA participants did not reflect on their interactions with other graduate students in their journals and there was no way to conduct observation of these types of interactions.

2.3.2.4 Social Interactions

Students are a central component of the learning environment and interactions with students have the potential to mediate the GTA teaching practices. Studies indicate that the social interactions with their students were important to GTA identity (Belnap, 2005; Sandi-Urena and Gatlin, 2013) and also recognized that given the unique student make-up of each individual class or section being taught, each GTA faced somewhat unique situations while interacting with their students. The ways that teachers interact with students provides a path for understanding the learning opportunities provided the students (e.g. Mehan, 1979; Mesa & Change, 2010). The social interactions between the GTA and students are a mediating learning environment factor.
2.3.2.5 GTA Observations

Graduate teaching assistants make observations of the learning environment before, during, and after teaching. The GTAs’ observations about the learning environment (i.e. other learning environment factors) interact with their model of teaching identity to mediate their use of teaching practices. The focus of the GTAs observations and their mediation of teaching practice a likely influenced by the GTA’s membership in multiple related communities of practice (Wenger, 1998). The GTA observations and teaching practices relate to their model of teaching identity and their membership in the new community of practice.

2.4 Research Questions

This research seeks to understand how chemistry GTA’s learn to teach chemistry. It was guided by the main question of: “How are teaching practices and the GTA’s model of teaching identity related?” I further considered the following guiding questions to develop my methodology and data collection methods and later in the analysis and discussion of the case study:

a) How are the community of practice and the GTA’s metapragmatic model of teaching identity related?

b) How are social interactions and the GTA’s metapragmatic model of teaching identity related?
An additional question emerged during the analysis of the first case: “What factors in the learning environment mediate GTA teaching practice?” This question related to the methodological approach that developed during the analysis of Case 1 and then applied in Case 2 as well. This second question resulted in reframing the main research question into: “How are teaching practices, learning environment factors, and the GTA’s model of teaching identity related?”

By answering these research questions, I will address three gaps in the literature. First, the study of chemistry graduate student identity development has focused on development of professional identity, that is, their development as scientists (e.g. epistemic development, etc.). This research will expand the discussion of graduate student identity to include teaching identity, an important facet of graduate student learning. Second, much of the research related to graduate teaching assistants has relied on K-12 research. To utilize this body of research, it has been assumed that the teachers and learning environments are similar and thus the research is transferable. This study seeks to consider the GTA/college learning environment as unique from the K-12 learning environments considered in the literature.¹ This study will provide information about teaching identity specifically within a higher education context. Third, many of the studies of GTA identity are phenomenological studies, which weakens the generalizability to other discipline contexts. This study is grounded in a strong conceptual framework informing its design and analysis. Finally, rich descriptive case studies of GTA teaching identity will help researchers reconcile potentially conflicted identities of scientist and teacher (Balinksy, 2007;)

¹ I do not agree with an assumption that GTAs are like other teachers. Their motivations for teaching are not the same. K-12 teachers have chosen teaching as a field of interest whereas GTAs are usually teaching as a source of funding for graduate school. K-12 teachers have several years of training whereas a GTA may have had a few days.
Aydeniz, & Hodge, 2011). This dissertation adds to the body of work related to graduate student teacher identity and may inform future work on GTA professional development.
3.0 METHODOLOGY AND CONTEXT

This study consists of two case studies of chemistry graduate teaching assistants. Chapter 3 begins with explaining the appropriateness of qualitative case study for addressing the research questions laid out in Chapter 2. This is followed by defining the case unit, the data collected for each case and then a description of the general context of the cases. Chapter 3 closes with a discussion of validity and reliability as it relates to a case study approach.

The qualitative research methods used in these case studies are ideal for research problems wherein variables are unknown and need exploration (Creswell, 2003). Such methods permit an approach to the research without constraints of predetermined categories. This allows the study of the phenomenon in depth and detail (Patton, 2002). Additionally, case study is the best approach for providing a richness of data that is important when little is yet known about the phenomenon or when there is only scant available research literature.

3.1 Case Study

This study considers the little explored phenomenon of chemistry graduate students’ teaching identity. Identity development is a complex process and is not something that can be empirically observed or measured. While factors that influence identity may be common across people, identity itself is unique to each person. Because of this uniqueness, case study is a commonly used methodology for studying identity (e.g., Volkman & Zgagacz, 2004; Horn et al., 2008).
Yin (2013) suggests three facets be considered when determining if case study is an appropriate research approach. First is the type of question being asked, with how and why questions being the most appropriate. The focus of this study is how the identity of the GTA is developing and changing over time and why possibly being present by implication. Second, case study is well suited to studies where the investigator has little control of the environment. The environment in which this study takes place provides no chance for a researcher to control for variables outside of the interest of the study. For example, the course content, the professor, and even the students are variables that cannot be accounted for in any systematic way. Third, the study should be focused on a contemporary phenomenon within a real-life context (Yin, 2013). This study occurs within the experiences of two graduate students engaging with teaching for the first time. This makes the boundary between the phenomenon of GTA identity and the context of the chemistry department difficult to distinguish. Case study supports the construction of well documented descriptions that provide detail that cannot be obtained with a statistical approach.

This dissertation consists of two single-case studies (Yin, 2013) of chemistry GTAs. Conducting more than one case study provides evidence that is considered more robust and compelling than a single case (Herriott & Firestone, 1983; as cited in Yin 2009). Additionally, multiple case studies support naturalistic generalizations that are intuitive rather than scientific (Yin, 2013). Similarities between the cases support the transfer of the conclusions to other cases and contexts.

A strong conceptual framework is necessary for case study research (Yin, 2013). A strong framework not only supports the design and analysis of the cases but in turn can be developed by the cases (Yin, 2013). Multiple cases and a strong framework improve the generalizability of the research findings by limiting the applicability of rival theories. However, case study is a dynamic
research approach, and while a strong framework is necessary it is not rigid (Yin, 2013). As a researcher becomes immersed in the data, during collection and analysis, there are opportunities for the framework to develop and change as more becomes known about the phenomenon (Yin, 2013). The initial approach to this study drew on two conceptual frameworks, but as the case developed, the synthesis of the frameworks was changed by the analysis as much as it supported the analysis.

Context is an important component of case study (Yin, 2013). While Community of Practice and Social Identification are frameworks that are based in case studies, the context of this study is substantially different from the context in which those frameworks were developed. Community of practice was largely explored through non-academic contexts, although it has been used in education research to frame understanding of teacher professional learning communities (e.g. Furtak, Morrison, & Henson, 2010; Stoll et al. 2006; Vescio, Ross, & Adams, 2008). Social Identification has largely focused on K-12 education and in situations where the discourse is centered on ideas of the human condition. Bringing the ideas from these frameworks into the context of GTAs in higher education is a substantially different context and case study will support understanding in this new context.

Identity is a social construct; it is enacted in social interactions (Holland & Lave, 2001; Bauman, 1996; Roth, 2004). The situative nature of Community of Practice means that there is no clear distinction between the development of the skills or practices and the development of identity (Johannsan & Land, 2000). Further, because identity exists in interactions, the boundary of an individual’s identity from the context is not easily defined (Yin, 2013). It is not bound solely within the GTA but is a negotiated experience between the participants in the community (Wenger, 1998).
3.1.1 Defining the cases

The cases were defined by specifying the criteria for selecting the GTAs. New graduate students in chemistry face a diverse set of expectations during their first semester. There are three distinct areas of responsibility that they take on when starting graduate school: graduate course work, research, and teaching. This study focuses on the teaching aspect of this graduate level work. Course work and research are considered as part of the case context. A GTA typically has responsibility for running discussion sections and lab sessions, grading student work (e.g. labs, exams), holding office hours and meeting with the professor (usually) to discuss upcoming material.

The central selection criteria for GTAs was that they were first year chemistry graduate students. Being first year graduate students made it likely that this was their first-time teaching. I selected first time GTAs because I believed that they would be more likely to show dynamic identity change, whereas 2nd year GTAs would already have more established teaching identities (Speer et al., 2005). I also chose to select participants from among the first-year graduate students because they are typically assigned to introductory chemistry courses, which serve a broad range of students and are a focus of chemistry education.

Participants were recruited from all first-year graduate students at the start of the Chemistry Department training. A follow up email was sent to the graduate students with a request that they reply to indicate interest. Three GTAs volunteered to participate in the study. Participants were compensated for their completion of the interviews and journal activities. Data was collected during the Fall 2015/Spring 2016 academic year with explicit consent of the participants and in full compliance with Institutional Review Board guidelines. Specific data
collected for each GTA is included in their respective chapters. Pseudonyms were used for the GTAs and any students included in example data.

As analysis of Case 1 (Jane) progressed, the decision was made to focus on two of the cases: Jane and Edward. This was for both practical and methodological reasons. The cases included had richer data sources due to the amount of data that was collected. Jane and Edward had more contact time with students than the third GTA and it was possible to collect more observational data. Edward’s case was also selected over the third GTA because he taught the same course as Jane’s case which would provide an opportunity to validate the learning environment factors that emerged in Case 1 as mediators of Jane’s teaching practices.

This case study was conducted in a large Midwestern university chemistry department. The chemistry graduate program is typical of an R1 research institution (ACS, 2008), with an average of 130 graduate students enrolled per year. Graduate students are funded through graduate teaching assistantship and graduate research assistantship appointments. Roughly 85 graduate students are supported as GTAs each semester. Approximately 30 new graduate students are enrolled each fall and all are supported as GTAs. New graduate students are typically assigned to introductory chemistry courses.

3.1.2 Context

The context of a case is important because it defines both a practical and a theoretical boundary for the case. From a practical perspective, the context provides a boundary that defines what data is inside the case. From a theoretical perspective, the context defines the boundary that defines a place for the GTA practice and social interactions to occur, between both the community of practice and outside the community of practice with the students.
The portions of the context that were relevant to this case study were the professor and GTAs assigned to the same course and the students whom the GTA taught. The chemistry department also played a role in establishing expectations and training for the GTA (Kane & Varelas, 2016). Figure 2 shows the relationship of each of these with respect to the context of the case and the Community of Practice. This figure shows the relationship between the case GTA and those that situate the case by being present when the identity is constructed and enacted. This includes the Community of Practice within which the GTAs are starting to participate and the students whom the GTAs are teaching. Students are placed outside the bounds of the Community of Practice. Students are an important component of Social Identification, but are not members of the community.

Figure 2. Defining the case.
Two learning environments overlap during these case studies. One is the learning environment of the undergraduate chemistry student. The second learning environment is the one in which the GTA is considered the learner, centered on learning to teach. It is the second environment that is the focus of this study. The overlap between these two learning environments is the classroom, where the study observations were conducted.

3.2 Data Collection

This section describes the data sources for the cases. Each type of data is described generally with an explanation of what it provides to the study. Specific details of the data collected in each case is included in the respective case chapters.

3.2.1 Observations

GTAs were observed during discussion at four different weeks over the course of the fall semester. The weeks were selected to cover a range of course related activities (reviewing quiz, preparing for exam) and by practical schedule considerations. Observation was conducted from an unobtrusive location in the classroom, where field notes were taken using the Classroom Observation Tool for Undergraduate STEM (COPUS; Smith et al. 2013).

The COPUS provided a systematical reliable method for recording the behaviors of the students and GTA during each of the observations. Twenty-five different student and instructor behaviors were available within COPUS to be assigned for every two-minute interval for the duration of the observation. In these observations, five of the student codes were observed and
seven codes were observed for the GTAs. Table 1 details the selection of COPUS codes that were found in this study. Multiple codes were possible in each two-minute segment. The developers of COPUS summarize the data into whole observation analysis comparing relative occurrence of each code. However, this study was more interested in the two-minute segment detail that COPUS provides to consider how GTA and student behaviors interact over the observation. The use of the COPUS codes is discussed in more detail in the data analysis section (see 3.3.1).

The observations were video recorded and, when necessary, back up audio recording was used to supplement the video. Observations were transcribed in full and the dialogue separated by turns. Two types of turns were defined in the transcripts. The first type of turn was a switch between the GTA as the speaker and the student as the speaker. The second type of turn occurred when the GTA changed from one question (or topic) to a second question. This was counted as a turn because it would initiate new discussions.

Table 1. COPUS Codes Used (Smith et al 2013)

<table>
<thead>
<tr>
<th>Student Codes</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>Listening to the instructor/taking notes</td>
</tr>
<tr>
<td>WG</td>
<td>WG</td>
<td>Working groups on worksheet activity</td>
</tr>
<tr>
<td>AnQ</td>
<td>AnQ</td>
<td>Student answering a question posed by the instructor</td>
</tr>
<tr>
<td>SQ</td>
<td>SQ</td>
<td>Student asks questions</td>
</tr>
<tr>
<td>SP</td>
<td>SP</td>
<td>Student presentation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lecturer Codes</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lec</td>
<td>Lec</td>
<td>Lecturing (presenting content, deriving mathematical results, presenting a solution to a problem, etc.)</td>
</tr>
<tr>
<td>RtW</td>
<td>RtW</td>
<td>Real-time writing on board, doc. projector, etc. (often checked off along with Lec)</td>
</tr>
<tr>
<td>PQ</td>
<td>PQ</td>
<td>Posing non-clicker question to students (non-rhetorical)</td>
</tr>
<tr>
<td>AnQ</td>
<td>AnQ</td>
<td>Listening to and answering student questions with entire class listening*</td>
</tr>
<tr>
<td>MG</td>
<td>MG</td>
<td>Moving through class guiding ongoing student work during active learning task</td>
</tr>
<tr>
<td>1o1</td>
<td>1o1</td>
<td>One-on-one extended discussion with one or a few individuals, not paying attention to the rest of the class (can be along with MG or AnQ)</td>
</tr>
<tr>
<td>Adm</td>
<td>Adm</td>
<td>Administration (assign homework, return tests, etc)</td>
</tr>
<tr>
<td>W</td>
<td>W</td>
<td>Waiting when there is an opportunity for an instructor to be interacting with or observing/listening to student or group activities and the instructor is not doing so.</td>
</tr>
</tbody>
</table>

* modified for use in group work.
3.2.2 Interviews

Interviews are commonly used in case study (e.g., Stake, 1995; Yin, 2013). They provide a method to gain insight into the participant’s understanding (Patton, 2002). Use of semi-structured interviews provided a consistent basis for questions between cases and the flexibility to explore emergent ideas and topics. The purpose of the interviews was to gain insight into the participants’ ideas about teaching and learning, specifically what they thought about themselves as teachers.

3.2.2.1 GTA Interviews

Two interviews were conducted with each participant (Table 2). The interview questions can be found in Appendix A. The first interview was conducted prior to the GTAs assignment to a specific course. This interview focused on the GTAs’ background with respect to teaching, their college experiences, content knowledge, and their expectations as they entered their first teaching assignment. A second interview was conducted with the GTAs at the end of the Fall 2015 semester. This interview focused on GTAs’ expectations about teaching and how well their experiences aligned with their expectations. This interview was also used to explore questions that arose from the observations and the journals.

Interviews were audio recorded and transcribed for further analysis. Interviews took place at the participants’ convenience and in the Chemistry Department. Interviews were scheduled for 60 minutes but in practice lasted between 34 minutes and 42 minutes.
### Table 2. Interview Data

<table>
<thead>
<tr>
<th>Case</th>
<th>Interviews</th>
<th>Case</th>
<th>Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Professor Interview</td>
<td></td>
<td>Professor Interview</td>
</tr>
<tr>
<td></td>
<td>January 2016</td>
<td></td>
<td>November 2015</td>
</tr>
</tbody>
</table>

#### 3.2.2.2 Professor Interviews

As a role model and ranking member of the community of practice, the professor in charge of the course had the potential to influence the GTA throughout the semester (Wenger, 1998). The lecture professors for each case GTA were interviewed (Table 2). This interview covered general teaching beliefs, expectations for their GTAs, and impressions of the case GTA (Appendix A). The interview was conducted in full compliance with IRB guidelines.

#### 3.2.3 Journals

Journals complement the observation and interviews. While interviews were developed around the literature and my own concepts about teaching and learning, a journal provides time and space for the ideas of the participant to come forward (Eekelen, Boshuizen, & Vermont, 2005; Green, 2010). The journals also provided evidence of motivation and self-observation to support the practices that are found in the observations (Meel, 2000).

GTAs completed seven journals during the fall semester, each covering two weeks of the semester except the last which covered three. The journals consisted of guided response prompts to engage the GTA in reflection about the prior two weeks and planning looking forward to the next week of teaching. Prompts were written in Microsoft Word and were sent to the GTAs by email. GTAs completed the journal by typing replies in the Word document and returning it by
email. The prompts were added to and revised over the course of the semester in response to changes in GTA experience, including their exposure to ideas about teaching and learning in the Chemistry 500 course. Appendix A includes all journal prompts.

3.2.4 Artifacts

Practices become reified in a community of practice through the development and use of artifacts such as worksheets (Wagner, 1999). The worksheets provided by the professor may have different affordances for practices engaged in by the GTA. Course worksheets were collected directly from the professor for each course a GTA was assigned. Fourteen worksheets were collected for case 1. Four worksheets were collected for Case 2. An example worksheet for each case is provided in Appendix B.

The course syllabus was collected to provide week-by-week content information as well as course structure (Appendix A). The content being covered in the course likely had impact on how the GTAs prepared for class and engaged with students during that week.

3.2.5 Data Collection Summary

Twelve observations were conducted in Case 1 and eleven in Case 2. GTAs in both cases completed seven journals. Table 3 summarizes the data collection of the observations, journals, and artifacts (i.e. worksheets).
Table 3. Data Summary: Observations, Journals, Worksheets

<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPIC</th>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
<th>Section 4</th>
<th>Section 5</th>
<th>Section 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matter</td>
<td>la.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Periodic Table, Measurement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Significant Figures, Proportions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Metric system, Exponents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Lewis Structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ionic compounds, oxidation numbers</td>
<td>la.6*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Density, Molecular Ratios, Moles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Avogadro’s Number, Molar mass, Stoichiometry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Stoichiometry, Percent composition, Empirical formulas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Reaction types, predict products, balance reactions</td>
<td>la.10</td>
<td>la.10</td>
<td>la.10</td>
<td>la.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Predicting products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Acid/Base reactions, Stoichiometry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Stoichiometry, Percent Yield</td>
<td>la.13</td>
<td>la.13</td>
<td>la.13</td>
<td>la.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Molarity, Solution stoichiometry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*observation excluded from data because of poor audio quality.
3.3 Data Analysis

Qualitative case studies generate large amounts of raw data. The analysis of data occurs in iterative stages because qualitative data is “continuously interpreted, on first sight and again and again” (Stake, 1994, p. 242). The data for this study included interview transcripts, observation transcripts, COPUS observation protocols, and course artifacts. The transcription process aided in familiarity with the data set. Analysis of the data then proceeded in a more deliberate fashion prior to writing the case studies.

The Data Analysis Section describes how each type of data was utilized and how the data afford the emergence of teaching practices and learning environment factors (Figure 3). These analyses are grounded in the framework described previously. In the first round of analysis, the focus was on the coding of the observation transcripts and the use of COPUS protocols. The practice codes of the observations were developed through open coding using iterative passes through the transcripts. COPUS and the practice codes were used to describe patterns of practice. Patterns of teaching practices across different weeks and different sections provided a window into understanding how the teaching practices are shaped by the learning environment factors. These patterns in turn provide a lens into the GTA teaching identity.
3.3.1 Units of Analysis

Several units of analysis were defined to facilitate the analysis of the data. These units of analysis are defined here:

**Cases.** The case was defined as the first-year graduate student assigned to teach a general chemistry level course at a large Midwestern university. There were two cases for this study.

**Week.** A week was defined as the set of class meetings that occurred over contiguous Monday to Friday. Observations were conducted over four weeks for each case. These weeks corresponded to the course syllabus weeks of 6, 7, 10, 13 of the semester.
**Section.** The group of students that attend class at a specific time and location with the GTA on a weekly basis. While each GTA had six sections of students, there were four sections of students observed in Case 1 and four sections of students observed in Case 2. Sections were identified as A, B, C, D in each case.

**Class meeting.** Individual class meetings were observed. Each class meeting was scheduled for 50 minutes. The data includes twelve class meetings for Case 1 and eleven class meetings for Case 2. Each class meeting was assigned a unique identifier that included the case, the section, and the course week. For example, in Case 1, the class meeting of Section C during Week 6 was identified as Observation 1c.6.

**Activity.** Each class meeting was divided into activities. An activity is a distinct continuous segment of time during the class that was defined by a specific activity type. There were 31 instances of activities identified in Case 1 and 24 instances of activities identified in Case 2.

**Activity Type.** There were four types of activities in the data: Going over Quiz/Exam, Group Work, Going Over Worksheet, Preparing for Quiz/Exam (Table 4). These described all of the activities observed in the classroom during instructional time. Time spent in class administration (e.g. handing back quizzes and exams, taking attendance) was not included in the data. For each GTA, every class meeting tended to follow the same sequence of activity types though they varied in length from week to week.
### Table 4. Activity Types

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Going over Quiz/Exam</td>
<td>GTA goes over answers to a quiz or exam.</td>
</tr>
<tr>
<td>Group Work</td>
<td>Students work individually or in small groups on the discussion worksheet.</td>
</tr>
<tr>
<td>Going Over Worksheet</td>
<td>GTA and whole class goes over answers to the discussion worksheet. This usually includes step-by-step problem solving and explaining, not simply giving answers.</td>
</tr>
<tr>
<td>Preparing for Quiz/Exam</td>
<td>GTA provides information that the students need for the quiz or exam. This is not active problem solving, but rather the GTA lecturing the students.</td>
</tr>
</tbody>
</table>

**Mode of instruction.** Class meetings were structured around two modes of class work.

One was *whole class instruction*, which included the activity types of *Going Over Quiz/Exam*, *Going Over Worksheet*, and *Preparing for Quiz/Exam*. The other was *student work* during which students worked on questions from the worksheet individually or in small groups. This included the activity type *Group Work*.

**Content Type:** Three types of content were defined: knowledge recall, algorithmic, and conceptual (Stamovlasis et al., 2005). Knowledge recall is a statement of a fact. Algorithmic content relies on knowing step-by-step rules. Conceptual knowledge required an explanation that was more than a memorized definition or use of algorithmic steps. The use of knowledge recall, algorithmic, and conceptual is not to suggest that a given piece of chemistry content is always of this type but that in the specific instance of this course and how it was presented on the worksheet and by the GTA, the content had certain features. Content type was identified in the analysis of GTA teaching practices to support the understanding of the different uses of teaching practices as the content changed over the semester.
3.3.2 COPUS

As previously discussed, COPUS was used to systematically categorizes the behaviors of students and GTAs during the observation of the discussions (Smith et al. 2013). Each observation was coded using COPUS twice: once during the original data collection and a second time while reviewing the video recordings of the observation. The entire set of COPUS codes were considered during the coding. There were several COPUS codes that were not found in the observations. This was likely due to the nature of the course (introductory level) and the discussion class compared to a science course more generally.

3.3.3 Teaching Practices

The COPUS set of observation codes described the behaviors of the GTA and the students. Practice codes were developed to describe the ways that the GTAs interacted with the students. Open coding was used to develop teaching practice codes that were grounded in the observation data (Strauss & Corbin, 1998). Practices were coded at the level of each turn. Practice codes were not treated as mutually exclusive and each turn could have multiple codes applied. Two examples of how the codes applied to the observation transcripts are provided here. Examples for each code can be found in Appendix C.

The first example of a practice code is taken from interactions in Case 1 (Figure 4). In the first example, Jane initiates an interaction with a student by directly asking if they needed help. This is an example of checking-in. The second example shows Jane asking if the student had completed the worksheet (checking-in) and using it as an opportunity to correct (P8) the students work.
The second example is also drawn from Case 1 (Figure 5). As the student attempts to talk through the explanation, Jane uses prompting (P5) to assist the student in getting to a correct explanation. This example is not exclusively prompting but also includes correcting and validating. In response to the student “ate” and "ite" Jane provided the correct terminology that the student was struggling to articulate. Further, her repetition of “metal” demonstrates validating with a small correction by Jane saying, “any metals”.

Figure 4. Example 1 of defining a practice.

Example 1:
1 Jane: **You need help?**
2 Student: Kind of.
3 Jane: Okay. I’ll be going over this, then you can shout out which one you need help with.
4 Student: Okay.

Example 2:
1 Jane: **Are you done?**
2 Student: Yeah.
3 Jane: *It’s not right*
Table 5 lists the practices that emerged from coding the observation transcripts from both cases. Practice codes were not mutually exclusive and more than one practice code may have been applied to the same turn. Call-Response (P3) was removed from the analysis because it was completely captured by leading through problem, prompting, and validating. Admin (P11) was also removed from the analysis as unrelated to instructional tasks. Checking-In (P1) was found only in Case 1. Practices 12-14 were found only in Case 2.
#### Table 5 – Practices Codes with descriptions

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P1. Checking-In</em></td>
<td>The GTA initiating a verbal interaction with a student or group of students that elicits responses from the students. P1 was coded when there was not an ongoing interaction. It does not include GTA initiated interactions that start with statements of the student being right or wrong, which would be coded as P8 and P9 respectively.</td>
</tr>
<tr>
<td>P2. Leading through problem</td>
<td>The start of a series of turns where the GTA introduces and works through a problem. This practice is coded only once at the start of the series of turns. Turns in this series often included P5 and P8.</td>
</tr>
<tr>
<td>P4. Understanding check/“Does that make sense”</td>
<td>An understanding check is a verbal GTA statement that elicits student feedback about their understanding of the material just discussed. A common phrase used in these cases was “does that make sense?” This is different from P1 because P1 comes at the beginning of an interaction and P4 comes at the end of an interaction.</td>
</tr>
<tr>
<td>P5. Prompting</td>
<td>A GTA question or statement that elicits a student response/answer or pushes the student to consider the next step in the problem.</td>
</tr>
<tr>
<td>P6. Do you have a question (whole class)</td>
<td>The GTA eliciting student input on what to do. This commonly includes asking the student(s) which problems to go over from the worksheet or providing the opportunity for student(s) to ask questions generally. This is different from P2 because it isn’t the start of solving a problem, it is finding out what students want to cover.</td>
</tr>
<tr>
<td>P7. Explaining content</td>
<td>The GTA engaging in a response or discussion of a topic, an extended set of steps to follow, or an answer that includes a “because”. This is different than P10 (Direct Answer) since it includes a content explanation or detailed procedure rather than simply an answer.</td>
</tr>
<tr>
<td>P8. Validating</td>
<td>The GTA providing an explicit or implicit indication that the student was correct. Explicit is found in statements of “yes” “yeah” or a repeat of the student. Implicit is found in the GTA moving on to the next question, a new prompt, or ending the interaction without correcting the student.</td>
</tr>
<tr>
<td>P9. Correcting</td>
<td>The GTA indicates that the student answer, written down on the worksheet or stated to the GTA, is wrong or incomplete. This can be explicit (e.g. “you’re doing these wrong”), or implicit where the GTA repeats the question that the student already tried to answer. This differs from P10 in that student has not asked the GTA to evaluate their work.</td>
</tr>
<tr>
<td>P10. Direct Answer</td>
<td>In response to a student question, the GTA gives an answer to a student question without an explanation, the GTA tells the student what to do with the problem, or the GTA provides validation/correction of student work. P10 must be in response to an implicit or explicit student question. This is different from P7 because it lacks conceptual detail or why component. This is different from P8 and P9 because it is in response to a student asking for evaluation of their answer.</td>
</tr>
<tr>
<td><em>P12. Encourage students to participate at the board</em></td>
<td>The GTA explicitly requests a student volunteer to work a problem on the board. May also include the GTA asking a specific student to work a problem on the board.</td>
</tr>
<tr>
<td><em>P13. Having student work at the board</em></td>
<td>The GTA has a student(s) work a problem on the board. There is likely no dialogue associated with P13. It was marked based on the video following a P12 code when a student went to the board.</td>
</tr>
<tr>
<td><em>P14. Ask student to explain/Why</em></td>
<td>The GTA asks the student(s) to explain an answer or statement. This could be an answer to a problem that the student (or different student) gave verbally, an answer that the student wrote on the board, or an answer that the GTA had given. Answer could also be a statement.</td>
</tr>
</tbody>
</table>

* * Found only in Case 1  
** ** Found only in Case 2
3.3.4 Data representation

Data representations allow for patterns to emerge from qualitative data (Eisenhart, 2006). The developers of COPUS considered the data at the level of the entire observation which they represented using pie charts (Smith et al. 2013). Other researchers have used bar graphs to compare COPUS codes across observations of many different instructors (e.g., Smith, Vinson, Smith, Lewin, & Stetzer, 2014). Lund et al. (2015) chose to use cluster analysis of COPUS codes to yield profiles. I chose to develop a representation of the COPUS data that allowed for the exploration of the codes at two-minute intervals within the individual observations. Instead I represented the COPUS data by plotting each of the codes along a time line (Radinsky, Goldman, Doherty, & Ping, 2010). This approach was taken because it provided for an analysis at the time scale of the interactions between the GTA and students. Such a representation allows for an interpretation of patterns of behavior over time during the observation that was not apparent in the pie chart representations originally used by the COPUS designers. Activity Type is also represented on the same timeline. Each Activity Type and COPUS code are represented at two-minute intervals as dictated by the structure of the COPUS observation tool. Figure 6 is an example of a COPUS Data Map generated from data in Case 1.

Practices were represented using bar graphs indicating the count of each practice. These representations were constructed for each case for the (1) entire semester, (2) by observation week, (3) by section, and (4) by activity types. Figure 7 is an example of this representation using data from Case 1.
Figure 6. Example of COPUS representation.
3.3.5 Learning Environment Factors as Mediators of Practice

Learning environment factors emerged as mediators of practice from analyzing different representations of the practices. Practices were categorized by different units of analysis: Week of observation, Activity Type during observation, and Section of students. These different representations of the practice codes demonstrated how the teaching practices varied depending on factors of the learning environment. These led to the emergence of five learning environment factors. Table 6 summarizes the relationship between the data and the learning environment factors.
Table 6. Evidence for learning environment factors as mediators of teaching practice

<table>
<thead>
<tr>
<th>Learning Environment Factor</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>Practices by Observation Week</td>
</tr>
<tr>
<td>Worksheet structure</td>
<td>Practices by Observation Week</td>
</tr>
<tr>
<td>Mode of instruction</td>
<td>Practices by Observation Week</td>
</tr>
<tr>
<td></td>
<td>Practices by Activity Type</td>
</tr>
<tr>
<td>Social interactions</td>
<td>Practices by Section</td>
</tr>
<tr>
<td>GTA observations</td>
<td>COPUS maps</td>
</tr>
<tr>
<td></td>
<td>Journals and Interviews</td>
</tr>
</tbody>
</table>

Learning environment factors mediated the teaching practices and teaching identity. Figure 8 provides a theoretical relationship of teaching practice, teaching identity, and learning environment factors. Three learning environment factors were related to the community of practice and two with social identification. Content, Worksheet structure, and Mode of instruction were three learning environment factors that were identified in the analysis that are related to the Community of Practice framework. Social interactions (i.e. the interactions between the GTA and the students) and GTA Observations are based in the Social Identification components of the conceptual framework.
3.3.6 Supporting Evidence in Interviews and Journals

The interview and journal data was explored after teaching practices and learning environment factors had emerged from the analysis of the observations. This provided additional supporting evidence that the practices that emerged from the observations were actually present. This type of supporting evidence is sometimes referred to as triangulation (Yin, 2013). Each interview and journal was systematically explored for evidence of the GTAs comments that related to teaching practice, learning environment factors, or teaching identity. Evidence of teaching practices that were seen in the observations were identified in the journals by looking for language in which the GTA described what he or she did during teaching. As an example of how supporting evidence is used, in Journal 1 Jane wrote:
“I read the question and ask the class what the answer is. If the answer is right I explain why and if the answer is wrong I work through the problem so they understand how to get to the right answer. I make sure to ask the class if they have any questions before I move onto the next problem.” (Journal 1)

In this excerpt, Jane indicates that she would prompt (P5) the students for an answer and then validate(P8)/correct(P9) the students responded. She then describes how she engaged in explaining content (P7) before moving on. There is also evidence of understanding check (P4) before she says that she would move on.

Jane’s descriptions of why she made choices about practice provides a second window into how learning environment factors mediated Jane’s teaching practices. In the following journal excerpt, there is evidence that Jane used the Social Interactions with students to make decisions about her practices. She used the repetition of student questions to decide about needing to explain concept to the whole class.

“The students asks (sic) me a question and if this question is reoccuring I address the concern to the whole class, so everyone knows what to do for that question.” (Journal 1)

3.3.7 Describing GTA Model of Teaching Identity

The description of the GTA’s model of teaching identity was developed from multiple sources. The first GTA interview was carefully considered for evidence of the GTA’s initial model of teaching identity. Descriptions of good teaching and descriptions of practices were used as a guide for understanding how teaching identity was manifested in the observations.

The interviews and journals were explored for evidence of the development of the metapragmatic model of teaching identity for the GTA. In addition to evidence of practices, the journals and interviews were coded for “I” statements and descriptions of what it meant to teach.
These excerpts provided structure to interpreting the relationship between teaching practices, learning environment factors, and teaching identity.

3.4 Validity, Reliability, and Limitations

It is challenging to maintain validity and reliability in qualitative studies. Several methods were undertaken in designing the study and analyzing the data to ensure a valid and reliable analysis (Patton, 2002). In a case study, a valid study would be one that tells the most accurate story of the phenomenon, given the conceptual framework. Reliability refers here to the ability of another researcher to understand how the data and interpretations led to the description of the phenomenon. In this study, reliability and validity are established by clearly demonstrating how the data was coded, analyzed, and interpreted to tell the stories of the GTAs’ identity development. Data that demonstrates that not every interaction contributes to the overall trajectory of GTA identity development also contributes to the study’s reliability.

The strength of the conceptual framework in informing the design and analysis also contributes to establishing validity and reliability in a case study by informing both the data collection and data analysis design. By using a strong conceptual framework to inform the research design (multiple sources of data, triangulation) and analysis, one can follow the logic from evidence to interpretation to claims and findings (Yin, 2013).

A limitation to consider for this study is that the very act of participating in the study can change the GTAs’ practice in ways that might not have occurred but for their study participation. Several possibilities might have occurred. For example, the journaling of necessity engaged the
GTA in reflection about their teaching. It is probable that this reflection would likely not occur outside of this journal. This reflection likely impacted the experiences and identity development of the GTA. Additionally, being observed during teaching could also have changed the GTAs’ practices. However, these are not considered to be significant threats to the validity of the study. While the GTAs’ identity development may be different relative to how it might have developed in the absence of participating in this study, the *description* of that trajectory will still be valid because this study does not seek to describe a typical GTA identity.

Qualitative case study is more susceptible to researcher bias than other approaches. It is inherent on the researcher to maintain awareness of any biases and make efforts to mitigate the influence of bias on the study. In this study, the issue of teaching quality is being explicitly excluded from the analysis. I am very passionate about improving undergraduate chemistry education and believe that GTAs play a critical role in this process. During the data collection and analysis, I continually assessed and reevaluated potential for bias through reflections in a research journal. Review of the analysis by a neutral party provided feedback for any issues of the analysis focusing on quality or otherwise potentially allowing unrecognized biases to enter the analysis.

### 3.5 Context

Context is important understanding the cases. This section describes the context that was mutual for both cases. This includes the departmental GTA training and the chemistry department. This section describes these context factors in relation to the case studies.
3.5.1 GTA Training

Departmental training of GTAs at the start of the semester was observed and field notes were taken. The chemistry department also provided some on-going training to new GTAs during the first semester as part of their seminar course work (Chemistry 500). The seminar introduced ideas about teaching and learning. This course included an introduction to ideas about pedagogy (e.g. misconceptions, Socratic questions, etc.), feedback on a teaching example that GTAs provided by video to the instructor, and discussions about resources available to help students. Observation notes and course materials from this seminar were also collected.

3.5.2 Departmental Context

A department wide survey of graduate students and faculty was conducted to situate how the Community of Practice regards teaching as an aspect of their practice. Professors and graduate students have different ideas about the purpose of laboratory learning (Bruck, Towns, & Bretz, 2010) and it is likely that there are similar differences in GTA and professor ideas about teaching in discussions as well. The responses from faculty and graduate students were used to provide context for the environment in which new graduate students were going to be engaged in teaching for the first time. This survey was developed to establish a broad sense of the departmental attitudes regarding teaching. Graduate students had a one-in-five chance for a $25-dollar Amazon gift card. Professors were not compensated. The survey was collected with full compliance with IRB guidelines.
3.5.2.1 Departmental Survey

The survey of the department was used to describe the expectations and understandings of the department regarding graduate student teaching. All levels of faculty were invited to participate including all adjunct instructors through full professors. All current graduate students were also invited to participate. Thirty-six faculty members were invited to participate in the survey. Eleven submitted surveys, of which eight were complete (two were blank). The current graduate student population for the department was 131 students. Of these twenty-five provided complete submissions to the survey.

The survey consisted of an open response section and a ranking section where participants were asked to rank the tasks that graduate teaching assistants engaged in during teaching. The full survey can be found Appendix A2. The participants were first asked to briefly describe their background (e.g., what level of faculty, years as a graduate student, etc). This allowed me to assess the breadth of the responses. The participants next had three open response questions:

- Describe what you feel is the role of a TA in introductory chemistry courses.
- Describe any training and/or support that is provided to new graduate students with regards to teaching.
- Describe the role that teaching plays in graduate student development.

The second component of the survey was a ranking task to assess the faculty and GTA perception of tasks engaged in by GTAs during teaching. These tasks were adapted from previous research (Belnap, 2005) and my own experience in similar classrooms. Participants were also provided with an optional question to elicit any ideas that they thought were not covered by the survey.
These responses were used to develop a narrative description of the department’s varied perspectives on teaching and GTAs. I discuss first the role of teaching for graduate student education. Second, I cover perceptions of GTA training. Third, I discuss the reasons given for why graduate students teach. I end with description of the different perceptions of faculty and graduate students of actual activities engaged in while teaching.

3.5.2.2 Graduate Student Teaching Role

The professors who responded to the survey had limited input regarding first year graduate students since none the respondents had experience teaching the first-year courses, which first year graduate students are most likely to be assigned. Overall, the faculty expressed the understanding that graduate students were responsible for fulfilling the requirements of the teaching job and that they were expected to be helpful for the students taking the chemistry courses. For the faculty respondents, fulfilling the requirements of the job focused on “running lab, discussion, and office hours” and doing the grading.

Graduate student responses concerning their role as GTAs highlighted their role in helping students adjust to college, keep them safe in lab, and make sure that students “know all the details”. Additionally, many graduate students mentioned the benefits of teaching for themselves, such as improving communication.

3.5.2.3 GTA Training

The faculty perception of GTA training was that there was very little and that the GTAs relied on the weekly meetings with the faculty, which could vary broadly in what was covered. One faculty respondent was against more training for GTAs because “they shouldn’t be
lecturing” because they would confuse the students. Graduate students described training as minimal, focused on safety, and that being a GTA was about learning on the job through experience.

### 3.5.2.4 How does teaching support graduate student development?

When faculty and graduate students describe the benefits of teaching the responses were largely focused on three areas. First, there were frequent responses among both the faculty and graduate students that teaching was necessary for graduate students to fund their education. This view was consistent with what had been found previously (e.g., Gutwill-Wise, 2001). There was the common implication that teaching was just for the money. Faculty and graduate students also frequently commented that teaching introductory material was helpful for the graduate students to strengthen their understanding of fundamental concepts. Last, both groups responded that teaching helped graduate students with soft skills such as communication and time management. Only one graduate student responded that experience teaching was important regardless of their expected career path.

### 3.5.2.5 GTA activities during teaching

The last question on the survey asked the faculty and graduate students to rank the activities that the GTAs engaged in most often to least often when teaching the discussion sections. There was evidence that there is a mismatch in the department between what professors expect that graduate students are doing and what graduate students indicate they are doing during discussion. Professors ranked *presenting solutions to problems, working examples for student, and lecturing* as the activities least often engaged in by GTAs. However, the responses from the
graduate students indicated that *presenting solutions to problems, working examples for student, and lecturing* were the activities in which they engaged most frequently. This mismatch in understanding of what graduate students do suggests that the expectations for teaching would be widely variable and dependent on the specific instructor with whom the graduate student works.

These survey results suggest that the faculty is disengaged from GTAs. They likely influence the department expectations for teaching but they were not aware of the activities that graduate students were engaging in during teaching.
4.0 CASE 1: JANE

The first case I present is Jane. To introduce the case, I provide a brief description of the data collected, the practices that emerged, and an overview of Jane’s model of teaching identity. I next discuss in detail the analysis of the case including practices and factors identified in the learning environment that mediated Jane’s practices. I end the discussion of this case by discussing Jane’s teaching identity and her metapragmatic model of teaching identity. This includes how her teaching identity relates to her initial model of teaching identity, how her practices and mediators of practice are related to her teaching identity.

4.1 Case 1 Introduction

Jane’s experience with learning chemistry and her background as a student informs the context of the case. The first interview provided a background into Jane’s experiences as an undergraduate and her expectations upon entering graduate school. Jane received a Bachelor of Science degree in chemistry from a medium sized graduate degree granting university. She started as a biology major and had switched to chemistry because she liked chemistry “when [she] got to a higher level [organic chemistry]” (Interview 1). Jane entered the chemistry PhD program the fall semester after finishing her bachelor’s degree. She chose to go to graduate school because “[she] had no idea. [She] just didn't have anything else to do.” Ultimately, she wants to pursue medically oriented research, possibly through also obtaining an MD.
Jane developed ideas about teaching during her time as an undergraduate. She recounted several strong impressions of effective teaching from professors in her undergraduate chemistry program. The effective professors were the ones that made it clear that they were there to help the students. In one instance, she reflected on how her organic chemistry professor told the class “I’m here to help you as much as I can. I’m here for you.” (Interview 1). Jane’s idea that being a teacher was being available to help built on her an already present expectation of the helpful role of a graduate teaching assistant. Her recollection of GTAs was that “…the TAs were very helpful. I always remember chemistry, if you didn't understand what (sic) lecture, you go to the TA” (Interview 1). These examples demonstrate that Jane’s approach to becoming a teacher is grounded in her experiences (e.g. Sandi-Urena, S. & Gatlin, T., 2013; “apprentice of observation” Lortie, 1975). In addition to being a learner, Jane had experience with teaching from the perspective of informal tutoring of her friends and classmates but no formal teaching role.

The context of the course that Jane was assigned to teach as a first-time GTA is also important as well. Jane was assigned as a GTA to a preparatory chemistry course, Chemistry 101. She was assigned to teach six 50-minute discussion sections each week, to be available to students for two hours of office hours, and to grade quizzes and exams with the other GTAs for the course. Chemistry 101 is a course designed for students who are not strong in math or have had no previous chemistry experience. This includes students who had not placed high enough on the chemistry placement exam to enter first semester college chemistry.

The professor for case 1 was a full tenured faculty member of 30 years. He had extensive experience with K-12 teacher professional development. Additionally, he was central to the initial development of the Chemistry 101 course, including being an author on the textbook used
in the course. He said in the interview that his teaching philosophy, “Teaching is providing opportunities for learning”, was central to how he supported the GTAs. He said that he built this philosophy in the design of the materials that he used in the course and that he provided suggestions to the GTAs with regards to using the materials. He described how he balanced providing structure to the GTAs through the worksheets and coaching provided in weekly meetings and emails with allowing them flexibility in how they ran their sections. His approach to coaching had three parts. 1) The professor explained his expectations for student learning in the classroom without limiting the GTA with specific rules. 2) He described helping the GTAs understand the learning environment of this campus, highlighting who the students they were teaching were (the student backgrounds and experiences may be different!). 3) He would explain the goals of each worksheet and discuss ideas of how to provide a structure in which students had the chance to work through the problems them instead of the GTA simply plowing through the answers.

4.1.1 Jane's data

Data for this case was collected during the fall semester 2015 (mid-August 2015-early December 2015). The first interview was conducted after the initial departmental training but prior to her assignment as a GTA to a specific chemistry course. The second interview was conducted on the last day of finals week. Jane had completed her required work related to her GTA appointment at this time. During the fall semester, Jane completed seven journals at two-week intervals.

Thirteen class meetings were observed during the fall 2015 semester. These class meetings spanned weeks six to thirteen of the semester. The observation from 9/28/2015 was
excluded from the analysis due to poor audio in the video. All other observations following this used supplementary audio recording. The summary of the data collected for Case 1 was presented in Table 3 (Chapter 3). The time spent in different modes of class work and activity type are summarized in Table 7. Jane’s use of instructional time was split approximately evenly between whole class instruction and student work. Whole class instruction included 13.3% spent going over quiz, 27.2% going over worksheet, and 5.3% preparing for exam. Student work, which was time students spent working on the worksheet individually or in small groups, was 54.2% of the instructional time in the observations of Jane’s instruction.

<table>
<thead>
<tr>
<th>Mode of instruction</th>
<th>Activity Type</th>
<th>Count</th>
<th>Time</th>
<th>% of instructional time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole class instruction</td>
<td>Going over Quiz/Exam</td>
<td>6</td>
<td>76 min</td>
<td>13.3%</td>
</tr>
<tr>
<td></td>
<td>Going Over Worksheet</td>
<td>12</td>
<td>155 min</td>
<td>27.2%</td>
</tr>
<tr>
<td></td>
<td>Preparing for Quiz/Exam</td>
<td>2</td>
<td>30 min</td>
<td>5.3%</td>
</tr>
<tr>
<td>Student Work</td>
<td>Group Work</td>
<td>11</td>
<td>308.5 min</td>
<td>54.2%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31</td>
<td>569.5 min</td>
<td></td>
</tr>
</tbody>
</table>

600 min of instructional time: 95% used

4.1.2 Jane's practices

I analyzed the class meeting observations by applying COPUS protocol. The COPUS data revealed patterns in student and GTA behavior that showed two modes of class work: *whole class instruction* and *student work*. As seen in Figure 9, the period of time from minutes 30 to 42 had a clearly different pattern of activity for both the students and the GTA. This was the period of completing the Worksheet Task. During this time, students were engaged in Group Work and asking Questions (brown squares and purple squares, respectively, in the “COPUS Student” row of Figure 9). Jane (shown in the “COPUS GTA” row) was engaged in One-on-One interactions
and Answering Questions (grey and purple squares). This pattern of interactions, which was found across Sections and Weeks in Case 1, is called “Student Work.” The remainder of the class meeting consisted of the activity types of going over a quiz, going over a worksheet, and preparing for an exam. The COPUS map shows students engaged in Listening, Asking Questions, and Answering Questions while Jane was Lecturing, Writing on Board, and Posing Questions. This pattern of interactions is called “Whole Class Instruction.” In Figure 9, student work is outlined in red and whole class instruction is outlined in blue.
Figure 9. COPUS data from Case 1. Blue is whole class instruction. Red is student work.
Each observation transcript was coded for the Jane’s practices as described in Chapter 3. The average of Jane’s practices over the entire set of observations were plotted in Figure 10 as described in Chapter 3. There were no occurrences of P12, P13, and P14 in Case 1. Jane’s most frequent practices for were prompting (P5), validation (P8), and direct answer (P10).

![Figure 10. Case 1 practices](image)

Practices were also divided by units of analysis to explore the learning environment factors that mediated Jane’s teaching practices. Representations were used to look for meaningful variations in the practices. Figure 11 shows the average count of Jane’s practices by three units of analysis: Week of observation, Activity type, and Section. Figure 11a shows Jane’s teaching practices across the different weeks of observation. This representation allowed for the exploration of the impact of content and worksheet structure on Jane’s teaching practices. Prompting (P5) was most common during Observation Week 3. Explaining (P7) and direct answer (P10) were most common in Observation Week 1.
Figure 1b separates Jane’s practices by Activity type. This representation allowed for the exploration of the impact of the activities and mode of class work. When considered from the perspective of Activity Type, validating (P8), correcting (P9) and direct answer (P10) are the most common teaching practices during the Group Work. As will be seen later, this is partially an artifact of the discrepancy in time spent on the different activities. However, this difference remains when time difference is accounted for by scaling the data.

Figure 1c considers teaching practices by the section. Considering Jane’s practices in this manner highlights how social interactions related to Jane’s teaching practices. Section differences in teaching practices show smaller variations, but the higher peaks for practices have different sections with higher counts of specific practices. For instance, checking-in (P2) is highest for Section C, and Sections A and B have the highest count of prompting (P5). These peaks in teaching practices, seen in the representation provided a process for exploring detailed selections of the data to understand the relationship between Jane’s teaching practices and learning environment factors.
4.1.3 Jane's identity: Overview

I labeled Jane’s model of teaching identity as *helper*. Her model of teaching identity is grounded in her experiences as a learner during her undergraduate education. As she begins to
teach, this model of teaching identity is seen in the teaching practices that emerged in the analysis. The variation in teaching practices suggests responsiveness of the model of teaching identity to the learning environmental. The enactment of the model of teaching identity becomes a metapragmatic model. *Helper* becomes more context specific: helping students help themselves.

In the following sections I will detail the analysis of the teaching practices and how the learning environment factors that mediated the teaching practices emerged from considering the practices from different perspectives. After detailing the teaching practices and mediating factors found in the learning environment, I will discuss Jane’s model of teaching identity and the emergence of the metapragmatic model of teaching identity.

**4.2 Learning Environment Factors that Mediate Practices**

*Practices* were considered from different perspectives to understand how Jane’s use of *practices* were mediated by factors found in the learning environment. I used the practice representations along with COPUS representations, to describe five learning environment factors that were related to the variations in Jane’s teaching practice. I describe these as mediators because they are necessary factors in the relationship between teaching identity and teaching practice but are not considered to be casual. This study does not try to understand the mechanism by which the learning environment factors are mediating the teaching practices.

The five learning environment factors that emerged from this analysis were: Content, Worksheet structure, Mode of instruction, Social interactions, and GTA’s observations.
Examining the data by the week of the observation provided a window into the influence of content and worksheet structure. The influence of the mode of class work was explored by considering the data by observation week and by activity type, Evidence for social interactions were found in considering practices by Section and COPUS maps. Evidence for Jane’s observations were found in her journals and interviews.

4.2.1 Content Mediates Jane's Practices

In this section, I describe how the patterns in Jane’s practices were mediated by the content of the course. As the chemistry content changed across the semester the types of practices used by Jane varied. These differences reflected how the specific content may have mediated Jane’s practices. Content is a learning environment factor that crosses the boundaries between the two communities of practice: chemistry learner and chemistry teacher. This means that Jane’s understanding of the content (e.g. how she learned it) has the potential for influencing the use of different teaching practices.

To understand how content was related to Jane’s teaching practices, practices were considered week-by-week as the content changed (Figure 11a, pg. 66). Four practices experienced peaks of frequency during different observation weeks. The peaks in certain practices were related to the nature of the content. I first consider how prompting and validating peaked in Observation Week 3.

4.2.1.1 Balancing reactions mediates prompting and validating

Observation Week 3 showed high counts of prompting (P5), validating (P8), and correcting (P9). Figure 12 shows these practices only. For clarity, validating and correcting were
combined into a single representation as validating occurred much more often than correcting. Jane engaged in *prompting* more often in Observation Week 3 than in any of the other observation weeks. She also engaged in a high count of *validating* and *correcting*. While *prompting* and *validating/correcting* could be related there was evidence that these could occur independently. Observation Week 3 (course week 10), focused on three areas of content: identifying reaction types, predicting products, and balancing reactions.

![Graph showing counts of practices per class meeting for prompting and validating/correcting across observation weeks.]

Figure 12. Content mediates practices of prompting, validating, and correcting.

When helping students balance reactions, *prompting* was a common practice, found in nearly every step of the interaction. Figure 13 is an example drawn from Observation Week 3 where Jane engages in prompting around a student question about balancing a reaction.

student: Nitrogen?

Jane: There's one on that side and how many on the other side?

student: 2

Jane: There's 2. How do you make the one on the left a 2 instead of 1.

student: Multiply by 2.

Jane: I would go ahead and do that. Next, let's check the oxygen. How many oxygen on the left side?

student: 3

Jane: Not 3.

student: Left side?

Jane: Yeah.

student: There's going to be 5.

Jane: Yeah there's 5 because there's two of those, right? So there's 5 oxygen and how many oxygen are there on this side?

student: 4.

Jane: I'll leave the oxygen a little later because that's a little confusing. One's 5 and one's 4. It's even and odd. Then you have your hydrogen. How many hydrogen on the left?

student: 2

Jane: Then on the right?

student: 1

Jane: How do you make that into a 2?

student: Multiply by 2.

Jane: Yep. Then check your oxygens.

Legend: Prompt Explain Validate/Correct Direct Answer Understanding Check Student Response

Figure 13. Example of prompting during balancing a reaction.
In this example, Jane interacted with a student to help her balance a chemical reaction. She prompted the student to count the number of elements, starting with nitrogen (Lines 1-6). At each step, the student gives a number (count) of the element. Jane validated the student’s answer by either repeating the number or moving directly to the next step. After validating (or correcting), Jane prompted the student for the next step. The algorithmic approach to balancing a reaction results in the alternating practices of prompting and validating by repeating steps of considering a single element on the reactant side and comparing it to the product side. As can be seen Figure 13, most of Jane’s turns during this interaction included prompting. In this case, prompting moves the student from considering how to balance one element to the balancing the next.

There was also a high rate of validating in Observation Week 3. In this example, validating was related to the occurrences of prompting. Since each step in the process of balancing a reaction is relatively simple, it was likely that Jane could validate the student’s response rather than correct it. To balance the reaction, the student needed to count the number of the element on the left side of the arrow and make the number on the right side of the arrow match. Validating occurred two ways during this observation: explicitly and implicitly. In looking at lines 3-5 of Figure 13, Jane validated the student’s response by repeating “2”. This was an explicit validation. Implicit validation can be seen in lines 15-17. In this portion of the excerpt, Jane prompted the student for the “hydrogens on the left”. After the student responded correctly that there were 2, Jane moves onto her next prompt without repeating the student’s answer.

Balancing reactions is a highly procedural task. There is little need at this level of instruction to have a deep conceptual understanding. This focus on procedure proficiency
encouraged teaching practices of *prompting* and *validating*. These teaching practices are useful for the GTA to make sure that students do not stray far from a productive process.

### 4.2.1.2 Ionic compounds and oxidation numbers mediate *explaining content* and *direct answer*

Two other teaching practices that had peaks based on the Observation Week were *explaining content* and *direct answer*. Observation Week 1 saw the highest count of *explaining content* (P7) and *direct answer* (P10; Figure 14). Jane’s use of *explaining content* and *direct answer* was related to content that covered during that course week. During this week, the content was focused on naming ionic compounds and assigning oxidation numbers. Students can learn this content using an algorithmic approach. Naming ionic compounds relies on memorizing the names of the components (e.g. cations and anions) and listing them in correct order. Assigning oxidation numbers is accomplished by following a list of rules, that were given to the students in the textbook and lecture, to systematically assign a numerical value to each element.

![Figure 14. Content mediates practices of explaining content and direct answer.](image-url)
Jane’s use of *explaining content* occurred when Jane explained how to use a given set of rules to assign oxidation numbers. In Figure 15, Jane’s interaction with the student explains each step of assigning the oxidation numbers of oxygen and sulfur in the sulfate ion. She *explains* how she uses the rule of “oxygen is negative 2” and that the overall oxidation numbers must equal the charge on the ion.

<table>
<thead>
<tr>
<th>Line</th>
<th>Jane:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>They can ... This can become positive, this can become a positive, and vice versa. This one, you have oxygen is negative two, and multiply by four to get negative 8. The overall charge has to be negative two, so then sulfur has to be is plus six.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>They have to be two...</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>How I write it out, I put sulfur, and there's only one of sulfur. You add it with the oxygen, so oxygen is negative two times four equals negative two, and you just solve it. <em>You see that?</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>Yeah.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>If you do it with this nitrogen, there's only nitrogen, so we put N as a variable. You add it, and then you have the oxygen, which is negative two. negative two time 3, and it equals overall charge of negative one.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:** Explaining  Understanding Check  Student Response

Figure 15. Excerpt showing *explaining content*.

In Line 1, Jane starts with *explaining* that elements can have positive or negative oxidation numbers. In Line 2, the student starts to interject with a possible question, but Jane continues with her explanation. She tells the student how to setup an equation to determine the oxidation number on sulfur. At the end of her explanation, an *understanding check* gives the student the opportunity to ask Jane for clarification or to confirm that Jane can move on. In Line 5, Jane wraps up her interaction with the student with a final clarification using *explaining content*.
Jane also used *explaining content* to cover how cations and anions must be put together to form neutral compounds. Jane used an algorithmic approach to assemble ionic compounds. In Figure 16 Jane explains how to determine the formula for zinc phosphate. She explains that the charge of the transition metal is something that “they tell you in the name”. She compares this with non-transition metals, the charges of which can be directly found on the periodic table. She then *explained* putting the ions together when she says, “this three goes down, this one goes down.”

Jane used *explain concept* to work students through the algorithms related to the content.

---

**Figure 16. Jane explains putting together ionic compounds with transition metals**

Jane: **No.** They tell you in the name. They have zinc phosphate, then this has the Roman numerals here, one. You can, or you don't have to put that Roman numeral on there. If they don't, and this is a transition metal, it has to be a transition metal, then you know it has a plus one charge. They give it to you. You already know zinc is plus one, so this is plus one. Aluminum, you know it's plus three. You know, you can find aluminum, because it's a metal. Transition metals, use Roman numerals. This, when you write it out, you have the zinc, it's plus one. You have the phosphate, which is negative three. This three goes down, this one goes down. Zn₃PO₄. Yes.

Legend: **Explain** Validate/Correct

---

*Direct answer* (P10) also peaked in Observation Week 1. *Direct answer,* or giving an answer without explanation, was a frequent practice in interactions in which students were asking for confirmation of their answers. In Figure 17, a student asked Jane if she “did them

---

2 There is an error in Jane’s answer. The correct formula is Zn₃(PO₄)₂
right?” Jane used *direct answer* by replying “this correct, that’s not correct.” While this example is also validating, Jane’s pointing to the student’s answers, and this action being in response to a student asking for confirmation that they are correct led to the assignment of *direct answer*.

---

1. student: Could you check my ionic compounds to see if I did them right?
2. Jane: **This correct, that's not correct.** This one, phosphate. **Same for this, correct.** Iron (II) nitrite. **Correct.** Sulfite, 2, 3, [inaudible] bromide. **Yep, except this one. You're on the right track except for this one. That's the only one I see.**

Legend: Direct Answer

Figure 17. Example 1 of *direct answer*

Jane also gave a *direct answer* when a student asked how they were supposed to know the formula for chromate (Figure 18). In addition to stating that chromate is a polyatomic ion, she further clarified where the student would find the information and how the student should know that this was (or was not) expected knowledge they should have. *Direct answer* was used here to address a student question that was related to knowledge recall.

---

1. Student: How are we going to know this, chromate?
2. Jane: **That's the polyatomic ions. You have to memorize that table, Table 3a. He did say that you don't need to memorize chromate, but he puts it on the discussion worksheet. This is CrO_4^-**.

Legend: Direct Answer

Figure 18. Example 2 of *direct answer*
In these examples of dealing with ionic compounds, the content was the primary mediator of practice. Naming ionic compounds was algorithmic content and led to favoring *explaining content*. Students sought validation of their answers which Jane addressed with *direct answer*. Jane used *direct answer* to address issues of knowledge recall, such as the names of polyatomic ions.

The content of the course was a driver of Jane’s practices. Content that was procedurally oriented, such as balancing reactions, was likely to result in more instances of *prompting* and *validating*. Content that was more algorithmically oriented, such as assigning oxidation numbers, drove more *explaining content* as Jane took students through problems step by step. While *prompting* and *validating* occurred with this content as well, it was more likely that Jane would explain the steps to complete the problems. In doing so, Jane used her knowledge of the chemistry concepts to inform her teaching (Wagner, Speer, & Rossa, 2007).

**4.2.2 Worksheet structure mediates Jane's teaching practices**

While content was a mediator of Jane’s teaching practice, the content cannot be separated from the structure of the worksheet. Indeed, the assignment of content type to the content in part relies on the way the content was presented on the worksheets.

In addition to the specific chemistry content, the structure of the questions on the worksheet also mediates teaching practice (Wenger, 1999). In a Community of Practice, the use of artifacts shares practices through scaffolding the process with new members of the community. The discussion worksheets, similar to the insurance company forms in Wenger’s study, are a good example of the reification of practice (Wenger, 1998). The structure of questions was likely related to the professor’s expectations for how students should work on
learning the content. These expectations were described in the interview with the professor. These expectations in turn can influence the teaching practices engaged in by the GTA.

The structure of the worksheet question mediates teaching practice. On Worksheet #6, which was used during observation week 1, students were asked to name ionic compounds. The text of the question has a clear expectation about how students should answer. This is because naming ionic compounds is based on a set of rules with no specific conceptual ties, leading to a straightforward, procedural question. Direct answer (P10) was the highest for this worksheet (Figure 19). For example, Jane used direct answer when students asked if their answer to a worksheet question was correct or to make a statement, such as the name of an ionic compound. The use of direct answer (P10) was high when Jane answered students’ questions regarding their correctness on questions that could be solved through an algorithmic approach.

Figure 19. Worksheet mediates practice of direct answer.
Figure 20a is a selection from worksheet #6. These questions asked the students to use an ionic name to get a formula or an ionic formula to get a name. This was made clear in the instructions. These two questions are algorithmic because specific steps can be used to get a correct answer.

**E. NAMING IONIC COMPOUNDS**

1. Write correct formulas for the following. Where an element is *not* one of the first twenty you may look up the element name. All anions should be ones that you know.

   a) silver phosphide  
   b) copper(I) chromate  
   c) iron(III) nitride  
   d) iron(II) nitrite  
   e) zinc phosphate  
   f) gold(III) sulfite

2. Write correct names for:

   a) CdBr₂  
   b) Cl₂O  
   c) TiSO₄  
   d) Al₂(CO₃)₃

---

Figure 20a. Question from worksheet used in Week 6

---

Figure 20b is an example interaction that Jane had with a student about this section of the worksheet. In this example, the student wanted to know about how to name the compound Al₂(CO₃)₃ and asked about using “2 lines” (i.e. Roman numerals). Jane responded in line 4 by directly answering that Roman numerals are only needed for transition metals. This was an example of direct answer, not explaining content, because Jane did not explain why but simply told the student a rule. Jane does, however, follow this up with an explanation of why when she explained that “they’re always changing”.

---

80
The worksheets also included questions that were less structured. These expectations of these questions were less detailed and led to student confusion. This was intentionally designed by the professor. For example, the question shown in Figure 21a covers ionic compound concepts was on worksheet #6. This question tells students that the content is about the formulas of ionic compounds with polyatomic ions, but the lack of labels on the table leaves the instructions vague and without an example. The table in this question was intended to help the students conceptually grasp how ionic compounds rely on a charge balance to have a neutral compound.

When a student asked, “what do you put on this table?”, Jane used direct answers to answer to address how to respond to the question without simply giving the student the answer to the question (Figure 21b). In Lines 2 and 4 of this excerpt, Jane gives the student an answer regarding what to do with the problem but with no explanation about how to do that problem. She says, several times, that the student needs to “write out the chemical formula” but she does

---

3 Intent of worksheet question design was discussed by the professor during the interview
4 Intent of worksheet question design was discussed by the professor during the interview
not explain to the student how to write a chemical formula and she does not provide an example. Therefore, this is an example of *direct answer* rather than *explaining content*.

---

C. FORMULAS OF IONIC SUBSTANCES WITH POLYATOMIC IONS

Complete the following table:

<table>
<thead>
<tr>
<th></th>
<th>K</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>ammonium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulfate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hydrogen sulfate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>perchlorate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Figure 21a. Question from worksheet used in Week 6

1 Student: What do you put on this table?

2 Jane: You're going to combine these to make a compound. You're going to use the x. You're going to use the cation and you're going to use this anion to form a compound.

3 Student: You just name it?

4 Jane: No, you write it out. You have to write out the chemical formula. You can name it for practice, but you could just write out the chemical formula.

Legend: Direct Answer

---

Figure 21b. Using *direct answer* to address question about Figure 21a.
Observation Week 4 had the highest count of checking-in of the four weeks of observations (Figure 22). The increase in checking-in was related to a specific question on the worksheet that confused the students. Figure 23 shows the question from the worksheet that likely led to the increase in checking-in. In Observation Week 4, students in some sections asked questions about what they were supposed to do on this worksheet. Jane then used checking-in with other students in the same section or other in later sections during the week.

![Bar chart showing checking-in count per class meeting](image)

**Figure 22.** Worksheet mediates checking-in.
Figure 24, the student tells Jane in line 1 that she doesn’t understand what the question is asking. Jane gives the student a direct answer in line 4, explaining what to do in the question. She tells the student to take “this” (the ratios that are included in the colored picture), and to “put it in each of the boxes”.

Figure 23. Question from worksheet used in Week 13.

Jane had an interaction with a student where the student asked how to do this problem. In
This interaction was followed by Jane checking-in with other students. She told them what the question was asking them to do. In Figure 25, Jane asked a group of students if they understood what to do on this question. In this example, it appears that the student was initially confused about the question. The student was not confused about the content but rather the expectation of the worksheet question. This confusion led to Jane engaging with students before they asked help.

---

<table>
<thead>
<tr>
<th>Student</th>
<th>I'm not sure I understand all of this. I was just trying to go through and do it. What are we supposed to be doing, I guess?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane</td>
<td>Did you read the directions right here?</td>
</tr>
<tr>
<td>Student</td>
<td>Mm-hmm (affirmative).</td>
</tr>
<tr>
<td>Jane</td>
<td><strong>You're literally going to take this, put it in each of the boxes, and fill in the boxes.</strong></td>
</tr>
</tbody>
</table>

Legend: **Direct Answer**

Figure 24. Jane using *direct answer* to address worksheet confusion.

This interaction was followed by Jane checking-in with other students. She told them what the question was asking them to do. In Figure 25, Jane asked a group of students if they understood what to do on this question. In this example, it appears that the student was initially confused about the question. The student was not confused about the content but rather the expectation of the worksheet question. This confusion led to Jane engaging with students before they asked help.

---

<table>
<thead>
<tr>
<th>Jane</th>
<th>Do you understand that you're just basically filling in these boxes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td><strong>Yeah. I'm going to set it up like that. That's why I erased.</strong></td>
</tr>
<tr>
<td>Jane</td>
<td>You can even keep it like this and say &quot;ratio over here.&quot; Put an arrow. This ratio's going to go here. This ratio is going to go in this step. You can just do that too. That's exactly what this is saying too, and that's what you're saying too. This goes to this step.</td>
</tr>
</tbody>
</table>

Legend: **Checking-In** **Direct Answer**

Figure 25. Jane using *checking-in*.

The structure of this worksheet question was a mediator of Jane’s teaching practice as she engaged in *direct answer* and *checking-in*. The increase in *checking-in* represents a shift to more
GTA initiated interactions. This shift is also seen in the COPUS data as an increase in Moving/Guiding behavior by Jane. All of the COPUS data maps can be found in Appendix D.

4.2.3 Mode of instruction mediates Jane's teaching practices

The mode of instruction is a mediator of teaching practice. The teaching practices during Whole Class Instruction were different from those during Student Work. Figure 26 shows the count of teaching practices during Whole Class Instruction and Student Work. Leading through problem (P4) and prompting (P5) were the most frequent teaching practices during whole class activities. Validating (P8), correcting (P9), and direct answer (P10) were the most frequent teaching practices during group work.

Figure 26. Practices by mode of instruction

5 Counts of practices per observation were adjusted for unequal time of the different activities. Counts of practices during whole class instruction were scaled up to be proportional to the amount of time spent during group work.
4.2.3.1 Whole Class Instruction

*Whole Class Instruction* included *going over quiz, going over worksheet, and preparing for exam*. During *Whole Class Instruction*, teaching practices that related to how Jane worked problems with the class (Figure 27) were more common than during *Student Work*. *Leading though problem* (P2), *understanding check* (P4), and *prompting* (P5) occurred at similar frequency during two activities: *Going over Quiz* and *Going over Worksheet*.6 These teaching practices defined the way in which Jane was engaging with students during *Whole Class Instruction*.

![Figure 27. Whole Class Instruction mediates practices](chart)

*Leading through problems* was more common during whole class instruction, which was GTA-led mode of instruction. Jane would go over answers to the quiz or to questions on the worksheet that she had selected. She would solicit input from students on questions to cover but she also clearly had selected questions that she intended to cover before leaving the class.

---

6 Preparing for exam was not included in this part of the analysis because it occurred very rarely.
Understanding check was a verbal check by Jane before moving on to another step. Jane’s use of understanding check provided students an opportunity to ask questions. Jane used understanding checks frequently before going on to another problem. This teaching practice was used less frequently in Student Work because Jane would move onto another group of students, or on to another student question, when there was an indication that they were done with the question. Figure 28 is an excerpt from Observation C1 where Jane is answering a student question during the Whole Class Instruction, specifically going over worksheet. Before moving on, Jane asked “does that make sense?” She quickly adds additional explanation and an example in line 7 before doing a second understanding check without receiving any input from the students. Jane then moved on to the next question without students asking any questions.

Prompting occurred at slightly more frequently during whole class instruction than during student work. Rather than simply provide each step to a problem, Jane prompted the students to fill in the next step or to answer why that is the next thing to do. During whole class instruction, Jane prompted every step of the problem and expected that students would provide a response. This is different than during student work where Jane did not prompt every step of the problem but prompted when a student appeared to be stuck, as evidenced by the student’s verbal pauses. Prompting was also limited by student questions. An interruption with student questions preempted the need for prompting. Figure 29 is an excerpt from Observation B3. In this excerpt, Jane is going over worksheet, specifically a balancing a reaction question. Jane prompts students (line 2), validates the student response (line 3), and prompts again (line 4). This quick pattern of prompting and validating is not interrupted by student questions. Jane engaged in explaining content in line 16 before returning to short prompt cycles. Jane ended this interaction with an understanding check and quickly moved on to another problem.
Jane: Yes?

Student: I put parentheses after the second HSO4. Would that be wrong?

Jane: Yeah. Technically, it's still correct, but it's wrong because there's no need to put the parentheses. The only time you're going to use the parentheses is, for example, the boron sulfate, is when it's more than one.

Student: Okay.

Jane: This has three of them.

Jane: Does that make sense?

Jane: Only put parentheses if it's more than one. See, I put no parentheses here. You could also, for example, for the first one, ammonium sulfate. If you do ammonium, NH4+, then sulfate, ammonium goes first. NH4+$^+$ SO4$^{2-}$. The two comes down, the one goes down. (NH4)2SO4. That's your answer. … … The reason is because this boron doesn't need a parentheses because it's only one element. You don't need to put parentheses, because you know there's only two of the boron. In this case, the sulfate, there's three of the sulfates. That means three of the sulfur, and then four times three, 12 of the oxygen. That's why we put the parentheses.

Jane: Yes? Anymore questions on this page, before I move on to oxidation. We're all good? We can do this?

Legend: Prompt  Explain  Validate/Correct  Direct Answer
Understanding Check  Student Response

Figure 28. Understanding check during Whole Class Instruction.
1 Jane: … … You want to balance this out. What I first do, usually I leave the oxygen at the end because that's everywhere throughout every compound so I don't want to mess with it… …

2 Jane: I look which one has the subscript and then go from there because you can't change the subscript on these compounds. It is what it is. It's the compound. I know that there's eight carbons here, on this side. How many carbons are on here right now?

3 student: 1
4 Jane: 1. So there needs to be 8, so what do I need to do?

… … (rounds of prompting/validating)

13 student: 9
14 Jane: 9. Then you add it up to get you?
15 student: 25
16 Jane: Yep, 25. You have 25 oxygen here and you have 2 here. … … How many hydrogen? 36. How many right now?
17 student: 2
18 Jane: How do I make it 36?
19 student: [inaudible] 18
20 Jane: Right? 18 times 2. … … How many in this compound? Add it together what do you get?
21 student: [inaudible]
22 Jane: So what do I put here?
23 student: 25
24 Jane: 25
25 Jane: Does that make sense? Yeah. I just go each way each. If that doesn't work out then that means … Right? Because 25. Then multiply by 2 and do it.
26 Jane: Any questions at all how I did this? Do you want another example or are we good to move on? Are we sure we're good? We know how to do this? Yeah? Okay.

Legend: Prompt  Explain  Validate/Correct  Direct Answer  Understanding Check  Student Response

Figure 29. Prompting during Whole Class Instruction
While prompting was more common in *whole class instruction*, there was also prompting during *student work*. During *student work*, students were more likely to interrupt the prompt-validate cycle. In the excerpt in Figure 30 Jane initially *prompts* a student to correct an answer (line 1) and explains “what does it need to have to be ionic?” in line 3. The student then asks a clarifying question in line 6. Jane did use *understanding check* in line 7, but in contrast to the previous example (Figure 29), Jane moved on when the student ended the interaction by confirming their understanding by saying “okay” in line 8. After the student ends the interaction, Jane goes to another student. This difference is presented here to highlight how *Whole Class Instruction* mediates teaching practice differently than *Student Work*.

---

| TA: You're missing some ionic compounds. | student: Oh yeah that's right. I don't know how you tell. |
| student: If it's ionic what does it need to have to be ionic? |
| Either a cation or an anion. |
| Yeah. Cation and anion those are ionic because of the ion. Cat-ion, an-ion that's what makes it ionic but one key thing when you're looking at these if it has a metal, ionic. |
| student: If it has a what? |
| TA: Metal. |
| student: Metal. |
| Right, because metals always hold the positive charge, most of the case, positive charge, and that's how you get your cation. Right? |
| TA: Okay |

Legend: Prompt  Explain  Validate/Correct  Direct Answer  Understanding Check  Student Response

Figure 30. *Prompting during Student Work*
Whole Class Instruction mediates teaching practices that maintained Jane’s control of the class. Jane’s use of leading through problems, understanding check, and prompting that, when used together during Whole Class Instruction, kept the class moving and allowed Jane to focus students on getting the right answer to the problem in the short period of time remaining at the end of the class meeting.

4.2.3.2 Student Work

During student work, students worked on the worksheet that had been provided by the professor. Jane engaged with students in one-on-one (or small group) interactions. Validating (P8), correcting (P9), and direct answer (P10) occurred more frequently during group work (see Figure 31).

![Bar Chart]

Figure 31. Student Work mediates teaching practice.

Validating and correcting are teaching practices that showed an interesting difference between Whole Class Instruction and Student Work. While the number of validating instances per observation are similar during both, correcting occurred almost exclusively during student
work. Student responses to Jane’s prompting during whole class instruction were likely to be correct, in that it is likely that students who would speak up during this time would be correct (Neal, 2008). In contrast, student work was a time that afforded Jane the opportunity to correct students. Figure 32 is an example of Jane being able to work one-on-one with a student to correct an error. This excerpt comes from a student asking for help with balancing a reaction. In line 3 Jane prompts the student to balance the next element, nitrogen. The student provides an incorrect response (line 4) and Jane implicitly corrects the student by repeating the prompt (line 5), explicitly correcting in line 7, and directing the student to really “look, look” in line 9. Jane finally corrects the student by pointing out the specific error in line 13.

<table>
<thead>
<tr>
<th></th>
<th>Jane:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>How do you make it a 2?</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>student:</td>
<td><em>Add 1? Or times by 2.</em></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Jane:</td>
<td><em>Times by 2.</em> Go ahead and do that. Times this by 2. <em>Right? Okay. Let’s go back to your nitrogen. Nitrogen, you have how many on this side?</em></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>student:</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Jane:</td>
<td><em>How many on this side?</em> (implicit correct by asking again)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>student:</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Jane:</td>
<td><em>No. (Correcting)</em></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>student:</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Jane:</td>
<td><em>Look, look.</em> (implicit correct by prompting again)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>student:</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Jane:</td>
<td><em>You have how many nitrogen in here?</em></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>student:</td>
<td>0 ... 1.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Jane:</td>
<td><em>You have 2 in front.</em></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>student:</td>
<td><em>Oh, 2.</em></td>
<td></td>
</tr>
</tbody>
</table>

Legend: **Prompt**  **Explain**  **Validate/Correct**  **Direct Answer**  **Understanding Check**  **Student Response**

Figure 32. Correcting during Group Work
Direct answer occurred more than twice as often during student work than during whole class instruction. Two things likely contributed to this difference. The first is that more student questions were likely to occur during student work and the second is that there was more repetition of similar questions and interactions. Jane would encounter the same question several times in the same section during student work; however, whole class instruction would not see multiple repetition of the same question during the activity. Jane also would move from a prompting and correcting cycle to using direct answer quickly during whole class instruction, to ensure that the correct answer provided to the students. In Figure 33 Jane moves directly from an implicit correction in line 7 to a direct answer without allowing time for the student to provide a new response. While this may be more efficient, it is likely that this repetition of questions reflected the affordance of student work for correcting and the high rate of direct answer.

<table>
<thead>
<tr>
<th></th>
<th>Jane:</th>
<th></th>
<th>student:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How many Os in this compound?</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Gets you?</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>How many Os in this compound?</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>How many Os here? Gets you 6. Os add up, those are good. That's your formula. Your balance chemical formula.</td>
<td></td>
<td>I missed the O part.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>This is 2, because there's 2 hydrogen.</td>
<td></td>
<td>Okay.</td>
<td></td>
</tr>
</tbody>
</table>

Legend: Prompt Explain Validate/Correct Direct Answer Understanding Check Student Response

Figure 33. Correcting during Whole Class Instruction
The two modes of instruction, *Whole Class Instruction* and *Student Work*, mediated the use of different teaching practices. During *Student Work*, students had the opportunity to ask questions and to get help without putting their ideas in front of the whole class. *Whole Class Instruction* afforded Jane the opportunity to get correct answers to students, either by giving them or *validating* them during a student response. It did not, however, provide a good opportunity for Jane to *correct* students. *Going over worksheet*, a significant activity type during *Whole Class Instruction*, typically occurred after the *Student Work*. The order of these activities meant that Jane had likely corrected many student errors before getting to *Whole Class Instruction*.

### 4.2.4 Social interaction mediates Jane's teaching practices

Jane’s interactions with the students in different sections were considered by counting the instances of unique interactions with students during *Student Work*. An *interaction* was coded in the transcripts by identifying the start of an interaction between Jane and a student. *Interactions* were represented by section to show the total number of interactions between the GTA and students (Figure 34). These representations support the analysis of the teaching practices by providing more information about the social interactions as they related to the content of the course and the social interactions between the class and the GTA.

Apart from content and activities, differences in students’ interactions mediated Jane’s teaching *practices*. Students initiated four interactions with Jane for every one that Jane initiated. This varies by section with *Section C* contributing greatly to this difference. Overall, students in *Section C* engaged with Jane through asking questions. *Section C* had a 20:1 ratio of student initiated to GTA initiated interactions.
The differences in how the students in each Section interacted with Jane are best demonstrated by considering the Week 4 observations. This observation was selected because it included a worksheet question that students had difficulty understanding and as well as a change in GTA behavior, with her sitting down during group work. The worksheet focused on in this section was discussed previously (see 4.2.2). In Observation Week 4, Jane sat at the front of the classroom while students engaged in group work on the worksheet for extended periods of time in each section. Figure 35 is the COPUS maps for all the sections Observation Week 4. The times that Jane sat at the front of the classroom are indicated by the blue boxes. Jane sitting down provided an opportunity for the differences in social interactions between sections to be more clearly seen. As I will discuss in the next section concerning Jane’s observations, Jane had confidence that students would ask questions if they needed help. This likely allowed her to sit down.
Case 1 - Section A - Observation 4 Data Map

Case 1 - Section B - Observation 4 Data Map

Figure 35. COPUS Maps for Observation 4. Continued on next page
Case 1 - Section C - Observation 4 Data Map

Case 1 - Section D - Observation 4 Data Map

COPUS Map Legend

<table>
<thead>
<tr>
<th>Activity</th>
<th>Quiz</th>
<th>Worksheet Task</th>
<th>Going Over Worksheet</th>
<th>Prepare for Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student COPUS</td>
<td>Listen</td>
<td>Group Work</td>
<td>Answer Question</td>
<td>Student Question</td>
</tr>
<tr>
<td>GTA COPUS</td>
<td>Lecture</td>
<td>Write on Board</td>
<td>Pose Question</td>
<td>Answer Question</td>
</tr>
<tr>
<td></td>
<td>Moving/Guiding</td>
<td>One on One</td>
<td>Administrative</td>
<td>Waiting</td>
</tr>
</tbody>
</table>
During Student Work, students in Sections A, C, and D asked questions, regardless of Jane sitting down (Figure 35). However, in Section B students did not ask questions for the first 28 minutes of the Student Work. Since the students were all working on the same worksheet, this difference is likely related to the students, which provides evidence for the mediator of teaching practice: social interactions.

The three sections that engaged in asking questions shared some patterns in the COPUS map and interaction analysis. When Jane sat down, there was usually a break in students asking questions, and Jane stopped sitting after questions resumed. In Section A, Jane started the student work portion of class by walking around and interacting with the students. She sat for approximately the last quarter of the student work. Students approached Jane at the desk to ask questions and she would answer but this did not result in Jane getting up from the desk. In Section C, student work started with the students asking questions while Jane was sitting at the desk. Between 2:00-8:00, students asked questions about the mapping question on the worksheet. Figure 36 is an example of the questions being asked during this time. These questions appear to prompt a change from sitting at the desk to moving around the room and interacting with the students. In Section D, Jane started the section by answering student questions and sat down at the desk after a break in the student questions. However, she did not remain long at the desk as students started asking questions again. This led to her moving and student questions kept Jane interacting with the class most of the time during group work. There were brief times during group work during which Jane sat at the desk.
In Section B, Jane started student work by sitting at the desk. She remained sitting for approximately 75% of the time students were working in groups. During that time students did not ask questions. At approximately 30 minutes into the student work, Jane simply got up and started checking-in by asking students about the mapping question. During these interactions, Jane asked students “how’d you do the mapping?” and then gave the direct answer explanation that was seen in response to the student questions in other sections. The lack of student initiation in Section B resulted in a lack of overall interaction, but also the most instances of checking-in. Observation 4 for all sections had the highest occurrence of checking-in (Figure 37).

Figure 36. Example of being asked about question in Figure 23

<table>
<thead>
<tr>
<th>Student:</th>
<th>Do I have to do it like this way, the map way? Or can I just do it my own way? Because I can do it my way and I think I have the right answer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane:</td>
<td>This one, it says, &quot;Don't carry out the calculations.&quot; It doesn't matter if you get the right answer or not. He wants you to understand why and what you're doing. He wants you to actually do this way even though you do a different way.</td>
</tr>
</tbody>
</table>
Social interaction with the students (or lack thereof) mediated Jane’s teaching practice during these observations. As was seen, Jane’s teaching practice was related to students’ asking questions. Some students (and sections) asked questions even when Jane was sitting at the desk. In those cases, there appears to have been an established expectation that students should ask questions. In Section B, Jane had to initiate interactions with students because the students did not ask questions. In the absence of those questions, it was Jane’s role to clarify the directions for the worksheet questions.

4.2.5 Jane's observations mediated Jane’s teaching practices

Jane’s reflections in her journals provide insight into how her observations impact her teaching practices and the interactions she has with students. In the previous section, I considered how social interactions mediated Jane’s teaching practices from the perspective of the different sections. This was an analysis of how others influenced Jane’s teaching practice. In this section, I consider how the teaching practices were mediated by Jane’s own observations.

4.2.5.1 Evidence of teaching practices in Jane's journals

Jane’s reflections provide evidence of the teaching practices that were identified in the observations. Her description of her teaching practices aligns with the teaching practices that emerged from the analysis of the observations. In her first reflection, Jane described her typical interaction with the students when going over the worksheet. In the following excerpt (Excerpt 1), Jane started with prompting (P5) the class, validating or correcting (P8/P9) after the students answered, and explaining the concept (P7). Jane described the teaching practice understanding check (P4) by describing how she would “ask the class if they have any questions” before moving on.
Excerpt 1
“I read the question and ask the class what the answer is. If the answer is right I explain why and if the answer is wrong I work through the problem so they understand how to get to the right answer. I make sure to ask the class if they have any questions before I move onto the next problem….” - Journal 1

Another instance of prompting is evident in Jane’s reflection on her teaching practice during office hours. After Jane led the student through one example of the problem, she used prompting to help the student work through a similar problem.

Excerpt 2 - “The student understood this problem, so I went ahead and asked a similar problem to the student. We still worked together on the problem, but I just asked the questions of “what should we do first” or “does our ratio look correct” and “is it okay to move on to the multiplication step.” I believe the student understood how to do the problem because was saying “oh that makes sense” and “I get it now.” - Journal 4

Jane described several instances of explaining content when reflecting in her journal. In Excerpt 3, in response to a student asking if an answer was correct, Jane used explaining content to give the student a direction for the question without giving them the answer. She ended the reflection with an example of leading through problem as a way to interact with a student when their answer was not correct and the student was not able to get the correct answer from Jane explaining the concept.

Excerpt 3
“One question was asking if they were simplifying the exponential problems correctly. I told them the rule for the specific problem and made them answer their own. If they can answer their own question correctly, then they have learned from their mistake. If they cannot answer their own question correctly, then I walk through the problem step-by-step to show them how to get to the right answer.” - Journal 2
Jane would use *understanding check* before she would go to the next question or topic on the worksheet. She described doing this during *going over worksheet* with the whole class in Excerpt 4. She described how she would ask if the students had any questions. However, she also observed that students would not ask questions and then would have poor performance on the quiz. She observed that reminding students they should ask more questions resulted in more student questions when she would use *understanding check*.

Excerpt 4

“One challenge I knew that I would face is students not asking questions when they need help. I would ask my students every time if there are any questions and when none of the students respond I move on to the next topic. When this happens majority of my students get those specific problems wrong on the quizzes. So I emphasized that they should ask questions because they all have the same questions. When I told them this reoccurring problem, the students were speaking up and started to ask more questions.” - Journal 3.

Jane’s observations extended to considering how students performed on the course quizzes and exams. In seeing what students did wrong on the quiz, she described using *direct answer* to inform students about “how the professor wants the quizzes graded and how to do better on the following quizzes” (Journal 1).

### 4.2.5.2 Jane's observations about students working in groups

Jane focused her discussions on having students work in groups, which was what the professor had instructed the GTAs to do. *Student work* allowed Jane to observe students’ knowledge, questions, and answers and she could use that to inform her teaching practice. Her journal reflections show that Jane wanted students to “ask questions to their classmates before they ask [her]” (Journal 1). This reflection aligns with the analysis in 4.2.4 that student questions
initiated the interactions between Jane and the students. Jane noticed that even when some students liked to work alone that “they would still help each other when they break off into groups” (Journal 1). She continued through the semester to encourage the students to ask each other first. In Journal 4, Jane reflected on students asking about problems where they were not using units. Jane “told them to use units” and then encouraged them to try again or to “ask their classmate.” She observed that encouraging the students this way “created a better atmosphere of learning.”

In her early reflections, Jane indicated that she didn’t “sit at [her] desk when class is in session, so it’s easier for [her] to get to the students and answer their questions” (Journal 1). As Jane built on her observation of students and as she encouraged them to work in groups, Jane started to act in the exact opposite way. As was discussed in 4.2.4, Jane started sitting down in the later observations. Changing from walking around to sitting is likely related to an established teaching practice of students working together in groups. Jane had an expectation rooted in observation that the students would ask questions and that sitting down would not hinder the students in asking those questions.

There is evidence that Jane was aware of how social interactions mediated her teaching practice. This is seen in her reflections about student questions. When Jane recognized that a question was occurring many times, she would “address the concern to the whole class, so everyone knows what to do for that question.” (Journal 1; also interview 2). Addressing the whole class this way is a way that Jane used direct answer. Jane could also use this knowledge to go group-to-group instead. She would check-in with the students to see if they had questions. In Journal 7, Jane noted that she had not expected students to have trouble with “the simple mapping of stoichiometry.” Jane’s observation of student trouble in her reflection aligns with
how the worksheet structure was a mediated her teaching practice (see 4.2.2). Her observations also align with the observation that Jane would initiate interactions with students if they were not asking questions (see 4.2.4).

4.2.5.3 Jane's observations inform differences in teaching practices across sections

Section differences not only resulted from social interactions but also from Jane’s observations. She used observations from discussions early in the week to inform her teaching practices in discussions later in the week. In describing a specific interaction in her reflection in Journal 1, Jane noted that she gained understanding about the “students’ knowledge level” and that she made changes to the following discussions. Jane also used her knowledge of student questions from previous discussion sections to inform her teaching practice in future sections in the absence of questions from the students. An example of this was seen in 4.2.4 when Jane interacted with Section B, the students who didn’t generally ask questions. Using her observation of the difficulties that students encountered in Section A, Jane decided to initiate interactions with students in Section B after giving them most of the student work time to ask for help.

4.2.6 Teaching Practice Summary

This section has shown the practices that were observed during Jane’s first semester of teaching. I considered how Jane’s teaching practices were related to learning environment factors. These teaching practices and learning environment factors provide a lens for understanding Jane’s teaching identity during her first semester of teaching. The next section explores how teaching practices and their interactions with learning environment factors relate to Jane’s teaching identity.
4.3 Jane's Teaching Identity

In describing Jane’s teaching identity, I start by describing the model of teaching identity which Jane brought with her from her experiences as a student. As Jane first starts teaching, she bases her teaching practices on role models from her own experiences (Wenger, 1998). As the semester continues, the analysis of teaching practices provides a lens into further understanding Jane’s teaching identity. Finally, I describe how the enactment of the Jane’s model of teaching identity, as seen in her teaching practices allow me to articulate Jane’s metapragmatic models of teaching identity.

4.3.1 Jane's model of teaching identity: Helper

At the beginning of the semester, Jane’s teaching practices and identity were rooted in her own experiences as a student in chemistry classes. These experiences provided Jane with role models (previous professors and GTAs) on which to base her teaching practices (Wenger, 1998).

Jane’s first interview provided a window into the model of teaching identity with which she began her teaching experience. In reflecting on her learning experiences in college chemistry, Jane presented a model of teaching identity that I labeled as Helper. In Jane’s first interview, the Helper model of teaching identity emerged as being defined as being approachable by students and being able to provide the support necessary for students to be successful.

Jane’s model of teaching identity has a sociohistorical basis (Wortham, 2006) in that it is based on her experiences as a student. Jane had several strong impressions of effective professors being the ones that made it clear that they were there to help the students. In one instance, she reflected on how her organic chemistry professor told the class “I’m here to help you as much as
I can. I’m here for you” (Interview 1). This idea of a good instructor being present for the student built on an already expected helpful role of a graduate teaching assistant. Her recollection of GTAs was that “…the TAs were very helpful. I always remember chemistry, if you didn't understand what (sic) lecture, you go to the TA.” (Interview 1). These examples show that Jane’s initial model of teaching identity is grounded in her previous experiences as a learner (Lortie, 1975; Sandi-Urena, & Gatlin, 2013) and aligned to a sociohistorical model that was apparently present at her undergraduate institution.

Further evidence of the model of teaching identity of helper is found in Jane’s journals. In her first journal, Jane reflected that it made her happy to know that the students “walk into my class not knowing how to do the problem, but walk out knowing how to do the problems” (Journal 1). In this early entry, Jane’s model of teaching identity of helper was centered on her giving help to the students, ensuring that they left with more knowledge than they came in with.

The model of teaching identity of helper is also supported by Jane’s reflection on wanting students to do well. Early in the semester, she personally assumes a lot of the responsibility for students doing well. When she reflects that “[when] students do poorly I feel as if I am doing a mistake in teaching style” (Journal 3), there is the suggestion that her helping was insufficient for getting students to an understanding that would make them successful in chemistry. She still saw herself as a helper in her final journal. She reflected that it was “nice to know that I helped students like chemistry and to see [the students] improve throughout the semester” (Journal 7). Jane’s model of teaching identity starts as a sociohistorical model. Through her teaching practices and her interactions with the different students, a metapragmatic model of teaching identity related to the sociohistorical model develops and can be observed.
4.3.2 Jane's metapragmatic model of identity: *Helping students help themselves*

It is through practice that aspects of identity can be observed (Wenger, 1998). The analysis of Jane’s teaching practices suggested that different learning environment factors interacted with Jane’s metapragmatic model of teaching identity. These analyses supported the description of Jane’s metapragmatic model of teaching identity as *helper*.

Three of the learning environment factors provided a lens into the relationship of Jane’s metapragmatic model of teaching identity and the Community of Practice. *Content, Worksheet structure,* and *Mode of instruction* are learning environment factors that related to the expectations of the community of practice. The analysis of teaching practices, through the lens of learning environment factors, show how the enactment of the teaching identity leads to the emergence of a metapragmatic model of teaching identity. In the enactment of the model of teaching identity, the definition of *helper* shifted from being a generic helper to a more specific idea of *helping students help themselves*.

It is the enactment of a model of identity in a specific context that defines the metapragmatic model of identity (Wortham, 2006). The model of teaching identity of *helper* is a sociohistorical-based model of identity and Jane’s interactions with learning environment factors (e.g. the sections of students, worksheet structure) contributed to Jane’s metapragmatic model of teaching identity of *helping students*. I described this metapragmatic model of teaching identity as *helping students help themselves*. This means that rather than helping a student get to a correct answer by simply giving them the answer, Jane focused instead on providing students with minimal amounts of support to get them past points of confusion and difficulty. Thus, students are then able to use the help that Jane provided to subsequently help themselves.
4.3.2.1 Teaching practice and metapragmatic model of teaching identity: Content as mediator

The responsiveness of Jane’s teaching practices to the content of the course suggest that her model of teaching identity aligned with expectations of the community of practice. The content of the course is defined by the community of practice. It is a corpus of knowledge that is considered to be important for the given level of chemistry instruction. In this, the content itself acts as a member of the community. By considering the content as a non-human actor (Latour, 1999), the frameworks of Community of Practice and Social Identification are expanded. Wenger considered the insurance forms in understanding how practices were being reified but did not consider how the content of the insurance forms also related to practice. In describing metapragmatic models of identity in a social studies class, Wortham considered the topics being discussed only in how they framed the discussion, how they were used, but not in how the content itself may have directed the discourse. Content provided an overlap between Jane’s experiences as a learner of chemistry to her new experiences as a teacher of chemistry. This overlap supported the development of Jane’s metapragmatic model of teaching identity as she transitioned into the role of teacher.

4.3.2.2 Teaching practice and metapragmatic model of teaching identity: Worksheet structure as mediator

Worksheets represent instances of reification of practice (Wenger, 1998). It is through worksheets that the professor can communicate expectations for practice. Jane’s teaching practices, as they related to the worksheet, demonstrate that her selection of teaching practices was influenced by the professor, an established member of the community of practice. As was
shown in 4.2.2, Jane worked with the structure of the worksheet in answering student questions by clarifying the question rather than giving answers. The worksheet structure was designed to have students figure out answers, not to simply be given answers. Jane’s teaching practices in dealing with the worksheets shows an adoption of the teaching practices that were intended by the professor. In the specific examples given in 4.2.2, Jane’s teaching practices focused on clarifying the question expectations though direct answer and checking-in. This supported the function of the worksheet rather than by-passing it. Jane’s metapragmatic model of teaching identity was responsive to the expectations of the community of practice that were communicated through the structure of the worksheet.

4.3.2.3 Teaching practice and metapragmatic model of teaching identity: Mode of instruction as mediator

The course structure is grounded in a long history of college instruction and the expectations of the professor. The professor provided the worksheets for discussion and with these an expectation for students to engage in Student Work. This mode of instruction mediated Jane’s teaching practices when students were working on the worksheet and were aligned with allowing students to help each other.

Worksheets were used during group work and it is difficult to fully separate the effects on teaching practice of the worksheet structure from the mode of instruction. However, having students work individually or in small groups was an expectation communicated by professor. The teaching practices that Jane engaged in supported students in this type of activity. She did this by engaging in teaching practices that relied on students to initiate interactions. In structuring the classes around the worksheet and Student Work, Jane allowed the students time to
engage with the content and the worksheet structure before she would step in. When students sought help, Jane would prompt students to get them to the next step. She would use direct answer to clarify confusion about what to do. When she recognized that students weren’t helping themselves, Jane would use checking-in to encourage students to get help. Jane’s teaching practices helped students help themselves rather than

Understanding the relationship of learning environment factors and teaching practices helps reveal the metapragmatic model of teaching identity. Jane’s model of teaching identity of helper is enacted as a metapragmatic model of teaching identity: Jane is helping students help themselves. Jane’s metapragmatic model of teaching identity is the situational enactment of the sociohistorical model to the specific context in which Jane is teaching.

4.3.2.4 Teaching practice and metapragmatic model of teaching identity: Social interactions as mediator

Social interactions were related to how the model of teaching identity was enacted as a metapragmatic model of teaching identity. Evidence in Jane’s journals supports the description of the metapragmatic model of teaching identity. Social interactions between Jane and students varied across sections and this also provides evidence for the metapragmatic model of teaching identity. As was described in section 4.2.4, students in some sections were more likely to ask questions and to initiate interactions with Jane during group work. Jane also shifted from walking around at all times to sitting down. Sitting down allowed Jane to give students the space to do the work themselves and then to help them when they asked for help. However, when Jane knew about expected difficulties and students didn’t ask questions, she initiated interactions intended to get students to critically think about problems. She used checking-in to find out if a
student needed help but hadn’t asked for it. This is an example of Jane allowing students to help themselves but also of her recognizing when students have not recognized that they need help. These interactions highlighted the ways in which helping took different forms in the different classes. A metapragmatic identity of helping students help themselves supports how Jane dealt with the ways in which different students engaged with group work and the worksheets. She allowed students to ask for help but also realized when she needed to give the students help when they hadn’t asked.

4.3.2.5 Teaching practice and metapragmatic model of teaching identity: GTA observations as mediator

Jane’s journals support the metapragmatic model of teaching identity of helping students help themselves. Jane’s conception of what it means to be a helper showed change when she reflected that there was “only so much that [she] can do” to help students and that “[the students] should also review the material [they] went over and do more practice problems.” (Journal 2). This reflection suggests that the enactment of Helper was becoming a more nuanced form: helping students help themselves rather than simply helping. Further evidence of Jane’s metapragmatic model of teaching identity was seen in Jane’s fifth journal reflection. As Jane learned more about the resources available to students in Chemistry 500, she made sure to make students aware of the resources so that “they know we [instructors] are here to help” (Journal 5).

In Jane’s reflection that “when [students] do poorly I feel as if I am doing a mistake in teaching style” (Journal 3), there was the suggestion that her helping was insufficient for getting students to an understanding what would make them successful in chemistry. This suggests that
Jane recognized that her help was not sufficient for every student to succeed, but rather that students needed to be able to use the help she provided to help themselves.

Through her reflections in her journals, there is evidence that Jane’s metapragmatic model of teaching identity was developing. She continued to describe herself as a helper in her final journal but the description had been refined. She reflected that it was “nice to know that I helped students like chemistry and to see [the students] improve throughout the semester” (Journal 7). However, she recognized that “this doesn’t mean that everyone learns well with my style of teaching.” Jane saw that not every student will take on their part to learn in chemistry. This recognition indicated Jane’s metapragmatic model of teaching identity, helping students help themselves, was how the model of identity had been enacted.

Jane also recognized that students didn’t always know how to help themselves. Jane observed that some students didn’t ask questions or avoided saying they needed help. She specifically recounts asking students about their understanding of algebra and based on their response she chose to skip going over a section of the worksheet (Journal 2). After seeing the students’ work on the quiz, Jane “learned that [she] should not assume anything and go over essentially everything on the worksheet” (Journal 2). Jane’s observation of the students’ lack of question when they demonstrated a lack of understanding on the quiz led to her decision to go over an example of each type from the work. However, this did not lead her to try to do every problem with the students. This example of students’ not helping themselves provides evidence of her metapragmatic model of teaching identity through the absence of the students helping themselves. Jane’s recognition that students often didn’t know when to ask for help was also evident in the social interactions discussed in 4.2.4.
At the end of the semester, Jane’s second interview provides evidence that Jane’s metapragmatic model of teaching identity had developed in this direction. She noted that she “didn’t have time in discussion to finish all of the worksheet” and she suggested that if the “students worked on it before they could ask more questions” (Interview 2). Jane’s encouragement of students to be ready with questions aligns with helping students help themselves. She also saw ways in which in her class practice supported students outside of class. By supporting students in group work, Jane saw that “group work helps them help themselves by establishing relationships that can be useful for working outside of discussion (emphasis added)” (Interview 2).

Finally, Jane described teaching differently than she did at the beginning of the semester. She initially described teaching as making “sure that the students know that any question is a good question. (Interview 1)” and focused on class management issues such as “being loud (interview 1).” At the end of her first teaching experience, Jane described her idea about teaching as being able “to give the knowledge to [the students] in a way that they are able to think outside the classroom” (Interview 2).

Jane’s journal reflections show an emergence of a metapragmatic model of teaching identity that aligns with what I have described above. At the start of the semester, she focused on how she could help students. This was a focus on what help she could give the students. Over the semester, this model of teaching identity evolved to be more inclusive of how her help could provide students with the competence and the skills to help themselves.
4.4 Case 1 Conclusions

This chapter described Jane’s model of teaching identity during her first semester of teaching. I began by describing the teaching practices and learning environment factors that mediated Jane’s use of those teaching practices. I discussed Jane’s model of teaching identity and how teaching practices provide evidence for the model of teaching identity. Last, I discussed the metapragmatic model of teaching identity.

*Teaching practices* emerged from coding the transcripts of the observations. There was not a single teaching practice that dominated throughout the observations. Content, worksheet structure, mode of instruction, social interactions, and Jane’s observations emerged as learning environment factors that mediated Jane’s use of teaching practices. Considering how the teaching practices and learning environment factors were related supported the description of how the model of teaching identity became a metapragmatic model of identity through enactment.

Jane’s metapragmatic model of teaching identity drew on a sociohistorical model of teaching that I labeled as *helper*. Through the interactions with the learning environment, the metapragmatic model of teaching identity emerged. I described this metapragmatic model of teaching identity as shifting from *helping students* to *helping students help themselves*. The differences in teaching practices between sections demonstrate how the metapragmatic model of teaching identity varied with the social interactions.
Here, I discuss how each of the research questions are addressed by my findings in Case 1. The research questions guiding this study were:

1) What factors in the learning environment mediate GTA teaching practices?
2) How are teaching practices, learning environment factors, and the GTA’s metapragmatic model of teaching identity related?
   2a) How are the community of practice and the GTA’s metapragmatic model of teaching identity related?
   2b) How are social interactions and the GTA’s metapragmatic model of teaching identity related?

4.4.1 Case 1: What learning environment factors mediate GTA teaching practices?

Case Study 1 addresses my research questions first with emergence of the learning environment factors that mediated teaching practices. Five *learning environment factors* emerged from the analysis of Jane’s teaching practices.

- **Content.** Jane engaged in *prompting* and *validating* when the content was readily approachable through a defined set of steps or pattern matching. For example, when helping students balance reactions, the back and forth of considering reactant then product relied on following a set pattern. Jane engaged in *explaining content* when the content required more understanding of the content than a pattern matching or procedures could account for. This was seen in the way that Jane handled questions about correctly assembling ionic compounds to have an overall neutral charge.

- **Worksheet structure.** Jane’s teaching practices were responsive to the difference between questions with straightforward directions and ones where the question was ill defined.
Jane used *direct answer* when clarifying what a question was asking a student to do and *explaining content* when the difficulty was with the content instead of the worksheet structure.

- **Mode of instruction.** *Leading through problem* and *prompting* were the most frequent teaching practices during *Whole Class Instruction*. *Validating, correcting, and direct answer* were the most frequent teaching practices during *Student Work*. These two *modes of instruction* afforded Jane with opportunities to engage with students using different teaching practices.

- **Social interactions.** Some sections of students engaged in asking Jane questions during *Student Work* even when Jane sat down. The differences in sections is best highlighted in the Jane’s use of *checking-in*. Jane used *checking-in* when students were not asking questions about confusing material. It was through previous social interactions that Jane was aware that students might be having trouble but weren’t thinking to ask questions.

- **Jane’s observations.** Jane indicated in her journals many ways that her observations impacted her teaching practices. For example, Jane had observed that students didn’t know when they didn’t understand the material and so she altered her teaching practices to make decisions about what content to cover during *Whole Class Instruction*, even if students did not ask questions. Jane engaged in *checking-in* when she observed that students were not asking questions during *Student Work*. 
4.4.2 Case 1: How are teaching practices, learning environment factors, and the GTA’s metapragmatic model of teaching identity related?

The model of teaching identity of helper supported student-centered teaching practices. As a helper, Jane structured the classes around students’ thinking by allowing time for them to engage in the worksheets during group work. Student initiated interactions, through questions during group work, were also possible because Jane’s model of teaching identity led her to teaching practices that were responsive to the students rather than imposing on the students.

Content, Worksheet structure, and Mode of instruction were learning environment factors that provided structure to the learning environment because of their relationship to community of practice. The content of the course, which is conveyed in the worksheets, conveyed the body of knowledge that was considered important by the community of practice. Jane used her knowledge and experience of learning the content to inform how she interacted with the students (Kurdziel et al. 2003; Olson & Hora, 2013; Volkman, Abell, Zgagaca, 2005). The worksheet structure conveyed expectations for how to engage with the students (Wenger, 1998). By encouraging the GTA to structure discussion around group work, the professor was conveying a preference for certain types of teaching practices. Jane responded to the structure of the worksheet, choosing to clarify questions for students or to address content as was suggested by the worksheet structure and the content (Latour, 1999; Wenger, 1998; Wink, 2017). These three teaching practices also afforded opportunities for student initiated social interactions to occur.

In the real setting of the classroom, the effects of content, worksheet structure, and mode of instruction cannot be fully separated from the social interactions and GTA observation. Teaching identity was not solely defined by the learning environment structure and the community of practice, it also emerged from the social interactions and GTA observations.
Student Work permitted social interactions to occur in ways that were not possible during Whole Class Instruction. During student work, the presences and absence of student initiated social interactions led Jane to use different teaching practices (Wortham, 2005). Jane’s observation was required for noticing when a lack of interaction suggested that she needed to intervene. The learning environment factors cannot be completely disentangled from each other, but considering each of them separately permitted an analysis that can be used to inform the design of GTA training.

The metapragmatic model of identity emerged from the enactment Jane’s model of teaching identity with the learning environment factors. Jane’s initial model of teaching identity as helper was a model of identity that was open to change. A helper seeks out ways to help. This is a model of teaching identity that is responsive to the community of practice and the students. The changes in Jane’s teaching practices over the semester show that her model of teaching identity developed into the metapragmatic model of teaching identity helping students help themselves.

The model of teaching identity that Jane initially draws on for her teaching was responsive to teaching practices and to the learning environment factors. Jane’s teaching practices varied over the semester, between sections, and by the activity type. There was a relationship between Jane’s teaching practices and her model of teaching identity. The analysis of Jane’s teaching practices supported the description of a metapragmatic model of teaching identity as helping students help themselves. Jane’s model of teaching identity was responsive to the learning environment.
5.0 CASE 2: EDWARD

The second case I present is Edward. To introduce the case, I provide a brief description of the data collected, the teaching practices, and an overview of Edward’s model of teaching identity. I next discuss in detail the analysis of the case including teaching practices and their relationship with the learning environment factors. I end the discussion of this case by discussing Edward’s teaching identity: how it related to his initial model of identity, how teaching practices and learning environment factors related to his teaching identity, and the metapragmatic model of teaching identity through the enactment of the model of teaching identity.

5.1 Case 2 Introduction

The participant for Case 2 was Edward. He was a first-year chemistry graduate student. After getting a PhD he intends to do non-academic research, such as working at a National Lab (e.g. Argonne National Lab).

Edward started undergraduate school as an economics and math double major but switched to chemistry because he had been “good at it and had a lot AP credit” (Interview 1). When he did start chemistry in college he started with organic chemistry. He described that he felt at a disadvantage starting in organic chemistry because he lacked experience in “doing college chemistry” (Interview 1).

Edward had experiences as a student with “bad teaching” (Interview 1). He described having a GTA that “would just give out the answer because oftentimes the class was very slow
moving.” Instead of helping students figure out the answers the GTA would just say “Here’s the answer” (Interview 1). Edward described “just giving an answer” as “bad teaching” (Interview 1). Other GTAs were more focused on using the “basics” and on working with the students to “figure it out” (Interview 1). Edward described the second approach to be more helpful for learning and stated that he would encourage students to ask questions. He drew on experiences in chemistry lab to describe good teaching as the GTA being clear about the expectations (Interview 1).

Prior to graduate school, Edward had experience tutoring other students but no formal teaching experience. He was assigned as a GTA to a preparatory chemistry course (Chemistry 101). He was assigned to teach six 50-minute discussion sections, to be available to students for two hours of office hours, and to grade quizzes and exams with the other GTAs for the course. Chemistry 101 is a course for students who had not placed high enough on the chemistry placement exam to enter first semester college chemistry.

The professor for Case 2 was a lecturer with experience working in industry prior to returning to academia. This was the first semester that she was lecturing for Chemistry 101 but she had experience with higher level courses previously and with a summer workshop that covered the same material. She explained during the interview that her expectations for the GTAs working with her for this class was that the GTAs were to be highly independent. She provided worksheets for class but the GTAs had to complete them individually to have the answers. She described that this was a way for her to encourage the GTAs to prepare themselves for teaching. The professor explained that she used the weekly meetings with the GTAs to discuss issues of student understandings or difficulties faced by the GTAs. Overall, she described a focus on allowing the GTAs the independence to make their own decisions about teaching.
5.1.1 Edward's data

Data for this case was collected during the fall semester 2015 (mid-August 2015-early December 2015). The first interview with Edward was conducted after the initial departmental training but prior to his assignment as a GTA to a specific chemistry course. The second interview was conducted during the week after final exams. Edward had completed his duties related to his GTA appointment at this time. During the fall semester, Edward completed seven journals at two-week intervals.

Edward was observed during four different weeks of the semester, for a total of twelve observations. The observations covered five of the six sections that Edward was responsible for teaching. Section D was observed only once and was excluded from the analysis.

The discussion worksheets for the weeks of the observations were collected from the professor. The worksheets provided by the professor were structured around questions copied from the textbook. An example worksheet is provided in Appendix B. The questions on the worksheet were not intended to induce cognitive dissonance in the way that the professor in Case 1 intended (professor interview). Table 3 (see Chapter 3) details the data collected for Case 2. Table 8 summarizes the time of the mode of class work and activity types in Case 2. Edward spent only 5.5% of his time (during observations) on Student Work. Going over quiz was 21.1% of the observed instructional time. Going over worksheet was the majority of the instructional time at 73.3% of the time.
Table 8. Case 2 Activities (count, time, % of instructional time)

<table>
<thead>
<tr>
<th>Mode of class work</th>
<th>Activity Type</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole class instruction</td>
<td>Going over Quiz/Exam</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>103.2 min</td>
</tr>
<tr>
<td></td>
<td>Going Over Worksheet</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>357.8 min</td>
</tr>
<tr>
<td></td>
<td>Preparing for Quiz/Exam</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Student Work</td>
<td>Group Work</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 min</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>24</td>
</tr>
</tbody>
</table>
|                        |                      | 488 min  | 550 min of instructional time: 81.5% used

5.1.2 Edward's teaching practices

I analyzed the observations by using COPUS during the observation. COPUS maps for each observation were prepared as described in Chapter 3. Figure 38 is an example COPUS map for Case 2. Case 2 COPUS maps included “student at board” which is an adapted code from COPUS “student presentation”. This code was not seen in Case 1. Additional COPUS maps will be included in sections as they are used in the analysis.
Figure 38. Example of COPUS map for Case 2.
Each observation transcript was coded for the teaching practices of the GTA as described in Chapter 3. Teaching practices were plotted in Figure 39 as described in Chapter 3.

![Figure 39. Case 2 Practices](chart)

The teaching practices for Case 2 were tabulated and grouped by Observation week, by Activity type, and by Section (Figure 40). These representations were used to look for meaningful variations in the teaching practices. Figure 40a shows Edwards’s teaching practices across the different Observation Weeks. This representation allowed for the exploration of the impact of content and worksheet structure on Edward’s teaching practices. Figure 40b separates Edwards’s teaching practices by activity type. This representation allowed for the exploration of the impact of activities and mode of instruction. Figure 40c considers teaching practices by the Section. Considering Edwards’s teaching practices in this manner highlights how social interactions related to Edward’s teaching practice. Three teaching practices were consistently the most frequent, regardless of how the teaching practices codes were categorized. Prompting (P5), explaining (P7), and validating (P8) were the most common teaching practices observed. This
resulted regardless of observation, activity types, or section. The absolute count of each teaching practice was less for *going over quiz* than *going over worksheet* but this is simply an artifact of the difference in time spent on these activity types. *Encouraging students to participate* (P12), *students work at the board* (P13), *ask students why* (P14) were three teaching practices that related to Edward having students do work on the board and explain their answers.

![Figure 40a. Case 2 Practices by Observation Week](image)

![Figure 40b. Case 2 Practices by Activity Type](image)
5.1.3 Edward’s identity: Overview

The analysis of Edward’s observations, interviews and journals suggested a model of teaching identity that I labeled as leader. Edward’s journals indicated that he described what did in class as leading students to the correct answer, not telling them the correct answer. Additionally, there is a consistency in the teaching practices across the different observations. The variability of teaching practices seen when considered by activity was a result of a difference in time spent on the different activities. This consistency may suggest that Edward’s teaching identity is only moderately responsive to environmental (e.g. course structure, worksheets) and social factors (e.g. students) by the point of the semester that the observations occurred. It may be that Edward already had strong ideas prior ideas about teaching. There are some small differences that suggest that variations in the metapragmatic model of teaching identity developed in responding to the differences in students (i.e. across sections) and the course structures (i.e. going over quizzes).
In the following sections I detail the analysis of the teaching practices and the learning environment factors. After detailing the teaching practices and learning environment factors that mediated those teaching practices, I will discuss Edwards’s model of teaching identity: how it can be seen in the teaching practices and interactions with the learning environment factors and how it is enacted as a metapragmatic model of teaching identity.

5.2 Edward’s Teaching Practices

Edward’s teaching practices were explored in similar manner as described for Case 1. I will discuss practices from each of the learning environment factors before discussing how Edward’s model of teaching identity is seen in the practices and their interaction with the learning environment.

Teaching practices were considered from different perspectives to understand how the learning environment factors mediated Edward’s teaching practices. Using the practice and COPUS representations, I considered how emergent patterns of practices related to content, worksheet structure, mode of class work, social interactions and Edward’s observations.

I will first describe two persistent patterns of practices that were found in the data and that I labeled as IRE and Board Work. The IRE pattern emerged when considering the teaching practices across the entire data set. A pattern emerges where prompting (P5), validating (P8)/correcting (P9), and explain (P7) are the most frequent practices observed in Case 2 (Figure 41). These practices were commonly found together, in a sequence initiated by Edward.
Figure 42 is an excerpt from Observation C3 that is an example of how this pattern appeared in interactions between Edward and students. At the end of his first turn, Edward *prompts* the student to identify the type of information needed for the question. After the student responds, Edward *validates* the student response in line 3 by repeating the student’s answer. This finishes the pattern of practices. A new round starts with Edward *prompting* the student again at the end of his turn in line 3.
This pattern of practices aligns with the initiate-respond-evaluate (IRE) style of teaching (Mehan, 1979; Sinclair & Coulthard, 1975). The IRE pattern of instruction is a heavily teacher-centered approach to teaching in which there is – “1) Initiation by the teacher, 2) Reply from the student, followed by 3) an Evaluative comment from the teacher (Mehan, 1979 cited in Sherin 2002).” IRE is commonly seen in college instruction and as such Edward had likely experienced this type of instruction (Neal, 2008; Sherin, 2002). A common variation of the IRE style of instruction includes an explanation by the instructor (Chin, 2006). Edward would sometimes extend the IRE pattern by explaining. In Figure 42 there is a short instance of explaining in turn 7 that extends the IRE cycle. The explanation started after a validation when Edward said “yeah”
and was extended into an explanation by his restatement of the student’s idea before starting a new IRE cycle with a new prompt of “what did you put on the bottom?”.

This IRE pattern was persistent across observations and sections with small variations. Figure 43 shows *prompting, explaining, and validating*, the key practices that define the IRE pattern, across the four observations. Observation Week 3 showed the most variation in the count of these three practices, being the lowest of each of the Observation Weeks.

![Figure 43. IRE by observation](image)

A second set of three practices were interrelated and typically appeared together. This will be referred to as the Board Work pattern. These practices were related to engaging students in working the problems on the board. A Board Work pattern started with Edward *encouraging students to go to the board* to do a problem. He then had a student *work at the board*. The Board
Work pattern ends with Edward either validating the student work or Edward might *ask the student to explain their work*.

As seen in Figure 44, Edward encouraged students to come to the board almost five times per class meeting on average. This encouragement was successful about half of the time, with one student doing work on the board that for every two requests. Edward would ask the student to explain their work only one out of three times that a student did work on the board.

![Case 2: Boardwork Pattern](image)

**Figure 44. Board Work pattern**

Figure 45 is an excerpt that shows Edward *encouraging students to go to the board*. In this example, students needed multiple instances of *encouraging*. In line 1, Edward asks a student to work the problem on the board. No one volunteers and Edward proceeds with an IRE pattern to work through the problem. In line 22, after finishing the problem, Edward again encourages the students to go to the board. Edward had a volunteer, George, but in line 23 rejects him because he was a frequent volunteer and Edward wanted another student to volunteer. In
Line 27, Edward encourages Susanne to volunteer. It takes a second try, but Edward was successful at getting a student to go to the board.

5.2.1 Content and worksheet structure mediates Edward’s teaching practice

The presentation of the content on the worksheets mediated Edward’s practice. This interaction of content and worksheet structure mediated Edward’s use of the Board Work Pattern.
Figure 46 shows that Edward repeatedly encouraged students to go to the board. Overall, it generally took Edward about two instances of encouragement to get a student to come to the board. The use of the Board Work pattern was more apparent in Observation Weeks 1 and 4.

![Figure 46. Board Work Pattern by observation](image)

During Observation Week 1, the second question on the worksheet was set up as a repetitive table (Figure 47). Edward repeatedly encouraged students to come up to the board to complete a line from the table. The combination of the table structure and the procedural steps used to answer the question may have provided the opportunity for Edward to engage in the Board Work Pattern.
2. POC 36. Write correct formulas for the compounds that result by combining each metal with each nonmetal listed across the top of the table.

<table>
<thead>
<tr>
<th></th>
<th>Se</th>
<th>Br</th>
<th>O</th>
<th>P</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ge⁴⁺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Al³⁺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li⁺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg²⁺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 47. Case 2: Week 6 worksheet excerpt

In Observation Week 4, the course content was focused on stoichiometry. The questions presented on the worksheet had little structure (Figure 48). The logic of answering the stoichiometry questions was repetitive and students could rely on a pattern to setup and solve problems. During Week 4, Edward encouraged students to go to the board to work each of the problems in turn. In Figure 48, each of the questions required a single mathematical step using mole ratios, the relationship between the moles of the two compounds. These questions each require the same steps to solve. The number of times Edward asked students to explain their work was lower than in Observation Week 1. This is likely because of the repetitive problem types. The worksheet mediated Edward’s practices because the question structure provided a structure in which Edward could easily engage students in the IRE method of getting through things.

37. Chemistry: How many moles of CO₂ will result from the complete reaction of 1.55 mol HNCO?

38. Chemistry: If 7.05 mol H₂O are produced, how many moles of N₂ are also produced?

Figure 48. Case 2: Week 4 worksheet excerpt
5.2.2 Mode of instruction mediates Edward’s teaching practice

Mode of instruction has the potential for different practices. The mode of instruction was overwhelmingly Whole Class Instruction. Only five percent of instructional time in the observations was Student Work. During that time, Edward

In Whole Class Instruction, two activity types were present, *Going Over Worksheet* and *Going Over Quiz*. There was some evidence that there was variation in the IRE pattern that related to the activity type. In Observation Week 3 Edward handed back a quiz and went over answers with the students. The length of the IRE pattern was shorter during *Going Over Worksheet* than *Going Over Quiz* during this set of observations (Figure 49).

![Figure 49. Length of IRE pattern during Observation Week 3](image-url)
Prompting was used as an indicator of the start of an IRE cycle and this was used to determine the average length of the IRE. Average length of an IRE cycle was determined by dividing the count of prompting by the time of the activity segment. For example, in class meeting 2a.3 there were 11 instances of prompts in 18 minutes during going over quiz and there were 35 instances of prompting in 27 minutes during going over worksheet. This is an average length of 1.64 minutes and 0.77 minutes respectfully.

During the observations in Week 3, the counts of prompting and validating decreased during Going Over Quiz (Figure 50). This difference in practice is likely because Edward focused more on getting the correct answer to the students. This resulted in a longer IRE cycle than in the average IRE cycle during Going Over Worksheet. The count of explaining remained similar to the other weeks because Edward is still explaining answers, but with fewer prompts to the students.

Figure 50. IRE practices during Observation Week 3.
In Figure 51 the interaction continues from Figure 42. In this excerpt, Edward started with a short IRE pattern before engaging in a long explanation in line 11. During this explanation, he does not engage the students in any questions or participation. These longer explanations are evidence of one way that the course structure mediated Edward’s teaching practice. In going over a quiz answer, Edward wanted to get the answers to the students in an efficient way. This led to longer IREs because of the extended explanation; prompting students for every step would not be efficient. This is an example of how Edward’s goal for the interaction led to a variation in IRE (Mortimer & Machado, 2000). When going over a worksheet, Edward had a stated goal of leading students to understanding a question (Interview 2). He does this by continuing to engage students with prompting, resulting in short IREs.
5.2.3 Social interaction mediates Edward’s teaching practice

Social interactions mediated Edward’s practices, although evidence was limited. In this case, evidence is seen most strongly in Observation 3. This observation had the most similarities across sections with regards to the *activity types* during the observation. This permitted the analysis to focus on the differences due to the social interactions.
Differences in IRE cycle length by section were seen in Observation Week 3. Overall, Section C has the longest average IRE pattern (Figure 52a) of 1.65 minutes compared to 0.98 and 1.0 minute for A3 and B3 respectfully. In Observation Week 3, each class meeting included time spent on the activity types of going over quiz and going over worksheet.

![Case 2: Observation 3](image)

Figure 52a. IRE length during Observation 3

In Figure 52b each section shows variation in the length of IRE cycle by the activity type. There were section differences to student questions that can be seen in the length of the IRE cycles. Section A had shorter IRE cycles during Going Over Worksheet than the other sections. In Section A, the IRE cycle during going over quiz is approximately twice as long as during going over worksheet. The length of the IRE cycle does for Section B was similar for both going over...
worksheet and going over quiz. Section C, by contrast, had the longest IRE cycles for both going over quiz and going over worksheet. These longer IREs were likely related to the students not asking as many questions, during going over quiz or going over worksheet, than the other sections.

The COPUS maps were used to understand how student questions related to the IRE cycle length. Figure 53 is the COPUS map for Section A observation 3. Student questions during Going over Quiz occurred from minute 14 to minute 22 (Student COPUS, yellow, circled). Students in Sections B and C did not ask questions during most of Going Over Quiz during that week. COPUS maps for those sections can be found in Appendix D2. Student questions interrupted the IRE cycle, resulting in shorter IRE cycle lengths. Student questions also extended the time that Edward spent on Going Over Quiz.
Figure 53. COPUS maps for Observation Week 3 Section A (2.a.3).
In addition to the difference in the length of the IRE cycle, variations in the Board Work pattern demonstrate another way the social interactions were different between sections. These practices were related to engaging students in working the problems on the board. These interactions started with Edward encouraging students to go to the board to do a problem. A student would work at the board and lastly, Edward might have asked the student to explain their work. Figure 54 shows how these three practices occurred in the different sections. These practices did not occur in every class meeting observation. More than one instance of encouraging was required to get students to work at the board.

Edward persisted in encouraging students to go to the board even when students resisted. Encouragement sometimes resulted in no students going to the board (Table 9; Observation A1) or some cases it was closer to one instance of encouragement to one student at the board. Edward was most successful in getting students to do work at the board. In Section E, students did work
at the board approximately 70% of the time that Edward encouraged students to do so. This was consistent for both observations of Section E (Table 9). Section B was the least effective section for Edward’s use of encouragement. In Observation B4, Edward encouraged the students 14 times resulting in only 5 instances of students going to the board. However, Edward more commonly asked students in Section B to explain their answers.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Encourage students</th>
<th>Students at Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>A3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>A4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>B2</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>B3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>B4</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>C2</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>C3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>E1</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>E4</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

5.2.4 Edward’s observation mediates Edward’s teaching practice

Edward’s observations of students mediated his use of teaching practices. In his journals and interviews, there is evidence that his observations of students were important for decisions he made about teaching.

One way that Edward could observe student difficulties was through having students work problems on the board. He would have “students come up that were often times wrong” (Journal 1). He described wrong student answers as a way to “highlight the faulty part of [the
student’s] reasoning” (Journal 2). Wrong answers also helped him “target [his] explanations to the students’ needs” (Journal 2).

Edward used observations from student performance on quizzes and exams to inform his choice of the content to present to students. In Journal 3, Edward recalled that poor student performance on the quiz was his motivation for coming up with extra problems for students to work. He would focus on showing students “how to properly set up a problem” because he knew this was the “biggest challenge to [his students]” (Journal 4).

5.2.4.1 Evidence of teaching practices in Edward’s journals and interviews

Edward’s journals and interviews support the teaching practices found in the observations. Edward’s use of two patterns of practice, IRE and Board Work, were validated in his journal entries. Edward stated that he would “lead [students] to the correct answer” (Journal 1) by asking questions like “what is an atomic number? What does it represent? Where do we write it on the symbol?” Edward described that he would work one example on his own and then “[have] them try again” (Journal 1). In these types of journal entries, Edward was describing using prompting, validating, and explaining, the IRE pattern, when he discussed how he would get the students to the right answer “through questioning” (Interview 2).

IRE cycles were longer when Edward was going over quizzes. Edward used IRE when going over quizzes to convey the correct answers to the students. He described that one way he interacted with students was to “go through the whole quiz and make sure [students] understood before moving on” (Interview 2). Edward focused on making sure the students had the right answer.
Edward used Board Work to get students to be involved in the class. He observed that calling on students “would make students, you could just see that they would all sit up and straighten up, and start paying more attention” (Interview 2). He also used Board Work to see the “faulty part of [the students] reasoning” and that then helped him “target [his] explanations” (Journal 2).

Edward observed that students would help each other during Student Work. He described students working in groups on the worksheet as “incredibly productive in helping students understand the material” (Journal 3). However, there was little evidence present in the observations to further understand Edward’s observations of student working together because only 5% of the observations conducted during this case study included any Student Work.

5.2.4.2 Edward’s observation of differences between sections

Edward recognized that there were differences in the ways that different sections of students engaged in class. He knew that in some sections that he was “not really going to get anybody to really volunteer” (Interview 2). As was discussed above in section 5.2.3, Edward was persistent in encouraging students to participate though during work at the board regardless of the section. However, students in some sections were more likely to participate by going to the board than others. Edward’s reflections in his second interview suggest that he was less forceful when he thought that students didn’t want to participate.

Edward also observed that some sections of students performed better than others on quizzes and exams. He used his observation of these differences to inform how much time he spent going over the correct answers to the quiz. In sections with higher averages, he would go over questions only if students asked him. Edward would ask students if they had “have specific
questions” (Interview 2). He would do then quickly go through the answer. For sections that had poor performance on a quiz, Edward said that he would go “through the whole quiz, making sure [students] understood” (Interview 2) even if students did not ask for specific questions. This difference in Edward’s choices about what to go over during going over quiz can also be seen in the amount of time spent going over quiz in the different sections. For example, in Observation Week 3, Edward spent 18 min, 7 min, and 12 minutes going over the quiz in sections A, B, and C, respectfully. This difference can also be seen in Observation Week 2 where Edward spent 21 minutes going over quiz in Section B and 31 minutes going over quiz in Section C.

5.2.5 Practice summary

This section described Edward’s teaching practices and the learning environment factors that mediated those teaching practices. The next section discusses Edward’s teaching identity during his first semester of teaching.

5.3 Edward’s Teaching Identity

To describe Edward’s teaching identity, I began by exploring the model of teaching identity with which he started the semester. Edward based his ideas about teaching on role models from his own experience as a learner (Wenger, 1998). Understanding Edward’s teaching practices provides a lens for understanding Edward’s model of teaching identity. I explain how the learning environment factors mediated Edward’s teaching practices (Wenger, 1998).
5.3.1 Edward’s model of teaching identity

Evidence of the sociohistorical model of teaching identity that Edward drew upon was found in his first interview and early journals. He described teaching as “like imparting the process into a student” (Interview 1). He also described the idea of a good GTA as one who “had a good grasp of the material, enough to work through the entire problem with you. Not just give you the answer” (Interview 1). Edward described what he thought he would be doing when he started teaching as structuring his class so that there was “repetition of what [students] covered, what [students] learned, asking the students questions” (Interview 1). He anticipated providing students with questions and tasks during discussion. This manner of describing teaching suggested a model of teaching identity that I labeled as leader. A leader focuses on getting students to the correct answers, not by simply telling the students the answers, but by providing examples and explanations. A leader controls the direction of the class (e.g. teacher-centered) with a goal of getting student to the correct answers. An alternative label for this model of identity could be guide but I chose to use the word leader because Edward described his own teaching in Journal 1 as he “tried to lead [emphasis added] them [the students] to the correct answer instead of just giving it to them by presenting an example.”

Evidence for Edward’s model of teaching identity was found in his journal entries. In addition to describing his goals for teaching as leading students to the correct answer, Edward reflected that he would correct a student’s wrong answer by “explain[ing] why [Edward’s] answer was the right one” (Journal 1). Edward thought of teaching as leading students to the correct answer by showing them the correct path. In his second journal, Edward described that he would “present and explain select problems from the worksheet.” He actively selected questions that he thought would be examples that would get students to understand the material. This was
an active role in directing his classes, again suggesting that he was leading the students through the material.

5.3.2 Edward’s metapragmatic model of teaching identity

Edward’s metapragmatic model of teaching identity of leader can be observed in his teaching practices. First, his teaching practices vary little based on week or section. His most common teaching practices, that I described as the IRE pattern, suggests that Edward is taking a very teacher-centered approach. IRE has typically been associated with a teacher-centered learning environment (Chin, 2006). In this sense, a leader takes the classes where the teacher wants the students to go rather than following the students.

Edward’s use of Board Work also supports the leader model of teaching identity. His consistent, and repeated, use of encouraging students to participate by doing work at the board is evidence that he was leading the students to do class work in specific ways. In situations where students failed to respond to repeated attempts to get a volunteer to do work at the board, Edward more directly told students to participate. He told students that they needed to “raise [their] hand, or [he] will start calling people” (observation B4). This is an example of leading the class rather than leading through problems but continues the idea of leader.

5.3.2.1 Teaching practice and metapragmatic model of teaching identity: Content and worksheet structure as mediator

The worksheets in Case 2 were typically very open in structure and enabled the choice of teaching practices by Edward to remain open. This then permitted a strong influence of the metapragmatic model of teaching identity on the use of teaching practices. The Leader model of
teaching identity, with an open structure permitted the consistent use of the IRE pattern. The few examples of structure in the worksheets related to specific content (i.e. ionic compounds and stoichiometry) that could be practiced in a repetitive way. As Leader, Edward used that repetitive structure to use the Board Work pattern of practices.

5.3.2.2 Teaching practice and metapragmatic model of teaching identity: Mode of instruction as mediator

Edward’s choices regarding dealing with the quizzes further illustrates his metapragmatic model of teaching identity of leader. Edward used his observations of student performance to choose how much of the quiz to go over with the students. For some sections, Edward gave students the choice of going over the quiz and in other sections Edward simply proceeded to go over questions to the quiz. Edward also chose which questions on the worksheet to go over. His choices for questions were made based on his expectations regarding student difficulties. As a leader, Edward gave his students the structure that he felt they needed given the course structure and his own observations.

5.3.2.3 Teaching practice and metapragmatic model of teaching identity: Social interactions as mediator

Even as Edward recognized that some sections were resistant to participating at the board (Journal 4), he continued to encourage all sections of students to engage in board work. As a leader, Edward chose to make each class do this and he kept encouraging students to participate even when he met with resistance. He adapted his practice when students did not respond to his encouragement. In some sections, he would keep pushing until someone did volunteer. In other
sections, he would give up and do the problem. However, he would return to encouraging the students for the next problem. Sometimes, no matter how much encouragement, he was not successful at getting students to participate (see Table 9). As a *leader*, Edward did not wait for students to initiate or engage. As *leader*, he took the class where he thought it needed to go and would persist in following that path even as students failed to engage with his process.

5.2.3.4 Teaching practice and metapragmatic model of teaching identity: GTA

**Observations as mediator**

In Edward’s reflections, there was some evidence that that the way that Edward thought about teaching changed over the semester. In part, this was because he recognized that “there are a lot of factors” that he couldn’t control (Journal 4). In his fifth journal, Edward commented on the influence of the Chemistry 500 course by saying that he changed his practice to include “general concept questions… and then going on to solving the problems.” However, there was not an *observed* change in Edward’s teaching practices. He still utilized an IRE pattern when asking students conceptual questions prior to going to problems. There also may not have been time to observe differences in his teaching practice as this journal was at the end of the observations conducted.

In his second interview, Edward’s description of teaching evolved to include explaining “how [he] understood” a topic. He would “try to get [students] to the [correct answer] through questioning” but would then “just give the right answer” if they didn’t get it (Interview 2). His described his role as a teacher was “to make sure that the consensus is not the wrong one” (Interview 2). As a *leader*, Edward told students that “you’ve seen me do stuff” and that students
“can come up with their own questions” (Interview 2) suggesting that by providing examples he was fulfilling his role as a leader.

Edward started teaching with strongly a held sociohistorical model of teaching identity that I labeled as leader after his own use. The minimal variation in the use of different teaching practices over the semester suggest that Edward’s metapragmatic model of teaching identity was strongly held and that the learning environment factors did not strongly mediate the relationship between his teaching practice and his teaching identity. The leader model of teaching identity may have been less responsive to the learning environment factors or the specific context may have provided different affordances than had been present in Case 1.

5.4 Case 2 Conclusion

This chapter described the development of Edward’s model of teaching identity during his first semester of teaching. I began by describing the teaching practices and learning environment factors found in the observations. I discussed Edward’s initial model of teaching identity and how teaching practices provided evidence for that model of teaching identity. Last, I discussed the metapragmatic model of teaching identity as being similar to the initially described model of teaching identity.

Teaching practices from Case 1 were validated by their use in Case 2. Three additional teaching practices emerged from coding the transcripts of the observations. Edward’s teaching practices were strongly dominated over the course of the semester by three practices: Prompting,
explaining, and validating. Case 2 provided validation of the learning environment factors as mediators of teaching practice.

Edward began teaching with a model of teaching identity that I labeled as leader. His teaching practices throughout the observations followed an IRE pattern using prompting, validating, and explaining. This was a very teacher-centered approach to Edward’s practice. Edward’s model of teaching identity was strongly established and the enactment of it as a metapragmatic model of teaching identity was not seen as different from the statement of the model of teaching identity. Edward’s teaching practices showed only minimal variation in response to different learning environment factors.

5.4.1 Case 2: What are the learning environment factors that mediated GTA teaching practice?

Case 2 provided evidence for the usefulness of for the learning environment factors as mediators of teaching practice that were identified in Case 1. This section summarizes the discussion of the learning environment factors as they appeared in Case 2.

- Content and Worksheet structure. Little variation in teaching practices were seen over the observations in Case 2. The presentation of the content on the worksheet was generally straightforward and commonly a list of questions. This resulted in content and worksheet structure being two learning environment factors that appeared to have only minimal effect on Edward’s choices of teaching practice.

- Mode of Instruction. Case 2 was almost exclusively Whole Class Instruction, so differences in teaching practice between the two modes of instruction could not be described. However, within mode of instruction, going over quiz and going over
worksheet showed variations. The IRE cycle length was longer when Edward was going over quiz answers than when he was going over worksheet. This difference in IRE cycle length was due to Edward focusing on making sure students had the correct answer during going over quiz. When going over worksheet, Edward used IRE to lead students to the correct answer with participation.

• Social interactions. Section differences in social interactions were most noticeable when Edward was going over a quiz. Student questions during this activity changed the length of the IRE cycle. The impact of section differences was also seen in the sections’ responsiveness to Edward encouraging student to participate at board.

• Edward’s observations. Edward used student performance on quizzes to inform his practices during going over quiz. Edward also observed differences in the ways that students responded to being asked to do work at the board. He continued to engage in the practice of encouraging students to participate even when he did not get a positive response.

5.4.2 Case 2: How are teaching practices, learning environment factors, and the GTA’s metapragmatic model of teaching identity related?

Edward’s teaching practices were strongly influenced by his model of teaching identity. He likely brought the set of practices that I labeled as the IRE pattern with him from his previous experiences learning chemistry (Neal, 2008; Oleson & Hora, 2014; Sherin, 2002; Volkamn, Abell, & Zgagaca, 2005; Wenger, 1998). A strongly held model of teaching identity and learning environment factors that provided an open structure led to little variation in Edward’s teaching practice.
Mode of instruction, specifically within the activity types that define Whole Class Instruction, and GTA observation interacted to lead to changes in Edward’s teaching practices. Edward’s observations of student performance on quizzes led to differences in the ways that he engaged students in going over quiz. His different goals for going over quiz and going over worksheet were seen in the difference in the length of IRE cycle as Edward shifted from making sure students have the correct answer in the first case to getting students to the correct answer in the second. Evidence for Edward’s model of teaching identity as leader was seen in the prevalence of the IRE pattern of teaching practices that showed little variation with the learning environment factors of the content, worksheet structure, and mode of instruction.
6.0 DISCUSSION AND CONCLUSIONS

In the preceding two chapters, I presented a detailed description of the two cases. I described two distinct models of teaching identity: helper and leader. Jane’s model of teaching identity, helper, was enacted as a metapragmatic model of teaching identity: help students help themselves. Edward’s model of teaching identity was leader. Learning environment factors were identified as mediators of teaching practice.

This chapter discusses how the two cases together also address the research questions introduced in Chapter 2. Further insights can be seen when both cases are considered. Implications of learning environment factors are discussed next. This is followed by a discussion of the implications for understanding GTA teaching identity, and issues of GTA training and professional development. I end by considering future directions for research.

6.1 Addressing Research Questions

6.1.1 What learning environment factors mediate GTA teaching practice?

Learning environment factors that mediated GTA teaching practice were identified in this study. Three of the learning environment factors reflected the influence of the community of practice on GTA teaching practice: Content, Worksheet structure, and Mode of instruction. Two other learning environment factors, Social interactions and GTA observations, reflected the ways that social identification played a role in the relationship between teaching identity and teaching practice.
Content, Worksheet structure, and Mode of instruction reflected the ways in which community of practice’s expectations were communicated from the professor to the GTA (Wenger, 1998). While each of these learning environment factors was considered separately for the analysis, they are linked and in fact influence each other. For example, the presentation of the content on the worksheet provided different choices for teaching practices.

The worksheets that were used in Case 1 had been intentionally designed by the professor to sometimes elicit confusion from the students and Jane’s practices responded to that. The worksheet structure also provided Jane with different ways to interact with the students around the questions. The worksheets that Edward had were laid out in a straightforward manner, simply listing questions for students to answer. In Edward’s case, the worksheet structure was open and allowed Edward to choose teaching practices that were related more to his own experiences and teaching identity and less about the expectations of the professor and community of practice.

The Mode of instruction provided different affordances for social interactions between the GTA and the students. Student Work allowed for more student-initiated interactions than typically occurred during Whole Class Instruction. Jane’s class meetings consistently had long intervals of student work whereas Edward’s sections had only infrequent and short instances of Student Work. Because of this difference in the amount of time spent on the different modes of instruction, Jane’s interactions with students were likely to be student initiated and Edward was less likely to encounter student initiated interactions. Mode of instruction cannot be completely separated from the worksheet structure. The structure of questions in Case 1 supported more Student Work than the nature of the worksheet structure in Case 2.

GTA observation was seen as a mediator of teaching practice in both cases. However, the types of observation by the GTA led to different practices. Jane’s use of Student Work resulted in
more potential for Jane to observe student work. Jane had with the opportunity to observe students’ thinking when she was asked questions. She was also able to use observations of student thinking and student difficulty in one section to inform her teaching practices in another section. For example, her observations helped her recognized that students didn’t always ask questions when they were having difficulty. Edward’s observations were more focused on student performance on quizzes and exams. He used those observations to make decisions about what information he would lead students through during class. Also, because his sections were structured in ways that he was always leading, there was fewer opportunities for Edward to observe student thinking. In following the IRE pattern of practice, Edward provided the students with structure to give an answer. In doing this during Whole Class Instruction, the answers given by the students were rarely incorrect. Edward was able to observe student thinking when a student did work at the board.

6.1.2 How are teaching practices, learning environment factors, and the GTA’s metapragmatic model of teaching identity related?

The GTAs’ metapragmatic model of teaching identity related to the use of different teaching practices and the emergence of learning environment factors as mediators of teaching practice. The Helper model of teaching identity was responsive to learning environment factors that conveyed the expectations of the community of practice. This responsiveness can be seen in the way that Jane’s teaching practices varied across the semester as the content and worksheets changed. There were also observable differences in the way that Jane interacted with students in different sections. The Helper model of teaching identity is open to student direction. In contrast, in Case 2, the Leader model of teaching identity appeared to have a preference for a specific set
of practices. Edward consistently led his classes, selecting which questions to do and engaging students using the IRE pattern of practices. The learning environment factors that conveyed expectations of the community of practice showed minimal influence over the use of different teaching practices. The differences between the learning environment factors between the two cases likely had different affordances to interact with the models of teaching identity. For instance, is the worksheet structure from Case 1 had been used in Case 2, there may have been more opportunity for interaction between the Edward’s metapragmatic model of teaching identity and the learning environment factors.

6.2 Implications

These case studies have three major implications. The first is detailing the learning environment factors that were important in this context for teaching practices. The second implication is the ability to describe how a model of teaching identity interacts with the learning environment. Taken together, these provide possible leverage points for improving GTA teaching practice through potential improvements in GTA training and professional development.

6.2.1 Understanding learning environment factors as mediators

Understanding learning environment factors provides a lens for describing the aspects of the Community of Practice and social interactions that are influential on a new GTA’s teaching practice. Learning environment factors emerged as I engaged in an analysis that assumed a direct
link between practices and identity. The emergence of learning environment factors in this study suggest a systematic method for describing how a GTA’s teaching identity interacts with the expectations of the community of practice.

Evidence for understanding models of teaching identity and metapragmatic models of identity can be found in teaching practices and how those teaching practices varied with the different learning environment factors. In the development of social identification, Wortham’s method of analysis was grounded in discourse analysis. Wortham’s work was undertaken in a context where the discourse of the learning environment included enactments of identity. The classroom talk in his study was centered around social ideas. In applying this theory to a new learning environment, I found that the discourse between the students and GTAs did not directly have evidence of teaching identity. In a chemistry classroom, the GTA-student talk is centered on atoms, molecules, and reactions. Where Wortham used signs and events of identification to describe the emergence of metapragmatic models of identity, I found evidence for understanding models of teaching identity in teaching practices and their interaction with learning environment factors.

Jane and Edward both used prompting and validating throughout the semester but these teaching practices were evidence of two different models of teaching identity. Edward’s use of prompting and validating, found in the IRE pattern, was related to Edward leading the students during class. It came out of his choices for what content to cover, which questions to present, and how he thought the students should proceed with the material and had a clear expected answer. For Jane, the use of prompting and validating was commonly found in her interactions with students during Student Work and was commonly in response to a student question. She used
prompting to get students to think about possible next steps. These two cases show how the same teaching practice can come from different places.

While individually similar, the teaching practices of prompting and validating where interpreted by the context to show evidence of two different models of teaching identity. This interpretation in context is similar to the way that Wortham’s signs had different interpretations depending on the model of identity and the topic of discourse that was present in the interaction. In Wortham’s examples of social identification (2006), the classroom discourse involved ideas about who people are. In a chemistry classroom, discussion of atoms does not directly provide evidence of who the GTA is as a teacher. However, the practices that the GTA uses to interact with undergraduate students around atoms provides evidence for the GTA’s teaching identity.

6.2.2 Implications for GTA teaching identity

Identity develops in interactions (Sfard & Prusak, 2005; Holland & Lave, 2001; Bauman, 1996; Roth, 2004) and these case studies focused first on the interactions rather than GTA interviews or self-report of practices. While Hands (2007) and Belnap (2005) used observation, it took a secondary role to interviews. Sandi-Urena and Gatlin (2013) did not include observation in their study, grounding their study in interviews only. The results of these case studies demonstrate how identity was observed through teaching practices that were interactions with the students. This flips the conversation about identity from what is perceived by the GTA to what is observable in practice.

The analysis of Jane’s teaching practices resulted in a refined description of her metapragmatic model of teaching identity (Volkman & Zgagacz, 2004). Edward’s metapragmatic model of teaching identity did not differ much from the model of teaching
identity that was initial described in his interview. While his initial model of teaching identity interacted with the learning environment factors but the combination of the leader model of teaching identity and the specifics of the learning environment factors did result in a refined description of the metapragmatic model of teaching identity.

Previous work concerning GTA teaching identity has recognized that the learning environment in which the graduate student teaches is a factor in their identity development (Belnap, 2005; Hands, 2007; Sandi-Urena, & Gatlin, 2013). This study refines this understanding by considering specific factors of that learning environment as method for understanding GTA teaching practices. It is through the interpretation of teaching practices and that the impact on identity of the learning environment in which the GTA is teaching can be understood (Sachs, 2005; Ye at al. 2011). The identification of learning environment factors as mediators of practice provides a more nuanced method for describing the learning environment (Belnap, 2005; Sandi-Urena & Gatlin, 2013). These learning environment factors have potential implications for developing GTA training. The learning environment factors were important for the GTA teaching practices and the metapragmatic model of teaching identity.

Jane and Edward’s initial models of teaching identity interacted with the learning environment factors, resulting in an enacted metapragmatic model of teaching identity. This finding highlights the importance of a beginning teacher’s identity for engaging with new practices (Horn et al. 2008; Nolan et al. 2011). The initial model of teaching identity shaped how the GTAs reacted to the learning environment factors and hence shaped their teaching practices (Kurdziel et al. 2003). This study expanded on the findings in the K-12 literature (Speer, 2005) and other disciplines (e.g. math; Belnap, 2005; Hands, 2006) to a less explored discipline.
6.2.3 Implications for GTA training and professional development

This study has implications for designing effective GTA training. The GTAs in this study had little initial training (Luft et al. 2004; Grier & Johnston, 2009) and on-going training provided in Chemistry 500 added to the GTAs’ vocabulary (e.g. facilitator) but did not appear to influence practice during the course of this study (Moje at al 2007). In the absence of training, Jane and Edward drew on teaching practices that they had been exposed to in their previous experiences (Lortie, 1975). While Jane and Edward taught the same content, and had similar backgrounds in learning chemistry, the experiences they drew on resulted in two different models of teaching identity. Engaging GTAs with training that explicitly draws out models of teaching identity before the GTA starts teaching (Lortie, 1975; Zeichner & Tabachnick, 1985) could improve GTA teaching practices by making them aware of how their model of teaching identity interacts with aspects of the learning environment.

Learning environment factors can also be used to inform the design of effective GTA training and professional development. A richer GTA training experience can be designed from the consideration of the learning environment factors that are important for the GTA teaching practices. Several possible implications for the design of training and professional development are discussed here:

- **Content.** The emergence of content as a mediator of practice indicates that more emphasis should be placed on engaging GTAs with course content during training. GTA training rarely considers the specific content of the courses the graduate students will be teaching (Gardner & Jones, 2011). It is frequently assumed that GTAs will have sufficient knowledge for teaching whatever material they are assigned. During GTA training, or on-going with the supervising
professor, content and learning outcome goals for the course should be made explicit.

- **Worksheet.** Worksheet structure matters for conveying practices (Wenger, 1998). The deliberate choices about the worksheet structure by the professor in Case 1 enabled the interaction between the worksheet structure and Jane’s practices. In Case 2, the worksheet structure was open and there were indications that it was not helpful for encouraging specific teaching practices. Working with professors to develop worksheets that focus not only content but practices and then communicating that to GTAs could be a way to engaging GTAs with more evidence based teaching practices.

- **Mode of instruction** – GTAs need materials that support productive modes of instruction. There were limited modes of instruction engaged in by the GTAs in this study. Support for different modes of instruction could be provided to the GTAs through the materials (e.g. worksheets). Explicit training in the use of different modes of instruction (i.e. how to get students to work in groups) could be helpful in getting GTAs to use different modes of instruction.

- **Social Interactions.** The GTA develops their practice and identity in the interactions with the students. Being able to respond to the interactions or lack of interactions from students is something that training could address. In addition to training being tied to content (Gardner & Jones, 2011), training should be aware of the students who will be taught. Students in Chemistry 101, a remedial course, may interact differently than students in a typical first year chemistry course.
• GTA observation. This study shows that the observations that the GTAs engaged in were important for their choices teaching practices and in how they interacted with the students. Developing a professional environment for GTAs that support reflection about their teaching could be an important step for improving the instruction of chemistry. This support could also include establishing better departmental expectations for teaching that recognize teaching as a component of professional development for graduate students (Moore, 2005; Grier & Johnston, 2009).

GTA training should incorporate course materials from the professor, rather than generic examples of content. Well-designed materials could also be introduced in GTA training and continued use of well-designed materials from the professor during the semester would continue to support the uptake of evidence based teaching practices.

6.3 Future Research

This study suggests several possible directions for future work that include expanding on the models of teaching identity and potential factors of the learning environment, focusing a similar study on the students, and expanding the study to a broader survey based study.
6.3.1 Additional case studies

These cases show how the model of teaching identity can interact with the learning environment factors in different ways, so describing additional models of identity will be important for expanding on the usefulness of understanding the learning environment factors. If these factors are going to be used to support the design of effective GTA training, additional research using the analytical approach developed in these case studies would be useful for identifying the ways that different models of teaching identity interact with the specific learning environment context.

These cases were conducted within very similar contexts of two different lecture sections of Chemistry 101. There are several ways that these cases could be expanded on. First, chemistry GTA responsibility also regularly includes laboratory instruction, which was not a component of this course. Exploring GTA teaching practices in a laboratory instruction setting could provide additional learning environment factors.

Another way to consider context would be to do a more controlled cross case analysis of GTAs in the same context. How would different GTAs interact with drivers of practice if they were given the same worksheets from the same professor? Exploring GTAs in the same context could deepen the understanding of learning environment factors that emerged in this study.

These cases considered a single aspect of graduate student identity, specifically their teaching identity. The understanding of GTA identity could be expanded upon by considering the GTA’s nexus of multimembership. Future research could explore aspects of several communities of practice and their relations to each other (Colbeck, 2008).
6.3.2 Materials development

This study can also be used to inform materials development. Understanding how GTAs are engaging with learning environment factors could be used by faculty to develop more effective materials. Instead of focusing solely on the ways that materials help the students, professors should also consider how their materials support the GTAs’ teaching practices. Future work could support professors in designing worksheets and other materials that are effective for the dual goals of communicating content and supporting other aspects of the learning environment factors in ways that could influence GTA teaching practices.

6.3.3 Use cases to inform larger study

These case studies could be used to inform a project aimed at developing a survey that could be used on a larger population of GTAs to gain a better understanding of GTA teaching practice and teaching identity across multiple contexts including types of course and institutions. Some more mini case study observations and interviews would likely be required to provide additional data before developing a survey.

6.3.4 Understanding the students

While the focus of this study was on the GTAs, the students were a key component of the learning environment. Their influence on the teaching practice was seen in the exploration of teaching practice by Section. A future study could look more closely at the student behaviors and their relationship with the teaching practices used by the GTAs. It would also be interesting to consider the student outcomes in cases with different GTA teaching identities and when GTAs use different teaching practices. For instance, how did Jane and Edward’s student perform in the
course and was there any evidence of relationship between the GTA’s model of teaching identity and the student outcome?
CITED LITERATURE


Appendix A

A1 Interviews

First GTA interview

1) Chemistry Background
   a) Undergraduate learning experiences
   b) Reflections on good instructors
   c) Why graduate school?
2) Teaching style/philosophy
   a) Expectations for teaching
   b) What does it mean to teach? What do you see as your role?
3) TA training (views and opinions of the experience, how was it useful/not useful, what it was like)
   a) Campus-wide training
   b) Departmental training (runs semester long?)
4) Prior teaching background/experience (if any)
5) Interview Task
REMINDER: You don’t have to discuss any topic that you are uncomfortable discussing.

Second GTA Interview

1) Chemistry Background
   a) Why graduate school?
2) Teaching style/philosophy
   a) Expectations for teaching
   b) What does it mean to teach? What do you see as your role?
3) TA training (views and opinions of the experience)
   a) Campus-wide training
   b) Departmental training (runs semester long)
4) Professor interactions
   a) Interactions with him/her
   b) Experience being observed and given feedback
   c) Suggestions given to you and how you viewed them
5) Current teaching experience
   a) Feelings about teaching
   b) How/what you prepare for class
6) Items based on prior interviews/data analysis (TBD)
7) Graduate experience
   a) Workload/time commitments
   b) What your teachers are like (which ones you consider good/bad and why)
8) Prior teaching background/experience (if any) comparison to this semester
9) Interview Task
REMINDER: You don’t have to discuss any topic that you are uncomfortable discussing.
A2 Survey

Departmental Survey – Professor

- Demographics:
  - Degree:
  - Position: Assistant Professor, Associate Professor, Professor, Adjunct Faculty
  - Courses taught prior to FA2015
  - Course teaching in FA2015

- Role of the TA
  - Describe what you feel is the role of a TA in introductory chemistry courses.
  - Describe any training and/or support that is provided to new graduate students with regards to teaching.
  - Describe the role that teaching plays in graduate student development.
  - Next is a list of activities that your TAs may have used in teaching. Please rank them from most frequently used by the TAs (1) to least frequent used by the TAs(?).
  - Optional: please describe any activity that you believe TAs use that isn’t covered in this list.

Departmental Survey – Graduate Student

- Background
  - What was your first semester in graduate school at UIC?
  - What course were you a TA for in each semester you have attended? Use NA if not a TA during that semester (have semesters with fill in the blank for the past 7 years)

- Role of the TA
  - Describe what you feel is the role of a TA in introductory chemistry courses.
  - Describe any training and/or support you had when you first taught as a graduate student.
  - What do you think about teaching and the role that it plays for you in graduate school?
  - Next is a list of activities that you may have used in your teaching. Please rank them from most frequently used (1) to least frequent used (?).
  - Optional: please describe any activity that you have used that isn’t covered in this list.
A3 Journal Instructions

Instructions for journals:

Please complete the journal towards the end of each two-week period. For example, the first journal is for the weeks of Aug 24-28 and Aug 31-Sept 4. Ideally, you would complete the journal somewhere around sept 3-7. You may wish to work on it sporadically through the two weeks as ideas come to mind or something happens in discussion or lab that you want to get down.

Space has been added in between the prompts, but this does not suggest a minimum or maximum amount of writing. Please use as much space as you need to get your thoughts down.

Save the file with your name at the end of the existing file name. Send to me via UIC email address.
Journal Prompt 1
Journal Prompts – Week 1 (Aug 24-28) and Week 2 (Aug 31-Sept 4)
Please do not delete the prompts. Add your journal responses to this document and save as the same name and add your name (TAjournal1.JohnDoe.docx)

Name:
List the content you were covering in the last two weeks.

Discuss your experience in teaching this material. To do this, you may consider the following as guides. Do not feel limited to these.
*Discuss your familiarity with this material.
*Describe how you prepared to teach this material, including lab and discussion?
*What challenges did you think you would face with teaching this material?
*If you encountered any of those challenges, describe what happened and how you dealt with it.
*How were your experiences with teaching this material compared with your expectations?
*Were there any challenges that you had not anticipated? Describe what happened.

Think about what went well in your classes in the last two weeks. Describe a specific situation when there was good teaching/learning going on.
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Think about what didn’t go as well in your classes in the last two weeks. Describe a specific situation where there was a challenge in teaching/learning.
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Describe an interaction with a student that you had in the last two weeks.
*Who started the interaction?
*What was the interaction about?
*Describe how you worked with the student to resolve the question/concern/comment.
*What do you think the student got out of this interaction?
*What do you feel like you learned about teaching during this interaction?

Discuss how you feel about teaching chemistry at this point in the semester. To do this, you may consider the following as guides. Do not feel limited to these!
*Describe how effective/ineffective teaching experiences in the last two weeks relate to your feelings about teaching.
*Reflect on ideas about how your preparations can influence/change/improve your effectiveness and/or how you feel about your teaching ability

Discuss how you are planning to prepare for teaching next week.
Discuss anything else that you want to journal about with regards to your experiences as a TA in the last two weeks.
Journal Prompt 2
Journal Prompts – Week 3 (Sept 8-11) and Week 4 (Sept 14-18)
Please do not delete the prompts. Add your journal responses to this document and save as the same name and add your name (TAjournal1.JohnDoe.docx)

Name:
List the content were you covering in the last two weeks.
Discuss your experience in teaching this material. To do this, you may consider the following as guides. Do not feel limited to these.
*Discuss your familiarity with this material.
*Describe how you prepared to teach this material, including lab and discussion?
*What challenges did you think you would face with teaching this material?
*If you encountered any of those challenges, describe what happened and how you dealt with it.
*How were your experiences with teaching this material compared with your expectations?
*Were there any challenges that you had not anticipated? Describe what happened.

Think about what went well in your classes in the last two weeks. Describe a specific situation when there was good teaching/learning going on.
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Think about what didn’t go as well in your classes in the last two weeks. Describe a specific situation where there was a challenge in teaching/learning.
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Describe an interaction with a student that you had in the last two weeks.
*Who started the interaction?
*What was the interaction about?
*Describe how you worked with the student to resolve the question/concern/comment.
*What do you think the student got out of this interaction?
*What do you feel like you learned about teaching during this interaction?

Discuss how you feel about teaching chemistry at this point in the semester. To do this, you may consider the following as guides. Do not feel limited to these!
*Describe how effective/ineffective teaching experiences in the last two weeks relate to your feelings about teaching.
*Reflect on ideas about how your preparations can influence/change/improve your effectiveness and/or how you feel about your teaching ability

Discuss how you are planning to prepare for teaching next week.

Discuss anything else that you want to journal about with regards to your experiences as a TA in the last two weeks.
Journal Prompt 3
Journal Prompts – Week 5 (Sept 21-Sept 25) and Week 4 (Sept 28-Oct 2)
Please do not delete the prompts. Add your journal responses to this document and save as the same name and add your name (TAjournal1.JohnDoe.docx)

Name:
List the content were you covering in the last two weeks.

Discuss your experience in teaching this material. To do this, you may consider the following as guides. Do not feel limited to these.
*Discuss your familiarity with this material.
*Describe how you prepared to teach this material, including lab and discussion?
*What challenges did you think you would face with teaching this material?
*If you encountered any of those challenges, describe what happened and how you dealt with it.
*How were your experiences with teaching this material compared with your expectations?
*Were there any challenges that you had not anticipated? Describe what happened.

Think about what went well in your classes in the last two weeks. Describe a specific situation when there was good teaching/learning going on.
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Think about what didn’t go as well in your classes in the last two weeks. Describe a specific situation where there was a challenge in teaching/learning.
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Describe an interaction with a student that you had in the last two weeks.
*Who started the interaction?
*What was the interaction about?
*Describe how you worked with the student to resolve the question/concern/comment.
*What do you think the student got out of this interaction?
*What do you feel like you learned about teaching during this interaction?

Discuss how you feel about teaching chemistry at this point in the semester. To do this, you may consider the following as guides. Do not feel limited to these!
*Describe how effective/ineffective teaching experiences in the last two weeks relate to your feelings about teaching.
*Reflect on ideas about how your preparations can influence/change/improve your effectiveness and/or how you feel about your teaching ability

Discuss how you are planning to prepare for teaching next week.
Discuss anything else that you want to journal about with regards to your experiences as a TA in the last two weeks.
Journal Prompt 4

Journal Prompts – Week 7 (Oct 5 – Oct 9) and Week 8 (Oct 12-Oct 16)
Please do not delete the prompts. Add your journal responses to this document and save as the same name and add your name (TAjournal1.JohnDoe.docx)

Name:

List the content were you covering in the last two weeks.

Discuss your experience in teaching this material. To do this, you may consider the following as guides. Do not feel limited to these.
*Discuss your familiarity with this material.
*Describe how you prepared to teach this material, including lab and discussion?
*What challenges did you think you would face with teaching this material?
*If you encountered any of those challenges, describe what happened and how you dealt with it.
*How were your experiences with teaching this material compared with your expectations?
*Were there any challenges that you had not anticipated? Describe what happened.

Think about what went well in your classes in the last two weeks. Describe a specific situation where there was good teaching/learning going on. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Think about what didn’t go as well in your classes in the last two weeks. Describe a specific situation where there was a challenge in teaching/learning. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Describe an interaction with a student that you had in the last two weeks. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
*Who started the interaction?
*What was the interaction about?
*Describe how you worked with the student to resolve the question/concern/comment.
*What do you think the student got out of this interaction?
*What do you feel like you learned about teaching during this interaction?

Discuss how you feel about teaching chemistry at this point in the semester. To do this, you may consider the following as guides. Do not feel limited to these!
*Describe how effective/ineffective teaching experiences in the last two weeks relate to your feelings about teaching.
*Reflect on ideas about how your preparations can influence/change/improve your effectiveness and/or how you feel about your teaching ability
Discuss how you are planning to prepare for teaching next week.

Discuss anything else that you want to journal about with regards to your experiences as a TA in the last two weeks.
Journal Prompt 5
Journal Prompts – Week 9 (Oct 19 – Oct 23) and Week 10 (Oct 26-Oct 30)
Please do not delete the prompts. Add your journal responses to this document and save as the same name and add your name (TAjournal1.JohnDoe.docx)

Name:

List the content were you covering in the last two weeks.

Discuss your experience in teaching this material. To do this, you may consider the following as guides. Do not feel limited to these.
*Discuss your familiarity with this material.
*Describe how you prepared to teach this material, including lab and discussion?
*What challenges did you think you would face with teaching this material?
*If you encountered any of those challenges, describe what happened and how you dealt with it.
*How were your experiences with teaching this material compared with your expectations?
*Were there any challenges that you had not anticipated? Describe what happened.

Think about what went well in your classes in the last two weeks. Describe a specific situation when there was good teaching/learning going on. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Think about what didn’t go as well in your classes in the last two weeks. Describe a specific situation where there was a challenge in teaching/learning. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
*Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Describe an interaction with a student that you had in the last two weeks. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
*Who started the interaction?
*What was the interaction about?
*Describe how you worked with the student to resolve the question/concern/comment.
*What do you think the student got out of this interaction?
*What do you feel like you learned about teaching during this interaction?

Reflect on what you are learning about teaching and learning in 500. What changes have you made (or thought about making) in your teaching? If you have received specific feedback from Mike yet, what has it lead you to think about?

Discuss how you feel about teaching chemistry at this point in the semester. To do this, you may consider the following as guides. Do not feel limited to these!
Describe how effective/ineffective teaching experiences in the last two weeks relate to your feelings about teaching.

Reflect on ideas about how your preparations can influence/change/improve your effectiveness and/or how you feel about your teaching ability

**Discuss how you are planning to prepare for teaching next week.**

**Discuss anything else that you want to journal about with regards to your experiences as a TA in the last two weeks.**
Journal Prompt 6
Journal Prompts – Week 11 (Nov 2-Nov 6) and Week 12 (Nov 9-Nov 13)
Please do not delete the prompts. Add your journal responses to this document and save as the
same name and add your name (TAjournal1.JohnDoe.docx)

Name:

List the content were you covering in the last two weeks.

Discuss your experience in teaching this material. To do this, you may consider the
following as guides. Do not feel limited to these.
* Discuss your familiarity with this material.
* Describe how you prepared to teach this material, including lab and discussion?
* What challenges did you think you would face with teaching this material?
* If you encountered any of those challenges, describe what happened and how you dealt with it.
* How were your experiences with teaching this material compared with your expectations?
* Were there any challenges that you had not anticipated? Describe what happened.

Think about what went well in your classes in the last two weeks. Describe a specific
circumstance when there was good teaching/learning going on. Think about this as telling a
story. Who are the actors? What roles did they play? What was the question/challenge/or
difficulty faced? How was it resolved?
* Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much
detail as you can remember. Think about recounting an event as one might as a witness telling a story about what
happened.*

Think about what didn’t go as well in your classes in the last two weeks. Describe a specific
circumstance where there was a challenge in teaching/learning. Think about this as telling a
story. Who are the actors? What roles did they play? What was the question/challenge/or
difficulty faced? How was it resolved?
* Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much
detail as you can remember. Think about recounting an event as one might as a witness telling a story about what
happened.*

Describe an interaction with a student that you had in the last two weeks. Think about this
as telling a story. Who are the actors? What roles did they play? What was the
question/challenge/or difficulty faced? How was it resolved?
* Who started the interaction?
* What was the interaction about?
* Describe how you worked with the student to resolve the question/concern/comment.
* What do you think the student got out of this interaction?
* What do you feel like you learned about teaching during this interaction?

Reflect on what you are learning about teaching and learning in 500. What changes have
you made (or thought about making) in your teaching? If you have received specific
feedback from Mike yet, what has it lead you to think about?

Discuss how you feel about teaching chemistry at this point in the semester. To do this, you
may consider the following as guides. Do not feel limited to these!
*Describe how effective/ineffective teaching experiences in the last two weeks relate to your feelings about teaching.
*Reflect on ideas about how your preparations can influence/change/improve your effectiveness and/or how you feel about your teaching ability

Discuss how you are planning to prepare for teaching next week.

Discuss anything else that you want to journal about with regards to your experiences as a TA in the last two weeks.
Journal Prompt 7
Journal Prompts – Week 13 (Nov 16-Nov 20), Week 14 (Nov 22-24/Thanksgiving), Week 15 (Nov 30- Dec 4) Please do not delete the prompts. Add your journal responses to this document and save as the same name and add your name (TAjournal1.JohnDoe.docx)

Name:

List the content were you covering in the last three weeks.

Discuss your experience in teaching this material. To do this, you may consider the following as guides. Do not feel limited to these.
* Discuss your familiarity with this material.
* Describe how you prepared to teach this material, including lab and discussion?
* What challenges did you think you would face with teaching this material?
* If you encountered any of those challenges, describe what happened and how you dealt with it.
* How were your experiences with teaching this material compared with your expectations?
* Were there any challenges that you had not anticipated? Describe what happened.

Think about what went well in your classes in the last two weeks. Describe a specific situation when there was good teaching/learning going on. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
* Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Think about what didn’t go as well in your classes in the last two weeks. Describe a specific situation where there was a challenge in teaching/learning. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
* Please try to think of a specific instance of an interaction in discussion, lab or office hours and provide as much detail as you can remember. Think about recounting an event as one might as a witness telling a story about what happened.*

Describe an interaction with a student that you had in the last two weeks. Think about this as telling a story. Who are the actors? What roles did they play? What was the question/challenge/or difficulty faced? How was it resolved?
* Who started the interaction?
* What was the interaction about?
* Describe how you worked with the student to resolve the question/concern/comment.
* What do you think the student got out of this interaction?
* What do you feel like you learned about teaching during this interaction?

Reflect on what you are learning about teaching and learning in 500. What changes have you made (or thought about making) in your teaching? How has Mike’s feedback effected your teaching? Describe how you think about your teaching as the end of the semester wraps up.
Discuss your experience teaching your revised lesson plan in 500. What did you learn from your initial plan? What did you learn from Mike’s feedback? What kind of feedback did you get from your fellow chem TAs?

Discuss how you feel about teaching chemistry at this point in the semester. To do this, you may consider the following as guides. Do not feel limited to these!
* Describe how effective/ineffective teaching experiences in the last two weeks relate to your feelings about teaching.
* Reflect on ideas about how your preparations can influence/change/improve your effectiveness and/or how you feel about your teaching ability

Discuss your overall experience learning to teach chemistry over the semester. Describe ways your teaching changed or remained the same. Why do you think your teaching went as it did? Discuss how you expect your experiences this semester will influence how you teach next semester.

Discuss anything else that you want to journal about with regards to your experiences as a TA in the last two weeks.
Every lecture of the course that was observed used an identical topic schedule for the semester.

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Monday</th>
<th>Wednesday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/24</td>
<td>Introduction; elements and compounds 1.1-1.2</td>
<td>Atomic numbers and the periodic table 1.3</td>
<td>Physical properties and states, 1.4</td>
</tr>
<tr>
<td>2</td>
<td>8/31</td>
<td>The Periodic Table, 1.5</td>
<td>Methods of Measurement, 2.1</td>
<td>Recording measurements, 2.2</td>
</tr>
<tr>
<td>3</td>
<td>9/7</td>
<td>LABOR DAY</td>
<td>Algebraic Variables and Formulas: M.1; Direct Proportions: M2</td>
<td>Working with Exponents, M.3</td>
</tr>
<tr>
<td>4</td>
<td>9/14</td>
<td>Units of Measure (metric conversions), 2.3</td>
<td>Molecules in Chemistry 3.1</td>
<td>Exam 1 ( Chapters 1, 2, M.1-M.3)</td>
</tr>
<tr>
<td>5</td>
<td>9/21</td>
<td>Lewis structures 3.2</td>
<td>Lewis Structures, 3.2</td>
<td>Binary ionic cpds. 3.3</td>
</tr>
<tr>
<td>6</td>
<td>9/28</td>
<td>Polynomic ions 3.3; Oxidation numbers 3.4</td>
<td>Density 4.1</td>
<td>Percentage and other ratios 4.2</td>
</tr>
<tr>
<td>7</td>
<td>10/5</td>
<td>Measuring and counting in substances 4.3</td>
<td>Moles and counting 4.4</td>
<td>Exam 2 ( Chapters 2.3, 3, 4.1-4.3)</td>
</tr>
<tr>
<td>8</td>
<td>10/12</td>
<td>Molar mass 5.1</td>
<td>Multiple conversions and chemical amounts 5.2</td>
<td>Percent composition, 5.3</td>
</tr>
<tr>
<td>9</td>
<td>10/19</td>
<td>Empirical formulas 5.4</td>
<td>Chemical properties and changes 6.1</td>
<td>Predicting products:  6.2</td>
</tr>
<tr>
<td>10</td>
<td>10/26</td>
<td>Synthesis reactions 6.2</td>
<td>Displacement and Oxidation-reduction reactions 6.3</td>
<td>Acids and Bases in Water-11.1</td>
</tr>
<tr>
<td>11</td>
<td>11/2</td>
<td>Acid and Base Reactions—Balancing 7.1</td>
<td>Counting in Reactions—7.1</td>
<td>Exam 3 ( Chapters 4.4, 5, 6, 11.1-11.2)</td>
</tr>
<tr>
<td>12</td>
<td>11/9</td>
<td>Counting in Reactions—Balancing 7.1</td>
<td>Mole stoichiometry, 7.2</td>
<td>Mass stoichiometry 7.3</td>
</tr>
<tr>
<td>13</td>
<td>11/16</td>
<td>Mass stoichiometry 7.3</td>
<td>Limiting reactant and Yield 7.4</td>
<td>Solutions and molarity 8.1</td>
</tr>
<tr>
<td>14</td>
<td>11/23</td>
<td>Solutions and molarity 8.1</td>
<td>Molarity and Stoichiometry 8.2</td>
<td>THANKSGIVING HOLIDAY</td>
</tr>
<tr>
<td>15</td>
<td>11/30</td>
<td>Molarity of acids and bases 11.3</td>
<td>The pH of acid-base mixtures 11.4</td>
<td>Review</td>
</tr>
</tbody>
</table>

**A4 Syllabus**

CHEMISTRY 101
PREPARATORY CHEMISTRY Fall 2015

Course Schedule with references to *The Practice of Chemistry, Sapling Learning Edition*
B Additional Case Materials

B1. Case 1 Example Worksheet

<table>
<thead>
<tr>
<th>Substance</th>
<th>Density (g cm$^{-3}$)</th>
<th>Molar mass (g mol$^{-1}$)</th>
<th>Grams in 100 mL</th>
<th>Moles in 100 mL</th>
<th>Molarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>C$_2$H$_6$O</td>
<td>0.7893</td>
<td>46.068</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ethanol)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C$_3$H$_6$O</td>
<td>0.7899</td>
<td>58.079</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(acetone)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C$_6$H$_12$O$_6$</td>
<td>1.562</td>
<td>180.155</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(glucose)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>7.86</td>
<td>58.847</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Au</td>
<td>19.3</td>
<td>196.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>19.05</td>
<td>283.03</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comment on any trends in molarity or in moles per 100 g.

B. MOLARITY CALCULATIONS: CALCULATING MOLARITY

Determine the molarity of the solute in the following solutions.
(a) A solution prepared by dissolving 2.11 × 10$^{-3}$ mol of C$_{12}$H$_{22}$O$_{11}$ in 25.00 mL solution
(b) A solution prepared by mixing 0.321 mol of NaCl in enough water to make 250.0 mL of solution.

(c) Determine the molarity of potassium nitrate, $\text{KNO}_3$, in a solution made by dissolving 0.350 g of potassium nitrate in water to make a solution with a volume of 1.00 L.

(d) A solution is prepared by mixing 10.0 mL of acetic acid ($\text{C}_2\text{H}_4\text{O}_2$, molar mass 60.0526 g mol$^{-1}$, density 1.05 g mL$^{-1}$) in enough water to make 0.050 L of solution.

C. **Molarity Calculations: Using Molarity**

(a) Find the number of moles of HNO$_2$ contained in 524 mL of 0.261 M HNO$_2$.

(b) What volume of 0.895 M HBr will provide 4.02×10$^{-5}$ moles HBr?

(c) How many moles Mg(OH)$_2$, are contained in 25 mL of a 0.700 M Mg(OH)$_2$ solution?
B2. Case 2 Example Worksheet

Pre-Assignment: Do this section before coming to class. TAs will check that it is done.

1. POC 6. The average density of air is 0.00129 g/cm\(^3\). Balloons filled with a gas that is less dense than air will rise. Those filled with a gas denser than air will remain on the ground. Which, if any, of the following balloons will rise? (Assume the mass of the balloon itself does not matter.)
   (a) The density of gas inside balloon 1 is 0.00145 g/cm\(^3\).
   (b) The density of gas inside balloon 2 is 0.00115 g/cm\(^3\).
   (c) The density of gas inside balloon 3 is 0.00122 g/cm\(^3\).
   (d) The density of gas inside balloon 4 is 0.00086 g/cm\(^3\).

2. POC 17. An experiment is conducted to determine the density of a compound. A graduated cylinder with a mass of 23.99 g is used. When 25 cm\(^3\) of the compound is added to the cylinder, then the combined mass of the cylinder and the compound is 41.23 g. What is the density of the compound?

3. POC 23. Suppose you need exactly 2.00 g of acetone for an experiment. The density of acetone is 0.791 g/mL. How many milliliters of acetone will you need? How many drops of acetone is this? (20 drops = 1 mL.)

4. POC 31. A sample of drinking water contains 688 ppm of lead. How many grams of lead are in 100.0 g of this water?

5. POC 34. A solution is 23.7% glucose by mass. How many grams of glucose are in 3000.0 mL of this solution if the solution density is 1.14 g/mL?

In-Class Assignment: Do these together in discussion.

6. POC 45. A solution containing 150.0 g of water and 22.6 g HCl is mixed with a second solution containing 125.0 g of water and 28.9 g HCl. Determine the percentage of HCl by mass of the final mixture.

7. POC 51. Gunmetal is an alloy (solid mixture of metals) that contains 88.0% copper, 10.0% tin, and 2.0% zinc, by mass. How many grams of each are required to make 92.7 g of gunmetal?

8. POC 61. How many atoms of oxygen are there in 275 formula units of Al(CrO\(_4\))\(_3\)?

9. POC 69. How many atoms of hydrogen are contained in 5 molecules NH\(_4\)C\(_2\)H\(_3\)O\(_2\)?

10. POC 74. How many moles of carbon atoms are there in 66 mol of Al(C\(_2\)H\(_3\)O\(_2\))\(_3\)-molecules?
## C1. Practice Codes

### P1. Checking-In

*The GTA initiating a verbal interaction with a student or group of students that elicits responses from the students. P1 was coded when there was not an ongoing interaction. It does not include GTA initiated interactions that start with statements of the student being right or wrong, which would be coded as P8 and P9 respectively.*

**Example 1 from C3**

GTA: *You need help?*

student: Kind of.

GTA: Okay. I'll be going over this, then you can shout out which one you need help with.

student: Okay.

**Example 2 from B3**

GTA: Are you done?

student: yeah

### P2. Leading through problem

*The start of a series of turns where the GTA introduces and works through a problem. This practice is coded only once at the start of the series of turns. Turns in this series often included P5 (prompting) and P8 (validating).*

**Example from C1**

GTA: *Yeah. It's like this, right?* What's the charge on fluorine?

student: [inaudible]-3.

GTA: No, look on the periodic table. What's the charge on fluorine?

student: Nitrogen, 9, 7 [inaudible].

GTA: That's the atomic number.

student: [inaudible]-1.

GTA: -1, there you go, yeah, -1. For neutral, you could just figure it out by looking at a periodic table. I'm going to show you the short way for neutral, but when it's charged you always have to do the long way. This is for the short way. This is -1, and boron is?

student: 0

GTA: Check your periodic table. It's plus what?

student: 3?

GTA: 3, so this is 1. You have it right here, 1, 2, 3.

student: Oh, that right there.

### P4. Understanding check/“Does that make sense”

*An understanding check is a verbal GTA statement that elicits student feedback about their understanding of the material just discussed. A common phrase used in these cases was “does that make sense?” This is different from P1 (checking-in) because P1 comes at the beginning of an interaction and P4 comes at the end of an interaction.*

**Example 1 from C3**

GTA: Because then, so if we're going from here to here, right? We're halving this and we're trying to separate, so we're going to, say the layout one. The 1 goes back up and the 2 goes back up to get these as separate. That's why you don't keep the subscripts.

GTA: *Does that make sense?*

student: Yeah.
### P5. Prompting
- A GTA question or statement that elicits a student response/answer or pushes the student to consider the next step in the problem.

**Example 1 from C3**

GTA: You're missing three ionic compounds here.
student: Three?
GTA: Mm-hmm (affirmative).
student: Ionic compounds are the ones with the ... Wait, a-t ...
GTA: **With what?**
student: With like "a-t-e," "i-t-e?"
GTA: Yeah, polyatomics is one. **There's also another big one.**
student: Transition metals?
GTA: Metals.
student: Metals, yeah.
GTA: Any metals.

### P6. Do you have a question (whole class)
- The GTA eliciting student input on what to do.

This commonly includes asking the student(s) which problems to go over from the worksheet or providing the opportunity for student(s) to ask questions generally. This is different from P2 because it isn’t the start of solving a problem, it is finding out what students want to cover.

**Example 1 from C3**

GTA: Top. The top ones are not balanced, okay? I'll send you guys my answers, you can see what you get on that. **Then in that same section, which one do you guys want to do? A, B, C, D, E?**

**Example 2:**
GTA: Anymore questions on the quiz? Concerns, comments? Okay?
GTA: Okay, so if there's no questions, you guys can get in your groups, start working on the discussion worksheet. You should be able to do everything. You did go over all of this stuff. I'll come around if you guys need help.

### P7. Explaining Content
- The GTA engaging in a response or discussion of a topic, an extended set of steps to follow, or an answer that includes a “because”. This is different than P10 (Direct Answer) since it includes the a content explanation or detailed procedure rather than simply an answer.

**Example 1 from C3**

student: But this is mass to mass. I'm looking for mass to moles.
GTA: Then you just stop right here. When you do these problems, you're basically taking this diagram and putting it here and using as much or as little as you need. Yeah, you're just going basically filling in these blanks, so you're saying, "Oh, I'm going from grams of this, NaCl," which you have, "to moles of NaCl, and I want to use this ratio." That's what he's going to do on the quiz, but give you boxes and you guys are going to fill in these boxes. Right now you're just doing the calculations, so you have these ratios, right? But you want to say what it goes to.
**P8. Validating** - The GTA providing an explicit or implicit indication that the student was correct. Explicit is found in statements of “yes” “yeah” or a repeat of the student. Implicit is found in the GTA moving on to the next question, a new prompt, or ending the interaction without correcting the student.

**Example from C4**

GTA: **Yeah.** Since this is 1, this is 2, on this side, overall, how many nitrogen you have?  
Student: 3  
GTA: **3.** and you had how many, you said, on this side?  

---

**P9. Correcting** – The GTA indicates that the student answer, written down on the worksheet or stated to the GTA, is wrong or incomplete. This can be explicit (e.g. “you’re doing these wrong”), or implicit where the GTA repeats the question that the student already tried to answer. This differs from P10 (Direct Answer) in that student has not asked the GTA to evaluate their work.

**Example 1 from C3**

[GTA walks up to a student]

GTA: **Okay, so you’re doing these wrong.** What's going to happen is ... This is single displacement instead of double displacement, so what's going to happen, the Cs and Os are going to mix. Leave V just by itself. The metal can stand on its own, right?  
Student1: **Okay.**

**Example 2**

GTA: **Yep.** Go ahead and do that. Okay, cool. Our hydrogens we checked off, our nitrogens, we checked off. Let's check our oxygens. How many oxygen in this compound?  
Student: 2  
GTA: **Overall, though?**

---

**P10. Direct Answer.** In response to a student question, the GTA gives an answer to a student question without an explanation, the GTA tells the student what to do with the problem, or the GTA provides validation/correction of student work. P10 must be in response to an implicit or explicit student question. This is different from P7 (explain concept) because it lacks conceptual detail or why component. This is different from P8 and P9 because it is in response to a student asking for evaluation of their answer.

**Example 1 from C4**

GTA: **Yeah?**  
student: Do we do this the same way? Just stop when we get to there, right?  
GTA: **Yeah.** You don't need to calculate anything.  

**Example 2**  
student: How do you do the percentage yield?  
GTA: Percent yield is actual over theoretical times 100. The information they give you is the actual, and you have to figure out the theoretical.

---

**P12. Encourage students to participate at the board** - The GTA explicitly requests a student volunteer to work a problem on the board. May also include the GTA asking a specific student to work a problem on the board.
GTA: **Okay, who would like to do the next one?** Not George
Student: So that was just a two steps?
GTA: These are all three step ones. This is the [inaudible} third step.
Student: Okay.
GTA: **Who would like to do it? Susanne, what about you? No?**
Student: I know how, I just don't ... [inaudible}
GTA: **That's OK, I can give you those.**

### P13. Having student work at the board
The GTA has a student(s) work a problem on the board. There is likely no dialogue associated with P13. It was marked based on the video following a P12 code when a student went to the board.

### P14. Ask student to explain/Why
The GTA asks the student(s) to explain an answer or statement. This could be an answer to a problem that the student (or different student) gave verbally, an answer that the student wrote on the board, or an answer that the GTA had given. Answer could also be a statement.

**Example 1** – during whole class going over worksheet (case 2 - B4)
GTA: No. **Why** can't we go straight to grams?
Student: Because if you go straight to grams, you're going to be in grams of CO2 and that's not what you want.

**Example 2:**
GTA: Yeah molecules. Can you tell everybody **why** it's molecules?
Student: Because it's a compound. It's more than one.

### P11. Admin/Class Management
Attendance, handing back quizzes, general class management. Unrelated to instructional tasks. Unrelated to content/instructional goals (removed from analysis)

**Example 1 from C3**
GTA: Okay, so I'm going to stop you guys there, so we can do this. I'm going to erase this. student: [inaudible]

*also: checking for worksheets*
Appendix D

D1. Case 1 COPUS Maps

Section A

Case 1 - Section A - Observation 2 Data Map

Time (min) 0  2  4  6  8  10  12  14  16  18  20  22  24  26  28  30  32  34  36  38  40  42  44  46  48  50
Activity
COPUS Student
COPUS GTA

Case 1 - Section A - Observation 3 Data Map

Time (min) 0  2  4  6  8  10  12  14  16  18  20  22  24  26  28  30  32  34  36  38  40  42  44  46  48  50
Activity
COPUS Student
COPUS GTA

Case 1 - Section A - Observation 4 Data Map

Time (min) 0  2  4  6  8  10  12  14  16  18  20  22  24  26  28  30  32  34  36  38  40  42  44  46  48  50
Activity
COPUS Student
COPUS GTA
Section D

Case 1 - Section D - Observation 1 Data Map

Case 1 - Section D - Observation 2 Data Map

Case 1 - Section D - Observation 3 Data Map

Case 1 - Section D - Observation 4 Data Map
D2. Case 2 COPUS Maps

Section A

Case 2 - Section A - Observation 1 Data Map

| Time (min) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 |
|------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Activity   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| COPUS      |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Student    |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

Case 2 - Section A - Observation 3 Data Map

| Time (min) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 |
|------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Activity   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| COPUS      |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Student    |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

Case 2 - Section A - Observation 4 Data Map

| Time (min) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 |
|------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Activity   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| COPUS      |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Student    |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

203
Section B

Case 2 - Section B - Observation 2 Data Map

Case 2 - Section B - Observation 3 Data Map

Case 2 - Section B - Observation 4 Data Map

204
Section E

Case 2 - Section E - Observation 1 Data Map

| Time (min) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 |
|------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Activity   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| COPUS      |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Student    |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| COPUS      |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| GTA        |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

Case 2 - Section E - Observation 4 Data Map

| Time (min) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 |
|------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Activity   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| COPUS      |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Student    |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| COPUS      |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| GTA        |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
Lianne E. Schroeder  
Learning Sciences Research Institute  
1240 W. Harrison St, Chicago, IL 60607  
The University of Illinois at Chicago  
lschro6@uic.edu - leschroeder@gmail.com  

EDUCATION  

**PhD in Learning Sciences** 2017  
University of Illinois at Chicago – Chicago, IL  
Thesis: Chemistry Graduate Teaching Assistant Identity Development  
Thesis advisor: Donald Wink

**MS in Chemistry** 2015  
University of Wisconsin-Madison – Madison, WI

**BS in Chemistry** 2013  
Colorado State University – Fort Collins, CO

RESEARCH EXPERIENCE  

**Case Study of Chemistry Graduate Teaching Identity** August 2015-May 2017  
In my dissertation, I conducted a multiple case study using qualitative methods.

**Understanding Student Self-Regulation** August 2012-May 2017  
This study first developed a methodology for understanding how students engage with different course components in an organic/biochemistry survey course. Data was used to develop and implement an intervention to support students in engaging in self-regulated learning practices. I used survey responses and student exam performance to understand how different students engaged in self-regulation over the course of the semester.

**Laboratory Curriculum Redevelopment** December 2011-May 2017  
This NSF supported project focuses on redeveloping a laboratory curriculum for a one-semester organic/biochemistry course. The MORE framework (Model, Observe, Reflect, Explain) is being used to support students critical thinking and metacognitive skills in addition to conceptual learning.

**Student Understanding of Solutions** August 2010-January 2014  
This project identified student misconceptions related to solution concepts of identity, concentration and reaction. I conducted clinical interviews, transcribed video, and developing a coding scheme using logic modeling.

**Evaluation of Advanced Placement Redesign** August 2010-June 2012  
This project evaluated the domain analysis and framework for AP Biology and AP Chemistry to determine how the articulation of the framework related to the development of the assessments. I developed a representational model of the domain analysis and contributed to white paper provided to the development committees.

**Concept Inventories** August 2010-Jan 2015  
This project seeks to develop cognitive diagnostic models for several concept inventories to be used by instructors to uncover and address student misconceptions. I worked on developing an internal document describing the history of the instrument development and intentions of the creators. I assisted in evaluating statistical analyses in the context of the question content and used this evaluation to recommend questions for a protocol study.
**Multiple Regression Analysis of Chemistry Student Retention**  
Summer 2011
I conducted a multiple regression analysis of chemistry student grade data in the first two years of chemistry. I determined minority status and if they had to repeat a chemistry course were negative predictors of their success in higher chemistry courses. This information has been turned into a university white paper and is being used to inform policy decisions regarding introductory courses and graduate student training.

**Use of Gesture in Organic Chemistry Problem Solving**  
January 2011-May 2011
The goal of this study is to understand the use of gesture in organic chemistry instruction and problem solving. I participated in development of the interview protocol, administered protocol to participants, and coded student response data.

**TEACHING EXPERIENCE**

**Lecturer**
Department of Chemistry, University of Illinois at Chicago  
2017  
- Preparatory Chemistry  
2015  
- Preparatory Chemistry

Department of Chemistry, University of Wisconsin-Rock County  
2007-2008  
- Chemistry for non-science majors, Introductory Chemistry, General Chemistry 2

**Faculty Assistant**
Department of Chemistry, University of Wisconsin-Madison  
2008-2009  
- General Chemistry 1, General Chemistry 2

Department of Chemistry, University of Wisconsin-Madison  
2005-2006  
- General Chemistry 1, General Chemistry 2, Organic Chemistry Lab

**Teaching Assistant**
Department of Chemistry, University of Illinois at Chicago  
2016-2017  
- Preparatory Chemistry

Department of Chemistry, University of Illinois at Chicago  
2012-2016  
- Organic/Biochemistry Introduction, Curriculum Development support, Preparatory Chemistry

Department of Chemistry, University of Wisconsin-Madison  
2003-2005  
- General Chemistry 1, General Chemistry 2
RESEARCH PUBLICATIONS AND PRESENTATIONS

PAPERS


Domingo, J., Abualia, M., Barragan, D., Schroeder, L., Wink, D., King, M., Clark, G (2017). Dialysis, albumin, and competitive binding; a laboratory lesson relating three chemical concepts to healthcare. *Journal of Chemical Education* DOI: 10.1021/acs.jchemed.7b00131


CONFERENCE PAPERS AND PRESENTATIONS


Schroeder, L., Clark, G. (2012, August) *Use of course management systems for ongoing feedback, course development and student reflection*. In R. Shelton (Chair) *Innovative uses of technology in undergraduate chemistry courses*. Symposium conducted at the Biennial Conference on Chemical Education, Penn State, State College, PA.
CONFERENCE SYMPOSIA
Schroeder, L. & Balyut, J. (chairs) (2014, August) Graduate Student Research in Chemical Education Research. Symposium conducted at the Biennial Conference on Chemical Education, Grand Valley State University, Allendale, MI.

CONFERENCE POSTERS

Schroeder, L., Clark, G., Wink, D. (2013, July - revised) Student confidence and resource use: Implications for understanding student reflective practices and course design. Poster session presented at the Graduate Student Conference on Chemistry Education Research, Miami University, Oxford, Ohio.


Schroeder, L., Clark, G. (2012, June). Use of CMS for data collection in a GOB course. Poster presented at Transforming Research in Undergraduate STEM Education, St. Thomas University, MN.


GRANTS
NSF 1431926 - Development and implementation of the MORE Pedagogy in Introductory Organic and Biochemistry Labs
- assisted in development of grant proposal for laboratory curriculum redevelopment

SERVICE
2015 – Chicago Public School Science Fair Judge
2014 – Learning Science Community Committee (UIC, LSRI), Brown Bag Organizer
2012 – Learning Sciences Student Associations (UIC), Vice President
2011 – Learning Sciences Student Associations (UIC), Treasurer
2010 – Chicago Public School Science Fair Judge
2005 – Science is Fun, science education outreach, Madison, WI
- Instructor, People Program - Fun with Chemistry, Wisconsin Initiative for Science Literacy, Madison, WI
2003 – Colorado State Science Fair, Special Awards Judge

PROFESSIONAL AFFILIATIONS
American Chemical Society, Division of Chemical Education
International Society of the Learning Sciences
National Association for Research in Science Teaching
HONORS AND AWARDS
2016 Chemistry Teaching Assistant Appreciation Award, University of Illinois at Chicago
2009 Chemistry Outstanding Teaching Assistant, University of Wisconsin-Madison

REFERENCES

James Pellegrino
Professor of Psychology and Education University of Illinois – Chicago
Co-Director of the Learning Sciences Research Institute
312-413-2320 pellegjw@uic.edu

Donald Wink, Professor
Department of Chemistry University of Illinois – Chicago
Director of Graduate Studies – Learning Sciences
312-413-7383 dwink@uic.edu